XEROX

Xerox University Microfilms
Ann Arbor, Michigan 48106

WESTERN AMERICANA

Reproduced from the original in the collection of
THE HENRY E. HUNTINGTON LIBRARY AND ART GALLERY

REPORT

OF THE

SPECIAL COMMITTEE

OF THE

UNITED STATES SENATE

ON THE

IRRIGATION AND RECLAMATION OF ARID LANDS.

REPORT OF COMMITTEE AND VIEWS OF THE MINORITY.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1890.

HD 1724
1890
[pt. I]

51ST CONGRESS, } SENATE. { REPORT No. 928,
1st Session. } { and views of the minority.

IN THE SENATE OF THE UNITED STATES.

MAY 8, 1890.—Ordered to be printed.

Mr. STEWART, from the Select Committee on Irrigation and Reclamation of Arid Lands, submitted the following

REPORT:

[To accompany S. 2104.]

Before giving a detailed account of the investigations of your committee, some general observations and suggestions as to what action should be taken by the Government to enable the people to reclaim and settle upon the arid lands of the United States are submitted.

Over two-fifths of the area of the United States, exclusive of Alaska, requires irrigation to insure regular crops, and in at least four-fifths of the arid region irrigation is a necessity for the production thereof. This arid region comprises between 1,200,000 and 1,300,000 square miles, being a third larger than British India and very similar to it in its general characteristics.

Attention is called first to that portion of the great plains between the Canadian line and Mexico, and the foot-hills of the Rocky Mountains and a line following where the rain-fall ceases to be sufficient to produce regular crops. This line is not a straight one. It curves both east and west, and is sometimes found about the ninety-eighth meridian of west longitude, and sometimes as far west as the one hundredth meridian. This region contains about 200,000 square miles. The soil is exceedingly fertile and the climate salubrious; and in the eastern part of it, while irrigation is important, farming can be prosecuted, except in seasons of drought, without irrigation. Still for a portion of each summer a supply of water under the farmers' control would always be of great importance.

The Missouri River with its numerous branches; the Platte River, also with several branches; the Arkansas, and a number of other streams of less importance, flow through these plains. To what extent these rivers and their tributaries, together with the water that may be stored in reservoirs which now runs to waste, carrying silt and increasing floods in the Lower Mississippi, may be utilized, is as yet undetermined. It is confidently believed that, with restraining dams to hold back the water of the numerous lakes found at the headwaters of the various tributaries of these rivers, and reservoirs constructed at other suitable points, together with the aid of the natural flow of the streams, a very large extent of country, now comparatively worthless, could be made exceedingly productive, while the floods in the Lower Mississippi would be greatly alleviated.

The rain-fall on these great plains comes not in gentle showers with cloudy weather, as is the case farther east, but falls in torrents upon limited areas; sometimes in one place and sometimes in another; and it often happens that while a violent storm is raging in one locality, a few miles distant there will be sunshine and a clear sky.

Experience has shown in Kansas, Nebraska, and other localities, where the country is settled and the land cultivated, that this erratic and irregular rain-fall is greatly modified and the moisture more evenly distributed. It is believed, from the experiences of this and other countries, that as settlement advances the climatic conditions will be very much improved, although there may not be much increase in the aggregate of precipitation. It is also anticipated that much irrigation may be practiced throughout these plains by the local storage of the storm-waters in small artificial reservoirs constructed by the farmers themselves.

There is another and a very remarkable development of water supply in various portions of these plains. Artesian wells have been bored along the valley of the James River, in the States of North and South Dakota, which surpass in the flow of water any wells in the United States, and probably any in the world. Wells have also been bored with success in Colorado, Kansas, Texas, and other places east of the Rocky Mountains.

All the country west of the eastern base of the Rocky Mountains to the Pacific Ocean requires irrigation, except that part of Washington, Oregon, and northern California west of the Cascade Mountains, and comparatively small areas in eastern Oregon, Washington, and northern Idaho, which receive moisture from the storms of the Pacific Ocean passing through the gap in the Cascade Mountains where the Columbia River flows. This arid region includes Montana, Idaho, Wyoming, Utah, New Mexico, Arizona, Nevada, nearly all of California, the larger portion of Colorado, Oregon, and Washington, and more than one-third of Texas.

The principal rivers and streams are the headwaters of the Missouri, the Platte, the Arkansas, the Rio Grande, and Red on the east of the summit of the Rocky Mountains. The great basin between the Rocky and the Sierra Nevada Mountains is drained by the Colorado and the Columbia Rivers and their tributaries The principal ranges of mountains are the Rocky, the Sierra Nevada, the Cascade, the Wasatch, and the Bitter Root.

A GENERAL DESCRIPTION.

Montana extends from the one hundred and fourth degree of longitude to the one hundred and sixteenth degree of longitude, west from Greenwich, and is bounded on the north by the British possessions, and on the south by Idaho and Wyoming. It contains 143,776 square miles. While it equals, if it does not surpass, any other State or Territory of the United States in mineral resources, it has a vast amount of good agricultural land, and an abundant supply of water for the purpose of irrigation. The eastern half of the State is watered by the numerous branches of the Missouri River, which head in high mountains where the precipitation is very great. The streams are of such an altitude as to afford an opportunity to divert them over very large areas of the most fertile land. The western half of the State is watered by the tributaries of the Columbia River, which find their sources in the Rocky Mountains, and flow west through numerous fertile valleys. The agricultural capacity of the State is very great, and the farmers in this region have great advantages in the home market created by extensive mining operations carried on, which must be continued for an indefinite period.

Washington, east of the Cascade Mountains, would be greatly benefited by irrigation, and large areas of it must be irrigated to produce crops. It is, however, more favorably situated than any of the other interior States on account of the great opening in the Cascade Mountains through which the Columbia River flows. The mouth of the Columbia River is a great storm center. The western or Chinook winds in winter focusing there, drive the clouds through the Columbia River Pass and their contents are precipitated when they strike the Bitter Root Mountains in northern Idaho and other elevations in eastern Oregon and western Montana and Washington. In these localities farming is successfully conducted without irrigation, although in most places the practice would be highly beneficial. There are large sections not reached by sufficient rain-fall, occasioned by the passage of clouds through the Columbia River Pass. These sections must be cultivated, if at all, by irrigation. To what extent the Columbia River and its tributaries may be utilized for this purpose in eastern Oregon and Washington is not yet determined. There is a large extent of Oregon east of the Cascades which possesses great natural fertility, but it is entirely dependent upon irrigation.

Idaho comprises 86,294 square miles. The northern part of it, commonly known as the Pan Handle, is well supplied with water, and farming is prosecuted with success without irrigation, although it would be of great advantage, and the water for that purpose can be easily obtained. The great valley of southern Idaho, through which the Snake River and its tributaries flow, is the largest interior valley in the United States which can be irrigated by one general system. The Snake River passes through this great valley and heads with its numerous branches in the high mountains of Wyoming, near the Yellowstone Park, where there are numerous important lakes which can be utilized as reservoirs to keep back the flood waters until the season of irrigation. The land of this great valley is exceedingly productive. That in the vicinity of Boisé City is already under a high state of cultivation, producing all the crops and fruits of the temperate zone to perfection and in great abundance. The climate is mild, being modified by the Chinook winds from the Pacific Ocean passing through the opening in the Cascade Mountains where the Columbia River flows. Their effects are felt in Montana and as far east as Utah. Idaho is also celebrated for its mineral resources and has, like Montana, a most important home market for its agricultural products.

Wyoming comprises 97,883 square miles. Much of this Territory lies at a high altitude, and its mountain peaks are covered with perpetual snow. It abounds in mineral resources, particularly in coal and iron. Its coal mines along the line of the Union Pacific Railroad are already being developed on a magnificent scale. It also has great agricultural resources. The line of the Union Pacific Railroad passes through the least inviting portion of the Territory. The traveler over this thoroughfare will necessarily underrate the value of Wyoming as an agricultural country, but it is now ascertained that the Laramie Plains and other parts of the Territory traversed by the Union Pacific Railroad, when irrigated, produce cereals and the hardier vegetables in great abundance. The northern part of the Territory is, however, the best agricultural country. The Yellowstone and other branches of the Missouri have their sources in Wyoming, and the numerous valleys through which they flow produce all the crops and fruits of the temperate zone. There are also large areas in the eastern part of Wyoming that can be irrigated and brought under cultivation. There can be no question about the natural resources of this Territory and that it is capable of supporting a very large population. It also has a home market which must increase indefinitely as its coal and iron mines are developed and utilized.

Colorado comprises 104,500 square miles, and it possesses many natural advantages. The Platte and Arkansas extend their branches into the Rocky Mountains, which constitute the backbone, so to speak, of this State, and their waters are already distributed over many thousands of acres of irrigated land. The Rio Grande also heads in the mountains of this State, and before it enters New Mexico passes through extensive valleys which are rapidly being brought under cultivation by irrigation works of great extent. On the western slopes, in the valleys of the Grande and Uncompahgre Rivers, there are considerable areas under ditch. Colorado is drained on the west by the Colorado River and its tributaries. It is also a great mineral State and contains mines of almost every description. It abounds in gold, silver, iron, and coal. The enterprise of the people of this State seems to know no bounds. The wisdom of its laws regulating the use of water challenges the admiration of all who investigate them. The success of the pioneers of this State in reclaiming the desert by means of irrigation, and their wisdom in legislating for its regulation, furnish examples which are worth following throughout the arid region.

Utah comprises 84,476 square miles. Here irrigation was first begun in the United States by the Anglo-Saxon race. It was inaugurated in 1848 by the Mormons when this was the most isolated portion of the continent between the British line and the City of Mexico. The frugality, enterprise, and perseverance of the Mormons in reclaiming the desert lands of Utah, and their mode of distributing the water and dividing the land among their people, furnish an example of what is possible in the arid region, and has already done much to encourage the pioneers of the West to build up States in a country which fifty years ago was designated on the maps as the Great American Desert. A person familiar with the history of the Mormon settlements in Utah, their hardships, privations, and successes, must necessarily sympathize with them as a people and look forward with anxiety and hope to the day when their institutions will be in harmony with the laws of the United States, and Utah be permitted to join the sisterhood of States. The Great Salt Lake basin is watered by rivers and streams flowing from the Wasatch Mountains, the Bear and the Jordan being the largest. The amount of land under cultivation by irrigation in this Territory is about 600,000 acres, which may be increased to 3,000,000 acres when the waters which are found in it and which flow through it are utilized and properly distributed. Utah has also mineral resources of vast extent, which are comparatively untouched. It has extensive coal-fields, rich and valuable mines of gold, silver, and lead, furnishing an important home market.

Nevada comprises 112,090 square miles. It abounds in mines of gold, silver, copper, salt, borax, and other minerals. Its agricultural resources by irrigation are sufficient, when developed, to support a large population. The western part of the State is watered by the Truckee, Carson, and Walker Rivers, which head in numerous lakes in the Sierra Nevada Mountains, where the precipitation is greater than in any other part of the United States, except in the Cascade Mountains in Washington. These streams flow into Nevada and sink in the sand or form lakes. It is estimated that from a million to a million and a half acres of land may be irrigated by these streams. The Humboldt River heads near the Utah line, and the Central Pacific Railroad passes through the valley of this river for about 250 miles. Much of this valley may be reclaimed by storing, and an economical use of the water. This river has many branches and fertile valleys, both to the north and to the south, which are already cultivated to a considerable extent by means of irrigation. While there are large parts of the State that must remain deserts for want of water, still there are valleys interspersed in the mountains throughout the State of exceeding fertility, and for which water can be procured for irrigation. In the southern part of the State there is a large extent of rich land, and the remains of irrigation works found in that vicinity show that the country was once inhabited by a race which cultivated the soil. The people of Nevada were at first exclusively engaged in mining, the agriculture that was pursued being solely for the purpose of supplying mining camps. But they are now turning their attention to agriculture with good success. This State will also have the advantage of a large home market in supplying the mining communities.

California is one of the most remarkable States in agricultural resources, variety of climate, and products in the United States, and probably is unsurpassed by any country in the world. It also commenced its career as a mining State, and for twenty-five years after the discovery of the gold mines little attention was paid to agriculture. It is noteworthy that the great valleys of California, now so productive, were regarded a few years ago as deserts, and were occupied only by roaming herds of Mexican cattle. Irrigation in this State is being developed on a grand scale and with wonderful success. Land that remained subject to private entry at $1.25 per acre for twenty-five or thirty years now commands $100 to $1,500 per acre, and a family can secure all the comforts of life upon 20 acres of this land. The work of irrigation in this State has only just begun. Enough has been accomplished, however, to demonstrate the fact that the possibilities of the growth and development of this country must continue indefinitely. Cities have sprung up within the last ten years in its alleged deserts, which rival the splendor of the most prosperous centers of the Atlantic States.

The methods adopted for irrigation in California furnish valuable lessons. They show that year by year the supply of water becomes more plentiful for new fields as the ground becomes saturated. It is estimated by the best judges that nearly all the valley land of California may be ultimately brought under cultivation by irrigation. The Sierra Nevada Mountains, as before remarked, are lofty, and the snow and rain that fall on them during ordinary seasons is simply immense. The Sacramento, the Feather, the Yubas, the Bear, the American, the Tuolumne, the Stanislaus, the Merced, the Kings, the San Joaquin, the Kern, and many smaller streams flowing from the Sierra Nevada into the great valley of California, when utilized with a proper high storage system in the mountains, will be found amply sufficient to bring under cultivation all the valley land from Red Bluffs to the Tehachapi Pass, a distance of about 500 miles with an average width of about 40 miles. The great valley of southern California, bounded on the west, north, and east by mountain ranges connecting with the Sierra Nevada Mountains, and on the south and west by the Coast Range and the Pacific Ocean, is fast becoming the most highly cultivated and productive part of the United States, abounding in semi-tropical fruit of all kinds as well as the productions of the temperate zone. A visit to its beautiful vineyards and its prosperous towns offers a new revelation to the traveler.

Arizona comprises 113,916 square miles. No part of it can be cultivated without irrigation. The southwest section of the Territory lies very low. The climate is warm and healthful. Its products are also semi-tropical. The grape, the orange, the fig, the date, the apricot, and all other fruits and products of the temperate and semi-tropical countries are cultivated here to perfection. The Colorado River, although furnishing an abundance of water, can not be utilized to any extent in Arizona without great expense. It may, however, be used above to reclaim a large section of country in California known as the Mojave Desert. This matter has not been fully investigated. The Gila and its branches are the principal streams of southern Arizona. This river discharges an immense volume of water in the wet season, but in the dry season it sinks and flows under the surface for miles on each side. The engineering problem to be solved here is how to bring this water to the surface. There are points where it crosses reefs of rock where dams can be constructed and the water conveyed in canals to reclaim large sections of country. The largest tributary of this river is known as Salt River. In the vicinity of the town of Phœnix, on Salt River, about 100,000 acres of land are already irrigated. The facilities for storing the water of Salt River are very good, and where the river leaves the mountains an immense reservoir of water may be had at comparatively small expense, which would irrigate an extensive region of country. This section is well adapted to the grape, orange, lemon, and other semi-tropical fruits. It also produces the cereals and all other crops of the temperate zone. There are many other parts of this Territory that can be reclaimed by irrigation. As a mining country it will furnish a valuable home market. There is no doubt of the capacity of Arizona to support a large and prosperous population.

New Mexico comprises 121,201 square miles. Along the valley of the Rio Grande the country has been cultivated by the Mexicans from a very remote period. The supply of water, however, for this Territory is very much diminished by irrigation at the headwaters of the Rio Grande in the State of Colorado. To what extent the waters of this river can be stored and utilized is a problem not yet solved, but it is confidently believed that, by storage of the flood waters, a very large extent of country, in addition to that heretefore cultivated, may be irrigated from the Rio Grande. There are numerous other streams in the Territory which are being diverted and utilized for irrigation. Water is also found under the surface in many parts of the Territory, and by means of pumping and flowing wells a sufficient supply may be obtained to reclaim much of the desert land. The Pecos River, in the eastern part of the Territory, is an important stream and is being diverted on a large scale by canals. This river extends into Texas, where it enters the Rio Grande, and may also be used, and is now being used, to reclaim a portion of that State. The Mexican grants, which cover a large part of the Territory of New Mexico, have been a drawback to its development, but the time is not far distant when these titles will be settled and the land divided up, as it is now being done in California. New Mexico has great mineral resources, particularly coal, which is found in abundance. Taken all in all its future will surpass what the most sanguine have heretofore anticipated.

The western half of Texas, which was supposed to be uninhabitable, constituting in that section the plains region first mentioned, will be largely reclaimed by the use of the running streams, artesian wells, and pumps. The experiments already made there have demonstrated that a large part of it may be reclaimed and rendered exceedingly fertile by such irrigation. Artesian wells have been bored in various places throughout the arid region frequently with good success. California has several important artesian belts, and is developing the underground flow of water to good advantage. Nevada has many artesian basins which will be utilized. The same is true of Utah, Idaho, Montana, Washington, Arizona, and New Mexico; but in the mountain region the running streams, supplemented by reservoirs for storage of storm waters must furnish the principal supply for irrigation.

Without further particulars at this place with regard to the arid region, it may be said that throughout its entire extent the grasses are more nutritious than where the rain-fall is sufficient to produce crops. The frequent rains in the Mississippi Valley and further east extract the nutriment from the plants and destroy the grasses, except when they are growing, so as to render them at other times comparatively valueless for stock; but in the arid region the vegetation, however dry, retains its nutritious properties, and stock will fatten where to the uninitiated it would be supposed they would starve.

Wyoming, Montana, the western portions of North and South Dakota, eastern Oregon, and Washington, Idaho, and Nevada are especially valuable for grazing purposes. The same is true to a large extent of Arizona, Utah, New Mexico, and Texas. This will be a perpetual source of wealth to the farmers who may cultivate the valleys by irrigation and use the uplands for pasture. Reclamation of arid lands will create cattle as well as arable farms, and tend rapidly to the division and use of the land in small parcels.

The amount of land that may be brought under cultivation in the arid region by irrigation is variously estimated at from seventy-five to one hundred and fifty millions of acres. It is safe to predict that at least one hundred millions of acres will be ultimately brought under cultivation by irrigation, and that, too, by the water in sight which, when properly utilized, will readily reclaim at least 10 per cent. of the whole arid area. It is worthy of remark that land cultivated by irrigation is much more productive than land where the rain-fall is sufficient to produce crops. The certainty of crops every year in an irrigated country where the water supply is sufficient is a most important consideration. Besides, in nearly every part of the arid region more than one crop can be produced each year from the same land, and a good crop is always certain with a constant water supply. Irrigation requires unremitting attention and high cultivation and with such attention and cultivation it is calculated that in any given period of ten years irrigated land will produce from three to five times as much as land cultivated by rain-fall.

The question for consideration is: What action should be taken by the Government to enable the people to reclaim these desert lands? The reclamation must be initiated and executed by the people, and not by their Government. In India, and, in fact, in all countries under monarchial or despotic rule, the work of irrigation has been carried on under Government control and largely with Government money. The Government of British India has already expended several hundred millions of dollars in constructing irrigation works, and is continuing such expenditures on a most magnificent scale. The reports show that the investment has been profitable to the Government and of the greatest possible advantage to the people.

But there is no necessity for the United States to engage in such expenditures. If the opportunity is furnished to the people of this country they will reclaim these desert lands so far as reclamation is necessary. The use of industrial co-operation in developing the mineral resources of the far West demonstrates the capacity of the people for great undertakings which in other countries require vast expenditures of accumulated capital. A person who will visit these mining States and Territories, and see the hundreds of miles of canal constructed for mining purposes in the most difficult parts of the Sierra and Rocky Mountains, the bed-rock tunnels miles in length, the deep shafts, the reduction works, and other vast enterprises which the people themselves have conducted by co-operation and without accumulated capital, will not question the capacity of the pioneers to reclaim the deserts. If he will then turn his attention to Utah, Colorado, California, and other localities where irrigation is practiced, and witness what the people have already accomplished, all doubt as to the ultimate result will be removed. It is necessary, however, for the development of this arid country to give the people an opportunity by laws suitable to the situation and adapted to the purpose.

GOVERNMENTAL ACTION.

On the 3d day of March, 1873, the following act of Congress was approved:

> That the President be, and he is hereby, authorized to assign two engineers of the Army and one officer of the Coast Survey now stationed on the Pacific coast, for the purpose of examining and reporting on a system of irrigation in the San Joaquin, Tulare, and Sacramento Valleys of the State of California, and for that purpose the officers so assigned may associate with themselves the chief of the geological survey of California, and also one other civilian distinguished for his knowledge of the subject.
>
> SEC. 2. That these five persons shall constitute a board, with power to fill vacancies, whose duty it shall be to make a full report to the President on the best system of irrigation for said valleys, with all necessary plans, details, engineering, statistical, and otherwise; which report the President shall transmit to Congress at its next session with such recommendations as he shall think proper.

Under this act a commission was organized composed of General Barton S. Alexander, Col. George H. Mendell, Prof. George Davidson, and R. M. Brereton, a civil engineer who had large experience in irrigation in India. A most comprehensive and instructive report was made by the commission and published by Congress. (H. R. Ex. Doc. No. 290, Forty-third Congress, first session.)

This report gives much valuable information on the whole subject of irrigation in India and other countries, and furnished material to guide the people of this country. The report was exceedingly beneficial, pointing out the way to the development of the great valleys of California, and has resulted in great good.

The Department of Agriculture, without any operative or executive powers, has done a good deal to extend a knowledge of the character and resources of the arid region. It begun in 1865 with a report by a former delegate from Arizona, Charles D. Poston, and continued between that and 1886-'87 to publish valuable reports by the late George P. Marsh, Professor Hilgard, of California, ex-Governor Furness, of Nebraska, and others, closing with the important and valuable volume on "Irrigation in the United States," which the Senate ordered published in 1887. This very useful report was prepared by Mr. Richard J. Hinton, who has also efficiently served your committeee during the past year as irrigation engineer and expert.

POLICY PURSUED BY THE DIRECTOR OF THE U. S. GEOLOGICAL SURVEY.

Subsequently the whole subject was turned over to the Director of the Geological Survey with general provisions for the classification of the public lands, he having previously prepared a valuable report on the arid lands of the United States. The most important action by the Government in aid of the reclamation of desert lands was the passage of the acts of October 2, 1888, and of March 2, 1889. By the first of these acts $199,000 was appropriated for topographic surveys, and $100,000 for surveys pertaining to irrigation. Of the sum appropriated for irrigation $60,000 was diverted by the Director from that purpose and added to the appropriation for topographic surveys, making the sum of $259,000 for topography, and leaving only $40,000 for irrigation.

By the act of March 2, 1889, $200,000 was appropriated for topographic surveys, and $250,000 for irrigation surveys. Of the sum appropriated for irrigation surveys $120,000 was diverted from that purpose by the Director and added to the $200,000 for topographic surveys, making the aggregate of $320,000 for topography, and leaving only $130,000 for irrigation surveys and the office and other expenses incidental thereto. Your committee regard this as a plain violation of the statute and a misapplication of the money.

In fairness to the Director, however, it is proper to state the substance of the reasons assigned by him for this use of the public money, together with the views of the engineers of the Irrigation Survey.

The provision of law authorizing this last appropriation sets forth in some detail the purposes to which it is to be applied, etc. Among those purposes it mentions "the necessary maps." The Director of the survey has construed the words "necessary maps" to mean topographic maps of the same kind as those that are provided for specifically in the first item of $200,000, and he has applied more than half the irrigation item to that purpose, leaving less than half of the $250,000 for the objects for which it was intended. It has always been held, both in Congress and by many decisions of attorneys-general and comptrollers, that when an appropriation is made for any specific purpose it is not lawful to apply any other appropriation to that purpose unless the law explicitly authorizes it. It would have been a most unjustifiable straining of interpretation to conclude that such vague and indefinite words as "necessary maps" meant so vast and costly an undertaking as a topographic map of the whole arid region, even if no specific appropriation for topography had been made. But when such an appropriation was specifically made, it should clearly have been held to be the only money which could be applied to topographical purposes.

It has been represented by the Director that a general topographic map of the arid region is necessary for the Irrigation Survey; that unless it is made the cost of that survey will be increased many fold. This statement it is impossible to comprehend. It is, of course, easy to see that such a map would give useful information of a general kind and would be convenient for many minor purposes. But the engineers, while admitting this, testify with one voice that its usefulness goes no farther; that such a map is not at all necessary in any imperative sense; that it will not save them any important amount of labor or expense; that the engineering surveys would be of the same character and cost the same whether they have the maps or not, and that no use has been made of any topographic map by any of the engineers engaged in the Irrigation Survey, except as a general map of the country.

The Director asserts that the maps will make trial lines unnecessary. The engineers say that trial lines are seldom necessary, and when they are, they are run for the purpose of settling questions upon which a topographic map could not possibly give any information whatever. The Director seems to entertain the idea that it will often be doubtful whether the slopes of a country in the trough of a stream will admit of leading the water from the river upon the bench land, and that a topographic map will settle such questions at a glance, while without the map the engineer would have to make an expensive survey. The engineers say that such questions can be settled in an hour, or in a day or two, by the simplest inspection. The only doubtful questions are those of the amount and cost of construction, which depend on the character of the ground through which a canal must run; and no map gives any information on that subject.

The Director asserts that the topographers are relied upon by him to discover the reservoir sites, and that they can do it at one-fifth or one-sixth the cost of their discovery by the engineers. The engineers say that in order to perform their duty in any district they must see the whole of it themselves, and that no map can take the place of the knowledge of a district which is gained by actually seeing it. This examination they are compelled to make, and in the course of it no reservoir site can escape detection. Their selection and withdrawal, therefore, can be accomplished without any material addition to the cost of the proper work of the survey as a mere incident of a necessary reconnoissance; while the Director's own estimate of the topographic work alone exceeds the entire cost of the engineering and hydrographic work combined.

The Director asserts that the hydrographic work will be very greatly cheapened by a topographic map showing the areas of water-sheds and their slopes from which the amount of water running off can be computed. The engineers claim that such a computation would be no better than guess work and would lead to no result, and that the only known method of finding the water supply of a drainage basin is to measure it. If guess work is sufficient they can guess as well without the map as with it. It must be remembered that a competent civil engineer is necessarily a good topographer, and understands also the nature of proper hydrographic work. The greater includes the lesser.

ARE TOPOGRAPHICAL MAPS NECESSARY?

The Director contends that the segregation of the irrigable lands can be effected much more cheaply by a topographic survey than in any other manner. This is a statement upon which any member of Congress can form an opinion without any advice from either topographers or engineers. The law vests the administration of the public lands of the United States in the General Land Office. It has for nearly a century provided a system, and grown up under it, by which the public lands are parceled into townships, sections, and quarter sections. The people are thoroughly educated to it and understand it. Surveys have been provided which make the subdivision and mark the corners on the ground, and the law recognizes such marks as the true and only lawful metes and bounds. The Land Office has a record system of all surveyed parcels, and it is the only record which the law recognizes. It has a system of maps or plats which the law makes a part of the official record, and the exemplifications of the plats and records under the seal of the Land Office are competent evidence in the courts.

The Geological Survey has been authorized and required to segregate certain public lands which it may find to be irrigable, but as the law has not taken the administration and record of the public lands from the Land Office, it is claimed that the work of the Geological Survey can go no further in this matter than to indicate to the General Land Office what particular lands it finds to be irrigable, and, therefore, subject to withdrawal from occupation, sale, and entry. How are these lands to be specified? Plainly, in such terms as the law provides—by townships, sections, and quarter sections. Upon what maps should they be represented? Plainly, upon such maps as the Land Office is by law authorized to employ. What can the Land Office do with a topographic map? Such a map has no recognition in the law for purposes of record and carries with it no substantive fact of which the Land Office can take the slightest cognizance. That office can not recognize any maps but its own. Probably the Director will admit this. But he asserts that the work of segregation will be greatly cheapened if the topographic map is made.

Now it is plain enough that in order to specify irrigable lands the irrigation engineers must first go over the country to find out what lands are irrigable. He must then identify what townships and sections include these irrigable lands and must identify the corners on the ground. He can then represent them on a transcript of the Land Office map, and report them, section by section, to the Land Office. In case the irrigation survey precedes the Land Office survey, the engineers can connect their work with the Land Office surveys, and this can usually be done by running a single line or by triangulation.

The engineers say that they find some convenience in topographic maps in the way of general information of a geographical character. But they can dispense with them without any serious inconvenience, just as they can dispense with many other things which might be convenient, and they can accomplish their work without them at a cost not materially greater than if they had them.

The maps already in existence furnish sufficient information for the guidance of the engineers. These maps are compiled from various sources. First, the Land Office surveys, which are the basis of all the maps of the public land States. Second, the railroad surveys, which furnish much of the topography of the country. Third, the topographic surveys of Wheeler, Hayden, and Powell. From these various sources the Director of the Geological Survey has already constructed, or rather perfected, maps of the arid region which are very creditable and useful. The committee will print, in connection with the testimony, several of these maps, one showing the arid region, one showing the timber in the arid region, and several maps showing the various drainage basins. It is believed that these maps are all that is required for the engineering work for irrigation.

INDEFENSIBLE USE OF PUBLIC MONEY.

If it be admitted, however, that the views of the Director of the Geological Survey are correct as to the necessity for topographic surveys in advance of irrigation surveys, such views are no justification for the diversion to topography of the money appropriated for irrigation. Congress provided how and for what purpose the money should be applied, and it is the duty of the executive officer to so apply it. He is not employed or empowered to use public money otherwise than is prescribed by law.

The act of March 2, 1889, not only made a separate appropriation for both the topographic and irrigation surveys, but declared that—

> The Director of the Geological Survey, under the supervision of the Secretary of the Interior, shall make a report to Congress on the first Monday of December of each year, showing in detail how the said money has been expended, the amount used for actual survey and engineer work in the field in locating sites for reservoirs, and an itemized account of the expenditures under this and any future appropriation.

This language plainly excludes the use of this money for any other purpose than actual engineering work for the purpose of irrigation in the field and the necessary office work connected with the same. No itemized account of the expenditure of this money has been rendered to the knowledge of your committee, but they have the statement of Capt. Clarence E. Dutton, of the U. S. Army, who has had charge of the expenditure of such portions of these two appropriations as were allotted by the Director to irrigation surveys, which statement is printed with this report. (Vol. 4, of the Testimony.)

WITHHOLDING PUBLIC LANDS FROM SETTLEMENT.

A provision was inserted in the act of October 2, 1888, which is working great hardship to the people of all the arid States and Territories. It was necessary to reserve "all the lands which may hereafter be designated or selected by such United States surveys for sites for reservoirs, ditches, or canals for irrigation purposes." This reservation was in the bill as it passed the Senate, and was inserted to prevent the occupation of reservoir sites and other places necessary for public use in connection with irrigation. But the following clause was unnecessary and the construction given to it has been disastrous. It did not come from the original friends of irrigation development. It adds to the provision above quoted the following:

> And all the lands made susceptible of irrigation by such reservoirs, ditches, or canals are from this time henceforth hereby reserved from sale, as the property of the United States, and shall not be subject after the passage of this act, to entry, settlement, or occupation until further provided by law: *Provided*, That the President may at any time in his discretion by proclamation open any portion or all of the lands reserved by this provision to settlement under the homestead laws.

Under this clause, reserving lands made susceptible of irrigation by the hydraulic works named, the following order was made by the Commissioner of the General Land Office:

DEPARTMENT OF THE INTERIOR,
GENERAL LAND OFFICE,
Washington, D. C., August 5, 1889.

REGISTERS AND RECEIVERS,
United States Land Offices:

GENTLEMEN: Information having reached this Department that parties are endeavoring to make filings on arid lands reserved for reservoirs, irrigating ditches, and canals, and for the purpose of controlling the waters of lakes and rivers and their tributaries in the arid regions, I am directed by Hon. Secretary of the Interior to call your special attention to the act of Congress approved October 2, 1888, U. S. Statutes at Large, vol. 25, page 526, as follows:

"For the purpose of investigating the extent to which the arid region of the United States can be redeemed by irrigation, and the segregation of the irrigable lands in such arid region, and for the selection of sites for reservoirs and other hydraulic works necessary for the storage and utilization of water for irrigation and the prevention of floods and overflows, and to make the necessary maps, including the pay of employés in field and in office, the cost of all instruments, apparatus, and materials, and all other necessary expenses connected therewith, the work to be performed by the Geological Survey, under the direction of the Secretary of the Interior, the sum of one hundred thousand dollars or so much thereof as may be necessary. And the Director of the Geological Survey, under the supervision of the Secretary of the Interior, shall make a report to Congress on the first Monday in December of each year, showing in detail how the said money has been expended, the amount used for actual survey and engineer work in the field in locating sites for reservoirs, and an itemized account of the expenditures under this appropriation. And all the lands which may hereafter be designated or selected by such United States surveys for sites for reservoirs, ditches, or canals for irrigation purposes and all the lands made susceptible of irrigation by such reservoirs, ditches, or canals, are from this time henceforth hereby reserved from sale as the property of the United States, and shall not be subject after the passage of this act to entry, settlement, or occupation until further provided by law: *Provided*, That the President at any time in his discretion, by proclamation, may open any portion or all of the lands reserved by this provision to settlement under the homestead laws."

The object sought to be accomplished by the foregoing provision is unmistakable. The water sources and the arid lands that may be irrigated by the system of national irrigation are now reserved to be hereafter, when redeemed to agriculture, transferred to the people of the Territories in which they are situated for homesteads. The act of Congress and common justice require that they should be faithfully preserved for these declared purposes.

The statute provides that all lands which may hereafter be designated or selected by the Geological Survey as sites for reservoirs, ditches, or canals for irrigating purposes, and all lands made susceptible of irrigation by such reservoirs, ditches, or canals are since the passage of said act absolutely reserved from sale as property of the United States, and shall not be subject after the passage of the act to entry, settlement, or occupation until further provided by law, or the President, by proclamation, may open said lands to settlement.

Neither individuals nor corporations have a right to make filings upon any lands thus reserved, nor can they be permitted to obtain control of the lakes and streams that are susceptible of uses for irrigating purposes.

You will therefore immediately cancel all filings made since October 2, 1888, on such sites for reservoirs, ditches, or canals for irrigating purposes, and all lands that may be susceptible of irrigation by such reservoirs, ditches, or canals, whether made by individuals or corporations, and you will hereafter receive no filings upon any such lands.

This order you will carry into effect without delay.

Respectfully,

W. M. STONE,
Acting Commissioner.

As the matter now stands no entries can be made of, or titles perfected to, any of the public lands of the United States requiring irrigation subsequent to October 2, 1888. The people residing in two-fifths of the area of the United States, wherein nearly all of the public lands are situated, are, by the construction given to this law, prevented from acquiring title to any public land fit for cultivation, and all settlements and improvements upon such land are suspended until further legislation can be had.

Attention is called to these facts to show the importance of speedy action on Senate bill No. 2104, reported from this committee. It is proper in this connection to state the general features of the bill and the objects designed to be attained by its passage.

PROPOSED RESERVATION OF ALL NATURAL WATERS.

The bill reserves the unappropriated waters of the lakes and rivers on the public lands for such beneficial uses as shall be determined by the States and Territories in which such waters are situated, and places them under the control of the States and Territories, subject only to the paramount authority of the United States. It reserves the right of way for ditches, canals, and other hydraulic works for the use of irrigation, and allows the flowing waters to be diverted from the natural beds of streams upon the arid areas. Access is also reserved over the public land west of the ninety-eighth meridian of west longitude to all natural waters on the public lands for man and domestic animals. It also reserves to the United States the adjudication of all questions and disputes that may arise in relation to the storage, conservation, flowing, and distribution of all natural waters, flowing or standing, located within or passing through the boundaries of two or more States or Territories within the area described. The bill repeals all laws for the sale or other disposition of the lands where irrigation is necessary, except the mineral land law and the homestead law.

Inasmuch as the people were not informed as to the extent of the reservation of lands referred to in the act of October 2, 1888, it will be necessary to amend the bill reported and provide that bona fide claims heretofore made upon irrigable lands shall not be affected by the reservation. There is, however, one difficulty about the matter. The streams in the high altitudes can be easily diverted upon lands that will produce grass for stock in summer and perhaps some of the hardier vegetables, but which are not valuable lands for settlement. Such diversion is a great waste, and deprives the settlements below, where crops can be produced to perfection, of the use of water for that purpose. The committee therefore recommend the following in lieu of the last section of the reported bill:

> That so much of the act of October 2, 1888, entitled "An act making appropriations for the sundry civil expenses of the Government for the fiscal year ending June 30, 1889, and for other purposes," as reserves, "all the lands made susceptible of irrigation by the reservoirs, ditches or canals" mentioned in said act, is hereby repealed; so that the reservation in said act shall only include all the land which may, after the passage of said act, have been or may hereafther be designated or selected by United States surveys for sites for reservoirs, ditches, or canals for irrigation purposes. And bona fide claims, made since the passage of said act, to land within the reservation hereby repealed shall not be defeated or affected by said act: *Provided*, That the diversion of water at high altitudes, where all the agricultural crops produced in the same latitude in the valleys below do not mature, shall confer no prior rights to the use of such water as against persons below who appropriate the water to irrigate land more suitable for homestead settlement, unless such diversion shall be approved by the commissioner of irrigation.

A BUREAU OF IRRIGATION AND ITS DUTIES.

The bill also confers power upon the Commissioner of Irrigation to regulate the amount of land which may be taken in a given locality by a homestead settler, not exceeding 160 acres. It further provides that when reservoirs, canals, and other hydraulic works shall have been completed so as to irrigate all the land in a given district, patents may be issued to claimants of the public lands in such district upon compliance with the laws in force at the time the claims were made; and also provides that when an irrigation district is formed in any State or Territory, and the laws of such State or Territory permit the legal voters residing in such district to tax the land of the State and of private individuals for the purpose of constructing such hydraulic works as are for the common benefit of all the irrigable lands in such district, the United States lands therein shall bear the same burdens as are imposed on State lands and the lands of private persons; and that the homestead settlers who take such lands with the irrigation works constructed for their reclamation, shall take them subject to the payment of the same charges as have been paid by private parties for the same purpose; provided that the amount of such taxes shall be approved by the Commissioner of Irrigation, and that the United States shall not in any case be liable for any of such charges.

It further provides that the people of a district situated in two or more States, or in two or more Territories, or in a State and Territory, may have the benefits of the act by the joint action of all the States and Territories in which any portion of the district is situated; or in case any of the States or Territories refuse to join, then the State or Territory in which the larger portion of the irrigable land is situated may perform all the acts necessary to enable the legal voters to reclaim the lands and secure the benefits of the act.

The committee, believing that irrigation pertains to agriculture and not to geology and other subjects under the charge of the Director of the

Geological Survey, and differing from the Director as to the mode of conducting such matters as relate to irrigation, have provided for the transfer of the Irrigation Survey to the Agricultural Department, and the appointment of a Commissioner of Irrigation in that Department.

OBSERVATIONS NEEDED OF CLIMATOLOGY.

The Secretary of Agriculture must deal with the climate, the soil, and the products, and employ a large force to collect and diffuse information with regard to all matters pertaining to the production of crops and the cultivation of vines and fruits. The Agricultural Department is particularly charged with collecting and diffusing information with regard to modes of cultivation and fertilization of the soil. Irrigation is a great fertilizer, and the proper application of water to the soil is a matter of the first importance to farmers. This relates to agriculture and not to geology.

In addition to the purely engineering work connected with irrigation, it is necessary to know approximately the amount of water discharged from each drainage basin, in order to estimate the quantity of land that may be irrigated; and it is also of importance to know the maximum discharge in time of great floods in order to make ample provision in strength of works and extent of waste weirs to avoid accident. This branch of the service is called hydrography, and it is the subject least understood in the arid region. Since it has been determined to transfer the Weather Service Bureau to the Agricultural Department, the employés of that bureau, and the army of volunteer observers connected therewith, can collect without any material additional expense to the Government all the information necessary on this subject. No other department of the Government is prepared to perform this service without an independent corps of observers. In a very short time the employés of the Weather Service Bureau will be able to do all that is required in measuring the streams and observing the climatic conditions with but slight supervision.

The passage of this bill, it is believed, will enable the bona fide settlers and land-owners to develop the arid region by their united efforts. It will give full play to the enterprise of the pioneers of the west. It avoids, as far as possible, Government interference, and frees the Government from the enormous expense which would be involved if the United States should undertake the supervision and control of this vast region as suggested by the Director of the Geological Survey.

It also prevents the delay which would be occasioned by waiting for the expenditure of many millions of dollars in geologic and topographic surveys, and in paleontologic, chemical, and physical researches under the Director of the Geological Survey, and also avoids the embarrassment which would be imposed upon irrigation by charging to it the expenditures made by the Director of the Geological Survey for other purposes.

URGENT NEED OF LEGISLATION PROPOSED.

It is necessary and proper that the Government of the United States should survey its public lands. That has been the policy from the beginning. It is unnecessary in the arid region to survey the mountains and deserts which are not suitable for cultivation, until they are required for some useful purpose, but it is important that the lands required by the people for homes should be speedily surveyed. The first step in such survey, the water sources and supplies being ascertained, is to locate the reservoir sites for their conservation and the lines of main canals and ditches needed for a proper distribution of the same. Such a survey would segregate the irrigable from other public lands, and enable the Government to dispose of them to settlers without surveying the waste lands for which there is no present demand. The amount of the annual expenditure for these irrigation surveys need not be large, although there is a pressing necessity in many localities for these surveys to enable the people to reclaim the land which they require for settlement. An intelligent direction of such surveys is necessary, and Congress should provide for the same.

The committee has also reported two other bills which pertain to the Great Plains region first described. Inasmuch as underground water is found throughout this region, and in many places where experiments have been made it has been brought to the surface in considerable quantities by artesian wells; and inasmuch as in other places important rivers sink and their waters pass beneath the surface, it is regarded as of the highest importance to ascertain to what extent these plains may be irrigated by artesian wells and by other means of bringing the underflow supply to the surface. To what extent these lands may be brought under cultivation by these means is yet unknown, but it is highly probable that great and beneficial results in the irrigation of these lands may be secured by bringing these waters to the surface.

THE SUBTERRANEAN WATERS OF THE GREAT PLAINS.

The first bill reported from the committee has been incorporated in the urgent deficiency bill and has become a law. It appropriated $20,000 for the purpose of an immediate examination of these great plains, to collect all the facts for the information of the people, and with a view to ascertain the expediency of making experiments by the Government as to the extent of these underground waters and the practicability of utilizing them.

The other bill reported relating to this section makes an appropriation of $350,000 for a survey and experimental wells and works in this region. The propriety of making this appropriation will be determined by the report which is to be made about the 1st of July.

If anything can be done to encourage the people of these great plains, it is important that it should be done speedily. There are over a million people in this arid and semi-arid belt who have paid into the Treasury of the United States no less than forty millions of dollars for public lands. These people are in want and are suffering all the hardships resulting from the failure of crops in a new country. They are anxiously looking for relief. Their crops having failed, and being without money, they are unable to prosecute experimental works of irrigation. The Government must demonstrate to them the practicability before they will have courage or can command the means to prosecute the work on any considerable scale. If no considerable relief can be obtained from bringing the underflow water to the surface, a knowledge of that fact will be of immense benefit in turning the attention of the people to some other means of relief.

Undoubtedly, as before stated, much of this land will ultimately be reclaimed from the rivers flowing from the Rocky Mountains, when the proper reservoirs and the requisite canals shall have been constructed. But this involves a larger expenditure than the people can now undertake, and it also involves an uncertainty for want of Government surveys.

There is still another means of irrigation which the people themselves will no doubt adopt to some extent, and that is the storage of the storm-waters in small ponds and lakes. The artesian wells and other methods of bringing the underflow water to the surface is the most speedy way, if it is successful, of obtaining relief, and for that reason the committee have recommended these appropriations.

It will not be necessary to continue appropriations of this character, and probably what is once done will be done for all time, and perhaps the appropriations recommended by the committee may be all that will be necessary.

It may be useful to the Government hereafter to bore some experimental wells in the other States and Territories, but the committee have confined their recommendation to that section of country where the greatest suffering exists, and where the largest number of people now are.

A REVIEW OF THE COMMITTEE'S INVESTIGATION.

The work of inquiry undertaken in accordance with the resolution of the Senate was carefully prepared for during the four months that preceded the meeting at St. Paul, Minn., on the 1st of August of last year. Under the direction of your committee the irrigation engineer and expert assigned to it by the United States Geological Survey, placed himself in communication with the official and other representatives of the people living within the arid regions of the west. Circulars were prepared and addressed to Federal, State, Territorial, and County officials, to chambers of commerce, boards of trade, agricultural and horticultural societies, to the representatives of the Patrons of Husbandry and the Farmers' Alliance, to societies of civil engineers, railroad land irrigation companies, and all others known to be interested in the problem of irrigation and reclamation. The result of this work was made apparent in the representative character of the testimony given before your committee. At the same time that these efforts were being systematically made to secure a full expression of views and information from practical sources and from the communities interested, circular letters were addressed, under the committee's instructions, to the State, War, Interior, and Agricultural Departments, for the purpose of obtaining—

First. Such information as the consular service could secure from countries wherein irrigation is now and has long been practiced.

Second. From the experiences and observation of army officers, public land officials, and Indian agents, such facts as their observation has enabled them to accumulate.

Third. From the observations and studies of the experts and officials of the Department of Agriculture, the deductions and statements they desired to make on soil, climate, products, grasses, forestry, and all data falling within their special fields of work and relating to the arid region.

All these preparations enabled the committee to accomplish its work more fully and systematically than otherwise would have been the case. The committee recognizes fully the interest aroused and activity with which its requests were met.

REPRESENTATIVE CHARACTER OF WITNESSES.

During the progress of the field inquiry, commencing on the 1st of August at St. Paul, Minn., and ending September 19, 1889, at Ogallala, Nebr., your committee held fifty-three sessions, examined three hundred and eighty-two witnesses, and travelled in all about 14,000 miles. In addition, it has examined fourteen witnesses at the capital and heard testimony for several weeks.

At St. Paul the first session was held in the hall of the chamber of commerce, which was placed at the committee's disposal. On behalf of that body an address of welcome was made by Mr. E. V. Smalley. The witnesses at this session were, all but one, from the Territory of Dakota, and represented the most important agricultural and town interests, including officers of the Farmers' Alliance, of the Black Hills section, the counties of Beadle, La Moure, Spink, Dickey, Grant, Marshall, Douglas, and Minnehaha, portions of what are now the States of North and South Dakota. At the next session held in Sioux Falls, S. Dak., the constitional convention of that State was found in session. The committee were received by the president of the convention, the mayor, and others; and at the session held, nearly all the convention delegates testified, representing fifteen counties. Sessions were held in the Dakotas on the train, as elsewhere, and many witnesses so examined were found presenting the collective opinions and wishes of their several communities. At Huron, the testimony taken includes the evidence of the president of the State Agricultural College, of the mayor, editors, farmers, engineers, and others, specially selected by a county committee.

En route from Huron the committee visited Redfield, Aberdeen, and Jamestown, examining the famous artesian wells at Huron and the points named, while also taking evidence at Jamestown. At Bismarck, the capital of North Dakota, the constitutional convention of that State, then in session, received the committee. The witnesses examined here were all representative, and included a former governor, many delegates to the convention, and several well-informed business men.

The Northern Pacific Railroad, from Bismarck westward, made arrangements to take the committee over such portions of the region as it was most desirable to see in the daylight. To this road, and others on the journey, the committee was indebted for the opportunity of traveling under conditions enabling it to see the largest areas with the least possible expenditure of time. As a result, much of the magnificent valleys and table-lands of the Yellowstone, Gallatin, Columbia, and Snake Basins, in the Northwest, were passed over during daylight, affording to your committee needed object-lessons in the physical facts relating to the reclamation of such region.

TESTIMONY IN THE NORTHWEST.

The progress of the inquiry through Montana was marked by the same interest as was seen in the Dakotas, though it easily intensified as the sections practicing irrigation were reached. At Glendive the board of trade met your committee. The witnesses here were selected by them as representative men. At Billings the town and county officials received us, and a very interesting session was held. Miles City, county seat of Custer, and near to it the United States post of Fort Keogh, was the scene of the most important session of the Yellowstone Valley section. Army officers, Federal officials, county and town officers met the committee at the depot, escorting it to the board of trade rooms. An exhibit of irrigation-grown grains and grasses was made, a map and official report of the county filed with the committee, and other valuable testimony was taken, as will be seen by the printed evidence. Bozeman, center of a large and well cultivated area, was reached after

Billings. After a ride through the valley, examining the irrigated farms, the committee held a session in the town. The witnesses were all practical men.

The next and most important session in Montana was held at Helena. The committee was received by the Territorial and city officials, as well as by the constitutional convention then in session. The testimony taken here includes a careful report of the State, prepared by Colonel De Lacey, civil engineer, for the Montana Society of Civil Engineers. The late surveyor-general, Mr. Greene, was a valuable witness. Among others before the committee were the Hons. Wilbur F. Sanders, Martin Maginnis, and W. A. Burleigh, Judge Hiram Knowles, Mining Inspector G. C. Swallow, and Civil Engineer William F. Wheeler. The testimony given will repay critical examination. Following the Helena session, after some examination of the region, the committee proceeded to Missoula. Attention is called to the testimony of Mr. H. M. Wilson, division civil engineer United States Irrigation Survey, as illustrating intelligently the character of its work. Missoula, the chief town of Bitter Root Valley, noted as the fruit section of Montana, was the seat of an interesting session, at which county officers, surveyors, and farmers testified.

Passing westward into Washington the committee found an interesting field in the eastern or subarid section of the new State. The examination of the Moxie farm, near North Yakima, as well as the session held thereon and afterwards in the chamber of commerce at North Yakima, offers abundant proof of the needs and advantages of irrigation, and of the great area that can be reclaimed therein. Ellensburgh, further west, where a brief session and field examination was made, showed by positive demonstration in its fertile and extensive irrigated fields the value of efforts for reclamation. The testimony of the secretary of the local board of trade will be found to be of value. At Walla Walla, further south, but still in eastern Washington, the committee was received by the city officers and the board of trade. The testimony taken here is regional in scope, and gives an excellent idea of conditions, climatic and topographic, in their relations to agriculture and horticulture, while showing the imperative need of water storage in order to make secure such cultivation. This evidence and demand was strongly supported by witnesses whose testimony was taken on the train at The Dalles and Baker City, Oreg., and at Palmer, Idaho.

The very important session held on the 17th of August at Boisé City, the capital of Idaho Territory, was characterized by a thoroughness of preparation, and the careful presentation of information, which deserves and commands from the committee a full recognition. The great value of the mass of testimony, written and oral, taken at Boisé City, is due to the fact that it was made to embrace every county in the Territory, and every phase they offer in considering the problems of reclamation. The committee was officially received on the train by Governor Shoup, Surveyor-General Straughan, and by other officers of the Territory, county, and city. All the formal honors of such a reception were duly tendered. In response to the circular letters sent from Washington, under the committee's direction, the governor and United States surveyor-general had prepared and sent out other circulars, calling forth from the county surveyors and others a series of valuable local reports. Mr. Straughan had caused these to be carefully systematized and compiled uniformly, and, with maps of each county, bound them in a handsome manner for the committee's use.

The evidence taken included that of the surveyor-general, the Delegate in Congress, ex-Governor Stevenson, Division Engineer A. D. Foote, United States Irrigation Survey, and a large number of other representative witnesses. A striking exhibit of fruits and vegetables was made in the council chamber of the capitol of Idaho, in which the session was held. The testimony in relation to Idaho demands careful consideration. The Boisé City session concluded the committee's work in the Northwest proper, which it will be seen includes, as to testimony, South and North Dakota, Montana, eastern sections of Washington and Oregon, and the Territory of Idaho. Eighteen days were occupied in the journey, and during that time one hundred and fifty-eight witnesses were examined, and forty-two other papers received, examined, and filed. The amount of travel alone was sufficiently fatiguing, but when the work of examination is also considered the labor required therein as afterwards will be indeed accounted as arduous.

The trip through the great valley of the Snake River, with its extensive lava beds and the magnificent American and Shoshone Falls, illustrating the volume of water for storage to be had and the engineering difficulties arising as to the means of distribution, followed, after leaving the Oregon Short Line road and entering northern Utah, by the noble landscape presented in the Bear Lake Basin, with its valley, table-lands, foot-hills, and mountains, in which could be seen the evidence of what irrigation produces in the farms and fields of the Mormon settlers, proved to be one of the most interesting experiences of the committee's tour. Recalling the fact that the farmers of Utah are members of the first English-speaking community that has practiced irrigation, observation of their work and its results became a matter of grave interest. Irrigation began in Utah with the first Mormon hegira very early in the fifties, and within its range that Territory offers the most valuable of all evidence as to what follows the redemption by irrigation of our arid region.

WITNESSES IN SALT LAKE AND NEVADA.

The sessions held in Salt Lake City on the 19th and 20th of August prove the value of the preparations that had been made. Governor A. L. Thomas, in response to the communications sent by the committee's expert and engineer, had made an elaborate effort to secure complete data. Under his energetic direction the taking of testimony had been systematically provided for. Officers of the United States Geological Survey, with the Director thereof, Maj. John W. Powell, also gave valuable aid. Director Powell accompanied the committee (meeting it at St. Paul and Bismarck) throughout the entire journey. Governor Thomas presented, through Prof. Marcus E. Jones, of the Deseret University, an elaborate report of the Territory, embracing every county, giving their water sources and supply, rain-fall and other precipitations, areas irrigated or reclaimable, facilities for storage, extent of irrigation ditches, dams, and other works, wells (artesian or otherwise), products raised, laws and customs governing duty of water, method of ditch ownership, natural lakes, rivers, and other streams or water supply, with estimates of what may be done with larger facilities. The witnesses testifying include the governor, secretary of the chamber of commerce, the probate judges, surveyors, and commissioners of many counties, local farmers, engineers, railroad men, and others—all representative in character. Elaborate maps were filed with the county reports, and though no other sessions were held in Salt Lake City, yet full statements from all parts of the Territory were brought before the committee.

The evidence taken at Salt Lake City relative to the results of irrigation among a peculiar community and amid conditions as severe for reclamation purposes as any in the West, deserves the most careful review. It is especially interesting in its relations to the smallness of the areas under cultivation, their minute subdivision and power to support the cultivators, as well as the method of water control, distribution and the using of the same. In no part of our arid region has the use of irrigation in agriculture presented more striking facts or within the lines upon which the local problems operate more satisfactory results. The Utah session was attended by fifteen witnesses. In addition there were filed with the committee one general report, eighteen county and four local reports, and two other special papers, all of them full of important data.

The examination of the Basin region was continued in the taking of evidence at Carson City, Nev. The committee was received by the State officers, who placed the supreme court room in the capitol at its disposal. Nevada presents the gravest of needs and the largest of possible areas in its relation to reclamation by means of water storage and irrigation. The State is thoroughly aroused to its own needs and the methods required to meet them. At the last session of the State legislature it was formed into districts for storage purposes, and a State board appointed. An efficient State weather service has been in operation since 1887. The testimony presented to the committee had been prepared for in advance by the exertions of the State surveyor-general and the board of reclamation in response to circulars and other requests of your committee. In addition to the report and maps prepared by the State board, the witnesses include representatives from the several counties.

The conditions of reclamation in Nevada demand serious consideration. It will be then found that with a fitting system of water storage and irrigation distribution this mountain State, instead of presenting reasons for gloom or despair, offers a bright prospect and a fair future of material prosperity. The Nevada witnesses, nineteen in number, include the secretary of the State board of reclamation and internal improvement, the United States surveyor-general, chief of the State weather service, county officers, with reports from different parts of the State.

Leaving the interior or basin sections of the arid West the committee held its next session in the city of San Francisco. It is necessary to say, in passing, that much work was done outside the taking of testimony in order to obtain a more complete understanding by the members of your committee of the conditions involved in the inquiry it had undertaken. Among other journeys was one by stage and boat to and across Lake Tahoe and by coach again through the valley of the Truckee to the railroad at Truckee. This enabled the committee to understand the hydrographic and other physical features of the great drainage and mountain lake areas, which are necessarily related to any plans of reclamation in western Nevada and eastern California. It was but one of several observation trips that formed part of the committee's general work, but the result of which can not be presented in the testimony submitted.

ON THE PACIFIC COAST.

The California State Board of Trade having undertaken in a comprehensive manner the work of replying to the committee's requests for information, it was proper that the sessions in San Francisco should be held in the rooms it had so courteously tendered. They were truly representative in character. A valuable State report was first submitted by the Hon. M. M. Estee, chairman of the board, which embraces the main features and facts in relation to reclamation and water storage, as well as the date of irrigation already accomplished. The witnesses called by the State Board of Trade were fifteen in number, and included, among others, William H. Hall, formerly State engineer, and now supervising civil engineer of the Pacific slope in the United States Irrigation Survey; W. S. Green, a well-known editor of northern California; George Manuel, a prominent civil and irrigation engineer of the San Joaquin Valley, resident at Fresno; Bernhard Mark, a successful organizer of horticultural land colonies; Dr. Perrin, a large landowner, extensively identified with irrigation colony enterprises; L. M. Holt, one of the earliest settlers and organizers of the famous colony of Riverside; Hon. N. P. Chipman (formerly Delegate in Congress from the District of Columbia), of northern California; Dr. Hilgard, of the University of California, an eminent scientific authority on all matters relating to agriculture, horticulture, climatology, etc., and ex-State Senator C. C. Wright, the author of the code of State laws known as the "Irrigation District System."

By these laws in the first place the just principle of prior appropriation, governed and limited as to beneficial and actual use, is applied to and placed under the control of the community to be benefited, and through which in the second place any given irrigation community, by becoming under the said laws a body corporate, can issue bonds and make contracts for needed works, establish rates, and hold liens on all the lands benefited for the payment of interest and principal. These laws leave to the local communities affected the use of the natural waters within them for beneficial servitudes only, enable them to construct, own, and control the works needed for water storage and distribution, and give the means of obtaining a credit for that purpose, which, when capital understands the security it offers, will assuredly command all the money that may be needed.

The San Francisco session was one of the most satisfactory held. Added to the testimony directly given, there will be found a valuable State report, a summary of an important paper on alkali soils and well-water supplies by Professor Hilgard, and useful statements by other citizens. The committee then proceeded southward, stopping en route at Merced and Fresno, in the San Joaquin Valley, to examine the results of irrigation at those places. Fresno was especially interesting as the center of an increasing land colonization system, which has, by irrigation and small farm holdings, already reclaimed an area of over 100,000 acres, on which a population of at least 26,000 persons are supported in independence and comfort. That is an area of less than 4 acres to each person. The land now "under water" in this immediate region is about 250,000 acres, and there is every prospect of the early cultivation of that entire area. The chief products are raisin grapes and others for table use and wine-making.

The next session was held at Tulare, at which nine persons testified. A large display of fruits, vegetables, and grain, grown under irrigation, was made. This session's testimony illustrates the success of co-operative endeavor and intensive farming, with irrigation, as carried out by men of small means, but energy and industry.

The session at Bakersfield, Kern County, was preceded on the committee's and Director Powell's part by a journey of observation of some 60 miles, covering the main features of the extensive system of irrigation works and fields constructed and worked by Messrs. Haggin and Carr. In this way valuable object lessons were obtained as to the possibilities of reclamation, covering alfalfa, grain, root, and fruit crops, as well as the raising of valuable stock. Kern County embraces, as the evidence and reports given will show, not only the most extensive single system of irrigation works owned and constructed by one firm within the United States, but other and most essential features of arid land reclamation.

There are still considerable areas supplied by the small ditches of individual or combined farmers, besides a section in which the supply of artesian water is large and the number of wells very notable. The Bakersfield testimony covers the views of resident farmers and a comprehensive and valuable report from William B. Carr, one of the owners of the Kern County canals. In it will be found statistics of cost, production, areas covered and cultivated, mileage of canals, and all other facts necessary for obtaining a fair understanding of the nature, extent, and cost of such an enterprise. Among the papers relating to irrigation added at the close of the California division will be found one of interest relating specially to Kern County and to the general question of legal control over natural water.

The remaining sessions in California were held at Los Angeles, September 1; on the train, near San Bernardino and Riverside, and at Riverside on the 2d; in the evening of the same day at Santa Ana, and at San Diego on the 3d; returning the same night to San Bernardino, and thence southward across the Colorado Desert, arriving at Yuma, Ariz., soon after sunrise on the morning of the 4th of September, where a session was held on the piazza of the hotel, surrounded by a fine example of tropical fruits grown in the gardens of the neighborhood. Twenty-eight important witnesses were examined orally at the southern California sessions. Among them were the most representative viticulturists and horticulturists, irrigation and civil engineers, organizers of successful fruit-growing colonies, and prominent business men. At all the points named the committee were received by the local chamber of commerce and the civic or county officials. At Los Angeles, San Bernardino, and San Diego, especially, were the courtesies and efforts to place correct testimony in the committee's possession more marked. At all points valuable maps and other exhibits were filed with the engineer expert who accompanied the committee.

EVIDENCE TAKEN IN ARIZONA.

The first session in Arizona, held at Yuma, was attended by a county committee, who presented an elaborate and carefully prepared report with maps. The ability displayed in this report, as well as in the testimony given, showed the talent and interest now being centered in connection with irrigation enterprises and their development in sections heretofore esteemed most unpromising. The lower valley of the Gila River is clearly shown to be a most promising field for semi-tropical fruits, sugar cane, and cotton. Rice too, it is claimed, may be profitably raised in the overflowed region below Yuma, now forming the head of the Gulf of California.

The committee passed from its session in the early morning of September 4 over the Southern Pacific Railroad for 156 miles to the north. The capital of Arizona was reached during the afternoon and a session held immediately on our arrival. As at Yuma, and afterward at Tucson, the witnesses at Phœnix were heard in the open air. Governor Wolfley, with the leading Territorial and county officers, were in attendance, and the session was made especially interesting by the intelligent engineers and others connected with the irrigation corporation operating in Salt River Valley. Reports were filed with the committee from the counties of Mariposa, Yavapai, and Apache, as well as a general one for the Territory, prepared by Mr. Farish, commissioner of emigration. Reports were also received from the engineer of the Walnut Creek storage reservoir, the dam of which has since bursted, causing a great loss of life. Lieutenant Glasford, U. S. Army, of the Signal Service, also filed a very interesting and useful report on the climatology of the Territory. En route to Tucson, on the 5th of September the committee took testimony on the train in relation to Pinal County and to a proposed and important storage basin at the Buttes on the Gila River, some miles above Florence.

Tucson was reached early in the day and a session convened at once. The committee were met by the officials of the city and county and by a committee appointed to make a report for southern Arizona. Reports for Pima, Graham and Cochise Counties were filed, and one also of an engineering project for a series of reservoirs and dams at Pantado, near Tucson. The witnesses orally examined in Arizona were twenty-four in number and in addition seventeen valuable reports were received and filed.

INTERNATIONAL QUESTIONS AT EL PASO.

Passing direct to El Paso, Tex., the committee were met by the city authorities, by the county officers, a representative of the governor of Texas, representatives of the land department of the Texas Pacific Railway, the governor of New Mexico with members of his staff, and also by representatives of the Mexican city of Juarez, and an engineer officer of that Republic. A committee of citizens had been preparing in advance for the session, and the city hall council room was placed at its disposal.

The problem under consideration at this point is a serious one, involving international complications, as well as others, injuriously affecting the prosperity of our own people inhabiting two-thirds of the 1,200 linear miles through which runs the Rio Grande River. That river has its rise in the lofty San Juan, Sagauche, and Snowy ranges, that form the western and northwestern run of the great San Luis Park or valley in southern Colorado. The rapid increase of irrigation works, and they, too, on a large scale, within that valley bids fair to absorb at an early day nearly or quite all of the waters in sight that through its upper channels flow down to and across the wonderful mountain bowl of San Luis and from the Rio Grande River and Valley. After crossing the great basin plain, almost diagonally, it turns southward and entering New Mexico passes through the Taos Cañon section, debouching again into the open valley at Embudo, to the north of Santa Fé. From that point to the deep cañons below Presidio del Norte, in Texas, the river for about 500 miles has run almost or entirely dry during the past year. There has been a growing scarcity of water for several years. Colorado and northern New Mexico have necessarily absorbed the major portion, yet below them are found Mexican and Pueblo Indian communities claiming water rights that have been theirs for centuries—rights which are guarantied to them by treaty and convention entered into and ratified by the United States and Mexico.

The long-established privileges in the natural waters and their use for beneficial purposes by at least 100,000 citizens and inhabitants of our own territory were found by the committee to be in peril by the almost complete absorption of the running waters from the upper portions of the Rio Grande. But this is by no means the most embarrassing part of the situation. The same deprivation most seriously affects the Mexican people resident at Juarez (Paso del Norte) and along the western side of the Rio Grande Valley in northeast Chihuahua, one of the northern States of the Republic of Mexico. El Paso, Tex., our principal port of entry for Mexico, is faced on the other and Mexican side of the river by the growing city of Juarez. There are at least 30,000 persons in and directly connected with these two cities and the immediate valley wherein they are located. The water famine and the uncertainty of the river channel—for the stream, when present, runs over a sandy and friable bed and bottom land for at least 2 miles in width—involves constant troubles and often threatens disturbing collisions, both as to the boundary line of the two countries and the actual and imperatively needed water supply required for general purposes.

The United States Irrigation Survey had been for some months before the committee's arrival engaged in making the necessary locations, surveys, plans, and estimates for the establishment of a dam and reservoir at a point just above El Paso for the purpose of storing therein the storm and surplus waters as well as the natural drainage of the cañon region wherein the proposed works are to be situated and constructed. Maj. Anson Mill, Tenth Cavalry, U. S. Army, a competent civil engineer, was, under the supervision of Director Powell, U. S. Geological Survey, in charge of this preliminary work. By direction of the Mexican President one of its official engineers, Señor Garfias, was co-operating with Major Mill and the other engineers and attachés of the United States Irrigation Survey. The irrigation situation was and is as immediately pressing to the Mexican people as the international questions might prove at any moment to the two Governments. These were the conditions that made the El Paso session perhaps the most important of any held by your committee.

The persons testifying included the mayors of both El Paso and Juarez; Engineer Garfias, the Mexican consul at Juarez; a committee of citizens who had prepared reports to offer, and several gentlemen long familiar with the laws, customs, and conditions affecting the questions at issue. Major Mill and his assistants, with maps, were present and amply elucidated their plans, while Director Powell reviewed the nature of the several hydrographic basins into which the great valley of the Rio Grande is physically divided. The whole session was one of marked interest, and the testimony and papers presented should be carefully studied. The utmost courtesies were extended your committee by the Mexican as well as the Texan authorities. Considerable field observation was made.

WHAT WAS SAID ABOUT WESTERN TEXAS.

At the El Paso session, beside the international dam project, evidence was presented by the State geologist of Texas and Mr. Roesler, of Dallas, in relation to the needs and possibilities of irrigation in that State, and by Mr. Bronson, of El Paso, in regard to the irrigation of the Pecos Valley, in southeastern New Mexico. It was shown, at sessions on the train while crossing the Staked Plains and at a session held in Fort Worth, that a considerable area of Texas requires the conservation and restoration of natural waters, both by storage of surplus and storm waters and by the restoration to the surface of those found beneath it, in order that the security of both agricultural and pastoral pursuits may be attained. The entire southwest section from El Paso downward to the Gulf, including the eastern half of the lower Rio Grande drainage-basin, as well as the minor but very important basins of the Pecos and Colorado Rivers, a distance at its broadest part of 6 degrees of longitude, requires irrigation in order to make possible the industries by which it alone can be reclaimed. For 3 degrees of longitude farther east the storage of water for use in the critical period just preceding harvest will also be found a necessity.

But northwestern Texas, like the central portions of both the Dakotas, presents an interesting series of problems for the geologist and engineer, as well as of encouragement for the practical farmer and settler seeking homes on the soil. These problems relate to the under-ground water supply, which in the Dakotas form the magnificent belt of artesian wells that make that region so remarkable, and on the Staked Plains and Pan Handle sections of Texas furnish, from what are believed by many competent observers to be subterranean streams, finding their way through under-ground channels and by steady pressure in given directions percolating through the resisting strata, a water supply for numerous wells which has already proven of considerable service, and which it is claimed can, at a comparatively small cost, be so explored, defined, and delimited as to be made of great value to the region and its residents. This region is also, as to the northwestern and western portions, one of remarkable springs that rise with great volume and force. In this respect, the evidence includes eastern New Mexico, and there is reason to believe that it will be found as to both wells and springs to extend over the extreme western portion of the Indian Territory into southwestern Kansas. In any event, the evidence presented at El Paso and Fort Worth, Tex., and elsewhere, is of great interest and importance.

TEXAS STAKED PLAINS AND NEW MEXICO.

At El Paso, Governor Prince, of New Mexico, with a committee of delegates from the constitutional convention, then in session at Santa Fé, met the committee to urge the importance of a session in that Territory. The committee proceeded to Santa Fé, where the party was met by the officials and courteously welcomed. The presence at Santa Fé of delegates from all the counties gave an excellent opportunity of obtaining a very complete summary of the water conditions and irrigation needs of New Mexico. The threatened destruction of water rights and farms, established and cultivated for many generations, by reason of the absorption in southern Colorado of the flow of the Rio Grande River, brings into grave importance interstate or interterritorial conditions and jurisdictions upon the rightful relations of which depends so much of the future well-being of the communities interested. The Santa Fé session proved, therefore, to be of value.

On the committee's return to El Paso a short session was held at Las Cruces, in the Mesilla Valley, Dona Ana County, the finest fruit region in the Territory, and a rapid drive over the valley was also taken. From El Paso the committee proceeded east to Fort Worth, Tex., taking testimony, as already referred to, and then proceeded northward to the valley of the Arkansas in southwestern Kansas. In passing from Texas the committee refers with thanks to the mass of the testimony taken and forwarded from the Pan Handle and Staked Plains counties in that State. This was obtained through the unremunerated exertions of Mr. F. E. Roesler, of Dallas, whose exertions for the public good deserve this acknowledgment, at least.

IN SOUTHWEST KANSAS.

Turning westward once more the committee held sessions at Kinsley, Dodge City and Garden City, Kans. It heard in that part of Kansas over thirty witnesses, representing by appointment every farming locality affected by the drought and, therefore, interested in the question of an industrial water supply. The interstate water question is certainly a live one for the farmers of southwest Kansas. The Arkansas River had given so indifferent a supply during the year that 300 miles out of the 500 miles of irrigation ditches constructed in Kansas east of the Colorado line were unsupplied with water and, therefore, were practically useless. The natural waters of Colorado are, by its constitution, State property, and by its law are all consumable within the State itself. As with the Rio Grande, so it is with the Arkansas. As it emerges from its sources and cañon channels within the Rockies, the absorption of its surface flow commences with the foot-hills wherever an available area is found for cultivation, until above Pueblo it debouches into the Plains section and flows eastward across Bent County. By the time it reaches the eastern line there is little or no water left to flow below, during the dry season at least. Percolation follows, of course, and in the course of time, as the irrigation engineers claim, the waters spread upon and absorbed by the soil return in large part to the channel below where irrigation is practiced. But even if this return seepage be as large in quantity as asserted, its gathering flow is necessarily slow and must in any event be attainable only after the occasion. In other words, it can not be utilized when wanted—the season of irrigation.

The sessions at Dodge and Garden Cities were notable for the bringing out boldly of a suggestive theory, which, if practical experiments tend to establish the truth of, will surely prove productive of great benefit, not only to the section under consideration, but many other portions of the arid region. The proposition involved is that a large proportion of the water flow of the Arkansas River, which at flood time is very great in volume, is lost by means of seepage. The valley bed is wide, the stream itself broad and shallow, the grade from the mountains eastward is at least 7 feet to the mile, giving a rapid descent, adding thereby to the surface loss, and the soil of the whole valley with the stratum beneath is composed of loose friable matter, with sand and gravel below in which the percolated waters are readily absorbed and held, while the impermeable clays beneath keep the current from passing to greater depths.

It was urged in the Kansas sessions, especially that at Garden City, that the "underflow," as it is termed, can be reached through very simple engineering, owing to the regular descent alluded to, by means of tunnels driven in the alleged seepage drift and from these drawn into reservoirs to the surface at proper levels and thence distributed over the thirsty areas for several miles miles north and south on either side of the river. The assistance of the Government is asked to demonstrate by experimental work the correctness of this theory or suggestion. Private enterprise has at or near Dodge City already started underflow works, and it is asserted with a remarkable degree of success. It is assumed, however, that no extensive works can be carried on for southwestern Kansas reclamation without entering and drifting into the river bed within the State of Colorado. The projectors are met, therefore, at the outset with the fear of opposing State jurisdiction.

COLORADO, WYOMING, AND NEBRASKA.

Entering Colorado the committee held sessions therein at Pueblo, Colorado Springs, Denver, Fort Collins, and Greeley, thus obtaining data and information from the principal points concerned in the State which, by its active enterprise, as well as the legislation on the subject of water uses, has placed itself with California as foremost in the work of intensive agriculture by means of irrigation. The sessions at Pueblo and Colorado Springs proved interesting because of the local facts obtained at the first place in regard to the Arkansas, and as to forestry matters in the State at the second point. At Denver the chamber of commerce was opened for the committee's use, and the testimony presented at the sessions held therein will be found among the most valuable of the investigation. The presence here of the supervising engineer for the Rocky Mountains of the United States Irrigation (formerly State engineer of Colorado), with that of the State engineer also, and of other civil engineers, who had all interested themselves in arranging the evidence taken, resulted in bringing before the committee a peculiarly representative mass of testimony.

Examination will show all phases of irrigation as seen in Colorado: field works, storage possibilities, the duty and economy of water, cost of construction and administration, areas covered and cultivated, percolation, seepage, volume, gauging of water, the legal questions involved, advantages of irrigation, increase in products and land values, character of water service, legislation to secure and conserve the same, with the nature and tendency of popular complaint and agitation; these and other issues were all brought out clearly by the intelligent gentlemen who presented their views at the Denver session. Among such witnesses were found, besides the engineers, members of the bar, judges of the courts, farmers of experience, business men of importance, two of the former governors, organizers of irrigation enterprises, and leaders in agricultural societies and associations. The utmost interest was manifested by the press of Denver, and in fact by the whole people of Colorado, whose public men and representatives were eager in aiding your committee's investigation.

From Denver the committee proceeded northward to Cheyenne, Wyo., stopping to take testimony at Fort Collins (at which point the State Agricultural College is located), and at Greeley, seat of our first successful irrigation colony, and the center of a very prosperous agricultural community, the result solely of the systematic application of water to the land by means of ditches. The evidence of ex-Governor Eaton, one of the earliest associates in the Greeley colony, though not one of its original organizers, should be read with care.

At Cheyenne the committee was again most fortunate in finding gathered at this point, the Territorial capital, the members of a constitutional convention engaged in the work of State-making. In conjunction with Governor Warren, Territorial Engineer Elwood Meade, and a number of representative citizens, the delegates gave to your committee a mass of information which shows the present and possible irrigation works and probabilities of Wyoming in a most comprehensive light. This progressive community has modeled its water laws and regulations upon the system pursued in Colorado. In so doing, Wyoming has certainly started right. A series of valuable reports, carefully prepared in advance by Engineer Meade, were filed with the committee, accompanied also with maps. Wyoming, like Kansas, New

Mexico, and Nebraska, is agitated by the problems of interstate waters, their flow and use.

Professor Hicks, of the State agricultural experiment station, Lincoln, Nebr., was present at Cheyenne and urged upon the committee the importance of one or more sessions in that State. A subcommittee, with the Director of the Geological Survey, the engineer expert assigned to the committee and the other officers visited Ogallala, Nebr., accompanied by Professor Hicks. This, the closing field session, proved one of the most significant. Great interest was manifested by the citizens, and witnesses were present from various portions of western Nebraska. An especial feature was the account given of the irrigation enterprise at North Platte, the most easterly of all such projects known to your committee.

In closing this portion of the review of your committee's extended and quite exhaustive field inquiry, it is not improper to recur again to the remarkably representative nature of the testimony taken, and of the deep interest the investigation everywhere aroused. If the committee had had the leisure and strength to have extended its labors and the field of inquiry, the requests that poured in upon it from all sides would have required many weeks to have met, and yet would have been time well expended. The wide reach, yet accurate nature of the facts gathered in the testimony presented with this report, will give thereto a growing value. If nothing else resulted than the presentation of this testimony for the use of the Senate and of the American people, the committee's investigation would be of value sufficient to fully warrant the labor and cost it has required.

CLIMATIC CONDITIONS OF THE TWO DAKOTAS.

The evidence taken at St. Paul and at various points in South and North Dakota, revealed climatic conditions that were a surprise even to the members present of your committee. It had been accepted almost as unquestioned that the Dakotas were among the most secure and most advanced in agricultural prosperity of all our western communities. That they are being populated rapidly under advanced circumstances as to pioneer life is most certainly true. The handsome towns and cities, the large railroad facilities already had, the neat dwellings and well-cared-for farms everywhere seen along their routes; the generally young, but always energetic and hardy population that was encountered; all these spoke volumes in favor of both the Dakotas; yet it is a simple fact that a large portion of these two new States, lies within the subhumid and arid areas of the United States.

The conditions of the last five years, culminating in the drought of the past year, have established to the minds of the most intelligent and sanguine of citizens in that part of these States, the conviction that without in some considerable degree obtaining artificial supply of water for agricultural purposes, farming will remain a very uncertain pursuit, and that, therefore, the general prosperity of the two States will be liable to be severely affected. The Dakotas, North and South, lie almost wholly west of the ninety-seventh degree of longitude from Greenwich. East and west it embraces 7 degrees, that of 104° being its westerly boundaries; degrees 98 and 99 are conceded to be within the subarid or subhumid belt, comprising from north to south what has been termed the Great Plains. The remaining 4 degrees are within the arid region proper, that of 100° of west longitude being accepted as the eastern limits thereof. The average rain-fall for seven years in South

Dakota—that is of nine stations, a majority of which are east of the Missouri—is 22.98 inches per annum. The summer season rain-fall is estimated at 15 inches; yet, it is shown to be wholly inadequate because of inequality of distribution as to time and place. Instead of rain when needed, the farmer is always in dread of hot winds, blasting the grain as it grows heavy for harvest.

Settlement began about 1875, and increased rapidly from 1880 until the new States were admitted into the Union, each with a population exceeding on admission that of any of the western commonwealths that have preceded them. From 1883, however, the insecurity of farming has been steadily and painfully made apparent. It was the concensus of opinion among all Dakota witnesses that the loss, owing to the drought of last year, as to wheat crop alone was not less than $20,000,000. Very naturally, if not quite logically, these people, possessed with the knowledge that they have paid into the Treasury for public lands alone over $20,000,000, are outspoken in asking some aid from the General Government in the way of at least instructing themselves and those who may join them hereafter as to the reasonable probabilities and possibilities of securing and storing a water supply sufficient to serve them in their summer needs.

The entire areas of the two Dakota States is 96,596,480 acres. Of this total at least 50,000,000 acres may be considered as within the arid region, having annual rain-fall of not to exceed 15 inches. North Dakota will average about 18 inches of precipitation per annum. At Fort Meade five years' observation gives 16.59 inches. At Bismarck, the capital of that State, the annual average is placed at 19.50 inches; at Fort Totten it is but 9.6; in the Red River Valley it will be about 22 inches. The Missouri River bisects the two States by the northwest and southeast, passing through three degrees of longitude and then turning almost directly east. West of that river there is little reason to expect that any system of reclamation will be of avail other than by storage reservoirs, running streams, and a large system of main canals and distributories, taking water from the Missouri River as far north as the forty-sixth degree of latitude and conducting it southward, using the numerous tributaries of the basin as both contributory and distributing agents, until the system, thus reenforced from hydrographic basin to basin, may be carried southward far enough to serve western Nebraska and Kansas, as well probably as portions of eastern Wyoming and Colorado.

THEIR WONDERFUL ARTESIAN BELT.

But it is in its remarkable basin or basins of artesian water that the Dakotas, especially South Dakota, are most to be considered in relation to agricultural security and as possibly a permanent relief at least from partial aridity. This is the general opinion of its people, as expressed through the witnesses and reports heard by your committee. An examination of the evidence will show that there are other sources of storage and distribution that experience will show to be equally reliable and, it may be, of more extended value. The central and northeastern section of South Dakota and the central portion of North Dakota present a large area of shallow lakes and lagoons which an accurate survey will probably show to be available, with proper engineering work, as a series of small reservoirs or drainage storage basins. The narrow streams or rivers which are characteristic of the whole area are apparently eroding their way still deeper. This is a feature of the majority of such bodies of running waters. Their currents are sluggish, the fall being but slight except towards their sources, while that of the Missouri is large. These streams will have to be stored and diverted from their natural channels into high-line canals for agricultural distribution. The low range of hills, known as "the Coteaux," lying on the east side of the great river afford, also, opportunities for local storage basins, all of which may yet be utilized.

The artesian belt of the James River Valley, or rather of its entire hydrographic basin, is the largest water body of its character known to the world. The James River takes its rise in the Devil's Lake basin and runs for over 400 miles almost due southward until it enters the Missouri River at Yankton, where the artesian belt has so far reached its largest development. The area thus embraced is at least 50 miles in average width. It contains about 7,000,000 acres, of which certainly 98 per cent. could be made available for tillage. From Jamestown, N. Dak., about 50 miles above the northern line of South Dakota, to Yankton, in the extreme southern part of the same State, there are now about 50 artesian town wells in operation, striking water at a depth that ranges from 1,576 feet at Jamestown to 610 and 600 at Yankton and Frankfort. There are in all nearly or quite one hundred flowing wells in South Dakota, though all but those named as town wells are usually of small bore and were sunk for farm purposes only. The remarkable features of this belt of artesian water are its quantity, force, and continuance. The pressure of the principal wells is from 25 pounds to the square foot at Highmore to 170 at Yankton, where five wells supply the town with water for domestic uses, town purposes, and as power for manufacturing.

A considerable number of artesian wells for farm uses are found in the same county. Aberdeen has two, Jamestown, Huron, Redfield, and other places one each, which furnish water enough, in volume and force, to supersede all other water-works, and to run flour and other mills and factories. The flow of water ranges per minute from 4,000 gallons at Columbia, 3,500 at Aberdeen, 1,500 at Yankton, down to 14 at Highmore. The cost of sinking such wells ranges from $2,800 to $7,300. If the business were systematized the cost may probably be not over $1,500 each. The altitude ranges from 1,906 at Yankton to 1,000 feet above sea-level at Grafton. There are in all eight or ten town wells in North Dakota, of which two flow brackish water. The valley of the Red River, in the north and eastern portion of the States, is blessed with an abundance of water, obtained by wells sunk to very moderate depths in which the supply invariably rises very nearly to the surface. The extent of the Dakota well basin is as yet unknown. Its amount or volume is evidently quite large. The facts given tend to prove that the flow increases, not diminishes, as is generally feared of artesian belts.

Discussion exists, of course, as to the sources of this water. Opinions largely concurred in the belief that it may be derived from the drainage of the eastern slopes of our northern Rockies. It is thought that this source can alone account for the pressure. The Black Hills is named, with considerable force, as a probable source. The extensive drainage area thereof and its altitude lend character to the suggestion. Another view is that the supply is in part derived from the extensive seepage of the Upper Missouri River. The altitude of the region and the trend of the rocks and other strata give interest to this suggestion. Be these theories as they may, there is no probability, on the face of the topographic and hydrographic features, that all the wells derive their supply from any one source. The wells of North Dakota, outside of the two at Jamestown, can not be so explained. The Devil's Lake Basin is one source, and the drainage from the Red River and of the Turtle Mountains to the north probably accounts for the artesian wells found in those sections of North Dakota.

Opinion was unanimous in the two Dakotas in support of a liberal appropriation for an irrigation survey, and the demand was made on all sides that the General Government should appropriate also a sum of money sufficient to defray the expenses of rapid geologic and hydrographic reconnoissances by which the three forms of developing a water supply already named might be fairly outlined and located in connection with the physical features of the Dakotas. It is considered especially desirable that a reasonable and speedy effort should be made to ascertain the limits and character of the several well-belts, and that some experimental wells be sunk to give knowledge to the people and courage to the settlers, present and prospective. The appeal is, in your committee's judgment, a reasonable one, especially in view of the fact that there remains at least 21,000,000 acres more of public land still open to settlement. The chief crops of Dakota are the hard wheat, for which it is famous, corn, oats, barley, potatoes, and hay. The loss by drought is put at 40 per cent. for wheat, 80 for corn, and 30 for oats.

Evidence was given showing how in a few instances the overflow of wells irrigated tracts of grain, and that such tracts furnished abundant crops while all other fields were blighted. It was stated that the rise in value of land if water security prevailed would be from $10 to $40 per acre. The president of the Agricultural College at Brookings estimated the immediate rise in the James River Valley alone at $20 per acre. Ten dollars was given as the present value of farm land per acre. With summer security of water each acre would be worth $30. That would be an increase of $140,000,000 in one section alone. It will be unnecessary on that basis to make a calculation for the 35,000,000 acres now occupied or held by individuals, as it would be so large as to prevent belief. Yet the James River estimate given is not too high. Still the people are, as pioneers, too poor as yet to undertake the work of defining and indicating the hydrographic supplies or the most profitable manner of using and storing them. This once done by the General Government, as they claim should be the case, there would be no difficulty, it is declared, of obtaining all the capital needed for the work of development and construction. Your committee agrees with this view.

WATER STORAGE PROBLEMS IN MONTANA.

The new State of Montana, with its 93,349,200 acres of territory, is traversed from east to west by the line of the Northern Pacific road, enabling the committee to carefully examine the most important tillable valley—that of the Yellowstone—in the State; also to have the opportunity of inspecting the capacity of the famous Bitter Root Valley in the extreme northwest section, for the raising of fine fruits, and at Bozeman, in the Gallatin Valley, to see the effects of irrigation on quite an extended scale. Montana is not only one of the three largest States—the others being Texas and California—but it is without question the best watered one west of the one hundredth meridian. It is heavily timbered also; its pastoral area is great, and according to the estimate of Statistician Dodge, of the Department of Agriculture, its tillable area is not less than 32.9 per cent., or close to one-third of the total.

The river courses that drain the central basin of this land find their beginnings in the sources of the Upper Missouri, with its great tributaries of the Yellowstone, Gallatin, Jefferson, Madison, and a score more important streams that all head in and receive their primal supply from the precipitation and drainage of the upper Rocky Mountain ranges. The valleys are usually narrow and long. The Yellowstone is an example, presenting as it does a tillable valley or bottom area of about 400 miles in length, with an average width of not to exceed 3 miles; in all about 780,000 acres. Such streams, large or small, usually present similar features of deep, narrow valleys, in which the waters appear to be slowly but steadily eroding deeper channels; then comes a precipitous rise to the mesa or bench land of from 25 to 100 or more feet in height. The mesas will widen their sections of the several hydrographic basins to from 8 to 12 miles in width. The secondary table-land or plateau is then reached by steep ascent, making them often as high as from 600 to 1,000 feet above the bottom land. These mesas and table-lands are everywhere covered with succulent grasses. They are found to be fertile in capacity, if water can be obtained. It is these facts that make Montana a typical region in which to conserve the waters by storage and subsequent distribution for purposes of irrigation.

The Yellowstone basin from a reclaimable area in the lower valley of 780,000 acres will rise rapidly under a system of scientific engineering to an agricultural capacity of from 3,000,000 to 8,000,000 acres. When storage shall be so advanced and distribution so systematized that the secondary table-lands may be reached and quickened, the largest area named will be readily compassed. Nor does this statement close the possibilities of the drainage or hydrographic basin of the Yellowstone. The tributary valleys found there, many of which are quite large, will furnish an additional 4,000,000 acres to the area of reclamation. This is illustrated in a report made by the authorities of Custer County, within which a large portion of the main Yellowstone Valley is located. That report gives the valley land area at 384,000 acres, and for fifteen other tributary valleys within the county, including the Tongue, Powder, Rosebud, and Otter, it gives their valley areas at 501,600 more acres.

The volume of water to be supplied from the Yellowstone alone is estimated by the same authority for use in the areas under consideration at 906,000 miner's inches per second, flowing under a 6-foot pressure. The testimony warrants the statement that the Yellowstone alone can furnish for irrigation purposes some 4,000,000 miner's inches. With proper storage this may be greatly increased, perhaps doubled. The wisdom of the policy which reserved as a national park the wonderland in which the Yellowstone finds its ample sources may yet be proven in ways heretofore unexpected. The storage of its quickening waters will be greatly simplified by the inability of speculative occupiers of the public lands to exploit those valuable sources. Hundreds of millions of dollars may yet be added to the nation's wealth as a consequence of the National Park reservation.

The Yellowstone is taken as an illustration of a fact impressed upon your committee by the whole of the investigation it has pursued, viz, that the earlier or primal attempts at irrigation are decidedly wasteful and often provocative of contention, disorder, and litigation. The valley or bottom lands, though the most readily reclaimable by simple local ditches, are seldom, perhaps never, the most desirable for farming purposes. It is always the warm red loams and soils of the mesa and table lands that will furnish the largest crops as a return for industry. It is on these benches, open to the sun, made up of the most fertilizing components and readily washed by water of alkali salts, that the Western farmer will in the not distant future, wherever water is accessible, make from his occupation a return almost as certain and controllable as does to-day the carder of wool and the weaver of cloth. In the open laboratory of nature the earth and sun will aid, not hinder, man when regulating for himself a secure supply of water; he will from seed-time to harvest find a sufficient reward for labor, skill, and investment.

In the careful report for the State, made by the Montana Society of Civil Engineers, which will be found in the testimony taken, the following table of counties and reclaimable areas are presented as an approximate estimate:

No.	County.	Area.	Supposed under cultivation.	Supposed can be cultivated by irrigation.
		Sq. miles.	*Acres.*	*Acres.*
1	Beaver Head	3,740	80,000	250,000
2	Cascade	2,570	50,000	600,000
3	Choteau	24,830	50,000	5,000,000
4	Crow Reservation	7,830	....	1,500,000
5	Custer	22,300	30,000	2,000,000
6	Dawson	25,650	50,000	4,000,000
7	Deer Lodge	4,760	100,000	350,000
8	Fergus	7,415	100,000	1,500,000
9	Gallatin	2,900	100,000	400,000
10	Jefferson	2,060	25,000	250,000
11	Lewis and Clarke	1,769	50,000	400,000
12	Madison	4,546	100,000	400,000
13	Meagher	7,160	35,000	500,000
14	Missoula	19,580	150,000	600,000
15	Park	4,740	15,000	500,000
16	Silver Bow	760	1,000	40,000
17	Yellowstone	3,390	50,000	500,000
	Total	146,000	986 000	19,790,000

Other statistics place the total area actually cultivated last year at less than 400,000 acres. The total given means all that is now occupied and used for farm purposes, grazing as well as tillage. The present year will see about 800,000 acres under cultivation by irrigation, and as much more "under ditch," that is within access to water supply thereby. No cultivation of the soil is possible in Montana without irrigation. Without ample storage of water the reclaimable area will be a limited one; with ample storage it will rise, according to different witnesses and reports, from 20,000,000 to 30,000,000 acres. The witnesses unite in declaring that with irrigation an acre of ground in Montana will exceed in productive value from 3 to 5 acres in the humid or rain-fall States. The witnesses were from Virginia to Nova Scotia, and from New York to eastern Kansas. The average production per acre is estimated as follows: Wheat, 35 bushels; oats, 50; barley, 45; corn, 28; alfalfa, from 4 to 6 tons. The percentage of productive capacity for Montana per acre may be stated as follows:

	Products.		
	Wheat.	Oats.	Corn.
Average number of bushels per acre in Montana	17.8	34.2	26.2
Average for the United States	12.3	22.3	27.0
Average per acre for whole arid region	18.9	24.9	28.9

The number of farms are 1,519, the percentage of agriculturists 20, and the average value of land is a little less than $8 per acre. During the past ten fiscal years 6,904,461 acres of public lands have been disposed of in Montana, of which total 5,304,778 acres have been settled upon, sold, or patented during the past four fiscal years ending June 30, 1889.

The statistics presented as to irrigation ditches were very imperfect. But from such as were presented it appears that there were in 1869 of mining ditches 287½ miles, constructed at a cost of $806,500. The present extent, including these, as many have been used for irrigation purposes also, is now estimated at 1,000 miles. There are now partially or wholly completed the following larger or district systems, constructed for rental investment by corporations:

Ditches.	Miles.	Acres to be served.	Estimated cost.
Benton Lake	35	50, 000	$175, 000
Clarke Fork	38	100, 000	140, 000
Chestnut Valley	10	25, 000	7, 000
Dearborn	45	51, 000	150, 000
Florence	50	10, 000	200, 000
Gallatin	25	50, 000	75, 000
Sun River	75	300, 000	500, 000
Teton	40	35, 000	80, 000
Total	318	611, 000	1, 327, 000

A large majority of witnesses concede that under a proper system of irrigation, storage, and distribution land now worth but little beyond the Government price of $1.25 will rise rapidly to $20 and $30 per acre. The testimony was unanimous in favor of liberal appropriations for the purpose of rapidly executing a proper hydrographic survey of the arid region. It was urged by several witnesses that the General Government should go further and appropriate money for the construction of at least the main reservoir works, which the engineer's surveys may indicate as necessary. The headwaters of the interstate rivers should, it was suggested by some, be made like the Yellowstone Park, national reservations, in order to hold for the public benefit only the water sources therein. All witnesses in Montana declared in favor of considering the natural waters as public property, inalienable from the land and to be used, under public control, for beneficial purposes. It was the general opinion also that as water was an absolute quality in land values, therefore the General Government as controlling the public lands should of necessity feel obliged to point out at least the way by which the needed water could be obtained. It was asserted by all that the settlers were too poor to either do the needed work or to offer inducements sufficient to capital to enter on the construction necessary.

WHAT SETTLERS SAY OF FOREST PROTECTION.

A most interesting, though incidental, feature of Montana and other northwest testimony, brought out by the extended forest fires that were raging, was the general hostility felt towards the present system of secret land-office agents. It was asserted on all sides that the timber lands should be retained permanently as public property, that those in charge ought to be known to residents, that rules and regulations should be adopted to effect an honest use of timber by the settlers, and it was also assumed that the resident population in and adjacent to our timber areas in the West could be relied upon, if treated with fairness, to aid the General Government in any reasonable policy adopted to prevent destruction of our timber lands by fire and depredation. These views were expressed all through the arid region wherever the question was broached. Your committee was struck with the earnest feeling manifested on this important subject and trust that legislative action may yet adequately embody this public expectation.

CONSTITUTIONAL PROVISIONS OF NEW STATES.

In the constitutions adopted for the State of North Dakota as well as Montana, the aroused and increasing public interest in irrigation is shown by the incorporation of provisions placing the natural waters under State control for their beneficial regulation and distribution. In Montana also the committee were given testimony from different sources concerning the need of changing the present systems of public land survey and distribution. Witnesses agreed on the need of reducing the homestead and in considering that with irrigation 80 or even 40 acres were sufficient. It was also suggested that, with the increase of agriculture such action would bring, the large cattle-ranches must also disappear, stock raising and breeding farms taking their place. Some of the large ranch-owners expressed themselves in support of this policy. Evidence was given showing the existence in Montana of artesian water belts. In the Yellowstone Valley there are a number of such wells, some sixty-five being found in and around Miles City. There are wells also at Helena and elsewhere. In the Lower Milk River Valley, now being opened by a new railroad, it is claimed that water in abundance is found at very moderate depths, which rises rapidly almost to the surface. The northwestern section of Montana is already famous for its early and fine fruits. Indeed, all the witnesses interested in cultivating land declared that for the growth of temperate fruits of all kinds the new State was unsurpassed. The orchard seen at Missoula gave warrant to this claim for Montana.

RECLAMATION CONDITIONS OF THE FAR NORTHWEST.

The States of Washington and Oregon present most interesting topographic and hydrographic features. In entering the first named State by the Northern Pacific Railroad, your committee had the opportunity of seeing the effect, on an area well within the arid region, of the extensive mountain lakes found in northwestern Montana and northwestern Washington, as also on a considerable section of northern Idaho. The regional aridity is subdued to a considerable degree. The extreme eastern quarter or third of Washington from north to south may properly be classified as sub-humid, while the central portion clear to the eastern foot-hills of the Cascades approaches more nearly to a general arid character. Washington, from 117° to 121° of west longitude, or four degrees, will be found a section in which the storage and distribution of water, while not at all times and places therein an absolute necessity, will always need such facilities and find them to greatly enhance its land values and industrial progress.

Entering midway of the western boundary the Northern Pacific Railroad gives the traveler occasion for seeing the character of a great area almost wholly unreclaimed, which the mesa or table-land of the

Columbia River Valley and its great tributaries presents. The Great Plains of the Columbia River to the northwest of the railroad will probably require for their arable use an extended series of hydrographic works. That they can be so reclaimed was testified to from many sources. One estimate was made of 8,000,000 acres, another of 12,000,000. According to a report of Brig.-Gen. John Gibbons, U. S. Army, commanding the Department of Columbia—

> Irrigation by private parties or companies has been successfully tried in a number of valleys, viz: The Klamath River Valley, both in Oregon and northern California; the Boisé River Valley, Idaho; the Snake River Valley, Washington and Idaho; the Colville River Valley, Washington; and, I understand, in the Rogue River Valley, Oregon. The rivers of this region are large and would furnish enough water to supply systems of irrigation ditches which could be supplemented by storage reservoirs if necessary, or when the demands increase.
>
> The region around Walla Walla is rich and productive and north of this is the area called the Great Plains of the Columbia, which, although not so well known, is a promising country. Both these regions are poorly supplied with water, at least during the summer months. The topography of this section is so imperfectly known that it is impossible to determine, without surveys, the practicability of irrigating by ditches or whether it would be necessary and practicable to make use of reservoirs. The Snake River above Lewiston has falls and rapids, and thus may afford an opportunity of running irrigation ditches to the lower lands below.

All of the great bodies of water named by General Gibbons present, in the mountain sections at least, the usual characteristics of the arid region—deeply eroded channels, low, narrow valleys, abruptly rising bench-lands, opening widely one or the other side of the river, but seldom on both sides, and then again rising into grass-clad table or plateau lands. Your committee, at its North Yakima and Ellensburgh sessions, had the opportunity direct of viewing the results of irrigation on an extensive scale. The Moxie ranch at the first named place illustrated in its 7,000 acres, irrigated from the Yakima River at an average cost of $8 per acre, what may be accomplished by private enterprise backed by capital, while at Ellensburgh the Kittitas Valley offered a splendid evidence of neighborhood energy and self-dependence. The Yakima Valley offers 200,000 acres of bottom lands for reclamation and at least a million more in available bench-lands. The rain-fall of the region is also sufficient to secure a large area of "subirrigated" land. That is to say, where the soil retains below the surface much of the precipitation and drainage that percolates into it.

Evidence taken at North Yakima and elsewhere in eastern Washington gives the production per acre of wheat at from 35 to 50 bushels; of oats at 60; of barley from 50 to 80; alfalfa yields from 6 to 10 tons per year, while potatoes will return more than 500 bushels to the acre. One half of eastern Washington needs storage and full facilities of irrigation. The cost will range from $3 to $5 per acre, and there may probably be found an abundance of water for storage. The cost of water in irrigation is about $1.50 per acre. Says one of the witnesses:

> The Kittitas Valley without water is but a sage-brush desert; but upon being irrigated it becomes a garden spot and produces bountifully of cereals, fruits, and vegetables. About 22,000 acres of land are under cultivation in the valley. * * * All small fruits, as well as apples, plums, pears, etc., grow to perfection; peaches do not do so well, except in localities bordering on the Columbia and Wenatchee Rivers. Vegetables of all kinds and of the finest quality are grown upon every farm. It is nothing uncommon for cabbage to weigh 50 pounds and upward; onions, 5 pounds, etc. Every farm in the valley is an example of individual effort in reclaiming the desert with muscle and water.

A former Federal judge, J. R. Lewis, of North Yakima, stated that—

> In these valleys of the Yakima, including the Naches Valley and the Yakima Valley proper, and the valleys tributary to the Yakima, the irrigating season commences in-

> the months of May and June principally. Very little land west of the Columbia River, in what is known as the Columbia River basin, is susceptible of cultivation without irrigation except, perhaps, for hay. Many people produce hay along the river by sub-irrigation. * * * The finest store-house we have is our snow-clad mountains. Fort Adams is an everlasting store-house. The waters of the Yakima and the Tietan flow in there in ordinary seasons, and without any storage whatever those would irrigate an extremely large area of country.
>
> Experience and observation show me that for a wheat crop of 45 to 50 bushels is a fair average on the base of the Blue Mountains. You can get 60 bushels of oats here on well-irrigated land, and from 60 to 75 bushels of barley on well-irrigated land, but there is very little ground in this vicinity that is properly irrigated. The Kittitas Valley is well irrigated, and you will find men talk of 75, 80, and 100 bushels of barley, and truthfully so, because they have the system established. On the Indian Reservation, just below us here, which must shortly be opened, there are 300,000 acres of land that can be irrigated.

In the extreme southeastern section, around Pasco, Walla Walla, and east to Lewiston, in Idaho, there is a region already famous for its fine fruits and vegetables, in which the use of irrigation adds enormously to the value of the land. It is a region also of accessible and not very deep artesian water, and it illustrates, too, the rapid increase of precipitation at rising altitudes. The average annual rain-fall at Walla Walla is given for five years past at 18 inches; at Dayton, 30 miles distant, it reaches 27 inches. That is a rise of less than 700 feet. To be accurate, the height above sea-level at Walla Walla is stated at 1,000 feet; at Dayton, at 1,675 feet. The difference of 10 inches, then, is at the rate of one-third of an inch per mile, or of 1⅓ in every hundred feet. The advantages offered by this region are testified to by some State census figures, which show that the proportion of settlement in Washington during two years past has been in favor of the section east of the Cascade range. In 1887 there were in Washington 144,000 persons; in 1889 the estimate made from county returns showed 240,000. In the western counties the total population was 142,132; in the eastern counties it was 97,868, an excess for the west of 44,264. The total increase for two years is given as 95,991. Of this, the region between 117 degrees and 121 degrees, or East Washington, got 41,298, while that west of the Cascades got 35,693. This illustrates the tendency of population towards the areas where agricultural security may yet be maintained by the will of man.

Oregon is estimated to have received 100,000 new settlers during the same two years or less, of whom 60,000 at least have remained east of the one hundred and twenty-first degree of west longitude. During the past twelve fiscal years ending June 30, 1889, these two States show a public land settlement as follows: Washington, 13,335,937.03, and Oregon, 6,149,540.05 acres, or a total of 19,485,477.08 acres. The amount paid into the land offices during the fiscal year of 1888–'89 was, for Oregon, $35,332; and for Washington, $39,538, or $74,870; or a total of one-eighth of the receipts for the whole arid region. Washington has made natural waters public property by constitutional provision.

The arid and subarid sections of Oregon are somewhat more extensive than the similar ones in Washington. Their great feature is the drainage basin of the Columbia River, in the north, with its extensive tributaries—the Deschutes, John Day, White and Powder Rivers—and on the east the lower valley of the Snake River, which forms the western boundary line of Idaho for two-thirds of its length. Below that is the Oregon portion of the Owyhee River and its branches. In the southwest, the Klamath River and lakes form an extended drainage basin in which large irrigation operations have already commenced. Evidence taken at the Dalles, Baker City, and Caldwell confirmed the extent of reclaimable land, of needed water storage, and of the need of capital as well as of an extended system of surveys, in order to bring out the facts which are desirable in order to prevent disastrous failures and a great waste of energy and industry. As far as can be estimated from the scattered facts presented, eastern Washington now has about 50,000 acres under irrigation, while the corresponding area of Oregon has about 100,000 acres. In the latter State there are about 50,000 acres under ditch, but not yet cultivated.

IDAHO AND IRRIGATION PROGRESS.

The condition of Idaho, as to the hydrographic facts, the available area for reclamation, the facilities for artificial storage, and the awakened interest of the people, was found to be among the most satisfactory of the communities visited by your committee. A considerable area to the north and to the west of the Sawtooth and Bitter Root ranges is considered in the Territory as outside of the arid range. This area embraces the counties of Idaho, Latah, Nez Perces, Kootenai, and Shoshone. A portion of Lemhi is also included. Unquestionably, however, this section will also be benefited and farming pursuits rendered more secure by water storage and distribution. The remainder of the Territory embraces 32,183,040 acres, of which about 7,000,000 acres are estimated to be irrigable and arable, fertile in soil, and having accessible storage capacity and an available water supply.

The testimony taken in Idaho covers carefully every section. From the statements so presented the committee offer the following tabulation as illustrating the main results and facts of irrigation enterprise:

Idaho ditches for irrigation, areas under water, etc.

Counties in which irrigation now exists.	No. of completed ditches.	Ditches.	Irrigated in 1889.	Estimated No. of acres irrigable.
		Miles.	*Acres.*	
Ada	*62	*448	60,000	900,000
Alturas	10	18	14,500	118,000
Bear Lake	69	206	21,500	39,000
Bingham, North	†16	253	245,000	2,236,000
Bingham, South	70	264	39 250	267,500
Boisé	‡30	60	83,500	....
Cassia	288	299	82,000	656,400
Elmore	‡50	‡25	10,000	230,000
Logan	‡65	‡125	50,000	1,250,000
Lemhi	250	‡300	9,715	500,000
Oneida	‡65	‡100	28,700	196,000
Owyhee	66	153	21,275	248,500
Washington	‡270	§34 ‡133	40,000	500,000
Total	1,311	2,418	715,500	7,141,400

*This includes three ditch systems, embracing 207 miles, incompleted when the visit of committee was made.

†The sixteen ditches given do not include the laterals. At an average estimate of 400 acres per ditch, the milage would be over 600.

‡Estimated on the basis of 2 miles per ditch serving 400 acres. This is near enough for an approximate; below rather than above the facts.

§The 34 miles are the definite lengths given of new ditch systems; the balance is an estimate.

The foregoing table shows some notable facts. The counties wherein are found the largest irrigated areas, as well as the great number of ditches with the smallest service to each, are those in which so large a number of Mormon citizens have settled. In Idaho, as also in Arizona, where there is likewise a considerable body of this peculiar people, they reproduce, as they have done in Utah, some of the physical and material facts of the Orient, from which they have also derived their peculiar religious-social faith and practices. The smallness of the ditches constructed indicate the limited area cultivated by each individual or family. It is, however, always sufficient to support them in that primitive plenty which constitutes their standard of life. The location as well as the length of the irrigation ditches seems also to instinctively follow the customs and habits of the Orient. The petty works, the careful observance of water rights, the economy of water observed, and the co-operative instinct, rather than plans, which mark their dealings with reclamation from aridity are all traits that may be found as characteristics of Mohammedan or other Eastern countries, where a strong sacerdotal régime has not only dominated the character but directed the daily pursuits of the people under it. The primary nature of this work can be seen when an estimate is made of the cost per acre.

In Bear Lake County the total cost for the 21,500 acres irrigated is given at $73,500, or a fraction over $3.60 per acre. The ditches of the northern portion of Bingham County cost $435,000, or a cost per acre of $1.775. Small as this price appears to be, it is necessarily costly, because wasteful. As the water in sight is absorbed, storage becomes a necessity, and the result is the abandonment finally of the small ditches, and the reconstruction of service works on a larger and, of necessity, costlier (at the outset) scale. Taking the medium between the two rates given, and the cost per acre of irrigation in Idaho may be set at $2.66 per acre, or a total for 715,500 acres of $1,187,000.

The extensive river system of Idaho renders the reclamation of its arid lands a very interesting problem. The need of storage was insisted upon by all witnesses and in all the reports offered. A majority appeal to the General Government for aid, and all are urgent for a complete hydrographic survey directed mainly to utilitarian results. The importance of the river system of Idaho can hardly be exaggerated from the stand-point of reclamation; the number and volume of minor mountain streams must also be considered. Some slight idea of the water supply may be obtained by the presentation of a few of the estimates made in the testimony:

	Cubic feet per second.
Flow of Snake River (at Eagle Rock)	5,000
Flow of Salmon River (in Cassia County)	1,820
Flow of Boisé River	6,000
Flow of Payette River	1,000
Flow of Weiser River	180
Flow of Big Wood River	154
Flow of Raft River	745

These estimates are necessarily partial. They embrace with tolerable accuracy the surface drainage flow above the point of measurement, but they take no account, of course, of the addition to the river volume accruing from the remainder of its other local areas of precipitation and drainage.

According to the testimony given the average annual rain-fall is about 13 inches. The snow-fall is given at an average of 6 cubic feet of packed snow on the ranges. This will give at least, in melting, about 2 cubic feet of water. The capacity, then, of Idaho for storage by main reservoirs at high altitude and at or near the sources of its great streams becomes one of the problems that may be approximately measured and calculated upon.

The testimony taken in Idaho will all bear careful examination. The Territory will take a leading place on irrigation questions.

THE COMPARATIVE GROWTH OF GRAIN.

Its other material conditions are also strengthened by the fertility of the soil, for, in addition to the grains, grasses, and roots of the Northwest, Idaho produces in remarkable profusion all the fruits of the temperate zone. The exhibition of such fruits, as well as of vegetables, made before the committee at Boisé City, was certainly one of the most remarkable in quality, quantity, variety, and size of the whole trip. The average for the whole arid region is less than 3 per cent. The percentage of tillable land in the Territory is given by Statistician Dodge at 37 per cent., being, with the exception of Utah, the highest in the arid region. Grass land is given by the same authority at 23.2; wood land, 3.6, and unproductive as high as 36 per cent. The average yield of wheat is 23.2 bushels per acre; of oats, 39, and of corn, 33.1. Montana is the only arid State surpassing Idaho as to the latter grain. The difference between Idaho and the balance of the country is, as to wheat, 1.7 bushels less; as to oats, 21.9 bushels more, and of corn, 4.8 bushels more. The average yield of oats is higher in Montana than elsewhere in the arid region. The farming population is but 25 per cent.; the number of farms is 1,885, and the average value per acre is set down at $8.64, being sixth in ratio to other arid divisions.

The total amount of public land taken up, sold, and patented in Idaho outside of mineral land, during the twelve fiscal years ending June 30, 1889, is given at 2,597,739.39 acres, of which total over 1,700,000 acres have been disposed of in the last half of the period. These figures are of value as showing the growing westward tendency of settlement. We may individually regard such present occupation of arid lands as unwise; but as legislators charged with the duty of observing the facts and reporting thereon as a basis for immediate or future action, it is not possible to avoid the conviction that such settlement will proceed, whatever may be said to discourage it.

UTAH—ITS SMALL FARMS AND WATER USAGES.

The conditions surrounding irrigation in Utah deserve the most careful review. They differ in many respects from other sections of the arid region. This difference begins with the physical features, and runs into all the social economic aspects also. The configuration of the Territory renders it for reclaimable purposes one of the most difficult in the arid region. Its only great river system, that of the Green and Colorado, is in its physical features of little service for reclamation purposes, for their courses are mainly marked by the existence of the precipitous cañon region. Outside, then, of the reclaimable portions of the basins of Salt and Utah Lakes, and of the Bear River plain to the north, with the small valley areas that belong to these portions, the cultivated sections of Utah are widely scattered.

The industrious people who have held this Territory since early in the "fifties" have made available in detached portions of Utah a considerable area of arable land by the careful use of every spring, pool, creek, or mountain stream that can by simple means be coaxed down to valleys or plains below. As will be seen by the table inserted hereafter, the total area reported as irrigated and producing crops in 1889 was only 412,269 acres. Allowing for omissions and making the total 450,000 acres, the figures show a loss by the drought of fully 200,000 acres. There are about 800,000 acres under cultivation in Utah, a considerable area being benefited by natural subirrigation. An estimate of 200,000 acres more will cover all that could be cultivated by the present ditches, and 3,500,000 acres is the outside estimate given in the evidence of the amount reclaimable under the reservoirs proposed by witnesses and in county reports.

Irrigation has prevailed in Utah for nearly forty years. Not one-fifth of the present population could be sustained without it upon the soil of the Territory. As it is, Utah feeds not only its own population of at least 175,000 persons, but has a considerable surplus for sale to others. The settlements of Utah are mainly located along the center of the Territory, from its northeast to its southwest corners. Beginning with Rich and Cache Counties, a strip of about one of the smaller counties wide proceeding southward is occupied by the Mormon farmers. In this area will be found Salt, Utah, and Sevier Lakes. It will have the valley of the Bear River to the north and of the Virgin to the south. The area thus occupied will average about one degree, or 60 miles, in width. The wisdom of the selection is easily seen when the hydrographic features therein are considered. Elsewhere there are smaller communities, but at least 125,000 are located within the east and west portions of the dozen counties into which this central belt of Utah is subdivided.

These communities are favorably located to command all local trade and communication, as well as the several sources of water; but the main concentration referred to is a striking characteristic of the sagacious economic manipulations which mark the settlement and development of the major portion of Utah—of all of it in fact outside the chief railroad towns and a few mining districts. It is these things which have given, as one of their special features, such an interesting development to irrigation under them. When the geographical significance of this line of settlement is taken in connection with the larger configuration of our mountain areas outside of Utah, it is difficult to escape the conclusion that it has been selected and directed by ulterior desires for controlling the development north and south of the whole region.

THE SMALL FARMS OF UTAH.

Be that as it may, it will be seen that Utah supports a considerable farming population—more, perhaps, per acre than elsewhere in the United States, unless a few of the California fruit colonies are accounted for. The farmers of Utah have large families as a rule; ten acres support a majority of them. The largest farm reported to the committee had but 200 acres in it. The average Utah farm is about 25 acres. There are a few ranches on which alfalfa and other fodder plants are raised on a large scale. Very few Utah farms are under mortgage. The average length of the ditches does not exceed 3 miles. Their average service may be estimated at 300 acres each. One cubic foot of water has supplied during the past year about 75 acres of land. The cost of water is less per acre to the Utah farmer than elsewhere within the arid region, ranging, as it does, from 25 to 60 cents per acre. In a few instances only it will cost $3 per acre, but it seldom reaches even $1.

There was not a single corporation in Utah at the time of your committee's investigation charging royalty and annual rental for water. There has been but one incorporated with that object in view. Nearly every mile of canal or ditch in the Territory has been constructed by combined and neighborhood effort. In actual cash these ditches have cost not to exceed $2.50 per acre; counted as paid in labor, however, and the cost has been about $4 per acre. That will make the nominal cost for 650,000 acres $2,600,000; the actual or cash cost may be put down at $1,625,000. There has never been a lawsuit over water rights; this at least was the general testimony of the witnesses.

The area irrigated last year is given in the table that follows:

Counties reported.	Irrigated areas in acres, 1889.	No. of canals.	Miles of canals.
Beaver	9,500	*32	*96
Box Elder	17,500	12	76
Cache	41,444	40	110
Emery	14,825	*34	*102
Garfield	5,000	*17	*51
Iron	6,997	*23	*69
Juab	4,000	*13	*39
Kane	1,825	9	*18
Millard	13,500	42	*120
Morgan	8,648	*29	*87
Pi Ute	12,135	31	*93
Rich	42,811	*143	*429
Salt Lake	38,587	37	213
San Juan	1,025	*4	*12
San Pete	3,500	*12	*36
Sevier	17,619	*00	*180
Summit	8,500	*28	*84
Tooele	6,250	*21	*63
Uintah	8,933	*30	*90
Utah	69,126	346	*1,488
Wasatch	18,000	*60	*180
Washington	18,892	31	186
Weber	44,052	25	75
Total	412,669	1,079	3,903

* These are estimates made on a uniform basis of 300 acres to each ditch and of laterals of 3 miles in length.

These results have been attained by neighborhood combinations, directed from first to last by a managing force which has stood to the farmers of that Territory in place of capital and corporate direction. It can not be denied that the result is unique, and the average independence and comfort obtained is as remarkable. The facts brought out in the Utah evidence offer examples worth considering and following as to the capacity of an industrious, energetic, though poor and struggling, community, to obtain even from aridity and desert a sufficiency of support, amounting indeed to substantial comfort. That has been done, too, without large compensation for capital. It is not explained upon the tithe system in vogue in Utah, for very little has actually passed in the construction of any portion of the Utah irrigation ditches. Its success belongs far more to the spirit which organizes neighborhood effort and seeks in co-operation to achieve self-help.

THE WATER LAWS AND THEIR CHARACTER.

The legal aspects of Utah irrigation are as remarkable as the economic ones. Indeed they are related to each other, and the laws could hardly have been framed by any other community. But their value extends beyond the locality for which they were framed. Prior appropriation is the foundation, but so modified by the uses of water in the interests of the community as to make of that principle something quite broader and more equitable than has elsewhere been the case. In other words, priority has not been abused in Utah. It is not regarded as giving the right to a monopoly. Accrued water rights then are protected by the Territorial laws, as is the case throughout the arid region. The county selectmen are *ex officio* water commissioners, with the power to record all appropriation and regulate the distribution of natural water. Appropriators can be persons or corporations. Rights are divided into primary and secondary, the latter being a feature of water legislation peculiar to Utah. A primary right vests under the following circumstances:

> (1) Whenever any person or persons shall have taken, diverted, and used any of the unappropriated water of any natural stream, water-course, lake, or spring, or other natural source of supply.
>
> (2) Whenever any person or persons shall have had the open, peaceable, uninterrupted, and continuous use of water for a period of seven years.
>
> A secondary right to the use of water for any of said purposes is hereby recognized and acknowledged to have vested and accrued (subject to the perfect and complete use of all preliminary rights) to the extent of and reasonable necessity for such use thereof, under any of the following circumstances:
>
> (1) Whenever the whole of the waters of any natural stream, water-course, lake, spring, or other natural source of supply has been taken, diverted, and used by prior appropriators for a part, or parts, of each year only; and other persons have subsequently appropriated any part, or the whole, of such water during any other part of such year, such person shall be deemed to have acquired a secondary right.
>
> (2) Whenever, at the time of an unusual increase of water exceeding seven years average flow of such water, at the same season of each year, all the water of such average flow then being used by prior appropriators, and other persons appropriate and use such increase of water, such persons shall be deemed to have acquired a secondary right.*

The measurement of water is definitely provided for by "fractional parts of the whole source of supply" or time limit, or by a specific ratio of measurement, or this combined with time limit. Provisions are made for repairs, damages, continuous use and service, against waste, and for the return of unused water to its proper channel; also for pro rata distribution when supply fails in volume, as to equal right of way, and for the organization of local copartnerships or corporate direction. Another act provides for irrigation districts and their lawful control, with trustees, and the powers as to water and its control and use, of any sub-civic or county body. The probate judge of Salt Lake County described the manner in which land and water are allied and controlled. As to the distribution he said:

> There are two or three systems. We have, first, the incorporators on the streams, controlling it themselves—they agree how it shall be manipulated; second, the county courts that matured and organized irrigating companies; and, third, private corporations, taking out charters the same as any other corporation would, as, for instance, a person or a company of men settle upon a stream and appropriate the water in it. In early times they had sufficient to irrigate what land they would break up. Those we will term the primary owners of the water. Afterward others would come who, finding a surplus of water in the stream, would appropriate still further water, and so on until all the water of that stream would be taken out. They dug their ditch, gave it some name, and took what water they could through their land. In establishing some streams there would be what is known as the first, second, and third right. The third right, when there is a scarcity of water, shuts off the entire stream, and the second and first rights take the entire stream. The owners of each of those ditches meet and appoint what is called a "water-divider" or "water-master," who has control of the ditch for that year, and whose duty it is to divide the water of the streams into ditches, as, for instance, if there were four streams drawing water, they would appoint a divider to turn the water of those streams into the ditches, and the water-master would take the water as it would get into the ditch and give it to the owners as their rights might appear. I do not think there is an irrigating ditch in the Territory under the irrigation law; they have all taken out private charters.

The witness said that is an incorporation where certificates of stock are issued under the general laws of the Territory. They elect their board of trustees and manage the affairs of the company. Those trustees appoint a water-master, who takes the number of shares each owner of it has and divides to each his proportion of the water that comes through a certain ditch from the stream. Those streams are mostly artificial streams, having been taken out from some large body of water. That system prevails more on the west side than on the east side, though there are some on the east. The stockholders have the land, but the water right can be transferred without transferring the land. It is a water right independently of the land.

---

* From Compiled Laws of Utah, sec. 2781.

Yet the water must be "in place," and in order to use it, the land served by that way must be obtained. As a practical fact a water right, that is, one share in a corporation, represents only the service of water for 1 acre of land. And it is a particular acre in a special place. Therefore the one share of water can only serve that 1 acre of land or rather any 1 acre within the area to be irrigated by that particular body of water in the service or duty of which one share has been obtained. In proof may be quoted the following:

> I do not think there is a corporation in Utah Territory that rents water exclusively.
>
> The **CHAIRMAN.** Then the only renters of water are the stockholders in these corporations who have a surplus, who have more stock than land, and they sell their surplus water to their neighbors?
>
> Mr. **SMITH.** Yes; that is the only system in vogue in this Territory to-day.

HOW WATER IS DISTRIBUTED.

In the distribution of water the horary or time system has been adopted. The irrigation survey engineer states that the following forms indicate the method of distribution by "the hour," as is the case in Spain:

No. —.

TIMPANOGOS IRRIGATION
TIME TICKET.

Mr. —— ——. On —— every alternate week, from — o'clock — m., and until — o'clock — m., —— amount of stream, all of the water in said ditch.

—— ——,
Water-master.

No.—

TIMPANOGOS IRRIGATION TIME TICKET.

Mr. —— ——: You are entitled to the use of water from the Timpanogos Ditch on —— every alternate week, from —— o'clock — m., and until —— o'clock — m., ——; amount of stream, all of the water in said ditch; when you are required to discontinue to use and turn it off.

—— ——, *Water-master.*
Per —— ——, *Deputy.*
PROVO CITY, UTAH, —— ——, 18—.

The annexed blank receipt shows the manner of meeting the water-tax levy on proof of labor performed:

No. ——
Am't of labor, ——
Am't of cash, $——
——
Total, $——
Issued to and received by
—— ——.
Date, ——, 188—

No. ——
Received of —— —— —— days' labor, $——
Cash .... ——
——
Total.............................. ——
In full for his water-tax, for the year ending March 1, 188—.

—— ——, *Water-master.*
PROVO CITY, UTAH, —— ——, 188—.

Within the Territory of Utah will be found several varieties of climate, ranging almost from semi-temperate in the north to semi-tropical in the south. The production of corn is limited; that of wheat and oats is large. Wheat brings 80 cents a bushel and runs from 25 to 30 bushels per acre. Oats bring from $1.16 to $1.60 per hundred pounds. Potatoes will give 300 bushels to the acre. One witness put the probable increase of cultivation by artificial storage at 200 per cent.; that is, from 650,000 to about 2,000,000 acres. The agreement was general that a farm of 40 acres was quite sufficient for profitable cultivation. In the southern portion of the Territory the raising of fruit is claimed to be a success. Artesian water is found in several counties and over large areas.

The disposition of the public land domain in Utah for the past twelve fiscal years outside of mineral lands has been 2,681,605.96 acres. The percentage of Utah in farms is 1.92 of the whole. The entire arid region has but 2.85 per cent. Of tillable land Utah has (whether or not there be water for the same) 45.5 per cent. of its whole area. Of grass it has 18 per cent; of wood-land but 3 per cent. The unproductive area is set down at 11.4 per cent. of the whole. The question of reclamation in Utah then is, as elsewhere, one of mountain precipitation, of subterranean supply, and of artificial water storage and subsequent distribution. The rain-fall ranges from 7 to 17 inches per annum. The snow-fall is from 5 to 25 feet. In the mountains the precipitation is as 3 to 1 in quantity over the lower lands. The average yield of corn per acre is given at 22.5, of wheat, at 17.8, and of oats at 26.3 bushels—an average which is close to the normal mean for the whole country. With these figures, it is evident that Utah holds larger promises than its past has achieved.

NEVADA AND ITS RECLAMATION PROBLEMS.

The hydrography of Nevada certainly presents most remarkable features. Difficult as they are, examination offers a great deal for the encouragement of comprehensive plans of reclamation. The prevailing ideas of an almost impossible aridity will be seen to be much exaggerated and mistaken. The committee ask a careful study of the evidence and reports taken in connection with this State. Indeed, it may be said that the whole question of arid reclamation by the storage and distribution of water on a large scale, in the interior portions at least of our mountain territory between 104 and 121 degrees of west longitude, will depend in a great degree upon its feasibility within the vast drainage bowl in which the State of Nevada, politically speaking, is embraced. That State especially emphasizes the physical and legislative problems also, which would seem at times in considering the possibility of conquering aridity by reclamation through water storage and conservation, with subsequent distribution by irrigation, to be almost in conflict with the boundaries of States and the self-government thereof. The water for storage in Nevada must be drawn largely from drainage areas outside of the State boundaries. Yet these are strictly so within the drainage basins that belong to Nevada—speaking in a physical sense.

The water area of Nevada proper is estimated at but 1,081,600 acres, while the land area is not less than 70,656,000 acres. The ratio is therefore less than one acre in seventy, the smallest water area of any subdivision of the Union. The arable land is set down in the report of the State reclamation commission at 20,000,000; the grazing at 30,000,000; mineral at 15,000,000, and forestry at 2,000,000 acres. The balance is desert, alkali, flats, sulphur, borax, and saline deposits. There are but thirty-five rivers and streams in the State, while of lakes and ponds there are nine hundred and twenty-five reported. All the streams of any large value, except one, have their rise outside of the State. The Colorado has its sources in those of the Wind and Green Rivers. Carson, Walker, and Truckee, all of importance for irrigation purposes, have their sources within the lines of California, but well within the tributary drainage region to the west. The Quinn, Bruneau, Owyhee, and Salmon are also parts of the waters of Idaho and flow into the Pacific, while the Virgin flows through both Utah and Arizona and finally into the Gulf of California. Of the 1,761 miles of flowing streams within Nevada, at least 850 are portions of streams rising and flowing from and into other States.

The Humboldt is in fact the one stream of importance, rising and sinking within the area of the State itself. The lakes, situated mainly in the western part of Nevada and on the eastern slopes of the Sierra Nevada, are, however, the most important features in the reclamation problem. The seventeen important bodies of such water cover an area in Nevada of 1,914⅓ square miles. This will be nearly doubled if all the mountain lakes which physical geography plainly shows are within the proper drainage areas of Nevada, are to be considered.

Reclamation from aridity then must be achieved in Nevada by means of the storage of water at high altitudes and on a large scale. This does not, however, exclude some moderate areas to be reached and reclaimed by local storage and distribution, or even as to a considerable number of acres by the systematic exploitation and restoration to the surface of under-ground waters by means of artesian wells and the use of natural springs. It is claimed by one authority that there is water obtainable by storage to reclaim 12,000,000 acres. The United States Surveyor-General and others make a high estimate, and give the possible total at from 16,000,000 to 17,000,000 acres. There is estimated as in sight water sufficient, with proper engineering, to reclaim 3,000,000 acres. Such reclamation now calls for a large duty of water. It is estimated at not less than one miner's inch per second for each acre.

The area of land, irrigated and cultivated, other than as meadows or for hay, is about 70,000 acres. There are 646,343 acres inclosed, and of these the cultivated area is but 141,496 acres. About 14,000 acres are in small grains and potatoes, yielding of wheat nearly 24, of oats about 29½, of barley nearly 30, and of potatoes 140 bushels to the acre. The average yield of hay, principally timothy and alfalfa, is over 3½ tons per acre. The smaller vegetables occupied in 1888 about 1,350 acres and made large returns. Fruit trees, temperate and semi-tropical in character, grow well, and in the valley of the Virgin, etc., in Lincoln County, southern Nevada, cotton and other semi-tropical products have been grown readily and yield largely. It can not well be said that Nevada lacks in fertility or climatic suitability. On the contrary, it was declared to your committee that—

> No more delightful place to live can be found upon the continent; no part of America has so many days of sunshine with delicious evenings and nights of comfort; no corner of the Union has the freedom from malaria, consumption, and kindred diseases, and in no State is agriculture pursued with greater ease or larger profit. The farmer is certain of his crop as well as of his market. Ready sale can be had for all that can be raised. Whatever grows here grows to the limit of quality. The wheat, in grain and straw, is as clean as the gold from the mine. The potato is a sealed package of white meal; the apple is the best of its species. In addition to all kinds of grain and grasses Nevada is particularly well adapted to the apple, the potato, the plum, and the pear, besides all small fruits and berries, while certain kinds of grapes grow to perfection.
>
> Some idea of the capacity of the State can be gained from studying the county of Washoe, which raises yearly 60,000 tons of the best kind of hay, besides wheat and other grains. It seems especially well adapted to alfalfa or lucern.

The reclamation of large areas of Nevada resolves itself, then, into two questions: They are, from whence can sufficient water be obtained, and where can it be stored. The matter of distributing when stored is one to be readily solved by good engineering. As to obtaining the water for storage in a region where the water area in sight is less than as one to 70 acres, and over the lower bench-lands and valley sections of which the average annual rainfall for the State is not over 6 inches, the questions involved are to be met only by consideration of the massive and controlling topographic and hydrographic features that dominate the whole region.

NEVADA'S NATURAL STORE-HOUSE FOR WATER.

Nevada's mountain ranges are the great snow-catchers. They form, therefore, its store-houses of water. One inch of water to eleven inches of fresh snow is a moderate estimate. On the basin and valley lands only a few inches of snow falls during the winter. Rarely, according to the surveyor-general and others, does it reach 25 inches. At and above 6,000 feet there is an average fall annually of 18 feet of snow, giving at least 19 cubic inches of water. Sometimes it will be three times as much, as has been the case during the past winter. The ranges within the State run parallel with the Sierra, and their area is not less than 52,000 square miles. Of this, at least 18,000 square miles have snow upon them all the year round, at a depth of from 4 to 26 feet. The ranges will give at least 16 cubic inches of water for the whole State. And this does not include the eastern slopes of the Sierra Nevada, which are much greater. The United States surveyor-general says of this precipitation, that—

> The snow caught by Nevada's mountains does not stay all the year upon their tops and sides, for the warm winds, by their natural direction in proceeding from the equatorial regions toward the great easterly circulating belt along the forty-second parallel of latitude, fall into the valleys of Nevada and follow them throughout the extent of the State in a south to north direction and eat away the snow from all the subsidiary ranges, thus causing streams of water to run down the cañons from early spring until about the end of July, by which time nearly all of the snow which lodged below 6,000 feet altitude is melted away and the water from it has run down to the plains below and has been absorbed by the soil or can be seen collected in a thousand shallow lakes of greater or less extent—natural reservoirs. With proper engineering, I believe that 90 per cent. of this, the first fruits of the winter storms, can be saved for the production of what are called here second crops, which in most cases will be limited to the foot-hills along the bases of the mountains, and matured in the months of September and October, by which time the greater part of this store of water will become exhausted, to be again replenished the succeeding spring. The remainder of the snow, which from its altitude is above the reach of the warm air currents spoken of, melts very slowly and much of it remains from year to year.

To the 16 inches storage to be gained from snow at the 6,000 feet must be added what falls below that altitude. It is estimated at 5½ feet of fresh snow, yielding at least 6 inches of water. This gives from snow alone a possible precipitation in water of 22 inches. The drainage shed of the eastern slopes of the Sierra Nevada is 4,800 square miles. This area is all tributary to Nevada; that is, it is part of the State's water-shed. According to the surveyor-general, this section stores the water as follows:

	Snow-fall.	Water.
	Feet.	*Inches.*
250 square miles	14¼	14
1,560 square miles	17 1/12	19
1,330 square miles	33	36

The remainder of the snow supply forms seasonal streams only. Over 90 per cent. of a possible 42 inches is now lost by evaporation and seepage. The latter fact produces the under-ground water supply known to exist in southern Nevada, in both Nye and Lincoln Counties, where it is claimed that, by reason of the large fall of 7½ feet per mile, a considerable deposit of artesian water has been found.

As to the conservation of water by storage, a statement made by the Washoe County commissioners illustrates its possibilities. It is reported that not over 3 per cent. of the "water in sight" is now used in that county, but that with storage 35 per cent. of it could be utilized.

THE LAKES OF THE SIERRAS.

The lakes of the Sierras afford the most interesting series of facts. One-third of Tahoe, the largest of the score or more valuable natural reservoirs, lying along the western boundary line, is within the State of Nevada. Donner Lake, which is one of the chief reservoirs of the Truckee region, is just within the boundary of California. To the north of Reno, lying along the eastern slope of the Sierra Nevada, may be found the upper, middle, and lower lakes of Modoc County, Horse, Eagle, and Honey Lakes in Lassen County, with Donner in Sierra County, all in the State of California, but as part of a great drainage basin, naturally affiliated with the area of which Nevada forms the largest portion. Lake Tahoe, at an altitude of about 6,000 feet, with a drainage area of 1,200 square miles, a surface one of 111,360 acres, a depth of many hundreds of feet, is the crown of the system, both in its wild mountain beauty and its wonderful adaptability to the needs of man in this matter of reclamation. Below Tahoe and within Nevada are the Walker and Carson Lakes, the Carson and Humboldt sinks, and still further south, Mono Lake in California.

The central river systems on the Nevada side of the Sierras may well be compared with that of the San Joaquin Valley on the west side of the great range. The examination of a good map will illustrate this. Inside Nevada, and close to its western border, may be found the Winnemucca and Pyramid Lakes. They lie north of the Central Pacific Railroad and are the "sinks" of the Truckee River. These basins or bowls illustrate what may be done in the way of storage, as the Winnemucca or Mud Lake is an example of a reservoir formed naturally. Fifty years since it was in general a mud bed. The Indians and others drove across it, making a well-defined road at points where the water is now 60 feet deep. One of the outlets was choked by a land slide and filled with trees and earth, making a compact dam, growing stronger every year by the impact of the waters. Surveyor-General Irish says:

> In 1844, at the time of General Fremont's first trip through this region, it was slowly filling, by reason of a great dam of brush and cotton-wood timber, which was pushed into the Pyramid Lake channel by a great freshet in the river some time before that date. The filling has continued to the present time; so that now, as before stated, the lake is about 70 feet deep, and completely covers all its bed. The length of this lake is 28 miles, and its average width 6¼ miles. Thus it is seen that in fifty years' time the Truckee River drainage has stored in Mud Lake 2.4 cubic miles of water. But this is not all of its storage capacity, for within the fifty years spoken of it has again and again filled up Pyramid Lake, a much larger body of water, through a rise and fall of at least 25 feet; so that I am disposed to place the storage by the Truckee River for a period of fifty years in these two lakes at not less than 5 cubic miles of water, over and above all the losses by evaporation and percolation. This would be at the rate of 14,719,795,200 cubic feet per annum, which sum is the result over and above all losses by evaporation, percolation, and used by irrigation for the past twenty to fifty years. This amount of water would cover a square mile 7,795 feet deep each year if diverted from the lakes and so used.

Such facts as these point with unerring certainty to the possibility of storage on a very extended scale. The State authorities are not un mindful of these facts. A board of reclamation has been appointed and an appropriation of $100,000 made for the commencement of a storage system. There is a very good State weather service. The water legislation recognizes the principles of public property and prior appropriation as qualified by beneficial use, when supervised by district and State authority. One of the civil engineers engaged on the irrigation survey last year made an examination of the Sierra Lakes and other storage possibilities for both the General and State Governments. Some of his estimates may be esteemed as oversanguine, but making all due allowances, the calculations are remarkable enough to be quoted.

	Surface.	To be raised.	Water capacity.
	Sq. miles.	*Feet.*	*Cubic feet.*
Donner Lake	55	40	5,575,680,000
Tahoe Lake	174	80	111,513,680,000

At to the river valley sites, selected for storage, the following will do as examples:

Valley.	Length.	Altitude above sea-level.	Water capacity.
	Miles.	*Feet.*	*Cubic feet.*
Hope	5	7,658	6,969,600,000
Long	20	5,078	5,625,680,000
Diamond	2	5,481	
Pleasant	3	6,000	3,345,408,000
Other sites (estimated)			3,000,000,000
Total			18,940,688,000

These are all part of the Carson water-shed, which, with its branches, is fully 1,000 square miles in extent. With other projected reservoir sites on the Truckee and near Pyramid Lake, the engineer estimates foot up a total possibility of 133,229,968,000 cubic feet of water in storage for reclamation purposes in western Nevada alone. The area that can be served thereby is placed at 3,000,000 acres. If it were put at one-half, it would of itself, were it accomplished, redeem Nevada from poverty and political feebleness, and bring her both prosperity and power. The sage brush plains and table-lands that would be reclaimed are not now worth over $2 per acre. It will take 20 acres to feed one broad-horned steer. If 2,000,000 acres were reclaimed in Nevada, every acre under water, without a foot of cultivation, would be worth $15 per acre—that is, the area would be worth $30,000,000. It would certainly not cost over $7.50 per acre to reclaim. That would be an increase over cost and present value of $11,000,000. When brought under cultivation, as well as under water, there is not an arable acre that would not be worth $30 to $70 per acre.

WILL IRRIGATION OPEN MINES AND MAKE HOME MARKETS?

It is objected already that agricultural production is overdone. This fallacious argument may be urged against land reclamation by irrigation. Those who may make it will surely do so without a full apprehension of the conditions. In the first place, people are going upon even the arid lands of Nevada. They will fill up these regions. The balance of the nation may contemn or ignore, but with a vast amount of unnecessary toil, just as our hardy miners unaided have once before exploited the wilderness, wringing the precious metals from savage nature and the hostility of the more savage Indian, so will the pioneer, rancher, herdsman, and frontier farmer yet make the desert "bloom and blossom as the rose."

The real issue is found in a question, and that is, shall we recognize facts and wisely aid in directing the energies by which they are wrought out? With this unappeasable pioneer movement will be found striking economic considerations.

The reclamation of our arid region means the opening of mines and the utilization on all sides of metaliferous deposits. It means new mines, mills, foundries, railroads, cattle farms, manufactories, towns, as well as fruit and grain farms. It means for Nevada the prospecting and opening of her 15,000,000 acres of mineral lands and her 3,000,000 acres of other valuable metallic and saline deposits. For every ton of alfalfa, there will be animals to consume; for every bushel of grain, mouths to feed; for every mine opened and every borax or sulphur deposit that is utilized, hundreds of laborers there and elsewhere will be set at work. Reclamation from aridity within our mountain area means vastly more than the raising of so many more bushels of grain. It means the opening of new and profitable industries, the laborers wherein will be the farmers' best customers. It is in this light that reclamation in Nevada especially presents itself.

WHAT NEVADA URGES ON CONGRESS.

The State has already added $500,000,000 to the world's stock of precious metals. The world has been enriched thereby; but Nevada is the poorer, for the economic organization of civilization, almost passing her by, has not enabled her retaining even a moderate amount of this precious wealth. With aid to reclamation there will dawn upon Nevada a great future. From this standpoint the argument of her State board of reclamation commissioners is one that should be candidly considered. They addressed to your committee an argument on behalf of national aid, from which in part we quote without other comment or assent:

> Many of the States and Territories in the arid region advance the following propositions:
>
> "(1) The General Government to undertake the reclamation of the arid lands and provide for their settlement and sale.
>
> "(2) That the desert-land law be so amended as to encourage individuals and companies to construct the necessary works for the reclamation of large bodies of said land.
>
> "(3) That Congress grant to each State of the arid belt, or to each Territory, upon its becoming a State, all the irrigable land within its borders, held by the General Government, such States to be charged with the supervision of their reclamation, and with their disposal to actual settlers."
>
> Of these, we favor the last. If the General Government feels that it would not be warranted in donating outright the money necessary to accomplish the desired end, then let it act as liberally as it can without detriment to the equity of other States, whose humidity is sufficient for all their requirements, and transfer in fee-simple to the State of Nevada all the lands in that State the title to which is now in the General Government and not otherwise appropriated.
>
> Were these lands put in legal condition to be sold to actual settlers, firms, corporations, and syndicates, the money derived from such sales could be placed in a fund to be known as the "State reclamation fund," the sale of said lands and the control of said reclamation fund to be managed by a State board. The money accruing to this

fund could be used for the purpose of reclaiming such lands, and for the construction of storage reservoirs, canals, and tunnels; and thus induce the purchase by the farmer of lands upon which he would be guarantied the necessary water for irrigation.

Thus all the irrigable lands in the State would be in demand by actual settlers, and money would flow in as fast as it could be utilized, and the fund would be found ample to do the work required.

Should the General Government be unwilling to make a donation of money, but will make this donation of land, the end would be accomplished, no doubt, as readily and thoroughly as by any other means.

The State has but a small tax-roll compared with other States. This board was only organized May 9, 1889. The State has appropriated $100,000, so that this board could make a beginning. It is to the General Government that we most look for aid to carry on this great work. The title to most of the irrigable land in the State is in the Government, so that should the Government assist us it would at the same time benefit itself.

The fostering care of the General Government should be extended to all the States of the Union without distinction or discrimination. Nevada, as one of the integral parts of the Union, asks that this be done in its behalf now, at a time in its history when its needs are more pressing than at any period since its organization as a State. Its mines, which for many years were the envy of the world, have very materially fallen off in their production of gold and silver, and very many of the people engaged in that industry have departed to other fields. There now remains a population of probably 63,000. Of these the great majority are engaged in other pursuits than mining. The miner, having dug his treasures from the bowels of the mountains, had no further use for the country, and left behind him only the tiller of the soil, or, to speak more in the parlance of the great West, the rancher. This individual, with a persistence worthy of better success, has made productive every acre of arable land to be found along the water-courses of the State, or where, by small expenditure, land could be irrigated, he did so with much success, considering the capital invested and the opportunities presented. There being no more land available for farming in this way, if the area of producing land is to be increased, it must be done by a system of irrigation fostered by the General Government.

Of what that system shall consist, or how it shall be established, perhaps others more versed in such problems than ourselves should determine; but it must be done, or the State, which has within its borders thousands of acres of productive land, must remain as it is, poor in wealth and sparse in population. Such being the condition of things, can the General Government refuse to render assistance, or will it allow one of its sovereign States to languish, when a very small moiety from its treasure-house would place it in a condition of permanent prosperity, and add to that State's capacity for increasing its wealth and supplying homes for a greater number of inhabitants? Surely the policy of this great Government is broad enough, is expansive enough in its conception of what is beneficial for the good of its whole people, not to allow the parsimony of the huckster to stand in the way of aiding and fostering one of its great commonwealths.

The General Government can help solve this problem by aiding this struggling people in a manner different from the aid given to the people of other States. Nevada has no harbors within its confines to be sea-walled or dredged, nor does it ask for expensive light-houses to light the commerce of the world to its custom-house doors, nor has it a river requiring improvement or the expenditure of money to make it navigable, save, indeed, the Colorado, which in other years may be deemed a stream of sufficient importance upon which the Government may expend labor.

Nevada is particularly an inland State, and, not being in condition geographically to ask the Government for aid to be applied as other and older States do, it does not seem presumptuous or extravagant to ask for aid and assistance for a system of irrigation which, when carried out faithfully, honestly, and conscientiously, will people its confines with American citizens, and will create homes for the progeny of American citizens in a land where only educated labor and a pride in American institutions are required to make the most prosperous and happy people on the face of the globe.

THE PHYSICAL FEATURES OF CALIFORNIA.

The State is second only in area to Texas, being 620 miles in length north or south, with a width of 150 to 200 miles east and west, and a coast line of 900 miles in extent. It ranges in climate from the temperate to the semi-tropical and in altitude from 15,000 feet above sea-level at Mount Whitney to a depth below of over 320 feet upon the Colorado Desert. Its topographical features are all on a vast scale, imposing in appearance and often strikingly sublime in their beauty. Two great mountain ranges traverse the State from north to south. The Sierra Nevada has an average of 8,500 feet, while the coast range rises from 4,000 to 6,000 feet above the level of the sea. This vast range is, indeed, the cloud-gatherer of that region, and upon its summits and high peaks break and precipitate into rain and snow, the heavy burden of the moisture driven in from the Pacific by the trade-winds of that ocean.

Between these two ranges lie trough-like the great axial valleys of the Sacramento and San Joaquin. On either flank rise the tumultuous upheaval of the foot-hill regions. Shasta at the north, with its 14,440 feet of snow-crowned peak; Whitney, with its vast bulk in the center, and Mount San Bernardino with its 11,000 feet of rugged heights; occupying the extreme southern point of the Sierras. The great mountains look down upon grand plains, varied in character, broad in extent, and fertile in capacity, when touched by the quickening waters. Their height above sea-level, from north to south, ranges from 556 feet at Redding to but 30 feet at Sacramento, and 282 feet at Bakersfield. This is the area which has made California foremost among the wheat producing States, and is now rapidly advancing her to the first ranks among fruit-growing and wine-making regions.

THE CLIMATE AND RAIN-FALL.

The conditions governing successful irrigation in California are as varied as its topography and climate. The Sierra Nevada will show on its summits an annual precipitation of from 35 to 90 inches, or even more. The entire coast region with its numerous sunny valleys have for almost their whole extent, a rain-fall precipitated on its western slopes that is nearly sufficient for every purpose of farming and horticulture. But the eastern side of the same range south of San Francisco Bay is almost deprived of moisture. The mountain summits break the cloud-tides as they flow inward from over the ocean and compel them to discharge their moisture before it can reach the western limits of the San Joaquin plains. The 25 to 35 inches of rain-fall on the coast range, and the 40 to 90 inches on the upper Sierra, diminish rapidly until it falls from 22 inches at the head of the Sacramento Valley to less than 8 inches in the southern part of the San Joaquin. Below that it descends to less than 3 inches, while in San Diego County on its coast and eastern mountain slopes it will range again from 6 to 40 inches.

It is in this great diversity that the needs of California and the means of supplying them are both found. Storage in the mountains and good engineering in the way of distribution will add enormously to the irrigable area of this wonderful State. Every system of water usage and distribution can be found therein; its practices illustrate the primitive wastefulness common to early irrigation, and the remarkable economy in the use of water which intensive farming and horticulture have already produced in the extreme southern portions of the State. Nowhere else in the world, except Madeira, portions of China, and Central Asia, has the "duty of water" been so thoroughly extended. As a consequence the price of land, the cost of water, and the security of crops have all grown in a steadily increasing ratio. Within twenty years land, which the owner protested against being taxed at 75 cents per acre, has been sold and is now selling at from $500 to $1,500 per acre. On the tract referred to more people are supported per acre and in greater comfort than elsewhere in the world.

The areas of fruit producing lands on which this occurs are small in extent at present, though they are quite numerous. These areas may be greatly increased by proper systems of water storage. They may be largely added to by the restoration and conservation of the underground supplies so steadily fed by the neighboring mountain drainage.

It is difficult to make anything like a close approximation of the reclaimable area of California. With the water "in sight," certainly 12,000,000 acres will be a low estimate. Water storage on a grand scale, such as the conditions warrant, will insure the reclamation of at least 20,000,000 acres. A large proportion of whatever area may be reclaimed will necessarily be devoted to the raising of products possessing a high market value. Its fruits are among the best in the world. It bids fair to become the successful rival of the oldest wine-growing and wine-making lands; its nectarine, prune, grape, and orange are already found in the markets of the world. The olive, fig, lemon, date, and other semi-tropical fruits are fast becoming of great commercial importance. Nearly all these products are the direct results of irrigation. They are all benefited by it when wisely directed.

The enormous addition to the wealth of the State and to the commercial prosperity of the whole country, which is the direct result of the high culture produced by irrigation, warrants a close attention to the united appeal of the people of California for such a survey of the public lands remaining therein and of the State's capacity for water storage as will insure to them that accurate knowledge which enterprise and investment require in the conduct of great affairs.

A careful tabulation of the assessment valuations in some of the counties of the State illustrates very forcibly the great increase of wealth produced by the practice of irrigation. It must be borne in mind that the figures given are not over 50 per cent. of the real values.

TAXABLE VALUES OF CALIFORNIA, 1879-1889.

GROUP No. 1.—*Counties enriched by irrigation.*

[Total taxable values.]

Counties.	1879.	1889.	Increase 1889.
Fresno	$6,354,596	$35,387,173	$29,032,787
Kern	6,005,460	11,831,780	5,826,320
Los Angeles	16,368,649	84,876,319	68,507,670
Merced	5,308,245	14,146,845	8,838,600
Orange	2,317,700	9,270,767	6,953,067
San Bernardino	2,576,973	23,267,955	20,690,982
San Diego	3,525,253	31,560,918	28,034,265
San Joaquin	17,377,129	38,802,606	21,425,477
Stanislaus	6,232,367	15,594,003	9,361 636
Sacramento	18,416,338	34,464,174	16,047,836
Solano	2,651,967	6,966,607	4,314,640
Tulare	5,204,777	24.343,013	19,138,236
Yolo	10,177,427	20,911,325	10,733,898
Total	102,516,281	350,922,885	248,405,414

Orange County was not formed in 1879. It was then part of Los Angeles County. The ratio estimated for increase is on one part in 1879 to four parts in 1889.

GROUP NO. II.—*Counties increasing in irrigation activity.*

[Total taxable values.]

Counties.	1879.	1889.	Increase 1889.
Butte	$10,743,426	$20,730,252	$9,986,826
Colusa	12,420,508	24,365,995	11,945,487
Lassen	1,230,764	2,527,449	1,396,685
Inyo	1,353,300	1,548,695	185,395
San Benito	3,947,728	6,332,911	2,385,183
Shasta	1,961,436	6,594,003	4,632,567
Siskiyou	2,651,367	6,966,007	4,314,640
Sutter	4,120,451	10,079,868	5,959,417
Tehama	4,199,998	11,901,255	7,701,257
Trinity	868,496	1,153,344	284,848
Yuba	4,293,630	7,046,316	2,752,686
Total	47,791,104	99,246,095	51,544,991

GROUP NO. III.—*Foot-hill counties partially irrigated.*

[Total taxable values.]

Conuties.	1879.	1889.	Increase 1889.
Amador	$2,468,642	$4,281,969	$1,813,327
Calaveras	1,871,850	4,315,461	2,443,611
El Dorado	2,312,590	3,879,887	1,567,297
Mariposa	1,295,048	1,849,641	554,593
Nevada	6,305,090	6,926,218	621,128
Placer	5,774,860	10,118,060	4,343,200
Plumas	2,115,173	2,309,441	194,268
Tuolumne	1,596,015	2,716,465	1,120,450
Total	23,739,268	36,397,142	12,657,874

The bay counties of San Francisco, Alameda, Contra Costa, Marin, San Mateo, Sonoma, and Napa, present the following comparisons:

Valuation in 1879, a total of	$333,146,966
Valuation in 1889, a total of	449,992,603
Making an increase of	116,841,637

These counties are partly affected by irrigation, to the direct extent at least of one-tenth part of the valuation given.

The remaining fourteen counties, of which nine are coast counties, show the following results:

Valuation in 1879	$70,755,631
Valuation in 1889	156,039,572
Increase in ten years	85,283,941

Thus it will be seen that from 1879 to 1889 the taxable valuation increased from $577,949,250 to $1,092,598,297 an addition of $514,649,047. Of this increase nearly one-half, or $248,405,414, was made in thirteen counties, or one-fourth of the State, and is almost wholly due to irrigation. It may be fairly estimated that to the increase of irrigation in California and the rise in land values, etc., as a consequence, is due at least $350,000,000 of the total taxable increase in valuation. That will be a marketable increase of $700,000,000.

California, though foremost in the extent and variety of its irrigation interests, enterprises, and methods, is behind several other communities within the arid region as to its statistics and data. The operations of the State engineer's office have extended quite systematically over a considerable portion of the San Joaquin Valley and the section south thereof. But a full, clear, succinct statement of the irrigated areas, number of ditch systems, and the mileage, with the cost thereof, is not accessible. From a number of authorities, your committee present the best average estimate obtainable, consulting therefor the State engineer's reports, the State board of trade, evidence offered by local witnesses, and county assessors' returns to the State board of equalization. The following is given as being well within the facts:

	Ditches.	Cost per mile.	Total cost.
	Miles.		
In the San Joaquin Valley, counties of Fresno, Merced, Kern, and Tulare	800	$5,400	$4,320,000
In the counties of Los Angeles, Orange, and San Bernardino	500	6,000	3,000,000
In San Diego County	36	19,613	706,068
In the remaining part of the State, twenty-four counties, where irrigation is practiced	1,700	640	1,128,000
Counting one-third of the mining ditches in the State as available and used for small irrigation, we have	289	3,188	921,221
Total	3,825	....	10,375,289

Without question the total valuation or cost is much below the true figures. Much of the data on which the estimates are based is taken from the assessors' returns made for the purpose of taxation. They can therefore be doubled. That will give a total cost of at least $20,000,000.

The acreage is as difficult to arrive at with certainty, but it can be fairly and moderately stated as follows:

	Acres.
In the San Joaquin counties:	
In farm crops	1,000,000
In vines	13,000
In fruit trees	16,000
	1,029 000
In the southern counties:	
In farm crops	580,000
In vines	45,000
In fruit trees	85,000
	710,000
In the balance of State (irrigated):	
In farm crops	1,500,000
In vines	25,000
In fruit trees	30,000
	1,555,000

The total acreage wholly under ditch and now irrigated is fairly within the annexed totals:

	Acres.
In farm crops	3,080,000
In vines	83,000
In fruit trees	131,000
Total	3,294,000

If all the areas directly cultivated by the aid of natural sub-irrigation, etc., be added, the total area in California will certainly be not less than 3,500,000 acres. The point of interest, however, in these figures is the profitable character of such cultivation, especially in the matter of fruit-raising.

The number of fruit trees in the State has recently been estimated at 1,537,000. It is safe to assert that no other acreage of lands produces such large results as that occupied by these trees.

According to Statistician Dodge, of the Agricultural Department, it will be found that California possesses, of its whole area, 39.8 per cent. tillable, 24.5 in grass land, and 10.1 in woodland, while 25.6 is reported as being unproductive. This latter, however, is most valuable because it is the mining area. These percentages contrast with the whole Union as follows: 41.6, 11.5, 35.5, and 11.4. From the same authority we find the

	Bush. per acre.
Yield of corn is	28.5
Yield of wheat is	13.0
Yield of oats is	28.2

The average for the United States in the same crops is 24.2, 12.3, and 27.0. Certainly the golden State, the larger proportion of which a few years ago was considered of but little agricultural value, need not fear a comparison with any other country. A region in which the discovery of gold revolutionized both the commercial and political affairs of the modern world, and lifted the American Union into the front rank of monetary powers, and which now promises to become the richest of all agricultural and horticultural countries, has a large claim upon the General Government for a wise liberality in dealing with its public lands and the capacity thereof for the storage and distribution of water for reclamation purposes.

The legal questions involved in the beneficial uses of water have been strangely complicated in California. The Indian community system prevailed before and during the Spanish occupation, having been made useful by the missionaries, who obtained such great control of that population. The Spanish conquerors were themselves original dwellers in an arid region. When the State passed under the control of this Republic, such small portions of it as were cultivated owed their fertility entirely to irrigation. The modes of distribution were recognized as being properly controllable by the community. Water was public property. The American miner, with his new enterprises and enormous energy, created a whole code of laws in regard to the use of water. Its basis was the pioneer principle of first come first served, and that has been reproduced in our jurisprudence as "prior appropriation."

In forming a constitution, the people of California incorporated the body of common law. Judges and courts have construed the common law to mean that the doctrine of riparian rights necessary in England and in our Eastern States should be applied to the use and distribution of water to agriculture. It is easy to see that this conflict of prior appropriation and riparian rights must create considerable trouble. A large majority of the earlier irrigation enterprises, generally found in the foot-hills region, were served with water secured under the miners' prior appropriation laws. When the land owner on a stream demanded his riparian use of the flowing water, litigation, or worse, at once ensued. At no time, however, were the communities in the southern part of the State organized upon the old Indian and Mexican control, involved in this dispute. The prior appropriations had often, it is charged, attempted to monopolize the water supplies, not for their own or immediate use, but for speculative purposes, and as a lien upon the future. This gave some color of equity to the absurd demands for riparian rights, as at times these were sought to be exercised by small land owners against the large appropriators of water and owners of great tracts of land. A few years since the supreme court of California brought the subject of riparian rights to a crisis by deciding in favor thereof.

As a result of this conflict, California has adopted a plan of co-operative or district control which bids fair to wisely settle all questions of water and its use, of irrigation, construction, and ownership, and of the methods and forces by which these shall be managed and paid for. This is embodied in several legislative acts known as the "Wright Irrigation District Laws." Under these acts the people of any drainage and arable area to be supplied by water from a common source, can, by obeying certain legal requirements, form themselves into an irrigation district, having a common seal, the right to sue and be sued, to make, own, and control irrigation constructions, to issue bonds therefor and pay interest on them, to levy taxes, to meet indebtedness and maintain works, to regulate the use of waters and decide the cost thereof to the farmer and consumer, to condemn lands and water rights, and in short to do all things necessary for a civil organization. These acts have all been passed during the last four years.

The constitutionality of the bonds to be issued have been assailed, but were affirmed and sustained by the supreme court. Since then, action under the district laws has been progressing quite rapidly. Some twenty districts had been organized at the time your committee was in California. The bonds of several had been successfully negotiated. Since then, at least ten more have been set in operation, the larger portion being in southern California. The amount of bonds involved ranged from $6,500 in a San Bernardino district to $3,000,000 in the district now forming in Fresno County. The area so far included will be over 3,500,000 acres. Probably one-sixth of this area is already irrigated. The effect of the policy embodied in these laws can be illustrated by a statement made in relation to the proposed Fresno district. The area embraced by it will be 600,000 acres. The amount of bondage indebtedness to be incurred is estimated at $3,000,000. Under the law a sinking fund is established, under which, at the end of the eleventh year, the bond redemption begins so that at the close of twenty-one years they will all be paid. These bonds are to bear 8 per cent. interest and the total to be paid will thus be over $5,000,000.

Under the present system every water user first pays a royalty for the right to use of about $2,500, and thereafter an annual rental of $2.50 per acre. In condemning a ditch system, the district may under the law regard the royalties paid as compensation, to their full extent, of the original outlay. They will pay, therefore, for the ditches on the basis of their annual rental values. The area now cultivated there does not exceed 120,000 acres. The additional 480,000 that may be reclaimed by the proposed new works will have no charges to meet other than those legally established for the payment of interest, the repayment of the bonds, and maintenance of the district irrigation works.

As the area of reclamation grows larger each year, the annual taxation must necessarily grow much smaller to each individual. The cost under private or corporative ditch systems, will certainly exceed at the end of twenty-one years that of the district system, by the entire amount of royalty the private enterprises would have exacted. And when the district debt should be paid off, the small annual cost for maintenance and repairs would be all that irrigators would have to bear.

Your committee have been so impressed with the wisdom and equity of this plan that in the general irrigation bill reported by it, they have presented as a bounty to the people of the States and Territories interested, the privilege of taxing the public lands for the purpose of irrigation as private and State lands shall be taxed, provided the States and Territories legislate as California has done for the organization of civil bodies to be known as irrigation districts, to be located as far as practicable within a common drainage basin that can be supplied by water from one general source.

Your committee conceives that such a policy is the natural and normal accompaniment of legislation, which proposes to maintain the public property in and control of all natural waters, to secure access thereto of man and animal, to make inalienable the right of way for all proper distributing channels and works, to divide the public domain under a strict homestead law, and to execute a survey sufficient to segregate the irrigable areas from those which are non-irrigable, while indicating the proper reservoir sites for impounding the drainage and storm-waters, defining also the lines for distributory channels and estimating the cost thereof. This being done—a work too that belongs to the General Government, and involves no vast outlay—it is right and proper that the initiative in the construction of works, and the cost thereof, shall be undertaken by the local communities themselves.

Merely as individual or combined farmers the settlers would not have credit sufficient to do this. As a body corporate under the laws of a State or Territory, with power to do such things as the California plan has devised, even a small body of settlers on an isolated portion of the arid region, will be able to place their bonds upon the market and secure the needed capital. And yet, the lender of the money could never become the master of that community, because the waters thereof will remain public property, and the works by which they can be distributed will be under public control. The security and certainty that this will bring, will insure the solvency of the community and its industrial progress, thus making payment of interest and principal an easy task. Municipal bonds are everywhere considered the best offered in the money market.

ARIZONA AS AN IRRIGABLE REGION.

Crossing the Colorado Desert during the night your committee reached Yuma on the Colorado River. At this place, but a few miles above the head of the Gulf of California and shortly after sunrise on a September morning, its session was held in the open air while around it were grouped specimens of fine tropical fruits. Yuma has an elevation above sea-level of a little over 200 feet, and possesses almost the highest temperature in the United States. Its site is that of the delta of the Gila and the Colorado River mingled with low rolling sand-dunes and other detritus left by the receding waters of the river and the gulf. With its warm, rich soil of sandy loam, its clear and invigorating atmosphere, and the unvarying warmth of temperature that prevails, it is probable that nowhere else within our present public domain can such favorable conditions be found for the cultivation of semi-tropical fruits, sugar-cane, cotton, hemp, and other fibrous plants, as in the valley areas adjoining this extreme outpost of our civilization.

Nor are these the limits of its products. Wheat yields largely. It was testified, too, that in one instance 483 pounds were seeded to 20 acres, was irrigated five times, and that it returned 52,750 pounds, which brought in the San Francisco market 50 cents per cental more than any other kind. Two crops can be raised annually. Barley produces from 35 to 40 bushels per acre, and a second crop of hay. Corn yields several crops yearly. Alfalfa will average 6 cuttings, at 15 tons to the acre. Potatoes have returned a yield of 400 per cent. from the seed. A commissioner of emigration for Arizona has reported that—

> The warm sunshine of the spring, summer, and autumn days causes the fruit in Yuma to mature early, and gives a delicious sweetness, flavor, and color to the orange, lime, lemon, and other citrus fruits, which they can not attain on the coast of the Pacific, where fogs dampen the fruit, mildew is produced, and dust coats both fruit and leaf. It is undeniable that nowhere upon the globe can a spot be found more favorable for the growth of citrus fruits than Yuma County.
>
> The annexed table shows the time of maturity for certain products.

Strawberries	January 15.
Apricots	April 1 to 21.
Mulberries	April 14 to 20.
Figs	April 20 to May 1.
Grapes	June 1 to 7.
Water-melons, etc	May 15 to 20.
Peaches	June 15.
Pomegranates	August 1.
Lemons	September 15 to 25.
Limes	September 15 to 25.
Dates	September 1 to 5.
Oranges	November 25 to December 1.

Cotton has been tried for years with varied but satisfactory results, though only on a small scale. The report of the Yuma County committee declares that—

> If watered regularly it becomes a large bush, and if properly pruned a tree, being in flower, boll, and cotton the year round. These bushes and trees have in instances borne steadily for fourteen years.

According to the same authority, the wild hemp is indigenous to the whole region—

> It seeds itself annually, and immediately following the overflows of the Colorado River takes possession of every nook, corner, and open area, to the exclusion of everything else. It covers not less than 100 square miles in an unbroken stretch, commencing near the boundary line of the Gadsen purchase and extending southwards along the river to Hardy's Colorado, below the point where the rising tides of the Gulf of California force back the flow of the Colorado River proper.

Within our borders there can not be found a soil so uniformly fertile and so capable of varied production under irrigation as that of the valleys of the Gila, Salt, and Santa Cruz Rivers, in southern and central Arizona. The bottom lands are so easy of cultivation that it is not uncommon, after removing the brush and stubble, to pass once over the ground with an ordinary cultivator and then sow with grain or grass. Within three or four months thereafter large crops are harvested. Analysis of this soil shows its fertile qualities to be superior to that of the Nile earth. In these valleys, as elsewhere in Arizona, unmistakable evidence of ancient irrigation, prehistoric in date, has been found, covering large areas. In some instances, of late years, the Mormon and other farmers who have settled in central Arizona have again utilized the ditch lines of the former inhabitants.

It was estimated at Yuma that in the Gila Valley alone and within the borders of that county, under irrigation works in process of construction, 600,000 acres will be reclaimed. At the time of your committee's visit, grains and fruit were ripening in the fields that were seen.

Phœnix, the capital of the Territory, lying in the extremely fertile valley of the Salt River, was next visited. The testimony taken at this session will repay close study by all interested in the resources of our country. Mr. J. W. Murphy said:

> The amount of land now under cultivation is, in round figures, about 100,000 acres; that is, under irrigation. There are in this county, in the Salt River Valley, about a

dozen canals, thirteen perhaps, with the combined capacity of about 2,000 cubic feet of flow per second. When the land is first irrigated, we estimate the duty of water here to be 60 acres per cubic foot, and requiring less water from year to year as it is irrigated until it reaches the minimum, when it will irrigate 150 or 160 acres. The canals now constructed would irrigate, in round figures, 200,000 acres.

He added that with the progress of irrigation, the filling of the land with water by percolation from flooding and ditches would render another 100,000 acres available to the present canal system. The canals in use and those projected and under way in that county will serve at least 200,000 acres without storage. A remarkable exhibit, by means of a chart Mr. Murphy presented to your committee, was made of the quantity of water in Salt River during the preceding twelve months. The first four months of the year the supply was only 400 cubic feet per second; during June and July it had about 100 miners' inches more. From the middle of November to the middle of May, which is the season of growing grain, the water was shown to be abundant.

For one six months it was not enough for the wants of the land, while for the other months the river carried more than 8,000 cubic feet, or nearly four times the amount that the present canal system can utilize. In the month of March alone, the river flows an average of 40,000 cubic feet, or twenty times as much as the canals can carry. These simple figures show the pressing necessity for a proper system of storage and they indicate the immense advantage to result from it. With an equal and accessible water supply all the year around there is no farm or fruit product that will not grow in the larger portion of southern and central Arizona, producing, too, from two to five crops per year. The same conditions are found in Pinal and Pima Counties. On the Pima Indian Reservation, and in the valley of the Santa Cruz and near Tucson, land will be found still under cultivation, that regularly produced crops before Coronado marched from the City of Mexico and the Spanish missionaries followed him in the sixteenth century.

The name of Arizona ordinarily brings to the minds of those who hear it the idea of a rugged, mountainous, mineral region, nearly all of which is arid desert and thoroughly irreclaimable. As a matter of fact, nearly 40 per cent. of its entire area is tillable, if water can be had, and to a degree, as your committee was shown, that is quite surprising. The problem of reclamation by irrigation must necessarily be solved by a system of large and small storage at high altitudes, yet in the southern portion of the Territory there are extensive areas to be reclaimed by the restoration through submerged dams and high line channels of rivers that are now lost in gravel and sand by sinkage. One example of this process is that of the Santa Cruz. It is estimated that 2,000,000 acres of fertile land can be so reclaimed. The sunken waters of the San Somoan plain or valley can also be restored to the surface and utilized for the cultivation of a great area. There are other extensive sections in which similar results may be obtained. Mr. Farish, commissioner of emigration, estimates the area of Arizona reclaimable by the present water supply at between 7,000,000 and 8,000,000 acres.

Lieutenant Glassford, of the Signal Corps, to whom your committee is indebted for a most intelligent report, estimates the valley lands of Arizona at from 6,000,000 to 10,000,000 acres, alluvial in character, and "unequaled in fertility and productiveness." He says:

That no portion of the Union presents such favorable conditions for the artificial catchment of water for agricultural or other purposes as does Arizona. In its great area, nearly double that of the six New England States, are presented physical features peculiarly adapted to the construction and maintenance of an immense system of irrigation based on the storage of water by artificial reservoirs, and the supply of which it will be the endeavor of the writer to show is abundantly provided for by rain-fall.

Were it possible to obtain a bird's-eye view of the Territory, the observer would see spread out before him an area equaling Italy in size, consisting of a series of mountainous plateaus, ranging in height from 7,000 feet in the northern part of the Territory to a few hundred feet in the southwestern portion. Of these plateaus those of the north will be found interspersed with mountain chains and deep cañons. In some places volcanic cones rise over 5,000 feet above the plateaus, while cañon gorges are cut as deep below. To these characteristics the plateaus of the southwestern portion of Arizona present strong contrasts, consisting as they do of level valleys, mesa or table lands, gradually sloping off towards the Gulf of California. Some of these are basins of what have been, at comparatively recent periods, immense inland seas. In places the loss of altitude is so rapid that immense cañons have been cut by erosion through the mountain chains and plateaus, and immense basins have been formed along the water-sheds of all the permanent streams.

These cañons and basins are of great depth and area, and present unrivaled facilities for the construction of a system of artificial reservoirs similar to that established by the British Government in India, where the Himilayas present much the same characteristic features. The streams, which in the north flow through cañons whose precipitous sides tower thousands of feet above the surface of the water, as they reach the southern mesas roll sluggishly along, with barely sufficient fall to prevent their sinking in the sand.

It is in the valley along the latter portions of the rivers of Arizona that are to be found rich alluvial lands uneqaled in fertility and productiveness.

The areas of these lands in Arizonia are variously estimated from 6,000,000 to 10,000,000 acres, or an area surpassing all of Massachusetts, Connecticut, and Rhode Island, or Belgium, and nearly equaling Switzerland. The vastness of these areas can scarcely be realized from the mere mention of the figures, but their extent can be appreciated when it is remembered that the entire area of such land susceptible of reclamation on the Rhone in southern France is less than 400,000 acres; Spain does not equal this, while the famous deltaic provinces of lower Egypt possess but about three times this area, and India, the oldest settled of all lands, has but about five times as much as France under cultivation through irrigation.

Lieutenant Glassford says that the exhaustion of water in the lower levels has already commenced in many places. Storage, therefore, becomes a necessity, he adds, in order—

> First, to widen the area of land possible to be reclaimed; and, second, to secure sufficient water during seasons of drought. Such storage being necessary to the general welfare, the question of the practicability of impounding water naturally arises.
>
> The solution of this question is found primarily in an accurate determination of the depth of the annual rain-fall, with both the maximum and the minimum that may be expected in the district under consideration; also any peculiarities of its distribution. * * * Having reliable data upon the above points, the next subject of investigation is, what amount of water-flow becomes available, due allowance being made for evaporation, the selection of reservoir sites, and proportioning their size to the area of the catchment basin after a study of the drainage area in every particular. These latter questions are for the engineer.

It is quite clear that the Signal Service officers had no thought of the necessity of a topographical survey such as the Director of the Geological Survey declares is required.

By a series of tables and charts Lieutenant Glassford presents the annual precipitation in this Territory. It appears that in the southwestern and western parts of Arizona the rain-fall is extremely small, ranging from 2 to 6 inches annually—a record as brief as is anywhere presented in the world. Rising into the more elevated eastern half, central, and northern portions, the annual average of observations taken by the Signal Service ranges from 10 to 20 inches. Just over the line in Utah it rises to 36 inches, and at the head of the Gila River it is 33 inches. These figures are those of valley and cañon stations only; and for mountain summit and high plateau from three to five times more must be added.

There are two rainy seasons in Arizona—one in winter, one in summer. With the disappearance of the last snows the summer rains commence. The winter precipitation never fails to flood the streams each year, and, continues Lieutenant Glassford, "Contrasting Arizona with the Pacific coast States, if she has not so great an amount of rain-fall it comes differently distributed, and experience may prove the dual rainy seasons of Arizona have not unequal advantages with the single but greater one of those States."

The present progress of reclamation is shown in the following table:

County.	No. of canals.	Length.	Area under ditch.
		Miles.	*Acres.*
Apache	......	24½	12,500
Cochise	......	51	8,300
Graham	......	60	35,000
Maricopa	23	304½	194,400
Pima	36	52	30,000
Pinal	28	50	78,000 *50,000
Yavapai	......	78	40,000
Yuma	10	120½	81,000
Total	......	740½	529,200

* In Pima Reservation.

These figures are entirely taken from county reports. The ditch system constructing in Yuma County will, when completed, have a total length of 241 miles and an acreage of 207,000. The total cost will be $1,318,000, or nearly $5,500 per mile. The canals under way in Maricopa County will, when completed, cover 404,900 acres and have a total length of 425 miles. Apache County reports 150,000 acres reclaimed, Pima County 2,500,000 acres, and Cochise 310,000 acres. Of the area "under ditch," about two-thirds are actually cultivated. One of the mistakes observed by your committee in the way of irrigation enterprise is found in the demand by active citizens, so far as heard before the committee, for the maintenance of large areas of land in few hands. The desert-land act policy was strongly supported by such witnesses, and they protested against its repeal, declaring that it is now impossible to organize irrigation enterprises upon the homestead principle, and the co-operation of the settlers in public lands under it.

Your committee believes such arguments to be fallacious and, as it has already shown, that the district system will, through community co-operation, result in successful reclamation on a large scale of our arid public domain. Owing to the want of railroad facilities and the circumstances attending the committee's inquiry in Arizona, it was found impossible to obtain the evidence of the smaller farmers therein, but all the facts go to show that the irrigation district system as projected in the bill presented for the organization and direction of a national irrigation survey is equally as applicable and beneficial to Arizona as it is to California or elsewhere.

UNDER-GROUND WATERS AND IRRIGATION IN TEXAS.

The session held at El Paso, Tex., was noticeable for its presentation of the international conditions which have arisen through the consumption of the Rio Grande water within the United States for irrigation purposes. The boundary and other questions involved by the shifting channel and conditions of that stream, have been already discussed. The irrigation aspect is, however, part of the international question, inasmuch as the entire consumption of the river by our own people is proving destructive to the very life of the heretofore thriving farming communities, within our neighbor's territory, found along the western bank of the lower Rio Grande Valley. There are 50,000 Mexican people largely dependent upon irrigation, whose equal rights to the water have been solemnly guarantied by treaty. At the time of your committee's session, the Rio Grande was nearly dry for a distance of 500 miles.

This fact was due not only to the drought, but as largely to the use of the stream for agricultural purposes by the farmers of the valley of San Luis, and of the Conejos, within the State of Colorado. At least 150,000 people resident in New Mexico, Texas, and the Mexican State of Chihuahua are in danger of continued impoverishment by the conversion above of the living waters to the uses of the enterprising people of southern Colorado. This must go on practically unchecked, unless the running waters are supplemented by the storage of the storm and flood supplies of the region. The Director of the Geological Survey has at length and with great ability analyzed the situation in the Rio Grande Valley. He has also given his views of the remedial measures that must be adopted.

Your committee calls earnest attention to the evidence taken at El Paso, Sante Fé, and Las Cruces, bearing upon the situation in the Rio Grande Valley, which will be found in the third volume of the printed testimony. Western Texas, in its relation to reclamation, is divided, by the experts who testified, into three divisions. From El Paso to the one hundred and fifth degree of west longitude, and southward to the gulf, it forms a territory entirely arid in character, the rain-fall ranging from but 8 to 11 inches per annum. The one hundred and second meridian marks the eastern limit of that which is termed semi-arid, and from the one hundred and second degree to the ninety-seventh degree the sub-humid area is found. These divisions present very different conditions. The whole region, almost an empire in itself, finds place within its borders for all the problems in irrigation. Within the arid section, mountain and local storage with surface distribution, must afford the chief solution for its aridity. Besides the Rio Grande, the Pecos, Colorado, Brazos, San Saba, Neuces, Devil, and other minor rivers and creeks, will assist in the reclamation of an extensive area.

Except along the Rio Grande above Fort Quitman, and below from Laredo, irrigation has been considered almost impossible. A generation since a much larger area, however, was cultivated in the Rio Grande Valley between El Paso and Presido del Norte. At present some 18,000 acres are under cultivation on the Mexican side. There are ditches for 30,000 acres. About 6,000 acres are cultivated near El Paso and below; altogether from Western Texas, testimony was received showing an irrigated area of at least 150,000 acres, with ditches in process of construction to serve at least 75,000 more acres.

The semi-arid section includes a large portion of that remarkable tract known as the "Staked Plains," as well as the Pan Handle section of Texas. One of the most intelligent witnesses describes this region as follows:

> Beginning at the Brazos River, which is at an altitude of about 900 feet, the country rises in steps toward the west. It is generally in the form of one plateau above another. So you proceed westward from Brazos River 20 or 30 miles, and you come to a bluff 200 or 300 feet in height, and above that is a plateau which extends 20 or 30 miles. The difference in altitude is from 150 to 300 feet in these plateaus. From west of the Colorado River the rain-fall is from 20 to 46 inches, with an average of 26, and in that country it has not been found necessary to irrigate, although it is

found advisable with the garden crops, vegetables, and things of that description. They have been benefited by irrigation. On the Concho near San Angela there are about 5,000 acres under cultivation by irrigation, and all the waters are obtained from the North and Middle Concho Rivers. About 50 miles north of San Angela that river springs out of the ground. Above that there is no river, but simply an old river-bed that extends all of 300 miles across the country into New Mexico. In the north branch of the Concho River, which is known where it crosses the Texas Pacific Railroad as the Mustang, irrigation is considered necessary. * * *

The Great Plain, where traversed by the Texas and Pacific Railway, constitutes a table-land about 65 miles in width, widening out northwardly, and extending into the Pan Handle several hundred miles. Its most southerly point is about 60 miles south of Midland, Tex. Its outline is well defined, its edges consisting of rocky bluffs extending for hundreds of miles, forming many bold promontories and shelters of coves. At some remote period of time its eastern edge was the shore-line of some great sea, which, as it receded eastwardly and southwardly, cut new shore-lines, converting the stretch of country between the plain and the Brazos River into a series of benches or table-lands, lying one above the other like the steps in a stairway, while the last step in the grand stairway, the eastern edge of the plain, has an altitude of 2,700 feet.

Before the creation of the Pecos Valley the plain seems to have been continuous with the eastern slope of the mountain ranges of New Mexico and western Texas. This would appear from the fact that the surface of the plain presents a gradual fall from the north and west toward the southeast, the altitudes from its western to its eastern edge being as follows: Douro Station, 3,100 feet; Odessa, 2,900 feet; Warfield, 2,875 feet; Midland, 2,780 feet; Marienfeld, 2,700 feet; the southern edge about 2,300 feet. Through some convulsion of nature a break in the strata was formed near its eastern edge, forming what is now known as Sulphur Draw, in Howard County, and probably several other fractures will be found north and west several hundred miles distant. This would seem to be indicated by the fact that the strata of the plain are continuous, and that water is usually found in abundance below the limestone, and that this supply does not seem in the least to be disturbed by either heavy local rains or long periods of drought. The water seems to come for a distance of hundreds of miles, and wherever the limestone is penetrated the supply is permanent. The local rain-fall seems to find its way through the various "draws" to the headwaters of the Colorado and Concho Rivers, and is eventually carried to the Gulf of Mexico, or passes through Red River into the Mississippi. The dark-colored "rises" of the Colorado River always indicate local rains in central Texas, and the "red rises" heavy rains on the Staked Plain. These rivers carry off the surface drainage. The underground drainage, namely, the waters under the limestone strata, work their way to the San Marcos, San Antonio, Guadaloupe, Nueces, Sabinal, and many other rivers, which rise and fall at the same time that do the Rio Grande and the Pecos, both of which receive their waters from the mountain snows of New Mexico and western Texas.

The "draws" above mentioned seem to be able-bodied rivers that have retired from business. In times gone by they have carried great volumes of water, and have cut their way through solid limestone ledges, their banks being well defined to this day.

During heavy rains they resume business in a small way, occasionally drowning a flock of sheep that are feeding on their grass-covered beds. Generally the water is lost in a few days, having percolated through the sand to the limestone layer beneath, which is generally impervious. Most of these "draws" are filled with silt and sand blown in from the plain. They drain many hundreds of miles in area, and in many of them water in great quantity is found at a depth of 2 to 20 feet. Several could, without great expense, be again converted into flowing streams, carried to the higher lying lands, and be made to irrigate a considerable area. Mustang Draw, in Martin County, by the use of 5 or 6 miles of flumes, could probably be put to good use in this manner, as water in abundance is found at a depth varying from 2 to 6 feet. All the "draw" water will, of course, be surface water, derived from local rains.

The "underground water" is generally found at varying depth. At Marienfeld, on the eastern edge of the plain, at from 60 to 90 feet; at Germania, 10 miles west, at 45 to 60 feet; at Midland, 20 miles west, at 35 to 50 feet; at Odessa, 40 miles west, at 30 to 50 feet; at Douro, near western edge of the plain, none. In a few localities "joint clay," a water-proof material on which the "underground" water rests, comes close to the surface. No water was found, though this material has often been penetrated to a depth of 500 feet. A few of the surface wells are brackish and several salty, but generally the water is good. Several springs containing soda, sulphur, or gypsum water, as well as a few wet weather salt lakes, are also found on the plain. The only permanent running stream on the Staked Plain is "Running Water," in Dickens County, a bright, sparkling stream that suddenly breaks out of the ground, ripples over a pebbly bottom for a distance of 10 miles and then mysteriously disappears like many other streams west of the Pecos River, notably Leon Wells, Comanche Springs, Escondido, Limpia, and Toyah Creek, or the underground river near Castle Mountain, in Crane County, which is working its way to daylight by washing away the roof covering it, occasionally causing a part of it to fall in. A similar stream exists in the northern part of Crocket County, which was not known to exist a few years ago, though a recent cave-in exposed an abundant water supply 20 feet below the surface.

Nearly all the wells dug or bored in the "underground" water, under the limestone, show a tendency to rise above the point where first water was reached. In some localities a rise of 20 or 30 feet was observed, showing that the supply is under considerable pressure. Borings at Odessa have shown five separate layers or deposits of water to exist between the surface and the "joint clay" 100 feet below. Between the Staked Plain and the Pecos River is an ancient fresh-water lake basin, known as "the White Sand Hills," which is covered with numerous ponds of pure fresh water. The supply is permanent, and said to be inexhaustible. The railway wells at Monahans, in this locality, furnish an immense supply. Altitude, 2,620 feet. The wells west of this and to the Pecos draw their supply from the seepage of the Pecos River. East of the Staked Plain the water supply in wells is variable as to quantity, quality, and depth. In Howard County good water is abundant in the southern part, rather deep in the northern part, and brackish in the town of Big Spring. In Mitchell County, generally good at 30 to 50 feet, sometimes strongly alkaline. Several wells bored are capable of furnishing 9,000 gallons of water per hour continuously. At a depth of 200 to 300 feet super-saturated salt brine, claimed to be chemically pure, is found in inexhaustible quantity, and a fine grade of salt is manufactured. The Colorado River carries water in its bed nearly all year round. Its water here is said to be brackish and salty. A chemical examination will have to determine whether or not the water can be used for purposes of irrigation."

The extent of the underground water supply described by Mr. Roesler may be partly realized by the fact that, sparse as the settlements are, nearly one thousand wells, about one-fifth of which are artesian in character and nearly all of which come close to the surface, have already been bored within the regions described. The surplus of these wells is in many instances distributed by small ditches and flumes. Small storage basins are also maintained by them. The semi-arid section is remarkable also for the great springs which are found in many parts of it. The most notable of all these are those at Lampasas, which discharge daily about 1,400,000,000 gallons of water. There are many others of lesser magnitude, but all are remarkable for the volume of water that flows from them.

The products of western Texas are valuable enough to warrant the cost of a thorough examination of its water supplies. The Staked Plain will furnish abundantly the best fruits and vegetables of the temperate zone, ripening them earlier than elsewhere, and competing easily also with both California and New Mexico as to the quality and quantity of its vines and their products. The underflow problems on the Staked Plains and in the Pan Handle, as well as the spring region of southeast New Mexico, are of the greatest importance and will bear the fullest examination.

WHAT NEW MEXICO PRESENTS.

Two extensive river valleys bisect the larger portion of the Territory of New Mexico. The Rio Grande, as is well-known, passes through it from north to south. Within the New Mexican portion of that valley and its immediate streams there are about 100,000 people dependent upon irrigation and the land cultivated through it for their sustenance. East of the Rio Grande, rising in the northern portion of the Territory, the Rio Pecos carries a considerable body of water southward into Texas to its junction with the Rio Grande in that State. For two-thirds of its course in New Mexico it can be made to serve a large area of arid land. Reclamation has already commenced therein on an extensive scale, and some 30,000 acres are now cultivated and under water. It is claimed that in the catchment basin of the Rio Pecos at least 20,000 square miles can be made available for irrigation purposes. A more moderate estimate, and probably a more correct one, places the reclaimable area in the lower part of the valley at 1,000,000 acres.

The ditch system partly completed and now in process of construction can supply water for 175,000 acres, and with a proper storage system will furnish enough to reclaim 400,000 acres. Your committee mentions this system, because, with the exception of one other in the northern part of the Territory, upon the Maxwell grant, it is the only one of modern character within the limits of New Mexico. Two years since there was not a house on the town site of Roswell; now there are 1,500 or 2,000 inhabitants. There was not a school-house within 50 miles; now there are several filled with children. Land that had really no market value is selling at from $25 to $75 per acre. There is no railroad within 150 miles of this newly-reclaimed region, yet it is testified that, notwithstanding this, all its products find a ready market at large prices.

The Rio Pecos basin and the region still farther east, is notable for its numerous important springs that break from the earth and flow down to the mesa, where their waters are absorbed and sink from sight again. They emerge from the earth with such volume and force as to show their artesian characters, proving without question that they come from the drainage-waters of the high and precipitious mountain ranges from the west. From all the evidence your committee has taken in regard to eastern New Mexico and northern Texas little doubt can remain that the whole region is underlaid with great bodies of water, some of which at least have the character of moving streams.

WATER FOR FOOT-HILLS AND MESAS.

West of the Rio Grande there is a region of numerous valleys heading into the mountains at considerable altitude with large areas of foot-hills, and towards the south an extensive mesa or table-land. No great bodies of arable land will be found there in any one section, with the exception probably of the San Juan Valley to the northwest. Yet there is in the aggregate a great body of irrigable land. The precipitation at high altitudes is quite large, and the storage facilities will be found ample. Small storage in the foot-hills can be availed of. The mesa land, which until recently had been given over to the wild steer and the horned toad, is now found to be of growing value for arable purposes. It has been proven at Deming and elsewhere that water can be obtained by bored wells at a moderate depth in volume sufficient to be pumped by wind mills not only for town use, but for gardens and small farming purposes.

The late Judge Bristol, formerly of the United States Court in New Mexico, testified that—

> So far as my experience in Deming is concerned, it is this: I have bought town lots 25 by 142 feet that, with the exception of my dairy and barn and the rest, are planted in fruit trees. I have a large pump and an 18-foot well in connection with another man. We are supplying water for fourteen or fifteen families, and several gardens are being irrigated from it. My garden is most prosperous, as I give special attention to it. Fruits of all kinds and grapes grow to perfection; the Bartlett pear, and even the peach, the Early and Late Crawford. This year we have as fine a flavored peach as any coming from the Chesapeake Bay.
>
> Before the railroad junction was made at Deming there was no water on this table-land, except occasionally when the water came down by flood. No water was known to exist there; but there is a region of country from 25 to 50 miles wide and 100 miles long north and south that we know of (and how much farther it exists we do not know) where if you dig down anywhere you will strike water at about 50 feet in in-

exhaustible quantities. To illustrate, at my place I have a powerful windmill, an 18-inch wheel (Holladay's). Each revolution of that throws out 100 gallons of water. You can run it up to 160 revolutions per minute. There are only 2¼ feet of water in that well, and that quantity can not be lowered with that pump. It is so all over the plain. * * *

In addition to that, in the water system to the north of Deming—Cook's peak mountain, which you probably know—there is one place where the water comes down every year from the mountains and passes through a range of foot-hills about 3 to 4 miles from the main chain of mountain. A perfect flood or river of water comes down there every year several times during the rainy season, and it has dug out immense excavations in the ground. These are filled with water, extending away out on the plain. It is a beautiful plain of the richest soil, and cattle from all over the country frequently, for several weeks at a time, gather in there. That would be a good place at which to build a reservoir, for it would afford accommodation for several thousand acres.

Judge Bristol declared that the opportunities for reclaiming lands and making homesteads were abundant; especially so on the lower mountains and among the foot-hills. As to the productiveness of the soil, he testified:

I simply say "water is king." Wherever water can be had or can be got on the soil it is wonderful in its productiveness. It is rich in all the elements of fruitfulness, even out on this barren plain that we have been calling a desert. Put water there and everything will grow in luxuriance. On the plains the greatest drawback at present, in my opinion, to successful cultivation is the strong spring winds which obtain in every country where there is no wind-break. As soon as forestry is cultivated here systematically, and trees are planted so as to break the prevailing winds, it will be a wonderful country for productiveness, providing you get water. The altitude of Deming is about 4,000 feet. It is on the first plain out of what we call the Mesa Valley of the Rio Grande. It commences on the bluffs of the Rio Grande and is a lovely plain all the way on into Arizona.

THE PRODUCTIVE CAPACITY OF THE TERRITORY.

Your committee was fortunate in securing at its Santa Fé sessions the evidence of men of the widest and most varied experience and ability. An engineer, Mr. Boyle, whose professional experiences in irrigation works has extended over Spain, portions of Hungary, the Danubian provinces as well as Australia, declared that New Mexico can "easily anticipate an increase of five times her present population within ten years if the storm waters that fall naturally be saved and used for the purpose of turning the water to the best advantage."

Speaking of the storm waters, Mr. Boyle said:

On the brightest days in July, August, or September, a storm will burst in the mountains, and the water will come tearing down the streams and practically run to waste. It often comes when the crops need it, but it goes to waste. If that water can be saved, it can be made advantageous instead of mischievous, and be made to support a large population.

The witness testified to the capacity of the soil, when supplied by water, to raise heavy crops. Wheat returns 30 and 35 bushels; oats, 40 to 45 bushels per acre. In northern New Mexico corn yields 20 to 25 bushels per acre. The onion crop of New Mexico, with proper cultivation, is finer than that of old Spain, and could easily be made to supply the United States. In the southern part of the Rio Grande, as well as in the Mesilla Valley, the climate and soil are admirably adapted to the raising of the finest fruits. In fair seasons, one acre of fruit land at Las Cruces will return an average of 20,000 pounds of grapes. Six to eight crops of alfalfa are cut per year, finding a ready home market at from $12 to $20 per ton. Mr. Boyle declared that the Territory and the climate is peculiarly adapted to the raising of the mulberry and the feeding of the silk-worm. He believes this pursuit will be a remarkable feature of industrial growth in that region.

It is to be noticed that everywhere, under irrigation, the highest quality of production is that which is most readily achieved with care and intelligence. Your committee dwells upon this point because it establishes the fact that the reclamation of our arid lands will not increase agricultural competition unduly; but, on the contrary, will broaden largely our supply of fruits and other products that must command high market values.

No statistics later than those of 1885 were presented to your committee. The superintendent of the Territorial census for that year says:

> The amount of the lands under cultivation in 1880 was 5,053 farms, with an acreage of 237,392 acres which was improved. The valuation was $5,514,399. The farming implements at that time were valued at $255,162. The live stock at that time was worth $5,010,800. The value of all farming productions at that time was $1,897,771. In 1885 there were 10,511 farms, a gain of 5,458, with a value of farming implements amounting to $1,595,370. The value of the farm products was $2,914,984, an increase of $1,016,910. That was on the farm products alone. The total land acreage of the Territory is 78,374,400 and the area for pasturage is 63,374,400 acres. Unoccupied pasturage amounted to 12,874,000. Public lands, subject to irrigation, amounted to 13,965,000 acres.

The opportunity for reclamation, if a storage system becomes available, can be illustrated in the basin of the Rio Grande above Fort Selden and Las Cruces, which is generally known as the Jornado del Muerto. This great drainage basin, larger than some States, contains at least 2,000,000 acres of reclaimable land. There is not in the whole basin, except the Rio Grande, which passes through its western part, a single living stream or spring. Water has been found at some points beneath the surface sufficient for the irrigation of several large and small ranches, but practically the whole basin is to all appearances entirely arid.

For the reclamation, finally, of this great body of fertile land there can be no doubt that sufficient waters can be obtained from the mountain and storm supplies which now run to waste, by impounding the same in storage reservoirs. The topography of this region is admirably adapted for reclamation, the grades and levels are such as to make engineering easy, while the lofty mountain ranges that surround it gather precipitation sufficient, if it can be utilized without interfering with any other basin, for all needed purposes. As elsewhere, each catchment area within the basin of the Rio Grande will be found to be dependent upon its own hydrographic resources, using the flowing stream as part only of a needed supply. The problems of reclamation in New Mexico deserve serious attention.

KANSAS SETTLERS AND THEIR DEMANDS.

Your committee's direct observation of western Kansas was confined almost wholly to the valley of the Arkansas, in passing westward to Colorado over the Atchison and Topeka Railroad. The evidence taken in the State and presented in the third volume of testimony covers, however, the entire area thereof west of the ninety-seventh degree of longitude. This includes about 14,000,000 acres, 12,000,000 of which are doubtless arable and fertile, capable of producing large crops of corn, small grains, vegetables, and grasses wherever water is obtainable, and the season of ripening is not affected by drought or the hot winds that prevail so injuriously over the great plains. The temperature of this region is continental in character, showing an average of fifty-three degrees, but ranging from fifteen degrees to one hundred and ten degrees. Great as is the diversity, the minimum as well as the maximum ranges are not widely extended in time. This is the region marked on our school-day maps as forming a large portion of the great American desert. It is almost treeless, and its coarse grasses have for centuries past been trampled into a water-shedding thatch, by the constant movement of buffalo herds and other wild animals.

Within the boundaries of the State of Kansas the Arkansas is the only mountain-fed water-course. All others are streams of the plains, having their sources within them, and furnishing somewhat scanty supplies for 200 or 300 miles in length, until they are absorbed in either the Kansas or Arkansas Rivers. The altitude of these plains rises from 2,500 feet on the east to about 3,500 on the west at the base of the Rocky Mountains. Generally its grades are remarkably even. The upper Arkansas Valley, for example, will have an almost uniform fall eastward of 7 feet to the mile, while on either side of its divides north and south the gradient will be about 16 feet. These important physical features practically govern the reclamation problems of the section.

THE UNDERFLOW OR SHEET WATER.

An immense flow of water passes from the Rocky Mountains at certain periods of the year down the channel of the Arkansas River. That river, after debouching from the foot-hills below Pueblo, Colorado, spreads itself in a shallow stream over a very wide valley underlaid with coarse sand and gravel at a short distance beneath the arable soil. It is estimated that 75 per cent. of this great volume of water sinks into this substratum. It is locally designated as "underflow" or "sheet water." It was testified to as being at least 30 miles in width. Other estimates place its percolation as extending over a territory north and south of the river of at least 100 miles in breadth. Mr. J. W. Gregory, of Garden City, whose intelligent statements will be found in the third volume of testimony, declares that this sheet or underflow has a perceptible current. The same declaration was made in Texas in regard to the underflow water of the Staked Plains. Mr. Gregory said:

> It would not be reasonable to suppose that it did not at least extend to the northern edge of the river valley and to the south side of the sand hills which skirt the river on the south, which would make an average width of at least 12 miles. What may be the average depth of this vast reservoir of sand and gravel saturated with water is not determinable from the slender data at hand, but it is safe to assume that it is more than 20 feet. That a steady current flows eastward through the porous strata of sand and gravel is a well-established fact and undisputed. It has been observed for years and by hundreds of people. In many wells the current is plainly perceptible, and in all any chance bit of wood or handful of chaff or leaves blown in by the wind floats to the east side of the well.
>
> All these facts are of utmost importance to us, because they prove that underneath our feet a broad and deep stream of water slowly passes down the slope, compared with which in volume the visible stream is as an infant to a giant. Let us gather an idea of the capacity of this subterranean stream to supply us with water.
>
> Carefully-conducted experiments, made in the past few days, show that a single square mile of this sand, 20 feet deep, contains about 209,000,000 cubic feet of water; enough to flood 19,200 acres of land to a depth of 3 inches. While it would be practically impossible to drain any given area of these substrata completely, it is well known that they yield up their waters with great readiness. The Garden City Water-Works well is but 25 feet in diameter, and penetrates the water-bearing stratum but 11 feet, and water can enter the well only at the bottom, the walls being of rock laid in cement, yet it will furnish 800,000 gallons of water per day. If, then, the half of these subterranean waters can be utilized to a depth of 10 feet over an area of 5 miles wide, enough water can be obtained to flood one-half of the land for 40 miles on each side of the river to a depth of 3 inches.

He added also:

> My experience and observation, however, have convinced me that there is an abundant supply of water easily available that will not only irrigate the Arkansas Valley, but also the broad plains north and south of us that have been mentioned in your hearing by gentlemen from Scott, Haskell, and other counties. I refer to the supply of water which we know exists in this bed of sand that underlies not only the Arkansas Valley but reaches out to places on either side of it at a considerable distance therefrom. To undertake to utilize that by digging, as was suggested by one gentleman, to a depth of 50 feet, to bring that water to the surface, would cost so much that it would not be practicable; but by opening fountains along the Arkansas River, where the water is only about 3 feet below the surface, and taking advantage of the general fall of 7½ feet to the mile, water can be carried to the highest land in this part of the country, excepting occasional knolls, and the percentage of that would be very small.

With other witnesses he urged strongly that the General Government should make a thorough examination of the whole matter, or, as he expressed it, * * *

> Should systematize and start it. That it should make the survey, and also establish as many fountains or supply sources as are necessary to make a thorough demonstration of the practicability of the plan. We have these wells. We have within the present limits of Garden City a lake the bottom of which is below the level of the river, from which water runs the whole year round. That is a practical exemplification of this system, showing that it can not help but be a success.

Such a policy he declared (and in this he was supported by nearly all the witnesses examined in southwestern Kansas) would encourage the people, enable them to combine, and give certainty to enterprises requiring private capital. At Dodge City, eastward from Garden City, a large enterprise of the class desired by Mr. Gregory is already under way and promises great success. Since 1884, when irrigation began in southwestern Kansas, at least $1,000,000 has been expended between Dodge City and Spearsville and their immediate neighborhoods in the construction of irrigation ditches for the purpose of taking the water from the river at the surface and distributing the same. The parties interested are now driving westward an underground canal in which to collect the sheet or underflow water and, by taking advantage of the uniform grade, will bring the same out into reservoirs from which it can be distributed through ordinary ditches.

The evidence taken shows clearly that there is no part of the Kansas plains region in which water can not be obtained at a moderate depth below the surface. Artesian wells are found in counties south of the Arkansas River, also north and west of Garden City, and at different points of the valleys of the Arkansas and of the Smoky Hill. In the extreme northwestern section the basin of the Republican fork of the Kansas, though much smaller in area than the Arkansas, is also, it is evident, underlaid with a great body of sheet water.

THE STORAGE OF LOCAL DRAINAGE.

Besides the possibilities involved in this supply, there are considerable opportunities for local storage of storm and surface waters. Some basins are quite extensive in area, but the larger number will be made by locally utilizing the ravines and "draws" that exist all over the region. The annual rain-fall reaches an average of 18 inches; last year the total was but 13. Even this would be sufficient to produce fair crops if it could be distributed at the right time, but, as all through the great plain region from north to south, the rain-fall fails the farmer during the weeks or days in which it is most needed. This is almost invariable, even though the year may have had more than an ordinary share of moisture. It is this fact which renders it necessary, from the experience of the people and the observations of your committee, for Congress to continue the policy already begun in the preliminary investigation ordered into the existence, area, and character of the artesian and other subterranean waters of the great plains.

In the valley of the Arkansas, since 1884, the industrious settlers of southwest Kansas have made a vigorous effort to make their industry permanent by means of surface irrigation. About 150,000 acres have been so cultivated. Last year less than 70,000 acres were served. The soil will produce abundantly. Of the grains, grasses, roots, and fruits of the temperate zone, corn returns 40 bushels, wheat the same, potatoes 150 bushels to the acre; four crops of alfalfa can be cut per year when irrigated, giving from 8 to 10 tons per acre. The buffalo grass is everywhere vanishing and what is known as the blue-joint or wire grass is taking its place naturally. Fine orchards were seen along the Upper Arkansas. West of the ninety-seventh degree a learned Harvard professor declared in a special report, printed as part of the census publication of 1880, that no trees could be grown. In that portion of Kansas alone there are now 36,000 acres planted with thriving and growing forest trees.

SETTLERS AND SETTLEMENT ON THE PLAINS.

The Public Lands Commission of 1879–'80 reported that the arable portion of our public domain was nearly exhausted. This statement has been repeated in learned publications, such as the Encyclopedia Brittanica, and by reputable writers on political economy. Ten million acres were then named as the limit of such arable area, yet it is a fact that since 1879 alone, west of the eastern limit assigned to the arid region, at least 110,000,000 acres have been taken up for farming and homestead purposes, and of this great area fully 50,000,000 acres have been located on the Great Plains.

The story of the pioneer settlement of this territory is full of suffering and pathos as well as of courage and success. One witness stated that he had lived in southwestern Kansas for more than twelve years and that in that time—

> There have been two or three new crops of people that have come in. Many of those who did come went away. For instance, in 1879 quite a good many people came into this Western country for perhaps two or three years before 1879. Then there came a season when they left, and they continued to leave up to the fall of 1880 or the spring of 1881. In 1882 new people commenced coming and continued to come. They rushed here in crowds and continued to do so until 1887. Now they are going back again, leaving the country quite largely. They came here, they saw the rich soils and the splendid climate, and they started in to plow and plant. Then the rains came in the spring and the crops grew magnificently on and up to, perhaps, the 1st of July, and then there was no more rain. The hot winds destroy the crops, as a rule. There are some exceptions, but as a rule they destroy the crops. People always think the next year will be better and so try on and on two or three years and then give it up.

Mr. Gilbert, the civil engineer in charge of the underground canal at Dodge City, testifies that—

> There has been quite a general moving out twice since I have been here, that is, within a period of about nine years. I think about one-third of the population each time. Those that remained branched out into the stock business and different pursuits and managed to hang along until another favorable season came. It is not practicable for a farmer to come here and make a living without irrigation. Every attempt has been a failure, and there have been two occasions in the last nine years that a large portion of the population have left.

Unquestionably, slow modifications are occurring in temperature and precipitation, owing to human settlement and cultivation of land. The Kansas testimony will be found full of interest in this direction. It is not meant that the rainfall has actually increased in quantity since settlement began, but that the changes produced in the earth by cultivation, owing largely to the drawing and shedding into the atmosphere through capillary attraction and evaporation of the waters contained therein, has had the effect of greatly increasing the evenness of local precipitation. With the continued cultivation of trees to serve as windbreaks, at least there will be great and most beneficial modifications in their effects upon the hot winds now so injurious to the settlers on the plains.

It has been estimated that nearly 1,000,000 homesteads of 120 acres each can be carved out of the eight degrees of longitude east and west that are under consideration. If such results could be achieved it would mean a population of at least 20,000,000 persons to be supported therefrom by the varied industries that would arise. It is this slow modification, perceptible to the more intelligent of the settlers, that continues to inspire them with courage. Each migratory wave leaves behind in its ebb some of these hardier spirits, and so the region grows in spite of all suffering and disappointment. Is it too much for these people, carving new commonwealths out of the wilderness, to ask of their Government such an inquiry into the physical facts relating to their water supplies as will enable them to understand the degree of dependence that can be placed upon them?

Your committee thinks their demand a reasonable one and believes that Congress will sustain these views.

There is one suggestion broached by a witness at Garden City, which is worth while to emphasize by quoting. This witness said:

> There is another thing I wish to say: I believe that the homestead law is based on the wrong idea. It should be based upon improvement and cultivation and not based upon residence alone. As the law now stands, a man comes out into this country, settles on the land, and builds a little sod cabin. With $50 or $100 of improvements he can not cultivate much. Therefore very little of the land is cultivated, and very little improvement is made. The country is covered with a little short Buffalo grass; that is a sickly vegetation, at its best, and three or four days of hot sun and dry weather will ripen it. The country is all just the same as though it were bare, and there is no vegetation to keep the air cool. The hot wind that blows over the crop is manufactured right near the crops. As you well know, a field of corn will be burned a rod or two into the crop and the balance will be nice and green. You take trees and plant them out on a piece of land 40 rods wide and they will make a little stunted growth. Break up 40 acres and plant them in the center of that 40-acre piece and they will make a fine growth. Now, if this law required a man to break up 140 acres, even if he did not cultivate it, it would cover the field with vegetation and there would be less hot wind. If you break a piece of prairie land, and can get away from it, you can afterward see it miles off by reason of its greenness, while all the land around it is parched and dry.

This suggestion was made elsewhere and at different occasions during the progress of the inquiry, and your committee considers it of importance and practical value.

RECLAMATION AND IRRIGATION IN THE CENTENNIAL STATE.

Irrigation in Colorado presented to your committee an interesting study. The first colony enterprise was organized and brought to success within its borders. The controlling force of corporation enterprise has there been modified, largely for the public good. No riparian issue has ever been raised to disturb the legal and common-sense aspects of reclamation by irrigation. Colorado, through its courts as well as legislation, was the first State to recognize the miner's law of prior appropriation of water, as applicable with restraining interpretation to beneficial use in agriculture. Embedded deeply in constitution and statute, Colorado has recognized as fundamental the principle which your committee sought to embody in the bill reported—that is, the public nature and property of all natural waters lying within a region so arid that agriculture can not be carried on without the artificial conservation and distribution of the same.

Colorado has applied two qualifying interpretations to the doctrine of prior appropriation. One is, that the beneficial use which is the basis of such appropriation of water must necessarily be limited in its application by the wants of all other subsequent users; that is to say, that an appropriation made in days when necessity was unknown could not be construed to deprive the members of a growing community of their pro rata share after the first or prior appropriator had received his portion. The other is, that water being public property, the carriers of the same by means of ditches or other methods can claim no ownership or possession in the water itself. Their remuneration is derived from the transportation and distribution through the channels they construct to the lands on which it is needed.

Colorado from the first has logically declared that water companies are common carriers, and their legal status to be the same as that of railroads or other transportation corporations. The State, following these lines, early assumed a direct supervision over the whole subject. Its area is divided into six irrigation divisions which are again subdivided into sixty-eight water districts, each one of these representing in the main a distinct drainage or irrigable basin or region deriving its supply from some common source. Associate Justice J. C. Helm, of the State supreme court, testifying before your committee, stated that that court announced the doctrine of prior appropriation before it was incorporated into the statutes, declaring it to be the common law doctrine for their conditions. Such a decision requires two acts to make it valid; that is, the diversion and use of water for a beneficial purpose. Referring to the custom of Colorado courts and "decreeing" a certain amount of water for a certain district, Judge Helm said:

METHODS OF WATER CONTROL.

> Our statutes divide the State into irrigation districts, as you know, and under the statutes the district courts, which are the highest courts of record next to the supreme court, adjudicate what we call the priorities of right. These districts are generally arranged with reference to the natural streams, and if from the principal natural stream in a district one hundred ditches have been taken, the court proceeds in the method pointed out by statute to determine the dates at which each of these appropriations were made when the ditches were constructed; the size of the ditches; their capacity; the degree of fall of the water. Then a decree is entered which declares these dates, declares these facts, and assigns the priorities to these ditches in accordance with the dates of the diversion. Under our views the use must follow the diversion within a reasonable time. These decrees assign to these ditch priorities in accordance as I have stated with the dates of the diversion, and, as I have said, the use, of course, is connected with that diversion. The question of reasonable time goes according, of course, to circumstances. But the proposition is, that if the ditch is dug with due diligence and the water is applied reasonably soon the priority relates back to the date of the commencement of the ditch. Possibly a statute might be framed which would declare how soon use must follow diversion, but so far we have no such general statute, and the court has not laid down the proposition. It would remain a question of fact to be determined at each particular case. This decree also determines the quantity going to each ditch. The decree of a given district must be considered, and the quantity of water assigned to each particular ditch or to all

the ditches taken together in the aggregate would constitute the quantity in use or the quantity assigned. If there is not water enough, those having priority under the decree would get it first. In each district there is an irrigation commissioner whose duty it is to superintend the distribution of water according to the decrees of the court. The governor appoints a commissioner for each water district.

ORGANIZATION AND MANAGEMENT OF WATER COMPANIES.

The questions relating to ditch ownership, organization, management, royalties, and rentals were clearly and judicially stated by Professor Carpenter as follows:

There is a mutual company class and one class of companies that are formed to sell water. The mutual companies generally divide the ditch into shares—each person taking a number of shares depending upon the extent of his property underneath. The amount of water he gets from the ditch depends in that case upon the number of shares he has in the ditch. They divide it according to the number of shares. In the second, or stock companies, they generally sell the water, or water rights. "Water rights," as a term in this State, is generally taken to mean the supply of water necessary for 80 acres of land. In those companies they agree, if they have water, to give a definite amount of water, not exceeding a certain quantity. There are two general types of contract; first, a contract made by the company with a man to sell him a certain amount of water on certain conditions, provided he keeps up his payments. The second is a water deed, which is given to the man in exchange for the first, when he has carried out the provisions of the first contract. These contracts represent the provisions of nearly all companies that I have been able to secure deeds of.

In most cases farmers have a perpetual water right. Under a few canals they rent water. The prices for perpetual water rights vary with the different canals. In the San Luis Valley they pay $400—that is $5 an acre for the perpetual right. In the northern part of the State the Larimer and Weld Company have a different price. In the case of the North Poudre it is $15 an acre. The North Poudre also has a charge of $1,200 for a perpetual right. Another prevailing price is $800, and another one is for $1,000. The Arkansas Valley Company charges that much. That is for a perpetual water right, but all subject to an assessment for maintenance. The farmers are assessed for running expenses. Very frequently there is a provision that an assessment for maintenance shall not exceed a certain amount, say $10 for 80 acres, for ordinary assessments. Then they very frequently have a provision that in case of a very extraordinary difficulty in that ditch, or extraordinary repairs, they may be subject to a certain maximum assessment, $20 or so. The ditch company is the judge; but they very rarely charge an extraordinary assessment, even when they have extraordinary difficulties. But for the larger ditches that does not seem to be enough (with the present amount of irrigated land under them) to maintain the ditch. If all the land were under cultivation that would perhaps be enough. In other ditches the assessment is more, depending somewhat upon the local conditions or the difficulties the company think they may meet. In the case of the union ditches, the associates keep the ditches in repair, and the prices are less, because generally the ditches are smaller and the expense of maintenance is less. A small ditch runs itself almost. In the small ones it is perhaps from 5 to 15 cents per acre per year for maintenance. Each large ditch has a superintendent whose business it is to distribute the water. The stock owners appoint, or in the case of a mutual company, they have a meeting as every company would have, and make their own arrangements. The superintendent is an officer of the company, and he distributes the water according to the farmer's holdings in the ditch. In the smaller ditches where they have plenty of water, each man takes all the water he wants.

A DEMAND FOR STATE OWNERSHIP.

Colorado has not yet grasped the idea embraced by the district system now being organized in California. To meet the evils and inequities which have grown up in the State as elsewhere, under the corporation system, an agitation has sprung into existence on the part of the combined farmers which makes a demand for State possession and ownership of all water ditches and their laterals.

The State being a large owner of land has already found it advisable to construct ditches in certain localities in order to make its lands valuable. One of the leaders of the agitation for State ownership declared that—

> The farmers have come quite generally to the conclusion that there must be a radical change in the control and management of the water. Most of them approve of State ownership. They take the model of the United States Government in controlling the delivery of the mails, which is the best possible service at the least possible expense. The Government in some form, whether the United States Government or the State government, should control the water. Whether any given Territory should be segregated into water districts, or be controlled as a whole, is a matter of detail. The point is that the water, as far as it goes, shall be justly distributed by men who have no financial interests at stake; men who are simply there for the sake of the service they are to perform. That would be the consensus of opinion in this State as to the delivery of the water to the farmers. * * *
>
> It has been heretofore, and is to-day, attempted to hold so-called water rights as independent and separate things from the use of the water on the land. The ditch owners assume to say, "We will sell you a water right and give you a piece of paper"—an alleged deed showing that that is your right. Yet a man may sell out the land to another who is ignorant of the water laws, and the second purchaser is thereby left without water. In fact it has been so arranged that a man has had to pay twice for those so-called water rights, in first buying outright and in after buying over again from the same company. But worse than that, the buying of any water right at all is paying a company that has really done nothing.
>
> The constitution of Colorado declares that the water is dedicated to the use of the people. The doctrine, as I conceive it, should be that when a piece of land is once cultivated with water, the State is interested in seeing that it should never be deprived thereof. Of course, everything should be done to compel the economy of water. While a man's selfishness impels him to get all the water he can, there is but one way to prevent a large waste. If the water were measured accurately to each man as he uses it, and at the end of the season it were ascertained what quantity he had actually used, then he would pay for the actual amount used. In that case the question for him to decide is, "How much does my crop actually need?" He would at once cease to waste the water. In other words, the duty of water would probably be increased to at least twice the amount at present. If the State had the matter under control so that the consumer would pay for what he actually used at the time he paid his taxes, there would soon be universal satisfaction with the system of water distribution.

ISSUES MADE FOR AND AGAINST WATER COMPANIES.

The great complaint in Colorado arises from the payment of royalties to ditch companies, also the alleged sale of water which carrying companies can not deliver. The farmers through their spokesman, asserted that royalty is really an imposition, giving them nothing but an alalleged right to water for a certain area of land. They further assert it to be a bond wrung from their necessities, for which no adequate return is made, because they assume also that the annual rental per acre is a sufficient remuneration for the carrying companies. They mortgage their lands to pay these royalties. In scant years they are deprived of sufficient water. The great desire to obtain royalties, they claim, causes the companies to contract to deliver more water than they can control. Those who have already none must therefore suffer or obtain the same from the ditches unlawfully, and they do obtain it, because the sustenance of themselves and families depend thereon. As a result, the courts are full of litigation, fines and punishments are frequent, and great bitterness is being engendered. Accusations of large profit somewhat wild in amount were made before the committee.

A prominent lawyer of Denver testified at some length as to the difficulties encountered by the ditch companies. Mr. Platt Rogers said that—

> The statutes of Colorado and the decisions of the courts take the position that a ditch owner is nothing more nor less than a common carrier, and that he is simply entitled to make a charge for the carriage of the water. In other words, it is declared by the constitution and enforced by repeated decisions that the water is the

common property of the people of the State, and that therefore it is incapable of private appropriation; that it must be put on the land for the purpose of use, and that the owners of the ditch perform no function except to carry it from the stream to the place where it is used. For that they are entitled to pay, and for nothing else. That being so, the county commissioners are vested with authority to fix the charges in case there is a difference between the user and supplier of water. In other words, the rule already applied to railroads is made to apply to ditches. I think that in actual operation this is an obstruction to the building of ditches for the revenue to be derived from the ditches simply as such. My experience is that the large ditch companies in this State have expected to get their revenue, and, in fact, have got revenue, from the fact that they are the owners of large bodies of land lying under the ditch, and that, save for the ownership in that land, the ditches would have not been constructed. So that if the question were presented now in respect to the use of large sums of money for the building of ditches, the right and power being in the people or in the county commissioners, that right and power would act as an obstruction, because the companies have not the right of making such rates as they think will compensate them for the construction of a ditch.

All the evidence presented in relation to the conditions prevailing in Colorado sustain the position advocated by your committee in regard both to the public nature of water as property, its inalienability from the land, the need of a proper engineering survey and examination of our arid public domain, and the advantage to be derived through district district organization and public ownership of irrigation works.

THE AREAS IRRIGATED.

Colorado is as notable for the physical data it offers in relation to irrigation as it has already been shown to be in the legal aspects thereof. From a report made since your committee's visit, by Prof. L. G. Carpenter, of the State agricultural college, there is shown to be the following:

Approximate areas "under ditch" in Colorado.

	Area.	Total area.	
	Sq. miles.	*Sq. miles.*	*Acres.*
Division I (Platte Division):			
Platte Valley, below the Poudre	283.21		
Platte Valley, above the Poudre, including Bear and Clear Creeks	551.64		
St. Vrain and Boulder Creeks	294.59		
Big and Little Thompson	134.22		
Cache La Poudre	393.54		
Total from South Platte		1,657.20	1,060,608
From North Platte in North Park		101.23	64,787
Division II (Arkansas Division):			
East of Huerfano River	489.68		
Cucharas	94.40		
La Vèta and Apache	84.17		
Upper Arkansas and Fontaine	106.91		
		774.56	495,718
Division III (Rio Grande Division)		1,564.00	1,000,960
Division IV (San Juan Division), including Dolores, Mancos, Pine, Florida, La Plate Rivers		135.00	86,400
Division V (Grand River Division)		210.00	134,400
Division VI (Bear and White River Division)		110.00	70,400
Total		4,552.00	2,913,273

By this table the total amount of land under ditch in Colorado at present is not far from 4,500 square miles, or 3,000,000 acres. The amount of land actually irrigated can not be so reliably estimated at present. It is much less than that under ditch.

Professor Carpenter estimates the total irrigated as not over one-third. This is apparently below the actual results. State Engineer Maxwell presented at the Denver session the following figures as a careful statement of the area east of the Rocky Mountains:

Divisions.	No. of districts.	Miles of ditches.	Acres.	
			Under ditch.	Actually irrigated.
No. 1 Platte	14	2,067.36	1,126,800	631,036
No. 2 Arkansas	13	943.20	440,240	116,047
No. 3 Rio Grande	8	1,033.68	596,097	250,263
Total	35	4,044.34	2,163,137	997,346

In the three eastern divisions there are also one hundred and sixty-two reservoirs, with a record capacity of 5,319,939,788 cubic feet, capable of furnishing one acre-foot of water to each of 122,199 acres. The total number of ditches, large and small, in the State is estimated at 2,000, and their mileage at 5,000. The duty of water is placed at 1.45 cubic feet per second for 80 acres. In some sections it is over 100 acres, however.

West of the range in the Grand River, Mesa County, Uncompahgre, and other sections, there were 110,000 acres actually irrigated. The estimate of E. S. Nettleton, the leading engineer of the State, reaches for last season, one of water scarcity, to 1,300,000 acres. From the various enterprises now in progress and for which it is claimed water can be obtained, the area under ditch in the present will not be less than 4,000,000 acres.

THE AREA THAT MAY BE RECLAIMED.

It is estimated that there is at least 32,000,000 acres of arable land east of the Rocky Mountains and within the borders of Colorado. Of course, no one indulges in the expectation of fully reclaiming that great area by even the most extensive system of storage; but it is quite probable that with the growing economy in the use of water; with the changes that are sure to come in methods of distribution, supervision, and ownership; with the storage system that is already begun and projected, and largely, too, by the application of mechanical means for the recovery to the surface of the waters beneath, that the reclamation of one-third of the area named may in the near future be reasonably anticipated. In the older irrigated portions of eastern Colorado the duty of water has been so much increased that 1 cubic foot now serves 100 acres, where recently it served but 60. Much evidence was given on this subject.

RECOVERY OF WATER AFTER USE IN IRRIGATION.

The system of district supervision, as well as the intelligent oversight of the State engineer, is yearly increasing the public knowledge of the effect of water on the soil, of its capacity to serve agriculture, of the immense proportion of the great mountain precipitation which passes into and under the earth's surface, and of the action and results of evaporation and seepage from stream and ditch. The close series of observations made in regard to the latter show some striking facts. They have shown already that a large proportion of the water used for irrigation, slowly but surely returns into the channels below from which it was taken above. Streams that constantly ran dry on the plains a few years since are now found to have considerable water in them. Many springs have broken out east of the cultivated area. The gauging of the Cache la Poudre, for example, has been so systematically carried on that the engineers are enabled to state the volume of water returning to the channels below, from the 260,000 acres irrigated, with great precision.

It is claimed that this fact should put an end to the fears entertained in communities east and south of Colorado, through which run water-courses that rise in the Rocky Mountains, of a final diversion from them of their proportion of such flowing streams. But it is evident that the processes of return by percolation are very slow indeed. As a result, even if the assumption is correct of a future fullness of volume, there must be great temporary deprivation in adjoining States and Territories through the present and rapid increase of irrigation in eastern Colorado.

UNDERGROUND SUPPLY—ITS CHARACTER AND POSSIBLE EXTENT.

The soil of the arid region when first irrigated and cultivated is of the thirstiest character and absorbs great bodies of water. As it fills up, however, the observations that have been made and the facts that present themselves seem to justify the theory that plant life while consuming the water distributed over the surface, also draws thereto the drainage waters that pass below. In this wise a compensating balance may be struck, and in the course of time the natural drainage of the irrigated fields fed from both surface and below, will be found to return to the streams an amount equal perhaps to that they have consumed.

One of the most interesting propositions, sustained, too, by reasonable illustrations, is seen in the use already established of pumping machinery for bringing to the surface the water found in the gravel beds below the alluvial. In twenty counties of Colorado, lying east of the base line which runs through Pueblo, which does not embrace the foot-hills, there are 25,000,000 acres of land, four-fifths of which is of an arable character could water be obtained. It is asserted by those interested in the use of mechanical power that at least one-fifth of the total area is underlaid by an ample water supply, to be found within a few feet of the surface.

The valleys of eastern Colorado have all been formed by denudation; upon the bed-rock have been deposited by the streams gravel and sand, which is now filled with water. This stratum ranges from a few inches to 64 feet in depth. At the base of the foot-hills it consists chiefly of large bowlders, decreasing eastward from large stones to coarse gravel and sand. At the foot-hills the water-bearing strata is narrow, but it widens out for many miles as the valleys are reached and the grade of the streams becomes less. The enormous snow-fall of the mountains melting as the season advances must under even ordinary conditions pass into the earth at least one-third of its entire volume. Under varying conditions a large amount is lost below. It is the recovery of the water that promises the greatest and most beneficial results throughout the whole plains region eastward to the line of industrial humidity. The problems involved in these suggestions have been almost wholly overlooked or ignored by the hydrographic engineer and the geologist. Practical men, whose experiences and suggestions are so often made the jest of the savant, have not, however, overlooked them.

CAPACITY OF THE GRAVEL STRATA FOR WATER STORAGE.

Your committee dwells on the facts presented in the Colorado testimony (vol. 3) bearing upon the questions here stated. That evidence demands careful study, because in these facts, your committee believes, the way opens to a reasonable solution of many reclamation questions in the area lying between the ninety-seventh and one hundred and fifth degrees of west longitude. Mr. West, one of the most intelligent witnesses heard at the Greeley session, stated that—

> The amount of water that may be stored in a cubic foot of sand or gravel, when fully saturated, has been ascertained by careful experiment to be as follows: Fine sand, 2 gallons; coarse sand, 2¼ gallons; sand and fine gravel, 3 gallons; coarse gravel and small stones the size of hen's eggs, 3.6 gallons. As a cubic foot contains 7.5 American gallons, it will be seen that very large gravel beds contain fully one-half water. Water is found in all the dry creeks and the valleys adjacent thereto in northern Colorado, east of the mountains, at varying depths from 2 to 20 feet. Actual tests have been made verifying this matter. * * * As investigation goes on, the area of land known to have underground reservoirs of water at a nominal depth from the surface is largely increased.

In addition to the 5,000,000 acres already assumed to be reclaimable by mechanical means in pumping water from below, it is estimated by the same authority, that in seven of the southern counties 300,000 acres more can be added.

> There is much waste land in these counties. The depth to water averages from 6 to 25 feet and the supply seems enormous, entire rivers and creeks flowing into the sand and being lost for surface irrigation. Fuel is plentiful and cheap in these counties, coal costing from $1 to $6 per ton, according to locality. In New Mexico it is estimated that 1,500,000 acres can be reclaimed by mechanical power. There is much waste land in that Territory. The depth to water is usually from 10 to 50 feet and the supply of water near the surface seems very large. Fuel is plentiful and usually cheap. Coal costs from $1 to $6 per ton. Mesquite is used for fuel in some localities.

The same conditions and means are found and can probably be applied to large areas in other States and Territories. Another witness testified to his observation of conditions that re-enforce the suggestion already made. He said:

> Another feature of the country adjacent to us is, that east of us is a system of sink-holes. You understand, I suppose, what is meant by that. Those have for their substratum, you might say, beds of sand. I am satisfied, from my experience, that those sand-beds can be made places for the storage of water. Our experience shows that wherever irrigation is employed springs break out where under ordinary circumstances they never flowed, and they frequently flow along into the winter, sometimes throughout the winter; and if these sand-beds were infiltrated with water I am satisfied that it would constitute a constant source of supply to the stream below, because water in those sand-beds finds its way to the stream. They generally overlie a stratum of alluminous shale which is impervious to the water, and it will flow out to the stream and constitutes a continuous flow.

Professor Carpenter, speaking of the same problems, also strengthens the theory of mountain drainage supply. Referring to the Republican basin in northeast Colorado, and its water, he said:

> Its supply must come from the mountains, I think, indirectly. It can not come from the seepage of irrigation in that immediate vicinity. The water from the mountains must outcrop at various places, as we know it does at the head of the Republican River, and so on through Kansas. The Republican River rises in the eastern part of the State entirely away from the mountains or any perpetual water-shed or water supply in the sense of rains or snow, yet I believe it is a perpetual stream and they are irrigating from it.

STORM WATER SURPLUS AND EXTENT.

State Engineer Maxwell presented charts and statements to your committee in relation to the surplus waters that are now entirely lost. The facts that he and other witnesses gave bear strongly and show clearly the necessity of storage facilities. They illustrated the peculiar hydrographic phenomena of our mountain sections. For example, Engineer Maxwell showed that on August 1, 1888, Clear Creek, Arapahoe County, discharged 8,700 cubic feet within two hours. The ditch takes but 1,131 feet. There was consequently lost 6,500 cubic feet per second of time, or in all 47,296,800 cubic feet. That is sufficient water to cover 1,086 acres 12 inches deep. Coal Creek, in the same year, discharged on one occasion in three hours over 963 cubic feet per second. On another occasion the same creek discharged in a short time 6,076 cubic feet per second. The amount of water lost in the first instance was 10,453,720 cubic feet, or sufficient to cover 240 acres with one solid foot of water. In the other the loss was 43,747,200 cubic feet, or sufficient to irrigate 1,004 acres with acre-foot of water. These isolated instances, as to the extent of the storm and surplus waters, show what may reasonably be expected in that direction when fuller survey and investigation is had, and the energy of the people with the aid of capital shall be united in the construction of storage reservoirs.

THE PRODUCTIVE VALUE OF THE STATE.

Colorado is especially adapted to the production of the grains, grasses, and roots of the temperate zone. The eastern foot-hills are found valuable for the fruits thereof, while in the valleys of the western slopes the finer fruits, such as grapes, apricots, etc., can be profitably raised. In the San Juan, to the southwest, the semi-tropical fruits and crops will be cultivated successfully on the mesa and valley lands.

Of the area of Colorado, 98.2 per cent. is not in farms. Of tillable land the area is 23.8 per cent.; grass land, 29; woodland, 3.8; and the unproductive is rated at 43.4 per cent. Colorado stands as to productivity as follows:

	Bushels per acre.	Average.
Corn	27.7	24.2
Wheat	19.6	12.3
Oats	31.7	27.0

From 1884 to 1889, the public domain lying within the borders of Colorado has been occupied to the total of 9,155,561 acres. This is within less than 1,000,000 acres of the total amount of arable land which, in 1880, the Public Lands Commission declared was the whole arable area left for settlement. Again, it is evident that the specialists do not know all the facts or are able to accurately forecast the future.

AS TO THE ECONOMIC VALUE OF SMALL HOMESTEADS.

The farmer witnesses before your committee were nearly all disposed to advocate large farms. On the other hand, business men interested in the welfare of the State, loaners of money on farm mortgages, ditch owners, and others advocated the division of the land into small holdings. One witness declared emphatically that he believed—

> The homestead law ought to be amended so that one person could not acquire more than 40 acres of land under its provisions in the arid region. My reasons for this position are, first, the average farmer could make more money farming 40 acres of land

by irrigation than he can a larger amount. The homesteader is a poor man, generally. He must borrow the money, at a very high rate of interest, with which to improve his land and live upon it, to provide himself with the necessary farming implements. He must go in debt for water, and wait for the harvest season for any returns from his toil and expenses. If he has 160 acres, his great desire to improve it all causes him to buy too much water, too much farming machinery—in short, it causes him to shoulder too much debt. His taxes and expenses are greater, and he is not capacitated to farm so much land, and farm it well, and the result is his harvest is no greater than it would have been had he carefully cultivated a smaller tract. * * * The law ought to be changed so as to make the cultivation of the land for a given time requisite to obtain title, rather than occupancy. Land that is cultivated in the arid region must have water. If the farm is once put into a state of cultivation, and has a water-right attachment, there is no danger but that it will be occupied, and forever after be a home for somebody. But under the law as it now is, a homesteader may put upon the land a trifling building, ever so small and worthless, sleep there occasionally, but in reality live elsewhere, and in a short time have title from the Government, called a homestead, which, in reality, remains wild land. The spirit of the homestead law is violated, there is no home upon the land; it is used entirely for speculative purposes. I am not stating an exceptional case. In many localities it has been and is now the rule to obtain what is miscalled a homestead in this way.

The evidence of Thomas F. Dunbar, whose business is that of loaning money and estimating land values for mortgage purposes, is so clear and forcible on this that he is quoted at some length here:

As a rule, I do very little in non-irrigated lands because we think them of very little value. Very few crops can be grown with any certainty on what we call dry lands. I confine my loans almost exclusively to lands under ditches and with ditch rights attached. * * * In the best counties, Larimer and Weld, land that is well improved and well down in grasses, under a ditch that is reliable and with perpetual water-right attached to the land, go as high as from $50 to $75 an acre, the very choicest; the second class from $25 to $50; that is, for loaning purposes. They could be sold and they do sell for that. Taking the new places, like the San Luis Valley, with perpetual water-right attached to the land, the advances on loans on mortgage average from $3 to $5 per acre. The highest advances made in the State will probably range at $25 per acre. The medium advances, about $10. The lands that can not be irrigated in the San Luis Valley are only good for grazing, and are not worth over $1.25 an acre. Lands under one of those ditches without a perpetual water-right to enable the acquiring owner to get water would be worth from $5 to $6 an acre.

Under cultivation, continued Mr. Dunbar, its value depends thereon. He said:

The trouble is with a man living on 160 acres of land, carrying a mortgage on the whole and only cultivating 25 or 50 acres. The holdings are too large. We want smaller holdings of land and better use of what we have. There should be close tillage, so as to make every gallon of water tell on every square yard of ground. They can not do it now. A man could well support and bring up his family on 40 acres if thoroughly well tilled, where he could do the work himself. He attempts to grab 320. The consequence is he has only got 10 per cent. of his land producing anything, or, if he does attempt to cultivate it, he has to do so by expensive and inefficient labor. He goes to an expense for machinery and gets no result. Instead of plowing 10 inches deep he plows 3 inches deep, and goes over a large area. Forty acres is enough for a man to live on with his family. Of course, he can not do that by raising wheat and oats. He should have fruit, vegetables, hops, and so on. There is a large demand for hops. I know a man making $300 or $400 an acre on hops, and a man can easily make $100 an acre on alfalfa. To get the best results a man must have a small area and cultivate closely and have a supply of farm-yard manure. Our soil here is very heavily charged with mineral matter and is very deficient in manure material. He must grow a variety of crops. We do not want men to raise a large surplus, but we want large communities and to have the land more closely cultivated, so as to bring our population nearer together, and have them produce everything that men can and need to live upon. That is what brings wealth into any State. All our immigration comes from non-irrigated districts. Everything here is new to such immigrants. The conviction is forced on my mind that a man is better off with 40 acres thoroughly cultivated than 160 acres half cultivated.

My observation is that a man is better off with 40 acres in the arid belt with every foot of it well cultivated, and his crop thoroughly attended to, than he is to have 160 acres skimped over. The man with 40 acres in the arid belt well cultivated will make more clear money in the end. I will lend him 25 per cent. more money on 40 acres of well cultivated land than on 160 acres half cultivated. The men that have a section of land have to have machinery and all that. Then a man's water-right will go farther on a small farm. His supply of water would have to be all put on at the same time.

Leaving Colorado your committee held sessions at Cheyenne, Wyo., and Ogallala, Nebr., closing at the latter places the extended and exhaustive field of inquiry that it has conducted.

WYOMING AND ITS HYDROLOGY.

The area of Wyoming embraces four distinct drainage systems or basins. The Rocky Mountains proper, passing from Colorado northward through the middle of the region, forms on its eastern slopes the important drainage division of the North Platte and its tributaries. North of this section and east of the Big Horn Mountains lies a region abundantly watered by streams that form part of the Yellowstone system. They only need diversion to supply the agricultural wants ot that rich and fertile section. Westward of the same range the important valleys and bench lands of the Big Horn and Wind Rivers form a third division. Fed by the precipitation falling on the western slope of the continental divide, is a considerable part of the Snake, Green, and Bear River basins belonging, by their configuration, to the great interior region of our western mountain system. This makes a fourth hydrological division.

There are over four hundred mountain streams within the borders of Wyoming, and the mountain area from which they flow contains at least 35,000 square miles, 22,400,000 acres. The Territorial engineer, Elwood Mead, claims as a moderate computation, that the annual precipitation on these storm-condensers and moisture-storers will average not less than 3 solid feet of water. This estimate contains 60,000,000 acre-feet; an amount sufficient, at the rate per annum of 1 acre-foot for 80 acres, to irrigate 10,000,000 acres of land. Major Powell has made an estimate as high as 12,000,000 acres. The precipitation is there, the mountains offer unequaled opportunities for storage, the numerous water-courses can be rendered available with added artificial facilities for full distribution, and the land will present, with its broad levels and fertile qualities, an easy work for the engineer and ample return to the farmer.

The agricultural possibilities of Wyoming are almost as great as its pastoral facilities, and they have been considered unequaled by the ranchman and cattle-raiser. It is worthy of note as an illustration of the development of the new West, that even in the territory that has been almost wholly given over to stock-raising on a large scale, the necessity for systematizing that business has compelled a resort to irrigation on a large scale, in the cultivation of grasses as well as grain, in order to secure permanent feed.

IRRIGATION RESULTS.

The ditch statistics of Wyoming are remarkable for the growth they exhibit in that direction. The great extent of mileage and the very large area "under water," does not, however, testify to a large degree of arable cultivation. The water is used most largely to secure and increase the pasture needs for the great herds maintained thereon.

From Engineer Mead's report, made to your committee, the following table is given:

Irrigation development by districts.

District.	Total No. of recorded ditches.	Total length as stated.	No. of claims, with statement of length omitted.	Total capacity as given.	No. of ditch claims, omitting statement of capacity.	Total acreage watered as given.	No. of ditch claims, omitting statement of acreage.
1*	643	1,322.385	39	5,911.584	48	482,434.00	89
2	327	582 793	31	6,649.844	53	279,164.64	62
3	262	817.419	91	3,644.078	72	395,563.00	114
4†	....	....	....	....	....	....	....
5	502	996.398	32	10,422.700	57	440,540.00	50
6	124	196.955	46	1,556.825	36	58,162.00	55
7	322	518.240	50	1,658.905	96	108,976.78	95
8	182	212.410	52	3,095.487	79	85,395.00	96
9	49	91.430	1	342.000	25	42,460.00	3
‡	7	11.905	....	136.560	....	4,180.00	....
Total..	2,436	4,249.935	242	20,381.723	466	1,946,875.42	564

* Seven reservoirs additional.
† District No. 4 omitted because of incomplete record.
‡ Unorganized district.

Of this area of nearly 2,000,000 acres not more than 80,000 acres are under cultivation other than for stock purposes.

WATER LEGISLATION IN WYOMING.

In legislation for the regulation of the water supply Wyoming has very largely followed the example set by Colorado. It has had the advantage thereby of being enabled to provide against some of the demonstrated failures of the older community. But it has nevertheless copied its fundamental error, in permitting the control and rental of water as a matter apart from the land which it is designed to serve. Engineer Mead shows the nature of the records required in the following statement:

> Under the Territorial laws the owners of the ditches are required to file, in the offices of the county clerks of the various counties, a statement showing their capacity, location, acreage watered, and such additional facts as are required to make a complete record. As there is no penalty attached to a failure to comply with this requirement many ditches are not recorded, probably five hundred in the whole Territory, and, owing to defective blanks used at first, many that are recorded have made incomplete statements, so that it is impossible to state accurately the area reclaimed. The present extent of irrigation development is an extraordinary record when it is remembered that it is principally the work of the past ten years. In extent the irrigated area exceeds the average of the land farmed in each of the New England States and should forever put at rest the cavil or question as to the ultimate wealth and greatness of this Commonwealth. If the pioneers in this work can, unaided and under great disadvantages, produce such results, what may not be accomplished through the intervention of ample capital or of State or national aid?

The constitution of the proposed new State enforces and broadens even the doctrine that water is public property subject to supervision for beneficial uses only.

REQUEST MADE FOR A LAND GRANT

The session held at Cheyenne, in Wyoming, was notable also for the vigorous presentation through Engineer Mead of a carefully prepared argument and demand on the General Government for the transfer in pport of irrigation development of the public domain remaining ithin the borders of Wyoming. The same policy was suggested in Nevada; but in Wyoming evidently it had been carefully considered by leading citizens, who put Engineer Mead forward as their representative. In stating this position Mr. Mead said:

> I want to say first what has been the development of this Territory before I give the plan. We have found it impossible and unsatisfactory to combine under the present system of land owning. The result has been that people have combined and built a ditch to water merely their own claims. We have in this Territory to-day probably three thousand ditches built, though there are on record only two thousand five hundred and fifty. The great majority of those are individual ditches. Each settler who went on a stream built an individual ditch to water his own claim. Another settler came and did likewise. I can show you on the office maps twenty-six ditches on one stream in one township. The Territory is charged with a division of water between those several claimants. Take a stream 80 miles long and undertake to divide the water between eighty claimants, and you will understand the difficulty. That plan is immensely wasteful of water and of everything. It is very difficult to maintain those ditches. The average expense of watering land by that system is over $10 an acre. If we could have highland channels that would water those areas, it should not cost half that much to get the water on the land, and more water would get on it. My idea is to turn this land over to the Territory or to the local government, under such regulations as will secure its final disposal to actual settlers, and the Territory could put the companies under such restrictions as would secure ditches, and could also manage the work of their being settled by actual settlers. We would then have a system that could be intelligently planned.
>
> * * * * * * * *
>
> This would be my plan: To turn these lands over to the States. The proper procedure would then be, either for the State or the National Government to locate these canals on the streams, say where they ought to be. Then it can make a close estimate as to the cost of construction, and what it would cost to operate the same. I would then allow private capital to build that ditch, and would permit the companies to charge (to have an agreement in the first place that they might charge) a fair rental for the water, and I would provide for that to be continued subsequently, if necessary. Then in regard to the land, I would do this: I would permit the ditch companies, perhaps, to have the management of the settlement. I would make them colonization agents, but I would have the State itself pass the title to the settler. I would not make any title absolute until I knew that it was a bona fide settlement; but I would put the settlement of it in the hands of the ditch companies. They will have the greatest interest in securing settlement. What the ditch company needs is an assurance that the land will be settled when the water is there. They want to be in a position, as soon as the ditch is built, to run it the next year to its full capacity. If they can do that they can furnish water at a much less rental.

In answer to a question relating to the regulation of the price of water Mr. Mead further said:

> Land upon which there is no ditch in this Territory will have a price varying from 15 cents to $1.50 per acre—I mean grazing lands. If you construct a ditch over such land, say a large ditch, so as to make it certain that there will be a considerable settlement there, that land is ultimately reclaimed, and the result will be that the land will enhance in value from the construction of that ditch from $5 to $15 per acre. Suppose a ditch company goes in at the present time to build that ditch and make it possible for the pre-emptor or homesteader or any one with a timber claim to go and file on the land, settle down, and get a title to the land without in any way contributing to that enterprise of the ditch company, it makes it possible for him to reap that unearned increment.

INTERSTATE WATER USES.

Wyoming, like Colorado, contains the sources of important interstate water courses. Governor Warren was emphatic in expressing the opinion that the use of water in Wyoming, however fully it might be consumed for irrigation purposes, would not eventually injure any adjacent State or Territory. He said:

> No matter how we would use the water in Wyoming, I can not conceive of any system that would not benefit the surrounding States and Territories. It is possible that some evidence may have been adduced, or may be offered, showing that the

Platte River has less water east of here on account of irrigation. In answer to that, I should say that if it is so, it is because the water is largely taken out in the first year's irrigation of large tracts of land. If you take out a stream and distribute the water over a great area, it will show less water the first season for a few miles below, but it never fails, later, to irrigate sufficiently with less water. There is one stream I know of that has been controlled by one company for eight or ten years. Originally that was a stream coming from springs that would run down about 50 rods, probably, and sink again. At many points that stream would be totally dry for three months in the year. They have taken out the water, and at the present time the water is not used at all upon what was formerly irrigated land, but is spread on the hill-side. What was formerly irrigated is now ditched, and the water is taken from there. That is a surplus of water which is carried down the hill, so that the purpose is to drain out the water down below. I say this very frankly that, if I were a citizen of Nebraska or any other State, and had interest in the waters that flowed from Wyoming, I would be glad to see irrigation practiced just as extensively as the water would warrant. In other words, I would like to have the waters kept back and stored in the land rather than have them come down in the flood time. There might be slight suffering, except on some large stream where very large operations could be conducted, but as a general thing the operations on any one stream would not be felt. When the soil was once filled it would operate to make the land need less irrigation.

FERTILITY OF SOIL AND PRODUCTS.

Ex-Governor John W. Hoyt, in reply to questions asked of the crops produced by irrigation in eastern Wyoming, especially on Laramie Plains, said:

I simply know that the experiment has been made of producing the different cereals, wheat, rye, oats, and barley. The work was begun five years ago and proved successful; in some places even without irrigation. The experiment was not a large one, covering only perhaps 10 or 20 acres, but it was very satisfactory. Potatoes are grown in the garden plats of the city of Laramie. The product is very fine and the yield very large. A good deal of snow falls upon the mountains there. The streams have their sources in the Medicine Bow range, and the streams very often are flooded and overflow at the banks, so that a very large amount of water could be saved at that season of the year that now goes to waste. If that could be stored (and there are natural basins in which it could be stored) the waters of the Big Laramie would be able, from a reservoir supply, to irrigate a large body of land. There are about 200,000 acres of beautiful land lying between the Big and Little Laramie Rivers, very rich, productive soil, which would produce very handsome crops of nearly every sort except Indian corn, if watered. There is already a ditch there taking some of the water of the Laramie, but there is a large quantity of water still in reserve, and there are natural basins in which the surplus could be stored when not needed.

I have no question as to the possibility of producing fine crops there. The specimens of wheat that I saw must have yielded 40 bushels to the acre, and they have claimed 50 bushels. Oats are produced in very large yields. Wheat is not grown to any considerable extent there; none of those crops, I ought to say, are grown to any considerable extent as yet. The water supply has not been sufficient and the persons who own the lands and would be encouraged under favorable conditions to commence the cultivation of crops have been delaying on account of the condition of the water supply.

I may not be able to furnish exact data, but I hear of 300 and 400 bushels of potatoes to the acre. The vegetable crop, I ought to say, is very remarkable. The root crops are very fine. There is a beginning also in the cultivation of small fruits and even with apples, so that many of our people are beginning to think of planting fruits. I am speaking of the Laramie Plains especially.

The chief agricultural area of Wyoming at present is found in the northeastern portion of the Territory, in the counties of Johnson and Sheridan. One of the witnesses said:

In the two counties there are 6,200,000 acres. By preserving the water I have no doubt that it could be increased at least five times what it is at present. There are about 450,000 acres at present under irrigating ditches. There is water enough in an ordinary season. There has not been this season, on account of the light fall of snow last winter. The present supply, if properly distributed, would irrigate at least 640,000 acres. I think that by the construction of storage reservoirs in the Big Horn and preserving the waters, 2,000,000 or 2,500,000 acres can be irrigated, counting both sides of the range in Johnson and Sheridan Counties. On the east side of the range the soil is a black sandy loam, very rich. On the western side of the range it is principally a red gypsum soil, very deceptive to look at, but very rich in the production of crops, being mixed with the loam. There are 45,000 acres now under ditch, and between 300,000 and 350,000 acres are already practically irrigated. The other portion, 100,000, is not yet fully reclaimed. It is mostly the second or third bench or mesa land. In 1887 there were 1,729 acres cropped to wheat; 7,816 cropped to oats. The amount cropped to barley was quite small, perhaps not over 150 or 200 acres. The oat and wheat portion has been increased very nearly if not quite 100 per cent. since that time. The barley area has probably been increased to 1,000 acres. About one-half the balance of the land was, in 1887, cropped to hay. That has been increased about only 75 per cent., owing to the lack of facilities for getting the products out of the country on account of the long distances from the railroads.

THE SUBTERRANEAN SUPPLY

A remarkable artesian basin, chiefly so because of the high altitude of its location, is found within the plateau known as Laramie Plains. This location is much higher than the artesian belt at Denver and vicinity. It has development sufficient only to indicate its possibilities. The water of the wells is chiefly used for domestic and stock purposes, but use has also been made of it in irrigation. The Territorial engineer regards this and other evidences of artesian waters as of considerable importance to future development.

THE WATERS OF WESTERN NEBRASKA.

The last session was held at Ogallala, in western Nebraska. The people of that region have been like those of the Dakotas and Kansas, denying the necessity of irrigation. The increasing drought of the last three years, as well as the varying nature of the local precipitation, has awakened them to the need and advantages to be found in the artificial application of the water to the land. Prof. L. E. Hicks, who occupies the chair of geology in the State university, was the principal witness at the Ogallala session. He declared that State lines ought not to control water-supply storage or distribution, that each hydrographic basin embracing a river or other large stream, and its confluents should, so far as water is concerned, within the arid region, be under distinct regulations and not affected entirely by the needs of the particular community within whose territory the principal water course may take its rise. He illustrated his argument by references to the North Platte, a stream which is not yet used up in Wyoming where it finds its source, as its confluent, the South Platte, has been in Colorado. A very large area of land could be reclaimed by it in both sections, but to do so would require engineering operations on a large scale. This would need to be carried on by a great corporation, or by State or National authority.

Between the North Platte and the Niobrara River in northern Nebraska, there is a great table-land at a moderate elevation. The distance between the two streams is about 100 miles. The soil on this plateau is very fertile, the subsoil is considered unequaled for the retention of water. The opportunities for storage, according to Professor Hicks, are very good. The eastern limit of the arid region in Nebraska will form an irregular curve, the center of which would be at Fort McPherson or 100° 30′. The northern point would touch 91° and the southern rest at 110°. The valley of the Niobrara contains a large body of land lying very favorable for ditching and in every way available for irrigation.

The stream carries a large volume, and at such rapidity that the old French voyageur called it "the water that runs." In the same section will be found the White and Loop Rivers, with considerable tributaries, all available for irrigation purposes.

In southwestern Nebraska the Republican River, one of the most notable streams rising in the great plains, forms with its northwest Kansas area, a considerable hydrographic basin. It has apparently no mountain drainage supply, unless from beneath the soil. The local rain-fall, to all appearances, furnishes its flow, which is quite considerable. All through the Republican Basin a large supply of water can be obtained at short depths below the surface. The rain-fall, in the region reviewed by Professor Hicks, is sufficient, with a small artificial supply for the farmer's use. In eastern Colorado 12 inches of water, artificially applied, is required. In western Nebraska the amount needed will range from 2 to 8 inches, according to proximity to the eastern line of aridity. The professor was emphatic in support of a thorough irrigation survey. He put the amount of land in the western half of Nebraska at 40,000 square miles, of which total 22,400,000 acres could be reclaimed by the use of water storage and distribution. Quite a remarkable artesian water belt was also reported.

A CHANGE DEMANDED IN FARM POLICY.

A number of farmers testified before your committee at its last session. They all declared in favor of irrigation, and gave evidence as to the insecurity for farming purposes of the average rain-fall. The Nebraska testimony, like that in Kansas and Dakota, strongly emphasizes the need on the part of the settlers upon the great plains of the cultivation of more limited areas than is the case at present. The pioneer enters homestead and timber-culture quarter sections, and probably adds a pre-emption claim. He has but a small amount of capital; the season is good, and the rain-fall abundant. With these advantages the large area entered tempts him to extend farming operations. Paradoxical as it seems, a successful harvest almost invariably causes the pioneer to run into debt for stock, seed, and machinery. Then comes drought and failures, and the farmer soon becomes a bankrupt.

It is evident that if he were to content himself with more careful cultivation of a smaller area at the beginning of his settlement that he could secure a supply of water by local storage, wells, or ponds, sufficient to make certain in any year the crops necessary for the support of himself, family, and stock. The grasses on the high plains would enable him to feed cattle, and his 20 or 30 acres, intensively cultivated, would give a good supply of winter feed. By a reasonable diversity of crops the farmer on the great plains would, even under present conditions, soon find himself in possession of a home without debt and a certain means of sustenance. Local storage and a well supply, either or both, can be secured in almost every portion of the plains region. It is by such means that the transition period, from the present insecurity to a permanent system of water storage and distribution, will be most surely sustained.

IN CONCLUSION

Your committee submits the following tabulated estimate of the areas under cultivation by irrigation, and the total "under ditch." This table is presented as approximate, but it is believed to be within the facts:

Total area under ditch and irrigated.

States and Territories.	Under ditch.	Cultivated by irrigation.
	Acres.	*Acres.*
Arizona	455,000	225,000
California	4,000,000	3,300,000
Colorado	3,000,000	1,600,000
Idaho	715,000	500,000
Kansas	300,000	75,000
Montana	986,000	350,000
Nebraska	50,000	5,000
Nevada	142,000	70,000
New Mexico	800,000	625,000
Oregon	191,000	150,000
South Dakota	100,000	15,000
Texas	200,000	125,000
Utah	700,000	413,000
Washington	75,000	50,000
Wyoming	1,947,000	75,000
Total	13,661,000	7,578,000

In the western part of the State of South Dakota, in the region near the Black Hills, there are quite large areas under irrigation from ditches and canals taking water out of the streams in that country, which lands amount to many thousand acres. The system of irrigation there is being yearly enlarged. A canal now in process of construction, your committee is informed, will carry water for distribution for such purpose over some 40 miles in length. Many of the farmers who located in the western portion of South Dakota in an early day were from those parts of the country where irrigation was successfully practiced, and therefore knew the benefits of such practice, and upon settling on the lands at once made preparation for irrigation, took out the water from the streams, and proceeded to use it as needed. These early examples were observed by those settlers coming later, and thus large tracts of the very rich lands of that region are free from any danger of failure of crops by reason of drought.

The projects under way during the past year and partially completed will bring the acreage "under ditch" to at least 15,000,000 acres. Had last year not been one of severe drought, and the closing one of several during which the water supply was insufficient, there would have been an irrigated area under cultivation of at least 9,000,000 acres. British India supports over 150,000,000 persons on less than 26,000,000 acres of irrigated land. Not one irrigated acre in the arid region was before irrigation worth over $5; 97 per cent. of it would not have brought the pre-emption price of public land, $1.25 per acre. Its average value per acre is not less than $30, or a total of $302,520,000 for the area cultivated by irrigation in 1889.

Putting the entire area "under ditch" at $25 per acre and we have a total value of $389,125,000. Allowing for the final reclaimability of 100,000,000 acres out of the 1,200,000,000 acres embraced within the area of whole or partial aridity, and allowing $20 per acre for its value when brought under ditch, we shall have as the result a real estate valuation of $2,500,000,000. It will, indeed, be much more. Seven-tenths of the whole area is still the property of the United States. This public domain is a trust for the whole people; those of the future as well as those of to-day. The people are moving westward; nothing stays that movement.

By far the larger part of our current land entries are now made well within the line of partial and complete aridity. Is it not due then to the people, our fellow-citizens, that we shall do all that can be done properly to lessen the hardship of their pioneer life and to enable them to make the most prosperous use of the opportunities that are before them? Should we not do the best possible to make available the unoccupied areas we still possess? Has any portion of our public domain, from the beginning of the history thereof, given any larger returns in manhood or in wealth wrung by severe toil from nature's most forbidding conditions, than that which has been wrought out and obtained in the regions west of the ninety-seventh degree of longitude? Your committee asserts that there is only one possible answer to these questions.

The passage then of the measures proposed by your committee will be wise in policy, just in action, and statesmanlike in results. In any event your committee insist that the legislation that may be adopted shall not present any dubious phraseology, so that under innocent words the arid West shall be deprived of two-thirds of the benefits that might be derived from a proper irrigation survey.

Congress certainly never intended to increase the appropriation for topographical surveying within the humid areas, nor facilitate the indirect growth of "research for science," by allowing the use of irrigation-survey appropriations in the making of topographical maps for the use of the Geological Survey. Both of these things have resulted from the past management of the Irrigation Survey, and, whatever other action may be taken, your committee believes that the facts it has presented will be a final bar to such singular interpretation of law and executive duty.

INDEX OF THE MAJORITY REPORT.

- Acts of Congress:
  - March 3, 1873, 8.
  - October 2, 1888, 9, 12, 13, 14.
  - March 2, 1889, 9, 11.
- Agriculture, Department of, 8, 14, 15, 17.
- Alexander, General Barton S., 8.
- Appropriations for irrigation surveys, 9, 12, 14, 90.
  - topographic surveys, 9, 11, 14, 90.
- Area irrigated and under ditch, United States, table of, 89.
- Acres reclaimable, extent of, 7.
- Arid area, United States, of, 1.
  - region west of Rockies, 2.
    - rivers of, 2.
    - mountains of, 2.
- Arizona:
  - ancient irrigation, remains of, 60, 61.
  - area irrigated, table of, 63.
  - climatic conditions of, 59, 60, 61.
  - desert land act defended, 63.
  - Farish, Mr., commissioner of emigration for, 61.
  - irrigation district for, 63.
  - rain-fall in, 62, 63.
  - rivers in, 6.
  - sessions in, 23, 59.
  - tropical products of, 60.
  - Yuma, session at, 59.
- Arkansas River, flowing through Great Plains, 1.
- Artesian wells and water belts, 6, 7.
  - investigation, 16.
  - experimental works, appropriation for, 16.
  - in James River Valley, 2.
  - east of the Rocky Mountains, 2.
- Basin region, investigation in, 20, 21, 23, 24.
- Black Hills, South Dakota, area irrigated, 89.
- Boisé City, irrigation near, 3.
- Brereton, R. M., civil engineer, 8.
- British India, its similar characteristics, 1, 8.
  - irrigation works of, 7.
- Bronson, Edgar, 25.
- Bureau of irrigation proposed, 14, 15.
- Burley, Hon. W. A., 19.
- California:
  - acreage under ditch, 56.
  - climate of, 54, 55.
  - conflicting water systems, 57, 58.
  - district irrigation system, 57, 58, 59.
  - fruit trees and cultivation, 54, 56, 57.
  - physical features of, 53.
  - productiveness of, 57.
  - rivers in, 5.
  - rain-fall in, 53, 54.
  - sessions in, 22, 23.
  - State Board of Trade, 21.
  - Taxable values produced by irrigation, 57, 58.
- Carr, William B., 23.
- Chinook winds and their effects, 3.
- Chipman, Hon. M. P., 22.
- Climatology, observations needed, 15.
- Colorado:
  - Area irrigated, table of, 77.
  - Area irreclaimable, 78.
  - Carpenter, Prof. L. G., 75, 77, 80.
  - Maxwell, Mr., State engineer, 80.
- Colorado—Continued.
  - Productive value of, 81.
  - Recovery of water after use, 78.
  - Rivers of, 4.
  - Sessions in, 28.
  - Small homesteads, economic value of, 81, 82, 83.
  - State ownership demanded, 75, 76.
  - Storm water, extent of, 80, 81.
  - Underground supplies in, 79.
  - Upper Arkansas River, 27, 28, 69, 75.
  - Water companies, their methods, 75, 76, 77.
  - Water laws of, 4, 28, [illegible], 76.
  - Water storage in gravel strata, 80.
  - West, George M., 80.
- Columbia River, its irrigable areas, 2, 3.
- Cultivation necessary for homestead settlement, 73.
- Dakota, North and South, reference to.
  - agricultural college, South Dakota, 32.
  - area of, 30.
  - artesian basin, waters and wells in, 30, 31, 32.
  - character of settlers, 29.
  - demand for survey and experiment, 32.
  - James River Valley, artesian wells in, 31.
  - rain-fall in, 29, 30, 88.
  - sessions held in, 18, 22.
  - value of farm lands in, 32.
  - wheat crop, loss of, 30.
- Davidson, Prof. George, 8.
- De Lacy, W., civil engineer, 18.
- Diversion of public funds denounced, 12, 90.
- Dodge, J. R., statistician Agricultural Department, 32, 41.
- Dutton, Capt. Clarence E., chief engineer, 12.
- El Paso, Tex., international session, 24, 25, 63.
- Estee, Hon. M. M., 22.
- Farmers Alliance, 17, 18.
- Foot, A. D., engineer, United States Irrigation Survey, 20.
- Forty-third Congress, Executive Document H. R. 290, 8.
- Furness, Ex-Governor, Nebraska, 8.
- Garfias, Señor, Mexican engineer, 25.
- Glassford, Lieutenant, Signal Service U. S. A., 24, 61, 62, 63.
- Geological Survey and Irrigation Work, 8, 10, 11, 12.
- Government irrigation works, unnecessary, 7, 8.
- Grasses, effects of rain on, 7.
- Grazing lands, extent of, 7.
- Great Plains region, relations to irrigation, 1.
  - subterranean waters of, 16, 17, 27, 29, 30, 31, 32, 63, 64, 65, 66, 69, 70, 71, 72, 79, 80, 81, 87, 88.
- Great Salt Lake Basin, its streams, 4.
- Green, Benjamin, 19.
- Green, W. S., 22.
- Hall, William H., supervising engineer, United States Irrigation Survey, 22.
- Hilgard, Prof. G. W., 8, 22.
- Hinton, R. J., "Irrigation in United States," 8.
- Holt, L. M., 22.
- Idaho:
  - agricultural products of, 41.
  - area irrigated, table of, 39.
  - cost of works, 40.
  - Mormons in, 40.

Idaho—Continued.
progress of, 39.
river flow in, 40.
snow-fall in, 40.
Interior Department, reference to, 17.
Investigation by Senate committee, character of, 17.
Irrigation Commission, San Joaquin Valley, 8.
Survey, the, a plain policy needed from Congress, 90.
Kansas, Southwest:
Artesian wells in, 71.
Climatic modifications, 73.
Gregory, J. W., Garden City, 70, 71.
Homesteads on Great Plains, 73.
Irrigation ditches, and cultivation, 72.
Local drainage, storage of, 71, 72.
Sessions in, 27.
Settlers on the Great Plains, their struggles, 72, 73.
Sheet-water, described, 70, 71.
Underflow works proposed, 27, 69, 70, 71, 72, 73.
Knowles, Judge Hiram, 19.
Laramie Plains, when irrigated, 3.
Legislation proposed, 15, 16, 17.
Maginnis, Hon. Martin, 19.
Manuel, George, civil engineer, 22.
Maps necessary, reference to, 9, 10, 11, 12.
required in surveys, 9, 10, 11.
Marsh, Hon. George P., report, 8.
Mead, Elwood, Territorial Engineer of Wyoming, 84, 85.
Mendall, Col. George H., 8.
Mill, Maj. Anson, U. S. A., 25.
Mineral Resources, 2, 3, 4, 5, 6, 7.
Mining enterprise, relation to irrigation, 8.
Mississippi River, controllability of floods, 1.
Missouri River, the, crossing Great Plains, 1.
Montana:
agricultural capacity of, 2.
area of irrigation, table of, 34, 35.
artesian wells of, 36.
forest protection, need of, 35, 36.
fruit region in, 36.
productiveness of, 34, 35.
public property in natural waters, 35.
testimony in, 18, 19, 32, 33, 34.
water-storage problems, 32, 33.
Yellowstone Basin in, 33.
Mormons and irrigation, 4.
first irrigation farmers, 20.
Murphy, J. W., civil engineer, 60, 61.
Nebraska, references to—
arid region, limit of, 87.
Hicks, Prof. L. E., geologist, 29, 87.
land area reclaimable, 88.
Niobrara, valley of, 87, 88.
North Platte in, 87.
rain-fall needed for agriculture in, 88.
Republican River Basin in, 88.
Nevada:
appeal to Congress, 51, 52.
aridity in, 47.
artesian wells and water in, 49.
conditions of reclamation, 21, 46, 47, 48, 49, 50.
cultivated land, area of, 47.
drainage, area of, 48, 50.
home markets by irrigation, 50, 51.
hydrography of, 46, 47, 48, 49, 50.
metallic and saline deposits in, 46, 51.
reclamation board in, 21, 51.
rivers in, 4, 5.
Sierra Lakes, relation to, 49.
snow-fall on mountains, 48, 49.
water-storage sites, 49, 50.
New Mexico:
area irrigated and in farms, 69.
foot-hills and mesas, waters in, 67, 68.
mountain storage needed, 69.
population of, 66.
productiveness of, 68.
Rio Pecos Valley, irrigation in, 67.
rivers in, 6.
river valleys in, 66.
wells at Deming, 67, 68.
New States, constitutional provisions of, 36.
Oregon, Eastern:
area irrigated, 39.
Oregon—Continued.
land occupation, 38.
new population, 38
rivers and valleys in, 38.
east of the Cascades, relation to irrigation, 3.
Short Line Railroad, 20.
Patrons of Husbandry, 17.
Perrin, Dr., 22.
Platte River and branches, 1.
Poston, Charles D., report on arid region, 8.
Powell, John W., Director Geological Survey, 8, 11, 12, 20, 22, 25, 29.
Prince, Hon. Bradford L., governor New Mexico, 26.
Public domain a public trust, 89, 90.
lands withheld from settlement, 12, 13.
settlers thereon, what they have done, 90.
Rain-fall, irregularity of, on Great Plains, 1, 2.
Reclaimable area by irrigation in United States, its possible extent, 89.
Restraining dams, at head of rivers, 1.
Roesler, F. E., 25, 26, 64, 65, 66.
Sanders, Hon. Wilbur F., 19.
Shoup, G. L., governor of Idaho, 19.
Smalley, E. V., 18.
Small farms demanded on Great Plains, 88.
Small farms, result of reclamation, 7.
Small storage needed, 88.
for farmers' use, 2.
Snake River, the, 3.
South Dakota Constitutional Convention, 18.
State Agricultural College, South Dakota, 18, 32.
State Department, reference to, 17.
States and Territories, general description of:
Arizona, 6.
California, 553, 57.
Colorado, 4.
Dakota, North and South, 29, 30, 32.
Idaho, 3, 39, 41.
Kansas, Southwest, 27, 69.
Montana, 2, 33.
Nebraska, Western, 87.
Nevada, 4, 5, 46, 47.
New Mexico, 6.
Oregon, 3, 19, 38.
Texas, Western, 24, 25, 26.
Utah, 4, 42.
Washington, 3, 7.
Wyoming, 7, 83.
Stephenson, Hon. E. A., 20.
Straughan, J. C., surveyor-general Idaho, 9.
Surveys General Land Office, system of, 10, 11, 12.
Survey systems, discussions of, 9, 10, 11, 12.
Swallow, G. C., mining inspector, 19.
Texas:
Differences in reclamation, 64.
Estimated areas irrigated, 64, 65.
Pan Handle section, irrigation in, 64, 65.
Products, value of, 66.
Rio Grande in, 63.
Springs in, their great size, 66.
Staked Plains, underground water on, 64, 65, 66.
Western and Staked Plains, 25, 26, 63, 64, 65, 66.
Thomas, Hon. A. L., governor of Utah, 20.
Topographic surveys, required for arid region, 9, 10, 11, 12, 90.
Utah:
area irrigated, table of, 43.
area reclaimable, 41, 42.
artesian water and wells, 46.
distribution of water, 45.
farms in, small size of, 42, 43.
productiveness of, 45, 46.
public lands in, 46.
snow-fall in, 46.
water laws of, 43, 44, 45.
Underflow waters in river beds, 16.
Value of arid land without water, 89.
Value of irrigated land, 89.
War Department, reference to, 17.
Washington, Eastern:
area irrigated, 39.
Great Plains of Columbia, 37.
irrigation in, 37, 38.
population, increase of, 38.
productiveness under water, 37, 38.
Washington, East of the Cascades, relations to irrigation, 3.

Wasatch Mountains in Utah, 4.
Weather Service Bureau, transfer of, 15.
Westward movement of settlement, 89.
Wheeler, William F., civil engineer, 19.
Wilson, H. M., engineer U. S. Irrigation Survey, 19.
Witnesses, their representative character, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29.
Wright, Hon. C. C., 22.
Wyoming:
  artesian basin in, 87.
  Cheyenne session, 28, 84.
Wyoming—Continued.
  governor of, 85, 86.
  Hoyt, Hon. John W., ex-governor, 86.
  hydrology of, 83.
  interstate waters, use of, 85, 86.
  irrigation development, table of, 84.
  land grant asked for, 85.
  soil and products, 86.
  Territorial engineer, evidence of, 28, 84, 85.
  water laws in, 84.
Yellowstone River, sources of, 3.

VIEWS OF THE MINORITY.

The undersigned members of the Select Committee on Irrigation and Reclamation of Arid Lands, having considered the matters referred to it by the Senate, and having made as exhaustive an examination of the general questions relating to irrigation in the arid lands as time would permit, have reached conclusions which they desire to submit to the Senate. While the report of the majority of the committee contains much valuable information, we find ourselves unable to agree with many of its statements and with some of its reasoning, and we think many important facts are overlooked. We also disagree with its chief conclusions, and recommend Congressional action which is opposed to that recommended by the majority.

The following report is arranged in sections, each one of which treats of a distinct topic. In them the principal facts relating to the subject under investigation by the committee are arranged in order, so as to lead naturally to the conclusions that are ultimately reached. Then follow, numbered in sections, the recommendations which it is desired to make. And, finally, still in numbered sections, the bills and the report submitted by the other members of the committee are examined in detail and the reasons set forth for dissenting from the recommendations and views therein expressed. An abstract of all the sections is here given, numbered to correspond with the sections themselves.

ABSTRACT OF THIS REPORT.

I. The arid lands embrace an area of 1,340,000 square miles or 853,600,000 acres. Of this amount 100,000,000 acres can be redeemed for agriculture through the agency of irrigation by using the total supply of the perennial streams.

II. The water supply of the arid lands is to be derived from the streams, which are the chief source; from the storage of storm waters, twhich is the second source in importance; from pump-wells, which are he third source in importance; and from artesian wells, which have some value for horticultural and stock-raising purposes.

III. The subhumid region lies between the arid region of the west and the humid region of the east, and embraces an area of about three degrees in width, equal to 250,000 square miles. Disaster has generally come to farmers who have attempted to settle in this region and carry on agriculture without irrigation.

IV. When the system of applying the water is good and the cultivation is thorough, waters used in irrigation are consumed.

V. It would be greatly to the advantage of the farmers on the irrigable lands if a proper system of measuring the waters with which they are supplied were adopted, and great waste would be avoided.

VI. Experience proves that the arid and subhumid lands are very fertile when irrigated.

VII. The forest lands are of limited extent and are being rapidly burned and need protection. These forests are distant from the irrigable lands, where the agricultural population must be established in homes, but the farmers are dependent upon them for their supply of wood and lumber. They are also dependent upon them for their full supply of water for irrigation. Therefore, in the interest of the farmers, the forests should be protected.

VIII. There are great areas of pasturage lands which furnish a scant but valuable supply of food for flocks and herds, and the farmers engaged in irrigation can utilize this pasturage to the best advantage. But it also is being destroyed and needs protection, and the farmers with permanent homes are the people primarily interested in its protection.

IX. The lands that can be irrigated are narrowly limited in area, so that only a small portion can be redeemed when all the waters are used. The best lands lie at the foot of the mountains and near to them, and should be chosen for this purpose. The mountain lands are not good agricultural lands, and the lands far down the streams can be used only by a great waste of waters. The irrigable lands should be carefully selected.

X. The irrigable lands should be segregated and declared such, and the right to use water on them should be established and a prohibition should be put to the use of water on all other lands.

XI. Irrigated lands are of great value, varying from $25 to $200 per acre.

XII. The size of the homestead should be reduced to 80 acres, and perhaps 40 would be better, that the public domain may be distributed among the greatest number of people.

XIII. Water rights are often established that impede the development of agriculture and are greatly obstructive.

XIV. International conflicts in relation to water rights are impending.

XV. Conflicting rights to the use of waters in different States are being established and bitter conflicts have already begun. These rights are of great magnitude, involving hundreds of millions of dollars. The general problem, therefore, is a national problem.

XVI. Many conflicts are arising between communities in relation to the use of water on the land, and between individuals in the same community. The waters should be divided by some just method.

XVII. Speculative water rights, where work of value has not actually been done and lands irrigated, should be summarily extinguished.

XVIII. Existing water rights should be maintained, but those that are improvident and obstructive must ultimately be condemned and the owners justly remunerated.

XIX. Waters that are to be stored have to be divided among the communities.

XX. In many regions the people are developing agriculture where it can not be permanently maintained, and the foundations for large claims against the General Government are being laid.

XXI. Both the waters and the lands of the arid region are rapidly being aggregated in the hands of a few persons or in the possession of great corporations. Thus a result is being secured unfavorable to the welfare of the great body of people who perform the labor on the farms—the actual farmers themselves.

XXII. The Government need not construct irrigating works. The increase given to the value of the land is more than sufficient to cover the expense of such construction.

XXIII. It is possible to divide the arid region dependent upon perennial stream waters into irrigation districts, so that each one may have a catchment area and a corresponding irrigable area where the waters of the district can be used to the best advantage and where water rights can be permanently maintained. Such districts have been provisionally planned and mapped by the Director of the Geological Survey.

XXIV. Irrigation districts should be composed of compact bodies of irrigable lands, with the pasturage and timber lands of the catchment area about them, and the farmers on the irrigable lands should control the catchment areas with all their values.

XXV. Interstate complications make it necessary for the General Government to provide a solution of the problems; and the United States and the several States are interested in the waters and lands; hence, the United States and the several States must alike make concessions and reach an agreement.

XXVI. The population in each of the irrigation districts planned seems usually to be sufficient to take charge of the interests involved in such districts in relation to the use of waters, forests, and pasturage. The district with the smallest population is that of Bill Williams' Fork in Arizona. The district with the largest population is that of the Upper South Platte, which includes the city of Denver, and probably has a population of more than 142,000 people.

XXVII. The solution of the foregoing problems is very simple. It consists in organizing natural irrigation districts through the agency of a survey by the General Government and necessary legislation by the States, and in turning over the practical work of irrigation to such districts.

XXVIII. The present Irrigation Survey is performing its duties in compliance with law and in an efficient and thorough manner, and the work under it should proceed at a reasonable rate of progress until it is finished. It is estimated that the irrigation survey will cost $7,000,000, but that in making the maps it will save $4,000,000 to the Geological Survey. Thus the real cost of the irrigation survey is but $3,000,000 over and above the cost of the Geological Survey. The work performed in two years demonstrates that this estimate is reasonable and justifies the further estimate that with the annual appropriation of $1,000,000 the irrigation survey of the entire country could be completed in seven years.

XXIX. The survey needed for the subhumid region of the Great Plains is purely a geological survey based on topography. It should be made as rapidly as possible, in order to serve the wants of the farmers of that region, who are already suffering by reason of their neglect of irrigation. Another reason for its prompt completion is to give to new settlers in these regions necessary information of the conditions under which success and prosperity may be secured.

XXX. To accomplish the solution of the problems by the method proposed, a bill has been draughted, which is appended to this report.

XXXI. An analysis of the bill is made by sections, and the effect of each section pointed out. The sections may here be characterized summarily. Section 1 of the bill provides for a survey of the arid lands into natural irrigation districts. Section 2 provides for the segregation of the irrigable lands. Section 3 provides that lands already irrigated shall be declared irrigable for the purposes contemplated in the bill. Section 4 provides that certain of the irrigation works shall be constructed only on sites designated and reserved therefor, in order to protect water rights and to conserve the waters for beneficial purposes. Section 5 provides for the division of the waters among the districts. Section 6 provides for the organization of districts situated in two or more States or Territories. Section 7 provides that the nonirrigable lands shall remain in the possession of the General Government, as forests and pasturage reservations and catchment areas for the irrigable lands, and also provides for the disposal of the irrigable lands to homestead settlers in tracts not greater than 80 acres. Section 8 attaches the water rights to the homesteads of the irrigable lands. Section 9 makes it unlawful to construct unauthorized irrigation works. Section 10 provides in general terms a plan for the organization of irrigation districts. Section 11 gives to the commissioners of the irrigation districts the authority to provide laws and rules for the use of the waters belonging to the districts and for the protection and use of the forests and the protection and use of the pasturage. Section 12 makes it lawful for the States and Territories to provide general legislation relating to the use of the waters, the forests, and the pasturage, and provides methods by which the capital for the construction of irrigation works may be obtained. Section 13 makes it lawful for the States to provide boards of irrigation commissioners to supervise and approve of the works authorized and the contracts made by district commissioners. Section 14 provides that cities and towns may be excluded from the irrigation districts, and gives the States and Territories authority to designate the waters which such cities and towns may use. Section 15 provides a method for obtaining the consent of the States and Territories to the legislation proposed in the bill, and refuses the rights and benefits otherwise granted to any State or Territory which fails to give its consent.

XXXII. The general effect of the bill is to turn over the control of irrigation to the States and the districts, the general statutes to be made by the States and the specific rules by the districts. Therefore it will accomplish local self-government in relation to irrigation and the forest and pasturage administration. It relieves the General Government of all subsequent legislative and administrative duties, except only to complete the irrigation survey of the whole and the linear survey of the irrigable lands, and also to administer the homestead laws, coal-land laws, mining-land laws, and townsite-land laws through the General Land Office.

XXXIII. The bill reported by the majority of the committee is in the interest of the great cattle companies that pasture their animals on the public domain, and opposed to the interests of the farmers making homesteads on the lands. Its effect is to give the companies access with their animals to "all natural waters, whether the same be running streams, lakes, pools, ponds, springs, or other surface bodies of water, or subterranean streams, pools, or underflows produced by natural seepage or drainage," in disregard of the authority of the States. It is also in the interest of the great irrigation companies rapidly developing in the West, turning over all water rights for irrigation to them and practically excluding the poor settler wishing to obtain a homestead on the land. Therefore it is disapproved.

XXXIV. The creation of a new bureau of irrigation in the Agricultural Department is unnecessary and unwise; therefore it is not recommended.

XXXV. The Director of the Survey has expended a portion of the funds for necessary topographic work as a part of the irrigation survey. This is strictly in compliance with the statute. It is also in compliance with the plan for the survey submitted to Congress by the Director prior to the enactment of the law. It is strictly in compliance with the representations made by the Director to the Committee on Appropriations and published by that committee in its report to the Senate explaining the bill. Three months after the passage of the bill the Director reported to Congress how this work had been organized and was being prosecuted, showing that it was strictly in compliance with the law and that topographic work had been begun. The topographic work is necessary, economical, and legal.

XXXVI. The recommendation to discontinue the topographic work of the irrigation survey is considered unwise. It is believed that through this method catchment areas, sites for diverting works, canal sites, reservoir sites, and irrigable lands can be discovered with the greatest economy and thoroughness. It is also believed to be the proper basis for a hydrographic survey.

XXXVII. The hydrographic branch of the irrigation survey should not be turned over to the Signal Service. The stations of the Signal Service in the arid lands are not at the places where the streams should be gauged. A new corps of men would be necessary, and it is believed that the measuring of the waters to be used for irrigation can be most economically and promptly done by the irrigation survey through the topographic work.

XXXVIII. The two bills are diametrically opposed in theory, purpose, and effect. The bill recommended by the minority is in the interests of the farmers themselves; the one by the majority in the interest of companies. The one proposes to continue the present irrigation survey, while the other proposes to create a new bureau of irrigation and a second geological survey.

XXXIX. Director Powell does not suggest that irrigation works should be constructed by the General Government, but he has consistently for a long term of years urged that the industry of agriculture by irrigation should be under the control of natural irrigation districts.

XL. No delay in the operations of the irrigation survey is caused by the operations of the geological survey, but wherever maps are made in the arid and subhumid regions for the geological survey they serve the purposes of the irrigation survey, and forward its work.

XLI. The legislation already accomplished by the act of October 2, 1888, which reserves the sites for irrigating works in the hands of the General Government and reserves the lands made susceptible of irrigation thereby for homestead settlement is wise and should not be repealed. The desert-land laws, the timber-culture laws, and the pre-emption laws, which are in effect repealed by that act, should not again be made operative, for by their agency large tracts of land have heretofore been aggregated in the hands of wealthy individuals and corporations.

XLII. Experimental boring without a geological survey for the discovery of artesian waters is unwise. The experience of the world demonstrates that the supply of artesian waters is always of insignificant amount and inadequate to the wants of agriculture, though such fountains are valuable for domestic and horticultural purposes. Especially is it unwise to create a new geological survey to discover artesian waters.

THE REPORT.

SECTION I.

THE ARID LANDS.

To the west of the ninety-third meridian, treeless plains stretching from the northern to the southern boundary extend westward to the Rocky Mountains. Across these plains the climate becomes more and more arid until the one hundredth meridian is reached, beyond which the climate is so dry that agriculture is dependent upon an artificial supply of water, the rains being insufficient to fertilize crops. This condition of aridity extends beyond the Rocky Mountains across the Great Basin and below San Francisco to the Pacific, but north of San Francisco there is a humid area which expands until the British line is reached.

This arid region embraces an area of about 1,340,000 square miles. The greater part of the region is composed of plains, table-lands, treeless valleys, and lofty mountains. The rain-fall is chiefly concentrated on the mountains, and thence flow many rivers. The most noteworthy of these are the Missouri, the Yellowstone, the Platte, the Arkansas, the Rio Grande, the Colorado, the San Joaquin, the Sacramento, the Shoshone and the Columbia. The mountains are not valuable for agricultural purposes, as they are rugged and inhospitable because of their great altitude. On them deep snows fall, and the summer seasons are cold and frosty. Though the plains, the table-lands, and the valleys are treeless, and bear scant vegetation, yet they are covered with rich soils. But agriculture dependent upon rain-fall is not possible. The lands can be redeemed for agricultural industries only by being supplied artificially with water; they must be irrigated. This condition is not unknown elsewhere in the world. Agriculture by means of irrigation has been practiced from the dawn of civilization to the present time in many lands. In fact much of the agriculture of the world is carried on under these conditions. The problems involved in irrigation are therefore old, and man has had great experience in bringing arid lands under the dominion of farming industries.

SECTION II.

THE WATER SUPPLY OF THE ARID LANDS.

In considering how these lands are to become available as homesteads for an ever and rapidly increasing population it becomes necessary to consider the supply of water which can be used in irrigation. There are four sources from which this supply may be drawn, namely, stream waters, storm waters, well waters, and artesian waters. The chief supply of water for irrigation must come from the utilization of the perennial streams—the springs, brooks, creeks, and rivers. The source of these streams is in the mountains, where there is a great concentration of rain-fall. It is computed by Director Powell, of the Geological Survey, who has studied this subject with care for many years, that 100,000,000 acres of land can ultimately be irrigated by the use of these stream waters; but this requires that the entire supply shall be utilized. Growing crops need irrigation for but a few months of the year, and if the streams are used only during such months and are permitted to run freely to the sea or to be lost in the desert sands during the remaining portion of the year, much less than one-half of this amount can be cultivated. To obtain the complete service of all of the streams for the fertilization of the lands it becomes necessary to store the surplus waters in reservoirs or artificial lakes. When the surplus waters are stored in this manner, so that the entire volume of all the streams during the year is controlled and spread over the soil, then, and not till then, can the 100,000,000 acres be brought under cultivation.

The storm waters constitute the second source of supply. The mountain storm waters feed the streams, and they can not be used both as storm waters and stream waters; they are therefore included in the stream waters. But on the plains, valleys, and table-lands, where the rain-fall is less and the lands are comparatively flat, the storm waters feed perennial streams only to a very small degree. A part of these waters are caught in the sand of the general surface and evaporated; another part flows down into the sand-blocked valleys, where it slowly evaporates. These waters, that flow only after storms and are called storm waters, can be caught and held in reservoirs or tanks and spread upon the lands for irrigation. Many great districts in the arid lands of the world are irrigated in this manner.

Still other rain waters penetrate the rocks and sands below, from which they can be recovered by sinking wells and bringing them over the lands through the agency of pumps. The lands irrigated in this manner throughout the world are, in the aggregate, of considerable importance, but the several tracts thus irrigated are small. In one district in Asia there are 400,000 such wells, and from them 1,125,000 acres of land are irrigated.

There is still a fourth source of water to be mentioned. In some districts of the world the geologic structure is such that the rock strata form underground basins. On the margin of these basins the edges of the rock that are turned up catch the rain waters, and they slowly percolate down through the rocks. Into these basins wells may be bored, and fountains will spring up and overflow. Such artesian waters are sometimes used for irrigation in supplying gardens, orchards, and vineyards, but nowhere in the world is agriculture in the proper sense carried on by means of artesian fountains. The areas where such waters can be found are limited in extent, and the amount of water which an average well will afford is small, and the number of wells which any district will permanently maintain is comparatively small.

Such are the sources of water supply for the arid lands. How much of the great area which has been described can be brought under cultivation by the use of storm waters, pump waters, and artesian waters is not known. No trustworthy data have been collected concerning these upon which estimates can be based. Still it is believed by Director Powell, who has studied the subject, that considerable areas will ultimately be redeemed in this manner, chiefly by the use of storm waters, in addition to the hundred million acres reclaimable by stream waters.

Director Powell has placed before the committee a map of the arid region, on which are delineated the lands which have been irrigated. This map appears with the report of the committee in connection with his statement. He has also furnished a table showing by States and Territories the amount of land cultivated in each. From this it appears that about 8,000,000 acres of land have been irrigated, and these lands are distributed through all the States and Territories of the arid region. Irrigation has, therefore, been practised in the United States to such an extent that it is no longer an experiment, and the history of the development of agriculture in this manner reveals many interesting and important facts which are of profound interest to the statesman who regards with solicitude the welfare of the people.

SECTION III.

THE SUBHUMID REGION.

East of the one hundredth meridian there is a belt of country two or three degrees in width where the supply of rain sufficient for agriculture is precarious. In some years the rain-fall is ample; in other years it is entirely insufficient, and in such seasons the farmer reaps no reward for his toil. The history of farming for the past two decades in this subhumid region is full of instructive lessons. Experience shows that wet and dry years alternate in groups. Two or more wet seasons will be followed by two or more dry seasons. When a period of sufficient rain-fall comes for several years in succession, settlers enter upon the subhumid lands in great numbers, tempted by the fertility of the soil and the salubrity of the climate, and their first years are marked by prosperity, especially in those regions where great wheat fields can be cultivated at small expense; but when a succession of dry years appear, and one crop after another fails, the wealth of the people melts away. For the means of subsistence the people mortgage their lands. Horses, cattle, and sheep must be dispensed with, because they devour the subsistence which wives and children need, until at last hunger drives the people away. In the meantime the money-lenders and speculators foreclose their mortgages and get possession of the lands, and when seasons of rain-fall come, another period of land speculation is developed, and the lands are cultivated as farms by people who in their turn must be ruined and driven from the country. Such years of disaster have come two or three times to some portions of the subhumid region. Kansas has been the scene of suffering three times, and in North Dakota and South Dakota the people are now passing through such a period. The disaster that arises from these years of poverty is greatly aggravated by the land speculators, who, with wealth at their command, are enabled during years of plenty to create a belief among the people that the climate is permanently changed, and, fixed in this opinion, the settlers fail to provide against the years of want.

Perhaps, in the history of the United States, there has never been so large a body of people so hopelessly ruined by false representation and speculative chicanery as the people who have settled from time to time in this subhumid region. To the statesman it is a question of the most profound importance whether any relief can be afforded to the people under this condition of affairs, and whether the subhumid region can ever sustain a large agricultural population. To the solution of this question the Director of the Survey appears to have devoted his energies, and he states that there are similar lands throughout the world supporting prosperous people in great numbers, people who resort to irrigation and thereby cultivate gardens, orchards, vineyards, and small farms. In such regions as our own subhumid belt, small streams are few, though rivers flow across them, which head in high mountains far away; and irrigation is, in the main, rendered possible by the storage of storm waters, though, to some extent, as in India, pump waters are used, and to a slight extent, artesian waters. The people who inhabit such lands do not engage in agriculture on a large scale; but in addition to their gardens and small farms, they raise flocks and herds. Unfortunately, in the United States this subhumid region has usually been the theater of farming operations on a large scale. The lands being treeless, they can be brought under the plow with little expense, and when the rain-fall is sufficient it is but necessary to plow and sow, and the farmer may reap in abundance. But such prosperity is always the forerunner of adversity.

SECTION IV.

WATERS USED IN IRRIGATION ARE CONSUMED.

When waters are taken from streams to be used for powers they can be returned, and are thus not lost but only utilized on their way to the sea. In the same manner, waters used for manufacturing and mining purposes can be returned to the channels; though they are sometime injured by being polluted, they are not lost. In contrast with this the waters used for irrigation are consumed; they are poured upon the land and are evaporated from the surface of the soil, but chiefly from the growing plants; they are thus taken up and discharged again into the atmosphere. As irrigation is practiced in most places in the United States, not all of the waters are thus returned directly to the air. By imperfect control of the canals and minor water-ways notable bodies of water escape to be returned to the natural channels. Other bodies of water escape by seepage or percolation through channels constructed in sands and other pervious materials. As irrigation is now practiced there is usually an excess of water put upon the land, more than will be evaporated by the plants and from the surface of the soil. This also escapes into the natural channels. All such escaping waters can be used again to a greater or less extent below. The amount of this waste water gradually diminishes with the development of more thorough methods of irrigation and cultivation of the soil, until at last, as in some places in southern California, such a high degree of excellence is reached in the processes of irrigation and cultivation that no waters escape in this manner. The waste water of irrigation is a measure of the degree of imperfection in the system of irrigation and cultivation. It should be the endeavor of the farmer to prevent waste by evaporation and by faulty methods of irrigation, for in this manner less water is needed, and the amount paid for the delivery of water will be less, while on the other hand the area actually redeemed by irrigation will thus be increased. In the estimate which the Director of the Survey makes, that 100,000,000 acres of land in the arid region can be redeemed by the use of all the streams, this fact is taken into consideration and it is assumed that ultimately the methods of irrigation and cultivation will be perfected as they are in regions of country like the eastern portion of Spain, where irrigation has been long practiced.

SECTION V.

THE CUSTOMARY METHOD OF MEASURING THE WATER SUPPLIED TO LANDS LEADS TO GREAT WASTE AND SERIOUS LITIGATION.

The settlers on the arid lands engaged in these new farming industries without experience, and they were usually not informed of the amount of water necessary to irrigate an acre of land for a season. They have therefore entered into contracts with the water companies to furnish the necessary water for definite quantities of land, whatever that might be. This condition of affairs leads to serious difficulties. The farmer has a contract right to the water necessary for the land he is cultivating. But such water may be used economically or wastefully. An economic use may be one half, one-fourth, or one-tenth of a wasteful use. Such wasteful use arises in two ways. The chief source of evaporation from the surface of cultivated land is from the growing plants. If the cultivated plants only are allowed to grow, and the weeds exterminated, the rate of evaporation is comparatively small; but if the farm is badly cultivated, the waste by evaporation is very great. The careful farmer uses but little water, the careless farmer very much. Again, the economic use of the water depends very largely upon the construction and maintenance of the minor canals, or furrows, which ramify over the land, or other works used to distribute the water. If these works are badly constructed or not carefully managed, the water bursts away and runs to waste. The waste from these sources can be avoided by the good management of the farmer; but he is not interested in its prevention. The party directly interested therein is the one under contract to supply the water, and it is not within his power to exercise economy. Thus it is that large quantities of water are wasted. When the fields are irrigated streams burst out from their borders and the water is lost, or the lands are badly cultivated and the waters are evaporated without doing duty to the growing crop. The ultimate result of this is that the farmers as a body have to pay for this waste water, and the careful farmers have to assist in paying for the waste of their neighbors. When waters thus run to waste, sometimes the companies and sometimes interested neighbors are compelled to interfere, and this causes conflict, embroils communities, and results in litigation. Contracts for the delivery of water should be made in terms of quantity supplied, and not in terms of quantity of land to which it is supplied; then the responsibility for economy will rest upon those who only can practice economy, and much conflict and litigation will be avoided.

SECTION VI.

ARID LANDS ARE FERTILE.

During the last summer the committee made a long journey, in passing through all the States and Territories were irrigation is practiced, and it appears from the statements made by the people, and from the examples which the members of the committee observed for themselves, that lands under irrigation are very fertile, and that although much labor and expense are attendant on such farming the farmer is well rewarded therefor. It is believed that the truth of this statement is abundantly demonstrated after all due allowance is made for exaggeration. It therefore pays to irrigate desert lands wherever water can be brought upon them at a reasonable expense. It was not uncommon to find desert lands separated from irrigated lands only by fence lines, the desert lands being valueless or nearly so, while the irrigated lands were valued and actually sold at rates varying from $25 to $200 per acre, depending upon their proximity to centers of population. It was further to be noticed that irrigated lands are usually cultivated to a high degree, for after the expense of bringing water upon them has been incurred, thorough cultivation is demanded that the investment may not be lost.

SECTION VII.

THE TIMBER LANDS.

The Director of the Survey also placed before the committee a map of the arid lands exhibiting the distribution of forests. In his statement, which is published with the report, a table is given of the number of square miles of forest valuable for merchantable timber in the several States and Territories of the arid lands. Such forests are found only on the mountains and very high plateaus, and they are chiefly composed of coniferous trees, as pines, spruces, and firs, which are exceedingly inflammable. It appears from the evidence coming from various sources that these forests are being rapidly destroyed by fire. The destruction of values in this manner is enormous, and unless something can be done to prevent it, the ultimate destruction of all the standing timber will come in a few years. These forests are mainly found in lands where agriculture is almost impossible, as the region where trees grow is cold and inhospitable. The forest lands are mountainous lands, while the agricultural lands lie below on the plains. It is thus that the farmer is usually dependent on a distant region for his fire-wood and for the timber which he uses in building his home and which he needs for a variety of purposes.

There is still another class of timber lands, the forests of which are scant and composed of low, scrubby trees valuable only for fire-wood and minor domestic purposes. Some of these forests are found where agriculture is possible.

The most important fact in connection with these timber lands arises from their relation to agriculture. The agricultural lands are below, in the valleys; the chief sources of water supply are in the mountains, where the forests grow, and these sources can be greatly injured through the destruction of the forests. To a large extent the waters that are to be stored must be held in reservoirs in the mountain regions, and if the hills are improperly denuded of their trees, the reservoirs will speedily become filled with débris. To serve the full water supply for the lands below the forest lands must be protected. It is thus that the farmers who live far away in the valleys are the people directly interested in the management and protection of the forests, for the double purpose of preserving their agricultural interests and for the supply of wood and lumber to be obtained therefrom. It is not possible to overurge upon Congress the importance of this question. Vast values are being destroyed by fire annually and the farming interests are being imperiled thereby.

SECTION VIII.

PASTURAGE LANDS.

Besides the forest lands and irrigable lands, there are large tracts valuable only for pasturage purposes. The grasses on these lands are in the main very scant, though nutritious, and on them many herds and flocks are sustained. A few decades ago, throughout the arid region, ranching industries sprang up on the public domain, and large tracts of land were claimed by individuals and corporations engaged in stock-raising. To such large tracts possessory titles were claimed, and they were sometimes inclosed in fences tens, or hundreds, of miles in length. At first this ranching commenced in a small way, but gradually the larger companies absorbed the smaller, buying out individual properties, or driving the owners away, until at last the strong arm of the Government was invoked, and in many cases the companies have been compelled to remove their fences and throw open the public domain to the use of all. Still, many of these ranches have a firmer hold on the country, which they have gained through the purchase of Spanish grants and tracts of railroad lands. Others have obtained title and possession of lands through the agency of the homestead laws, pre-emption laws, timber-culture laws, and desert-land laws, and by purchase of lands granted to the States by the General Government. Often these lands have been acquired by companies through the agency of their employés, who take up tracts under the various acts of Congress for the purpose of acquiring title thereto and transferring the same to their employers. Some of the irrigable lands have been aggregated in large holdings in the same manner.

Rapidly the existing cattle companies are being consolidated and organized into trusts with beef companies in the cities farther to the east. Thus great syndicates are formed having their ramifications throughout the entire country so as to control the raising of cattle, the marketing and butchering of the same, and the distribution of the meat to the people. In the mean time the development of agriculture by irrigation is giving support to many smaller farmers who cultivate tracts of lands for themselves and raise flocks and herds to compete with the great companies. These farmers in vast numbers complain bitterly of the power which the great syndicates have in controlling lines of transportation and markets; but their chief complaint against the companies arises from the fact that the syndicates are able to cover the lands with their herds and occupy the public domain to the exclusion of the few animals held by the smaller farmers who can not afford to employ herders to guard and protect the small number of animals which they own. Thus they are compelled to keep them in their own fields or lose them in the great herds. In this connection it should be explained that the natural pasturage lands can not be economically used and fenced in small tracts, as many acres are required to support a single animal.

Notwithstanding all these facts the farming interests are gradually encroaching on the ranching interests. The value of the farming interests is already greatly in excess of that of the ranching interests, and the people engaged in farming are likewise vastly more numerous than those engaged in ranching; and this disparity must rapidly increase in the future. In fact, the time is approaching when the ranching interests will be largely absorbed in the farming interests; and this is already accomplished in many districts. The ranchmen are beginning to farm by means of irrigation, and the farmers are increasing their flock and herds. It is believed that it would be highly advantageous if these interests could be wholly consolidated, so that the people who are engaged in farming could have control of the pasturage lands and utilize them to the extent of their value.

There is another consideration of great importance relating to the pasturage lands. This exists in the fact that if they are overstocked they are destroyed. Some of these impoverished grass lands ultimately recover; others do not. Already extensive districts have been laid waste in this manner, and it is believed that the permanent settlers who have agricultural homes will be the people most interested in the protection and utilization of the pasturage lands; and if this condition were secured the cattle-raising industry would become an adjunct to the farming industry which is carried on by irrigation. If a proper system could be devised the ranchmen who are permanently located would gradually become farmers, while those who roam from region to region with their flock and herds, and who thus destroy the pasturage lands, would have to abandon their nomadic industries and seek fixed habitations, and would thus become permanent inhabitants with interests in common with all the farmers.

SECTION IX.

THE IRRIGABLE LANDS LIMITED.

The irrigable lands are limited in extent. The area of the arid region which can be irrigated is a small fraction of the entire region. This arises from the fact that all the waters that can be used are insufficient to serve all the possible irrigable lands. It therefore becomes necessary to select the lands to be redeemed. On the wisdom of this selection vast interests depend. It is possible to irrigate lands in the mountains and on the high plateaus, but if the water is used there it can not be used below, and these elevated lands will not make the best homes for the people. The climate there is rigorous; and the variety of agricultural products that can be raised is limited, being chiefly hay and vegetables. To use the water on such lands is largely to waste it, and to drive agriculture into the mountains is to doom the people engaged therein to a dreary life in a subarctic climate. It is therefore manifestly to the interest of the greatest number of people that the agriculture of the arid lands should not be established in the mountain regions. The valleys and plains below are warm, salubrious, and rich, the variety of agricultural products is great, and if the waters are used on these lands they will give support to a prosperous people.

But not all of the valley and plain lands can be irrigated, and selections from these must be made, and on the wisdom of these selections much depends. If the lands are selected far down the valleys, the waters are wasted in reaching them. It is generally the case that after leaving the foot-hills of the mountains, the creeks and rivers of the Western lands are rapidly absorbed in the sands, and thence evaporated; in fact, a great many of the streams disappear altogether within a few miles after leaving the foot-hills, being lost in sinks or salt lakes. It is thus estimated that more than half of the streams that flow from the mountains do not ultimately discharge their waters into the sea, while of the water of the streams that do ultimately flow through to the ocean a very large part is lost on the way where it is caught by the sands. If the lands are selected far away from the mountains and the waters are taken out near to the mountains, then long lines of canals must be constructed, involving great expense. And experience shows that it is not practicable to conduct water along canals dug in the soils and sands of the plains and valleys to a great distance, for into the sands on either side the waters percolate and are steadily lost to agriculture on their way to the distant tracts. In order that the greatest area may be irrigated, therefore, it is necessary to select the irrigable lands on the highest good land that can be found to which the waters can be taken. The agriculture of the arid regions should be aggregated on compact bodies of land below the mountains, in the valleys and on the plains, where the climate is genial and the waters will not be wasted. The agricultural people will thus be collected in comparatively dense communities separated by wide spaces of pasturage and timber lands, which they can utilize to great advantage.

A difference of 100 or 200 miles along the course of a stream may make a difference in the amount of land that can be irrigated of five, ten, or twenty fold; that is, the waters will irrigate that much more land if it is selected above. It thus appears that a proper selection of the irrigable lands must be made so as to exclude tracts in the mountains and on the high plateaus, and also far down the valleys where the waters would be wasted in reaching them. The ultimate area which is to be redeemed through the agency of streams depends very largely on a wise prevision in the selection of the lands to be irrigated. If the lands are badly selected, and rights and interests are vested to the use of waters on lands improvidently chosen, the development of agriculture will be limited. In the interest of the future agriculture of the arid lands the most important function which the General Government can perform is promptly to select the irrigable lands and direct the attention of settlers thereto, and permit them to make homesteads thereon, thereby preventing the establishment of improvident rights. The people settling in the country can not do it for themselves in a proper manner, as they are necessarily ignorant of the facts and conditions; they therefore settle at random on tracts scattered promiscuously throughout the regions where irrigation is possible. Some tracts are well selected; others are badly selected.

SECTION X.

THE IMPORTANCE OF DEFINING THE IRRIGABLE LANDS.

It is a matter of prime importance that the irrigable lands shall be selected and defined and water rights established to such lands in advance of settlement, so far as that is yet possible, in order that the agricultural industries growing up in the arid lands may be permanent. It has already been shown that the amount of land which can be irrigated depends upon wise selection; if the selection is made at random, or improperly, the area which it may be possible to irrigate may be reduced to one-half, one-quarter, or even one-tenth of the normal amount; hence, for the welfare of the greatest number of people, these lands should now be selected and defined.

It is also important that the people settling on these lands shall be informed definitely of the catchment area of the waters relegated to their lands, in order that they may protect them from spoliation, and in order that they may not endeavor to acquire water rights which they can not ultimately maintain.

It is also important that the amount of each selected tract of irrigable lands shall be restricted to the amount which the water of each catchment area will serve. If this is not done, then the owners of the land, the farmers, become interested in the failure of their neighbors. For if another man's prosperity enables him to develop the irrigation of his farm to the fullest extent in a short time, and thus subtracts from my prospective rights and hope for prosperity, he becomes a dangerous rival; but if I know that he may develop all of his lands and that there will still be left a sufficient water supply for my lands when the time comes that I can use it all, his prosperity is no longer dangerous to me. In the same manner, if each agricultural community has a body of water rights inhering in a catchment area attached to the defined irrigable lands of that area, sufficient and no more than sufficient for the irrigation of that area, the prosperity of that community is not a menace to another agricultural community having similar water rights pertaining to similarly defined irrigable lands.

The principle at the foundation of the plan herein proposed is exceedingly simple. It is that the arid lands depending for irrigation upon perennial streams shall be divided into irrigation districts so that each shall have a defined body of irrigable lands and a defined catchment area, and that the lands and waters shall thus be related, the lands being just sufficient, and no more, to use all the water which the catchment area will provide. If this is established, the district which develops rapidly can not destroy the district which develops slowly. One community can not become the rival and enemy of another — all community water rights will be clearly defined and can be maintained.

SECTION XI.

THE VALUE OF IRRIGABLE LANDS.

If the irrigable lands are wisely selected and are declared irrigable lands and the right to use the water on such lands is established, and a prohibition is put to the use of waters on other lands in such a manner that water rights inhere perpetually in the designated irrigable lands, such lands will be immediately given great value, varying from $25 to $200 per acre, depending upon their proximity to cities, towns, mining regions, and railroads.

SECTION XII.

SMALL FARMS BEST FOR THE ARID AND SUBHUMID REGIONS.

It is an established principle of agricultural economy that where land has high value cultivation must be thorough. With land of small cost it may be more profitable for a farmer to bestow a small amount of labor per acre upon a large farm than to bestow a larger amount of labor per acre on a small farm. But if the cost of land is great he must cultivate his land thoroughly, and if he employ only his own labor his farm must be small.

Irrigated land is expensive in two ways: First, outlay is necessary in the original construction of reservoirs, dams, canals, and other irrigation works, to reclaim the land; second, money must be expended annually in the maintenance of irrigation works, and much labor is required through the irrigation season in systematically leading the water to different parts of the land as it is required. For these reasons the cultivation of the soil must be thorough or the investment in irrigation will not be remunerative. In order to get the proper return for the money invested and the labor annually expended, the highest cultivation is demanded. So great is the labor of leading the water on the lands, and so great is the labor necessary to cultivate the soil to a high degree, that the area one man can profitably cultivate is much smaller than in a humid region. The labor necessary to cultivate 40 acres of land in a humid region is sufficient to cultivate only 10 or 15 acres in an arid region. Hence the homestead unit for the arid region should not be so much as 160 acres, but only 80 acres, or perhaps only 40 acres.

Such limitation of the area which may be secured by homestead will work no hardship to the farmer, for his smaller farm in the arid region is more productive than a larger farm in the humid region. As just explained, he is under the necessity of maintaining a high degree of cultivation, and this leads to correspondingly large production. But this is not all. Agriculture watered by means of irrigation is in two ways essentially superior to agriculture watered by rains. First, the supply of water, being under the control of the farmer, is better regulated, and the land does not suffer either from violent rains or from droughts; second, the dryness of the air in the arid region is favorable to the growth of crops, so that even in the years most favorable to agriculture in the humid region the irrigated lands of the arid region yield a more abundant return.

It was found by the committee, in passing through the Western States and Territories during the past summer, that the farmers who were practically engaged in agriculture fully recognize these facts, and the general sentiment expressed was that the homestead privilege should not include more than 40 acres of land; others believe 80 acres to be the right quantity, while nowhere among the farmers was it claimed that 160 acres should be given as a homestead. The universal sentiment of the farmers of the West, who are practically informed on these matters, is in favor of a much smaller homestead than is now given to the settler. The value of a tract of irrigable land with water right attached is always great. Everywhere in the arid region such tracts are valued at and sell for from $25 to $200 per acre; so that a tract of 80 or even 40 acres is no inconsiderable gift to the settler.

SECTION XIII.

OBSTRUCTIVE WATER RIGHTS.

For the proper utilization of the waters of the streams, there is another condition of importance. In inaugurating irrigation plans it is often the case that a stream is diverted by the construction of imperfect dams of brush, sand-bags, or loose stones sufficient to take out a portion of the water and turn it into a canal, but insufficient to take out the entire volume. Such diverting dams and the low-line canals which they feed are constructed along the course of the river. In order to supply them with water a much larger volume must run down the stream than is taken out into the low-line canals. To maintain rights thus established is to prevent the complete utilization of the waters. If the entire volume of the stream be taken out at some point above them all, where headworks can be constructed to fully command the stream, then the water is cut off from the low-line headworks and canals and is made to serve a much larger area at a smaller expense per acre; but vested rights in many cases prevent this economical use of the river. This difficulty is frequently experienced, and has already become of grave importance; and such impedimentary and improvident works have ultimately to be bought out. For this reason it becomes necessary to designate the points where waters can be taken out from the principal streams, in order that the water may be utilized on the best lands and to the greatest extent.

In the progress of irrigation, the small streams are generally utilized before the larger. In very many cases these small streams are used low down in their courses, on lands lying near to the trunk streams into which they flow; afterwards, when it is desired to take out the waters of the trunk streams, it is found that the lands which their waters could serve are already served by waters from the small streams, and to use the larger rivers it becomes necessary to buy out the interests of the farmers on the small streams, who must then move back higher up the little tributaries with their farms. It is thus that in a second way obstructive and improvident rights are established. The experience gained by the irrigation of 8,000,000 acres of land shows that such obstructive and improvident rights have been established in very many places, and they greatly impede the progress of development, and through these conditions the small farmers that first make homes for themselves are bought out by great land companies who seek to control large volumes of water and large areas of land.

SECTION XIV.

INTERNATIONAL CONFLICTS ABOUT WATER RIGHTS.

The committee, in its travels through the arid region last summer, visited El Paso. While there the attention of its members was called to some serious international troubles arising through the use of the waters of the Rio Grande for irrigation in the El Paso Valley, a part of which lies in Texas and another part in the Republic of Mexico. Agriculture by means of irrigation has been practiced in this valley for nearly two centuries, on both sides of the river, and naturally the people believe that they have a prescriptive right to use the water to fertilize their lands, acquired by utilization through a long term of years. But during the past season the supply was insufficient for the usual purpose, and much suffering has arisen therefrom, and great farming values have been destroyed. In seasons of great rain-fall the water is sufficient to cultivate much larger areas than in seasons of small rain-fall. The permanent development of agriculture therefore depends upon the water supply afforded in dry seasons. In late years large areas of land have been cultivated on the Rio Grande in Colorado. There has also been a great development of agriculture in New Mexico on the tributaries of the Rio Grande. The effect of this is to cut off the water from the Rio Grande to a large extent, so that when dry seasons, like the last two, come, an insufficient supply of water is afforded by the Rio Grande to the people of the El Paso Valley, both in the State of Texas and in the Republic of Mexico. Immediately above the line between Texas and New Mexico there is another district of country known as the Mesilla Valley, which lies wholly in the Territory of New Mexico. Here, also, the supply of water was insufficient, from the fact that it had been cut off by irrigation above.

The committee found that the people of Mexico were complaining bitterly about the destruction of their agriculture, and the matter has now come to be an important international affair. This case illustrates others that must soon arise. The Colorado River of the west flows from the territory of the United States into the territory of the Republic of Mexico, and its waters can be used in either or both countries, and ultimately some equitable division must be made or international disputes will arise. In the same manner the waters of the Columbia and other rivers at the north, which are needed for irrigation, must be divided between the British possessions and our own; and at the present rate of settlement and development in that country these problems will soon appear and must be settled in some just and amicable manner.

SECTION XV.

CONFLICT OF RIGHTS BETWEEN STATES.

There is another class of difficulties arising the miscellaneous and unregulated appropriation of water and the use of rights through prior utilization. Unfortunately the arid region has not been divided into States and Territories by natural boundary lines, so that each drainage basin is under the jurisdiction of some one State or Territory. In the main, artificial boundaries have been adopted, described in terms of parallels and meridians. Through this unfortunate circumstance interstate interests are involved in the division of the waters. These interstate questions are numerous and of great importance, involving values of many millions of dollars.

Nearly all the great rivers and many of the great tributaries of the entire arid region and of the subhumid region, or more than one-half of the area of the United States, exclusive of Alaska, run through two or more States or Territories. In a few cases they are boundary lines; in others they head in one political division and run through another. In all these cases the waters must be divided on some equitable and wise principle.

In general the headwater States and Territories have it in their power to control the situation. They can take the water and laugh at the rights of the people lower down the rivers. The North Platte is to be divided between Wyoming and Nebraska; the South Platte, between Colorado and Nebraska; the Arkansas, between Colorado and Kansas; the Canadian River, between New Mexico and the Indian Territory; the Pecos, between New Mexico and Texas; the Rio Grande del Norte, among Colorado, New Mexico, Texas, and the Republic of Mexico; the Colorado, among Wyoming, Utah, Colorado, Arizona, Nevada, and California. All of the principal rivers of Nevada head in California. The Bear River is to be divided among Wyoming, Idaho, and Utah; the Snake is to be divided among Wyoming, Idaho, Oregon, and Washington; the Columbia is to be divided among Montana, British America, and Washington; the Missouri and its tributaries are to be divided among Montana, North Dakota, South Dakota, and perhaps Nebraska.

The lands are already divided by State lines, but they are practically valueless without water. The waters are flowing in the rivers and are to be taken out to serve the lands. The real value inheres in the waters. The lands, valueless without water, obtain a value of from $25 to $200 per acre with water. How, then, shall the waters be divided? It is a low estimate to say that the water values to be divided amount in all to more than $500,000,000. The States can not divide the waters among themselves; the National Government must, therefore, become the arbitrator between them, and it should immediately intervene to divide the waters in some wise and just manner that will command the judgment of men. The importance of this matter can be illustrated on every hand throughout the arid region.

The principal rivers on which irrigation depends in the State of Nevada have their sources in the Sierra Nevada, within the boundary lines of the State of California. Nevada has but a small farming population, and this chiefly depends upon the waters of the rivers that come from California, and it is in the power of California to destroy the irrigation already established; that is, it is possible to divert the waters of these streams onto the mountain lands where grass and hardy vegetables may be raised, but where the more valuable crops can not be produced. Again, if the agriculture on these streams—the Truckee, Carson, and Walker Rivers—is to be increased by the storage of waters, the reservoirs must, in the main, be situated in California. It is thus that the agriculture of Nevada can not be maintained by State authority. The time is not far distant when properties, having a value in the aggregate of many millions of dollars, will be in dispute between California and Nevada. Most all of the catchment area of the Snake River is in the Territory of Wyoming, where waters can be stored to irrigate several million acres of land. But all the good land lies in the Territory of Idaho. The right to the use of water for irrigation is prolific of disputes between the States, and every State and Territory of the arid and subhumid regions is involved. Rights have already vested to such an extent as to make the solution of this question difficult; but the near future will see them multiplied on a large scale.

SECTION XVI.

CONFLICT BETWEEN COMMUNITIES.

Everywhere in the arid region the scarcity of water is in contrast with the abundance of land, and out of this arise conflicts between communities. Along the course of a stream which will irrigate a few hundred thousand acres of land there may be a number of places where the water can be diverted to advantage. At each of these places headworks are constructed, and canals are made to lead the water therefrom to bodies of land, and in each case a group of farmers are dependent upon a single canal, and a number of canals give rise to a number of such communities, all having interest in the common waters of the natural stream. The rights between such communities are adjusted by a legal principle which has grown up in the States and Territories involved, which is styled the right of prior appropriation. In general this prior appropriation by canal is established when the canal itself is begun and a proper record of the same made. Prior appropriation in this case means prior construction of canal. As the communities grow and the agricultural area is enlarged by the prosperity of the people, a limit to this enlargement is reached.

If the principle holds that the canal appropriates to the extent of its capacity the earlier established communities may continue to expand until the capacity of their canals is reached. If the later established communities, having later canal rights, have in the mean time been using this water, they are cut off from its use by the development of the communities on the canals of earlier date. In this manner agricultural industries are established to be ultimately destroyed.

The larger streams originate in the confluence of smaller streams, and these smaller streams often have valleys where their waters may be used. It often happens that the waters of a larger stream are taken on the land first, and then settlements are established on the smaller and distant streams which take the water away. It is under such conditions that conflicts between communities arise, and as they involve the industries of the farmers and the chief values of the country, they are necessarily bitter. It has been proposed of late years to remove this cause of conflict by making the land instead of the canal the appropriator of the water. Should this rule be established it becomes necessary for the people of one community to watch the people of another, and to observe with great care the development of agriculture in every district situated on the same principal stream and its tributaries, in order that no right may be established in conflict with existing rights. Unfortunately artificial county lines have been established, so that drainage basins are often divided, and county administration thus fails to provide sufficient remedy and regulation.

If the land instead of the canal appropriates the water, then every farmer's prosperity limits the prosperity of his neighbor, for as he develops his land by irrigation he secures rights to water which prevent others from developing their lands to the fullest extent. It is thus that the industry of farming by irrigation develops conflict and establishes a plexus of rights difficult to control.

If the annual flow of the stream were constant these difficulties would be greatly ameliorated, but dry and wet years occur. When great rainfalls occur for a series of years agricultural development is stimulated and the people irrigate a greater area of land than they are able to maintain when the dry years come. It is thus that in seasons of drought communities depending upon irrigation are plunged into conflict. The problem of dividing the waters of years of scarcity between the fields with justice to all is one of great difficulty. In older communities it has been solved in many ways, but they all provide an administration which has great power and which acts summarily in times of stress, leaving ultimate rights to be settled by the slower process of law in the courts.

SECTION XVII.

SPECULATIVE WATER RIGHTS.

It has been pointed out that in the arid lands the source of value inheres in the water; but such waters are forever flowing away, to be lost in the sands or swallowed by the sea. Hitherto waters unused have not been attached to specific lands, nor to any lands whatsoever. Any unused source of water might be seized by any one. In the local practice of the country it is only necessary to stake out a claim and have it recorded in order to make a seizure on such waters. Gradually in some of the States it has become necessary, in order to preserve the life of the claim, to do some work or make a show of some work on an irrigation structure. In this manner the streams of the arid region are being covered with claims for speculative purposes. When it is determined to actually construct irrigating works and thereby redeem definite bodies of land, these interfering speculative claims must be bought out. Such claims are numerous and are they held at great prices when bona fide works are to be constructed, and stand in the way of the actual development of the country, and if they are maintained their extinguishment will become a permanent tax on agriculture, as the selling value of such claims must be added to the investment or plant with which farming is started.

SECTION XVIII.

EXISTING WATER RIGHTS MUST BE MAINTAINED.

Already 8,000,000 acres of land are irrigated in the arid region. It seems probable, from the evidence brought before the committee, that works have been constructed capable of irrigating an additional amount of 2,000,000 or 4,000,000 acres. These people have redeemed their lands, have brought water upon them, and for that purpose have constructed canals; and they have made homes, built themselves houses, planted their orchards, and inclosed their fields. Their rights are sacred and must be maintained, and nothing should be done to despoil them of the fruits of their industry. The larger part of the lands which have been selected have been wisely chosen and fall naturally into the irrigable tracts as described. Other lands have been unwisely chosen and impedimentary or obstructive rights have been established. Such rights can not be extinguished, even though they are impedimentary and obstructive, without just remuneration. It is therefore proper to declare all lands that have heretofore been irrigated in any district to be irrigable lands, but such rights should not be held for speculative purposes to coerce their purchase at exorbitant rates. It should be in the power of each community to extinguish these rights by public condemnation and due payment to the owners of the property.

SECTION XIX.

THE STORAGE OF WATERS.

The season of irrigation in the arid region varies greatly in length. In high altitudes and latitudes it is not more than fifty or sixty days in length, while in low altitudes and latitudes it may be four months in length. It also varies for different crops. But whatever its length may be it is still limited. When the streams are directly taken to the lands by means of canals, it is only during this season of irrigation that the waters are used; during the non-irrigating season the waters flow away to the sea or are lost in the desert sands. There are also floods, especially in the earlier part of the irrigating season, when all the waters of the streams can not be used. It is thus that a limit is established to the area which can be irrigated by the use of the seasonal flow of the streams.

The non-seasonal flow is utilized by storing it in reservoirs or great artificial lakes. The investigations made by the Irrigation Survey show that the non-seasonal flow can be impounded and used in the season of irrigation, often with great economy, and by this means the total area irrigated will be greatly increased—more than doubled. In the storage of water important conditions arise. This water should be stored in the mountains wherever possible, and such possibilities are frequent, as the mountain valleys often present favorable sites. When the water must be stored below, much more is lost by evaporation than when stored at higher altitudes. Under the most favorable circumstances there are not more than 40 or 50 inches of annual evaporation from a body of water in the mountains, while in the very low lands this evaporation is from 80 to 100 inches annually.

It must be further noted that all storage reservoirs must necessarily be at some distance from the lands to be irrigated, as the lands must lie at a lower altitude than the reservoir in order that the water may be conducted to them by canals. When the waters are stored in the mountains, far distant from the lands, they are discharged from the reservoirs, before being used, into the natural channel, to be taken out by the canals below. It is thus that the farmers on the lands far down the river must construct a large part of their storage basins in the mountains and away from home, and afterwards divide them among the canals below after they are commingled with the flow of the waters not dependent upon the storage basins.

If the reservoirs were on the low lands, near to the farms, then the waters would usually have to be conducted to them from the principal streams during the non-seasonal flow; so the waters would have to be divided among the reservoirs. Thus it is that when the waters are stored above they are divided after they are caught; when stored below they must be divided before they are caught. This makes it clear that some system must be provided for the division of the non-seasonal flow of the streams as well as of the seasonal flow.

SECTION XX.

THE DEVELOPMENT OF AGRICULTURE ON LANDS WHERE IT CAN NOT BE MAINTAINED.

As the water supply is limited and the land supply practicably unlimited, the unregulated selection of the irrigable land yields disastrous consequences, from the fact that lands are often irrigated where water rights can not be permanently maintained. If the lands first irrigated are low down on the course of a stream, irrigation above will take the water away; and this becomes a serious matter when the waters are taken away from a larger stream by using the small streams in detail on their own valleys. If this higher irrigation is in the mountains, it is a waste of water, as has already been explained, and the older settlements are destroyed by the newer, to the great disadvantage of agriculture at large. But this evil can usually be remedied by local legislation. When, however, the mountain lands are in one State and the low valley lands in another, the remedy is found with greater difficulty. It must necessarily be found in the powers of the General Government. If the lands first selected for irrigation are far down the stream, then the waters used are largely wasted on the way, and only a small area can be irrigated, even though the stream has unimpeded flow above; but if, after water rights are once established in the lower region, the waters are taken out far above on the lands where the supply is not wasted, very much larger areas can be cultivated; and it is difficult for the people below to maintain their rights to the full flow of the stream, which is chiefly lost before it reaches them; and if they could maintain their rights it would be a great disadvantage to the country at large, as it would seriously diminish the area of farming lands. When communities of different States thus build up conflicting rights, those below are entirely at the mercy of those above, unless the General Government intervenes to afford protection. It would seem to be unwise for the General Government, which still to a large extent possesses the lands, to permit the growth of industries on lands where they can not be maintained without a great sacrifice to the general interests.

There is still another condition, which makes this problem more serious. The volume of the streams being variable from year to year, there are seasons of plenty and seasons of scarcity. When seasons of plenty come, agriculture is rapidly developed in all of the communities; but when seasons of scarcity arrive, the established industries must suffer, either above or below, or in both places. Practically the suffering is experienced by the communities below. The Government of the United States is rapidly disposing of its lands, through the agency of the desert-land laws, timber-culture laws, pre-emption laws, and homestead laws, to settlers, who in most cases are required to irrigate them in order to obtain possession. Lands taken under the desert-land act must be irrigated. Lands taken under the timber-culture act must also be irrigated if the trees are actually grown; and lands taken under homestead privileges must be made homes, if honestly acquired, and therefore they also must be irrigated. It is thus that the lands pass out of the hands of the General Government into the hands of individuals under a contract, real or virtual, that they shall be irrigated, and the Government in turn receives the money of the settlers for these lands. When farmers under contract with the Government to irrigate their lands do actually irrigate them and create conflicting rights, can the Government properly and honestly see the people of one community to whom it has sold lands despoiled by the people of another community to whom it has sold lands, all under contract that the lands shall be irrigated, which is the condition of spoliation? It is feared that such communities will believe they have a case in equity against the Government, and that, when their industries are overthrown, their homes destroyed, their property ruined, they will seek compensation from the General Government. If irrigation goes on unregulated for ten years more as it has during the last ten years, claims to the amount of hundreds of millions of dollars may be presented to the General Government. It is none too soon to consider this question. Already the basis of such claims is laid in many regions. At the present time the people of Kansas are developing lands of this character to the extent of four to five hundred thousand acres in the valley of the Arkansas, which, at the lowest rate at which irrigated lands sell, will be worth more than ten millions of dollars. Should poor men, ignorant of these facts, be permitted and encouraged to make homes on the public domain where they must ultimately be ruined? Will they not then come and beg of the Government for relief?

SECTION XXI.

AGGREGATION OF WATER RIGHTS AND LANDS IN THE HANDS OF THE FEW.

In the arid lands the fields are not fertilized directly from the rains. The water to serve them must be brought directly from streams having their sources in the mountains. For this purpose dams must be built, canals constructed, and reservoirs established. To do this work organized labor must be employed, and often great capital is necessary. A poor man can not go upon a tract of land and make a homestead for himself; he must combine with others to do this work, or with his neighbors to make a contract with some company to construct the necessary irrigating works. Often these preliminary works are of great cost, and before the first acre of land can be cultivated tens or hundreds of thousands of dollars must be expended—in some cases millions of dollars. It is through this condition of affairs that water rights are being aggregated in great companies; and when the water is limited and the land practically unlimited, the value primarily inheres in the water. This relates to the stream waters, on which the chief development of irrigation depends. Storm waters, pump-well waters, and artesian waters can, in the main, be managed by individual farmers, but stream waters require a preliminary outlay of money on a large scale. Under these conditions many irrigating companies have been organized. In the early history of irrigation in the West these companies laid claim to ownership in the water, but gradually, by legislation and judicial decision, this right of ownership has been greatly curtailed, and the tendency seems to be to consider the canals as common carriers of water. In this manner the farmers are able, to some extent, to regulate the price at which waters shall be delivered to their lands. Still, the companies own the sites where the waters must be taken from the streams, and the lines of canals through which the waters must flow; and hence they own the right to deliver the water, though nominally they do not own the water itself. The companies also have it in their power to enforce their claims with great vigor, for if during the season of irrigation a field is deprived of its necessary supply of water the crop thereon is speedily destroyed; and when gardens, orchards, vineyards, and perennial crops are planted great values may be annihilated by withdrawing the water supply for a few weeks at the critical time.

Great increase is given to the value of land by irrigation, and with a desert claim before him the farmer is usually willing to make very liberal contracts to secure this increase in the value of his land. Hence it arises that the settlers make contracts with water companies at exorbitant rates, and usually these contracts are perpetual. When, in later years, it is found that the contract is improvident the farmers become discontented and a conflict arises between the users and the carriers of water, often disastrous to both parties. This unhappy state of affairs is greatly exaggerated by the conditions under which the water companies are organized. In the main they are developed by promoters, or middlemen, who make contracts with the farmers on the one hand and issue bonds to capitalists on the other, and who construct the works at great profit. For this purpose construction companies, or *credits mobilier*, are organized. When the works are constructed the bonds or the stock of the companies, one or both, are in the hands of the capitalists, and lands in the hands of the farmers, and the promoters with their profits are gone. This condition is injurious to both parties whose interests remain, and the conflicts that arise therefrom are great and the resulting litigation is enormous.

Many water companies having met with disaster in this manner, the new companies were led to take warning, and another direction has been given to these enterprises. Here the companies attempt to make their profits primarily through the increase in value given to the lands, and the promoters go among the farmers and take options on their lands. When a tract sufficiently large for the purpose has been secured, the works are constructed and the lands bought. The companies then sell the lands at the increased value, with rights to the use of water and with contracts to furnish water perpetually or for a term of years.

The possession of the lands is sometimes obtained in another manner. The employés of the company and others are induced to make filings on the lands under the various acts of Congress for the acquirement of desert lands, timber-culture lands, homesteads, and pre-emption lands. Then to irrigate these lands the men who file on them enter into a contract with the company to furnish water, and mortgage their lands for this purpose. Sometimes the more thrifty settlers ultimately pay up these mortgages and possess their farms; but often, and usually, the mortgages are foreclosed after title passes from the General Government to the individuals, and the companies own the lands. In many cases this seems to be the understanding from the first, and nominal settlers are the agents of the companies, standing between them and the General Government. Large tracts of land are also aggregated in single holdings by purchase from railroad companies, and by the purchase of old Spanish claims.

It is thus that the farming values of the arid country fall into the possession of a comparatively few companies organized in the centers of trade in the East or in foreign lands. There are some very prosperous communities where such large possessions are not obtained, but where the people have settled on the desert lands in colonies and own the irrigation works. A number of such colonies have been founded in Colorado, greatly to the advantage of the people themselves. The people of Utah, under church regulation, have managed to control the waters used in irrigation by communities, and, in the main, the farmers themselves own the irrigation works.

The extent to which irrigation companies are being organized is very great throughout the entire arid region. To illustrate this fact an extract is here given from the report for 1889 of the Hon. L. Bradford Prince, governor of New Mexico. It is as follows:

> A list is subjoined of the corporations formed for purposes of irrigation during the single year ending September 1, 1889. The most important operations now in progress are those of the Pecos Irrigation and Investment Company, in the valley of the Pecos. This company is now constructing two immense canals; the first being 40 miles long, 35 feet wide at the bottom, and carrying 7 feet of water, and the other, 45 miles below, being no less than 50 miles long, 45 feet wide at the bottom, and also carrying 7 feet of water. These are both to be fed by the Pecos, the flow of which is calculated to be 1,000 cubic feet per second. The intervening space is to be supplied by immense reservoirs; three of which are in process of construction; one being 1½ miles long, three-fourths of a mile wide, and 12 feet deep; one 1¾ miles long, 1 mile wide, and 18 feet deep; and the largest, which merits the name of a lake, being 7½ miles long, 2¼ miles wide, and 40 feet deep. This vast work will cost about $1,000,000, and it is expected to irrigate between 200,000 and 300,000 acres of land. No one can even imagine what New Mexico will produce when her immense acreage of fertile soil is brought under cultivation through enterprises of this kind.

List of corporations for irrigation.

Corporation.	Locality.	Corporation.	Locality.
Reservoir Irrigating Company.	Near Navajo Springs.	The Dark Canyon Ditch Company.	Lincoln County.
The Pecos Valley Land and Industrial Company.	West side of Rio Pecos, in Lincoln County.	Springer Land Association.	Colfax County.
The Pecos Irrigation and Investment Company.	Lincoln County.	The Lincoln County Ditch Company.	Rio Hondo, Lincoln County.
White Oaks Development Company.	Do.	The Spring Valley Ditch Company.	Lincoln County.
Peñasco Tank Irrigating Dam and Ditch Company.	Do.	Perry Fountain Ditch Company.	Do.
The Union Ditch Company.	San Juan County.	Albuquerque Irrigating Canal and Land Company.	East bank of Rio Grande in Bernalillo County.
The Guadelupe Valley Ditch Company.	Lincoln County.	The San Juan Water Company.	San Juan River, San Juan County.
The Rio Chama Mining and Improvement Company.	Rio Arriba County.	The Fort Sumner Land and Ditch Company.	Any place within the Territory.
The Detroit and Rio Grande Reservoir and Pipe Line Company.	Doña Aña County.	The Roswell Water Company.	Roswell, Lincoln County.
Lower Felix Ditch Company.	Rio Felix, Lincoln County.	The Dark Canyon Water Company.	Lincoln County.
The Bowman Irrigation Company.	Lincoln County.	The Mountain Irrigation Company.	Do.
The First New Mexican Reservoir and Irrigation Company.	Do.	Uña de Gato Canal and Irrigating Company.	Not specified.
San Juan South Side Canal Company.	San Juan County.	The Santa Cruz Land and Irrigation Company.	Rio Grande, between La Joya and Santa Cruz.
Lincoln Acequia Company.	Lincoln, Lincoln Co.	Jicarilla Mining and Water Company.	Not specified.
The Guadelupe Valley Irrigating and Milling Company.	Lower Rio Peñasco.	The La Plata Ditch Company.	Do.
The Pecos River Ditch Company.	West side Pecos River, terminus near Salt Creek.	Rio Puerco Irrigation and Improvement Company.	Bernalillo County.

In the same manner water companies or irrigating companies whose purpose it is to acquire water rights only, or acquire water and land titles, are being organized in every State and Territory where irrigation is necessary; and these organizations are on a large scale and have no difficulty in securing capital necessary to their enterprises by reason of the great value given to the lands through irrigation. It is probable that companies have already been organized to take out more than three quarters of all the stream waters of the arid region. But these companies, in the main, have been organized since the passage of the act of October 2, 1888, by which the sites for head-works, canals, and reservoirs are reserved in the hands of the General Government, and by which the irrigable lands commanded by the waters are reserved for homestead settlement. It is thus that a vast body of companies stand ready to seize upon these waters and lands, and are now attempting to undo the legislation already accomplished in the interests of the people.

The effect of organizing irrigation companies on a large scale in this manner is to stimulate inordinately the development of agriculture by irrigation on the arid lands. To obtain laborers on the works and settlers on the lands the companies often organize immigration bureaus, and thus bring into the country great numbers of people, especially foreigners. All this tends to rapid development, but it is an unhealthy state of affairs. It is believed that the normal development of the country, through the agency of settlers who are enterprising and desirous of making homes for themselves, will be more in the interest of the country and will result in greater prosperity than if the settlement and development of the country should be put into the hands of promoters or middlemen. It is believed that if the settlement of the West should be placed in the hands of these irrigation companies, an era of wild speculation would be inaugurated in which hundreds of thousands of people would be involved, that vast numbers of people would speedily be attracted to the arid lands, that agricultural industries would be developed beyond the needs of the country, and that these stimulated industries would ultimately collapse, involving many in ruin, while the promoters of these schemes would secure great wealth, chiefly through the agency of construction companies and the sale of bonds.

SECTION XXII.

IRRIGATING WORKS SHOULD NOT BE CONSTRUCTED BY THE GENERAL GOVERNMENT.

The statement has been repeatedly made that a great increase is given to the value of land by conducting water to it. The primary cost of conducting waters to lands greatly varies under the differing conditions. It is usually from $2 to $10 per acre. But as a result of this outlay the lands themselves are greatly increased in value, from $25 to $200 per acre. The increase in the value of lands ought to be used for their redemption, and it is amply sufficient; in fact, there is always a surplus, which is an unearned increment, and to the members signing this report it seems just that the farmers themselves should be the persons to reap this harvest of values. Especially should great care be taken by the General Government to develop a land system for the disposition of its public domain by which this result may be secured. The arid lands of the West should not become the theater of exploitation and speculation, as they are now becoming, and should not fall into the hands of large owners; nor should middlemen be able to reap the great rewards which the redemption of the land involves. All these advantages should accrue to and be distributed among the great army of settlers who are to till the soil. The many should be benefited rather than the few, the laborer rather than the promoter.

SECTION XXIII.

IRRIGATION DISTRICTS.

Nature has divided the arid lands into districts which are usually well defined. The entire region is composed of drainage basins, and through the midst of each one flows a stream, and it is bounded above and on either side by the crest where the waters divide. Such a district, therefore, is natural, and in such a district all of the conditions for prosperous agriculture exist and are unified. Let us take a single district for an illustration:

The Big Thompson, of Colorado, is a stream which flows into the South Platte River. It heads in the Front Range of Colorado, and its basin is there sharply divided by the crest of the mountains from the basin of Grand River, which flows westward into the Colorado. On the north the Big Thompson basin is sharply divided from the basin of the Cache la Poudre, and on the south in like manner it is separated by a sharp ridge from the basin of the St. Vrains. The Cache la Poudre and St. Vrains divides converge in the direction of the South Platte. In the direction of the Platte River the Platte Valley itself clearly marks the limit of the Big Thompson basin. Now within this natural basin, thus plainly demarkated, we have, first, in the mountains and foot-hills above, on either side, a great catchment area. Below, in the valley, there is a fine body of irrigable lands upon which the waters of the catchment area may be used. All of the waters of the Big Thompson can be used in this valley, and yet it will not all be redeemed. There will, therefore, be left large areas of pasturage lands which the farmers on the irrigable lands could utilize to advantage. Then on the foot-hills and mountains of the catchment area there are great forests, which are rapidly being destroyed, to the injury of the farmers below: first, because the sources of their water supply are being destroyed; and second, because they need the timber to use on their farms. Therefore they are the people interested in the preservation of the timber and in the protection of the grass lands. And the people who are farming in the lower valley of the Big Thompson are also interested in the mountains, from the fact that the reservoirs to hold the waters for their farms must lie in these mountains and in the foot-hills.

Here, then, we have a body of irrigable lands sufficient to support a large population, aggregated in the midst of a valley, and about them grass lands, timber lands, and a catchment area for the water which they use. It is a natural division of the country, and all the people who dwell in the valley and live by farming are interested in all parts of the catchment area, for the waters which fertilize their fields are derived therefrom and can not be divided until they are caught in reservoirs and carried in canals, which all the people must unite to construct, either directly through their own labor or indirectly through the employment of water companies. It is thus that the basin of each of the great creeks and small rivers of the arid lands is a natural irrigation district, and the people in each one have a common interest in the entire district, because it is the catchment area for their waters. All such headwater districts are called by Director Powell districts of the first class, and in them are found the greater part of the irrigable lands of the arid region.

But there are still other natural districts. The great rivers, which are formed by the union of many creeks and smaller rivers, flow on for long distances and ultimately pass out of the arid lands or reach the sea. The division of the lands lying along the trunks of these streams when the headwater districts are all laid out gives rise to a second class, which the Director of the Survey calls river-trunk districts. It is usually the case that such a river in its course has in one reach a valley stretch on either side and in another high table-lands through which it runs in a deep cañon, or high mountains on either side. These high table-lands or mountains form catchment areas which enlarge the volume of the trunk stream, and each catchment area has below it a stretch of valley land that can be irrigated, so that we again have high catchment areas above with low valleys of irrigable lands below. It has been found by the Director, who seems to have studied the subject carefully, that all of the great trunk streams can be thus divided into natural districts, with catchment areas and irrigable lands in each, but that in a few places it may be necessary to establish artificial lines as boundary-lines.

In the arid region there are many streams whose waters do not flow to the sea. The streams, gathered in mountain catchment areas, roll down the valleys and are lost in the sands, or, as they are locally called, "sinks," where such waters are evaporated. When streams disappear in this manner, never to appear again at the surface, it is often popularly supposed that underground rivers exist, but there is no foundation for this popular error, as it is well known that the rivers are caught by the sands and evaporated, a sand plain constituting a more efficient evaporating surface than a body of water. These streams which do not roll on to join others are in the West known as "lost rivers," and Director Powell calls the natural districts which they constitute lost-stream districts.

There are thus three classes of natural basins, which constitute three classes of natural irrigation districts, and it is possible to divide the entire arid region into districts of these classes. Now it is proposed to take advantage of these natural conditions to aid in the solution of the problems which the new industry of agriculture by irrigation presents.

As a further illustration of this matter, the following quotation is made from the statement of Director Powell to the Special Committee on Irrigation, printed on pages 22 and 23 of Volume IV of their report:

> I place before you to-day a map of the Rio Grande, including all the area drained by that stream north of the Texas line. There are some important facts relating to the utilization of the arid lands which can be well elucidated by considering that region of country, and I present the map again for that reason. In talking to you about the irrigation problems presented in the valley of the Arkansas, I called your attention to the fact that that valley could be divided into districts, each one an independent unit. The whole arid region may be divided in like manner into natural districts or drainage basins, each one of which has its problems so interwoven that the entire district must be so considered in planning its system of irrigation works, but which is practically independent of all other districts. These hydrographic basins, as I call them, are of three classes, viz, headwater districts, river-trunk districts, and lost-stream districts. The headwater districts commence in the mountains and extend down the streams far enough to include catchment areas and farming areas. These headwater districts are not only found on the main streams, but on all perennial laterals or tributaries. Usually each lateral or tributary forms a natural district by itself. But the great rivers flow on across the plains and down the great valleys, and their trunks must be divided into districts, each one of which presents an independent system of works. These I call river-trunk districts. Then in the arid lands there are many streams which do not flow into great rivers and ulti-

mately to the sea, their waters being lost in the sands or emptying into salt lakes. These I call lost-stream districts. All of these classes are represented in the Rio Grande region, the map of which is before you.

In considering this subject and planning the work of the Irrigation Survey, it has been found that a natural district or hydrographic basin must be considered as a unit in which all the problems must be solved. In order to report upon the district and recommend a plan of works, we must know in such a district how much water will be supplied for irrigation, where the diverting-dam sites, reservoir sites, and canal sites are situate, and where the lands to be irrigated lie. And it has been found, after a careful examination and from the best data we have on hand, that there will be one or two hundred such districts in the arid region, and that if the survey is carried out it will need a separate report on each. I have therefore found it necessary, for the administration of the survey, to consider these hydrographic basins, and have been studying them for some time—in fact for years before the survey was organized, for I early recognized that ultimately these natural features would present conditions which would control the engineering problems of irrigation, and which would ultimately control the institutional or legal problems. The study which I have made in the survey in this direction of course can not be considered final. An actual survey on the ground is necessary to define the limits of each basin, and a very careful survey is especially necessary to define the limits of the trunk districts. The headwater districts, or those of the first class, and the lost-stream districts, or those of the third class, are quite easily discovered; but the districts of the second class require very careful study for their determination. The meaning of this will more fully appear from the illustrations which I am able to present to you to-day in considering the Rio Grande Valley.

First, we have the Saguache River, a river with tributaries—a number of beautiful creeks. The river flows into a sink, and the drainage is lost in the sands. Now, the utilization of that water affects that valley only. It is independent of all the other regions of country. The region of country at the sink is one of sand, and it sinks in these sands and is evaporated. It is only on very rare occasions, many years apart, that there will be a great flood which will cause it to overflow and open a channel to the Rio Grande. In all ordinary years all the water which is used must be in the valley here [indicating], hence it is an independent basin. This is what I call a district of the third class, a lost-river district. It will be noticed that in this district the people who engage in agriculture here can not possibly have any conflict about water rights with the people of any other district. They may use all of this element which they can catch and spread it upon their lands, and nothing will be cut off from any other district; nor can they obtain water from any other district to put upon their lands. And they are interested not only in the water; they and they only are interested in the forests about the fountains whence their waters come, and they are the people who should be interested in the grasses which grow in the valleys and on the hills and mountain slopes.

The Saguache district, therefore, is clearly defined in nature. Its boundary is marked everywhere by the parting of the waters.

Passing over to the Rio Grande proper, we have the San Luis district, which is also a headwater district. The San Luis Park is a beautiful tract of land, and high mountains stand around it and gather great quantities of water. This is a region lately redeemed for agriculture, but already all the flow of critical years with extreme dry seasons is used in agriculture, and the companies that are specially interested in these water rights are preparing to store and use all its waters which flow through this season. It may be possible that they can use all and that the area of good land to be cultivated will be sufficient. We do not yet know the amount of water that flows in the streams, nor do we know the amount of good available land. Be that as it may, we are able to state that this great district is a unit, and that it must be considered as such in planning the proper system of irrigation works, and that its people will be as a body interested in the management of its waters, its forests, and its pastures. And they are the only people to be interested except to this extent, that if the waters are not used here they will flow into trunk districts below, to be used there. If the people of the districts below, in New Mexico, could lay an embargo upon irrigation in the San Luis Valley, larger areas in New Mexico could be cultivated, but the loss of water on the way would be such that they would not equal in area the lands that could be irrigated in Colorado. It is therefore manifest that it is to the advantage of the agricultural interests of the country that the people of Colorado who live in the San Luis Valley should be permitted to develop their agriculture to the utmost, and use all the waters that they can put upon good agricultural lands.

The Rio Grande, in crossing the line between Colorado and New Mexico, enters a cañon and flows for about 50 miles through the gorge, and its waters can not be taken out along this stretch. This cañon ends where Taos River, coming from the east, joins the Rio Grande. The Taos is a beautiful stream and all of its waters can be used in its own valley. All that run during the season of irrigation and all that run throughout the year can be stored, so that the waters of the Taos may ultimately be cut off from the Rio Grande.

The region of country on either side of the cañon of which I have made mention—Embudo Cañon—has lava-fields and is not agricultural; but some fair timber grows there and much water comes down into the cañon, so that when the river emerges into the valley at the foot of Embudo Cañon it is a fine stream, and must always be so whatever water is taken out in Colorado above. Some 40 or 50 miles below the river enters another cañon. Between these two cañons lies the valley of San Ildefonso, into which come some small creeks from the east, and the water of the Rio Grande can be taken out at the foot of Embudo Cañon and spread over the San Ildefonso Valley and make here a river trunk district, or district of the second class. This is a district also well defined in nature. Its catchment area is lava-fields above and mountains on every hand, and its irrigable or farming area is the low valley stretching back from the Rio Grande on either side.

Near the foot of San Ildefonso the Chama enters from the west. The Chama is a large river for that country, and its smaller tributaries drain great mountains, and there are many beautiful valleys scattered about through the region. The lower portion of the Chama runs through a sand plain, and these sands are volcanic ashes which drift and blow into the river and fill it with sediment. The Rio Grande above the mouth of the Chama is a clear, beautiful river, but at the mouth of the Chama it is transformed by the mud of the Chama itself. It then becomes a river of mud and continues such to the Gulf, as it takes up sands along its way. The Chama Basin is another natural basin, having timber lands, pasturage lands, and agricultural lands.

At the foot of San Ildefonso Valley the Rio Grande enters White Rock Cañon and continues its course through a deep gorge for 40 or 50 miles. Along this course its waters can not be used for irrigation. The cañon walls are hundreds of feet, and in some places more than a thousand feet, above the waters. But the high volcanic plateau on the east furnishes a notable amount of water to this stream, and on the west there is a group of great volcanoes from which many beautiful streams flow; so that if all the water should be cut off at the head of White Rock Cañon, there would still come into the Rio Grande, through the course of this gorge, a vast body of water to be used below—water which can not be used elsewhere, as none of the streams above on either side of the cañon have agricultural lands along their courses. But they have great forests. Here some of the finest forests of New Mexico are found. This is the great catchment area for the valley below White Rock Cañon.

Some flood waters will always come down the Rio Grande from San Ildefonso Valley, however thoroughly the country may be utilized, and additional water will be caught in the cañon itself, and so the valley below will have a good supply. White Rock Cañon empties below into a valley which I shall call the Albuquerque Valley. In it lie Bernalillo, Albuquerque, Los Lunas, Socorro, and other towns. Now, all the water that comes out of White Rock Cañon can be used in the Albuquerque Valley, as it may be diverted below the White Rock Cañon and carried out and stored on the flanks of the valley. There is now much agriculture in this valley, and some of it is very ancient. Including the catchment area about White Rock Cañon and the hills and mountains on either side, and the valley where agriculture can be carried on, we have another natural district or hydrographic basin—a district of the second class, or stream-trunk district. Now, it will be seen that all the water to be used in this great valley comes from the mouth of White Rock Cañon. Whoever has control of that point—owns that dam site and has the right to take the water out of its natural channel and carry it into canals—has command of all the agriculture of that great district.

I wish to explain further that the people who have settled here have taken out the waters of the Rio Grande and utilized them during the season of irrigation, but they have not yet resorted to storage and the waters which they use are used to very poor advantage. The flood-plain, or strip of country next to the river, which is sometimes overflowed, is broad and sandy; the river itself is shallow and is a river of mud, and it is very wide; so it flows into these sands and is evaporated to a very large extent and thus lost to agriculture. Then the people have constructed low-line ditches near to the Rio Grande and take out the water by a system which is exceedingly wasteful and which is destroyed more or less with every flood. Ultimately they will find it to their advantage to take the water higher up, near the mouth of White Rock Cañon, and carry it out by high-line canals and store the surplus in the lateral valleys. By this means the area of agriculture in the valley can be increased five or ten fold.

It is possible to take all the water of the Rio Grande there during the season of irrigation. It is also possible to take out all the water there during the non-irrigating season. If the water for the non-irrigating season is to be stored, you are compelled to take it out there. You can not take it out by the present ditches, for they do not flow on high enough ground; but if a canal is constructed from the mouth of White Rock Cañon, and a diverting dam built there and lakes made—there are good places—all the water could be used in the valley. So, not only is it necessary to take the water out at that one point and utilize the entire flow during the season of irrigation, but it is also necessary to take it out at that point in order to store the water which now runs to waste. So that if the water is taken out at this one point of which I speak, altogether, the area of irrigation will be multiplied ten times. But that can not be done without considering the rights of the people who now use some of the water by improvident and obstructive dams.

Off to the east here, as you see on the map, is the Santa Fé Creek, on which the city of Santa Fé is situated. It also constitutes a distinct basin, with irrigable lands, timber lands, and pasturage lands, and all its waters can be caught and used in the Santa Fé Valley, so that no considerable amount will ultimately flow from the Santa Fé Creek into the Rio Grande.

On the west we have the Jemez River, where another natural district of the first class is found. The Jemez River drains the Tewan Mountains and plateau. The catchment area is well wooded. Fine forests are found and great mountain meadows are seen, but the land above is cold and is not valuable for agriculture, except for pasturage, and perhaps a little hay may be cut with advantage. The many streams which head in the Tewan Mountains and plateau find their way into deep cañons. On leaving the mountains nearer Jemez Pueblo the whole body of the stream can be taken out and put on the mesa above Albuquerque, or west of Albuquerque and Bernalillo. It is another natural hydrographic basin of the first class.

Below Albuquerque we have the Rio Puerco. All of its waters can be used in the upper portion of its valley, and there is much more land than the water will serve. Very little water ever runs into the Rio Grande from the Puerco, and that comes only at flood-time. It is a hydrographic district of the third class, with irrigable, timber, and pasturage lands, and with many fine sites for reservoirs.

Where the Albuquerque district should end and the next district, embracing the Mesilla Valley and the El Paso Valley, should begin, I am not able to state, but from such information as I have been able to collect, I believe that below Socorro a new natural division can be made.

Let us go on to consider the region of the Rio Grande below, from Socorro to a point on the river 30 or 40 miles below El Paso. Here there are two valleys, Mesilla Valley above El Paso and the valley below, a part of which is in the Republic of Mexico and a part in Texas. Now it is possible to cut off from these two valleys all of the waters which flow during the season of irrigation in critical years and destroy all the agriculture in those two valleys unless the waters of the non-irrigation season are stored. During the non-irrigating season large bodies of water come into the Rio Grande from the mountains on either side. There are high mountains to the west and high mountains to the east, but there are few perennial streams, and they are only small creeks. The principal body of the water comes in as storm water. But the area is pretty large and its waters can be stored immediately above El Paso and at the head and along the flanks of the Mesilla Valley. At the Point of Rocks, at the head of Mesilla Valley, all of the waters of the Rio Grande can be captured again and they can be taken out into the Mesilla Valley and used once more.

The waters of the non-irrigating season can be stored on the flanks of the valley, and there is more land than all the waters will serve. Still there is a mountain catchment area on either side of the Mesilla Valley, the waters of which will flow through the valley at El Paso at flood times, and these waters can be stored to be used in the valley below in Texas and Old Mexico. But I do not think there is enough of these waters to support all the agriculture now developed if the waters of the Rio Grande are all taken out at the Point of Rocks. To maintain the irrigation now developed in the El Paso and Mesilla valleys, some division of the waters must be here made. The catch from Socorro down, coming from the mountains on either side, and the surplus which may come down in great floods from the Rio Grande above, must be divided between the Mesilla Valley and the El Paso Valley to maintain the agriculture already established, and to give some development to the same. Just how this can be done to advantage is not known; the topographic survey has not proceeded far enough. We know where the waters can be stored for the El Paso Valley, and I have already explained that to the committee some days ago. We can create a great reservoir with reasonable economy immediately above El Paso; we can also create a reservoir, or series of reservoirs, in the Mesilla Valley; but how much water can be caught and held in these reservoirs we do not know, and can not know until the topographic survey is completed, for on that we depend to determine the water supply.

It is safe to say, however, that the reservoir at El Paso may be constructed, and I incline to think that the rights to the present irrigation in the Mesilla Valley may be maintained, the rights in the El Paso Valley maintained, and that irrigation in both districts may be increased—but to what extent and to what size these reservoirs should be constructed is yet unknown. It will require another year's survey to determine these facts. This, however, is certain, that there can be no development of irrigation in these valleys through the use of the waters of the irrigating season only; in fact the present agriculture can not be maintained unless the waters are stored. The irrigation already developed in Colorado and the upper valleys of New Mexico is destroying the agriculture here. Two more years of development will cut it all off when dry seasons come. The only hope for these valleys is through storage, and how the entire problem is to be solved by storage is not yet known. Nor can it be done without some interference on the part of the United States. If the General Government does not step in and by definite legislation assign specific waters to El Paso and the Mesilla, the El Paso Valley will surely be destroyed, and the Mesilla Valley can be almost ruined by the people of the Albuquerque Valley. What is needed is the construction of storage reservoirs and their protection, and the assignment of specific catchment areas to those reservoirs. The Government must say that a certain catchment area can be used for the Mesilla Valley and that the remaining catchment area can be used for the Albuquerque Valley.

A State, a Territory, and a foreign country are involved, and they can not settle the problem for themselves. There is only one way to protect this ancient irrigation in the El Paso and Mesilla Valleys and their right to use the water of the irrigating season, and to proceed as they have heretofore done without storage, and that is to destroy all irrigation in Colorado and all of the lately developed irrigation in the valley of the Rio Grande in New Mexico above, and to prohibit forever the use of the waters there; and this would mean that to maintain seventy-five to one hundred thousand acres of agriculture, several million acres of development must be stopped. Of course this can not be done. They must resort to storage, and somehow storage rights must be fixed and maintained.

The area drained by the Rio Grande above El Paso is a little more than 23,500,000 acres, or about 37,000 square miles. But much of the region is mountainous. Even if there was water enough it would not be possible to irrigate one-half of the land; of the arable lands only a portion are irrigable, from the fact that there is not water to supply them all. It may be that when all the waters of the Rio Grande are used in Colorado and New Mexico and in the valley of El Paso, in Texas and the Republic of Mexico, from three to four million acres can be cultivated; but this can be done only by using all of the waters and storing all those that now run to waste. And then the irrigable lands must be properly selected, so that the waters can be used to the best advantage. That none may be wasted they must be stored where there is the least evaporation, and the lands must be selected near where they are stored, and the waters must not be permitted to run through sand valleys, where they are evaporated. They must be taken out from the streams and stored to the best advantage and used without waste. Then it may be possible to irrigate to the best advantage and used without waste. Then it may be possible to irrigate Of course the estimate is rough, because the sur- from three to four million acres. veys have not been perfected, and it may be too great; I do not think it is too small. Now the problem which you ask me to solve is this: How can these waters be used to the best advantage; how can they be divided among the best lands; and how can the rights of the present irrigators be maintained? I shall try to answer these questions, and certain collateral problems that are involved; and to do so, shall go over the ground again, district by district.

Commencing then at the head of the Rio Grande Valley, we first meet with the Saguache. This river sinks in the sands; except in very great floods it discharges no water into the Rio Grande. Its valley therefore is an independent district, one of the minor class; all that can be done in the Saguache district is to select the best irrigable lands and provide that the waters shall not be used where they will be largely wasted.

Then we have a district drained by the headwaters of the Rio Grande—a district, of the first class. All, or nearly all, of its waters can be used within the district on good lands, but they must be selected or the waters will be wasted. The district lies wholly within the State of Colorado.

The next district below on the river is the San Ildefonso. This is a trunk district and thus belongs to the second class. For 60 miles down below the Colorado line the river can not be taken out, as it runs in a cañon. The lands on either side are of little value and should be used only for pasturage and forest purposes. This upper portion of the San Ildefonso Valley is naturally the catchment area for the waters to be used in the valley below the mouth of Embudo Cañon. There are some creeks that come into this valley from the mountains on the east. This district, therefore, has a great catchment area which will supply a large quantity of water, which should be dedicated to the use of the farmers of the valley below. But they should understand that they can not maintain rights to use water coming from the San Luis district; that they should develop their agriculture wholly from the supply of their own catchment area. The best lands lie on either side of the river in the valley below Embudo Cañon and along sections of the eastern tributaries. These lands should be selected in sufficient amount to use all the water for irrigation, then there could be no controversy about the water-rights in the district. Settlers could not go upon the non-irrigable lands and illegally take the water; farming could be developed in the valley to the greatest extent and on the best lands, and the farmers would be secure from depredation by other farmers going above them and "pirating" the water—to use a term common in the western country.

Midway in this district, and at the head of the irrigable lands, the Taos joins the Grande. It is a fine stream and its drainage basin constitutes a district of the first class. All the waters of the Taos can be used in its own valley, and it should be established that the people of that district have a right to use all of those waters, and that the people in the San Ildefonso Valley below can never maintain the right to have those waters flow down to their valley; that the Taos Valley is not a part of the catchment area of the San Ildefonso Valley.

In the lower part of the San Ildefonso Valley the Chama joins the Rio Grande. The basin drained by this river constitutes a district of the first class. All its waters can be used at home, and it should be established that the people have a right to use them there, and that no right can be maintained to the use of its waters outside the district.

At the foot of San Ildefonso Valley the Rio Grande enters a deep cañon, known as White Rock Cañon for a course of 50 miles. Along this course it receives many important tributaries that drain high mountains. This mountainous region is in part covered wiih timber and in part with rich grasses, and it constitutes a catchment area for a district below. At the mouth of White River Cañon the waters can be taken out again and spread over a large valley. In this valley there are already a number of considerable towns. Albuquerque is the principal city, and we will call it the Albuquerque Valley, and the district, including the valley and the catchment area above, the Albuquerque district. It is, of course, a trunk district, and hence belongs to the second class.

Now, it should be established that the people of the Albuquerque district can not maintain rights to use water not caught within their district; that all the volume of the Rio Grande in the San Ildefonso above belongs to the people of that valley; that the only waters which the Albuquerque farmers can use and permanently maintain rights to are those falling from the heavens over their district. The irrigable lands of the Albuquerque district are in excess of the water supply. The nearer to the mouth of the White Rock Cañon they can be used, the greater the area that can be irrigated. Perhaps this district should terminate at Socorro. Perhaps it should go down to San Marcial. A careful topographic and hydrographic survey is necessary to determine this boundary. The district would at any rate be more than 150 miles in length, and it is a long sand basin. If the irrigable land should be selected in the southern end of the district, much of the water would be lost on its way; if it is selected in the northern end of the district, this water could be saved. The Rio Grande will irrigate 200,000 acres in the northern end of the valley. But there are lands already irrigated in the southern end of the valley, and their rights should be maintained, at least until they are justly extinguished. Doubtless this will ultimately be done. It is of prime importance that no more right be established in the southern region of the district.

To the east of the White Cañon lies Santa Fé Creek. It is a beautiful stream of water, and the region which it drains forms a district of the first class. Here the city of Santa Fé is situated, and the waters of the great creek are all used in irrigation during the summer months. An attempt has been made to store water, but it has proved a failure. The site of the reservoir was among hills that had been denuded of their forests and grasses, and the reservoir was destroyed by the enormous and rapid accumulation of debris. Other and better reservoir sites have been found where the forests are not yet destroyed. The farmers of the district should have control of these forests, or they can not greatly increase the area of irrigation in the district. The lands to be irrigated lie on a plateau in the neighborhood of the city and are already of great value. The principal catchment area is in high mountains where there are extensive forest lands and where there should be pasturage lands, but these are largely destroyed by overfeeding. The pasturage and timber lands greatly need protection in the interests of agriculture below.

Just above Bernalillo the Jemez joins the Rio Grande, and here we have another district of the first class. The Jemez now discharges a part of its waters into the sand, for there is a long stretch of dunes extending from Zia down to the Rio Grande. Still the river has a volume sufficient to carry part of its waters over the sands and discharge them into the Rio Grande. The catchment area is the Tewan Mountains and the Tewan Plateau, a lofty region covered with beautiful forests and rich grass lands yet uninjured by fire or overfeeding. The mountain meadows are abundant and beautiful, and the forests are among the best in New Mexico. The lands to be cultivated by this river lie on the mesa west of the Bernalillo and Albuquerque. The waters can be stored in the mountain meadows and elsewhere very cheaply, but it will be expensive to take the water across the sand dunes on to the irrigable lands of the mesa. The mesa itself and the catchment area both should constitute one district. The waters of the mountains should be attached to the lands of the mesa, and the right to use the water should permanently inhere there. The settlers in the valley of the Rio Grande should not be able to acquire rights to the waters, for in so doing they will be chiefly wasted. The catchment area is a volcanic district, and volcanic cinders and ashes abound; and these conditions make it necessary to carefully protect the lands, otherwise they will sink the streams and fill the reservoirs. The forest area is therefore chiefly valuable as a catchment area, and which should never be denuded of its trees.

The next stream is the Puerco, which comes in below from the west. It heads in the Nacimiento Mountains, on the western slope of the Tewan group. Along this range of mountains there are several beautiful streams that flow into a distant valley into the channel of the Puerco and here land in the sands and pass only in extreme floods into the Rio Grande. Practically it is a district of the first class. Its waters have been used in irrigation in the settlements near the mountains, which are, to some extent, well situated for such purposes. But farming is chiefly carried on in the valley of the Puerco, and in that region can not be permanently maintained to advantage. The rights to irrigate so far from the mountains must be permanently extinguished if the Puerco is used to the best advantage. The catchment area is the slope of a great mountain range covered with fine forests, and there are many good reservoir sites. The pasturage is also extensive, but the pasturage and the forests must be protected to save the agriculture. The irrigable lands of the Puerco should be carefully selected and no other lands should be cultivated. The reservoirs must be selected in the valleys and on the slopes of the mountains, where they will be subject to destruction by silting if the forests and grasses are not carefully preserved.

From Socorro southward to El Paso is a distance of about 200 miles by the river. There is already irrigation in the Mesilla Valley above El Paso, and there is also much farming below El Paso in Texas and the Republic of Mexico. Through much of the way from Socorro to the head of the Mesilla Valley the river cañons again, and there is a natural catchment area for the country below. This upper region should be declared the catchment area for the Mesilla Valley. At the mouth of this cañon there is a place called Point of Rocks, near Fort Selden. Now it is possible to take out all the waters of the Rio Grande derived from the catchment area above, which has already been described at this point, and there is land enough in the Mesilla Valley to use it. But this would cut off all the water from the El Paso Valley below. There is a short pass or gorge just above El Paso through which the Rio Grande runs. This divides El Paso Valley from Mesilla Valley. To maintain the rights of the present irrigators in Mesilla Valley and El Paso Valley alike, it becomes necessary to unite these two valleys into one district, and to divide the waters between them. There is water enough coming in the catchment area described to maintain all the agriculture yet developed and to increase it somewhat. How much we do not know, as the survey is unfinished. Nor do we know how to divide the waters. The El Paso Valley is partly in Texas and partly in the Republic of Mexico. The Mesilla Valley is in New Mexico. It is thus that the waters of the Rio Grande in this district must be divided between three peoples, and unless some authority steps in and makes this division the irrigators of the Mesilla Valley can take all the water and destroy all the farming below in Texas and Old Mexico.

The survey has developed the fact that we can store water with reasonable economy and in sufficient amount immediately above El Paso, at the gorge of which I have spoken, to supply the wants of all the farming in the valley below in both countries, and from the same reservoir an additional area can be served; but there is no wisdom in constructing this reservoir unless steps are taken to provide a catchment area for it, and to protect that catchment area from spoliation. It is thus that the El Paso problem can not be solved by the construction of a dam at El Paso and the establishment of a reservoir to hold water for the valley below. A catchment area must be provided, and on providing this the rights of the Mesilla Valley must be maintained. It is true that if the dam is constructed at El Paso now, flood waters in sufficient quantities will come down to serve present wants, but these flood waters can be caught above, and ultimately will be caught above, and it would be unwise to pay no heed to the ultimate conditions. How many years ere this will be I do not know. It will depend upon the rate of development, an uncertain factor. But schemes have been projected and begun in the Rio Grande Valley within the last eighteen months to take one-half of the ultimate supply of water. Most of these schemes have been projected without any proper consideration of the conditions to be met in order to utilize the greater amount of land. If they are completed and rights finally established on the ground selected, then one-half of the value of the Rio Grande Valley is forever destroyed. The rights and interests thus established will be so wasteful of water that the Rio Grande will sustain only one-half of its possible population. This statement is very conservative. It may be, and it is even probable, that the water will be able to do only one-third of its duty. And the Rio Grande is a fair illustration of the facts and conditions pertaining to every great river on the arid lands.

This, then, is needed in the Rio Grande Valley, that its agriculture may develop normally and that all rights established may be maintained: In each district the catchment area and the irrigable lands should be determined and defined. To define the irrigable lands it is necessary to measure the waters, in order to discover how much land can be used. Then the irrigable lands should be declared such, and the law should prevent any other lands being irrigated. Then the catchment areas should be defined, and settlement on the catchment areas for agricultural purposes should be prohibited, and the people farming on the irrigable lands should have a right to control the catchment areas and to protect and use the forests and grasses. Then, in each district the storage basins should be segregated and reserved from sale and occupation, so that they may not fall into the hands of speculators, whose rights would have to be purchased before the waters were stored; but the people who live in the district, as a body politic and corporate, should have a right to control these storage basins for the common use. The dam sites and the canal sites ought in like manner to be designated and preserved from sale to individuals and held for the common use of the people. By this plan the irrigable lands would be held in severalty by the people; the sites for reservoirs, canals, and dams, and the catchment areas would be held in common in such district. But in the El Paso district, in which the catchment area is in New Mexico and the Mesilla Valley, and a part of the irrigable lands in New Mexico and a part in the El Paso Valley of Texas and Old Mexico, some means must be provided to divide the waters. It is an interstate and an international problem; but the rights of all of the people now cultivating the soil must be maintained.

To define the districts a topographic survey is necessary; to define the catchment areas and irrigable areas, and to select the reservoir sites, canal sites, and dam sites, a topographic survey is necessary; to divide the waters a hydrographic survey is necessary, and a hydrographic survey is based upon and can be most economically made through the agency of a topographic survey. In selecting the lands in the headwater districts, they should be taken in regions low enough to have a good agricultural climate. In the trunk districts the land should be as near to the points where the waters are taken from the rivers by diverting dams as possible, that these lines may be the shortest and that the least water may be wasted. The reservoir sites, other things being equal, should be selected on the highest lands, where the evaporation is least. As far as possible, reservoirs should be maintained at the least cost and where the danger of destruction is least. The principal lines of canals should all be designated in advance, in order that impedimentary and obstructive rights may not be established. If these things were done in advance of more dense settlement, and then the people permitted to control their affairs in their own way—divide the water among themselves in each district as they please, protect and utilize their forests in obedience to their own judgment, corrected by experience as time goes on, use the pasturage for their flocks and herds, and protect it from destruction that they may thus use it—the arid lands would furnish homes to prosperous, peaceful, and happy people.

The above statement by the Director makes it clear how all the arid lands whose irrigation depends upon the use of the living streams can be divided into natural irrigation districts, so that each body of irrigable land, when properly selected, may have its own catchment area, with a definite and known supply of water on which its people may depend.

SECTION XXIV.

IRRIGABLE LANDS AND CATCHMENT AREAS INTERDEPENDENT.

If the irrigable lands are properly selected they will lie in solid bodies of cultivated fields and gardens, for in this shape they can be cultivated with the least expense and with the least waste of water. About these bodies of irrigable land will stretch pasturage and timber lands on every hand in the hills and mountains. These lands should not become the property of individuals, for they form the catchment areas for the waters needed to serve the irrigable lands, and require special protection for this purpose. The farmers also require the use of the fuel and lumber which the forests will afford, and should protect them from fire for that purpose. The farmers on the irrigable lands can also protect the pasturage and use it to advantage.

It is plain that the people primarily and fundamentally interested in the catchment area are those who cultivate the lands of the irrigable districts, and such people should have control of the catchment area with all its forests and grasses. The farmers are not only interested in the water supply of the catchment area, together with the forests and grasses, but they are also interested in the same area because their principal irrigating works must be constructed thereon. Away from their irrigable lands and on the catchment areas the headworks of canals must be constructed. There also the principal canals themselves must be dug, and there the reservoirs must be situated. In the mountains and on the foot-hills and high in the valleys and on the plains their waters are stored. The chief irrigating works, therefore, for the collection and storage of water, are on the catchment areas outside of the irrigable lands, while only the minor distributing works are on the irrigable lands themselves. It is thus that the real farming on the irrigable lands is largely dependent on the non-irrigable lands of the catchment area, and the farmers must have control of them in the interest of the agriculture which they carry on by irrigation. The best method to protect these in the interest of the farmers themselves is to let them remain as Government reservations for the purposes for which they are needed, and permit the people to protect and use them; and it is believed that these concessions to the districts should be made.

SECTION XXV.

INTERSTATE COMPLICATIONS.

It appears from the exposition that has been made of this matter, that some of these natural districts will embrace portions of two or more States. In most of these cases the catchment areas will be in one State and the irrigable lands in another. From this arises the most serious of complicating conditions, and it appears to make it necessary that the States themselves shall agree to the districting of the country by natural boundaries.

The States that are already organized in the arid lands claim the right to control the waters for irrigation and other beneficial purposes, and they assert this right in their constitutions; and in most cases these constitutions have been accepted by the General Government on the admission of the States from the Territorial condition. But the great body of the lands in these States still belong to the General Government, and these irrigable lands receive their chief value from the waters. The forest lands and pasturage lands almost wholly belong to the General Government, and the irrigable lands are dependent upon them for the water supply. It is thus that the States are alike interested with the United States in the lands and waters, but there seems to be a divided jurisdiction over them. This makes it necessary for the General Government and the State governments to agree on some wise and just policy.

The United States is interested in all of the questions which have heretofore been presented, first, because it is the chief owner of the irrigable lands, the forest lands, and the pasturage lands, and is the custodian of their values, which it seeks to distribute among the greatest number of people who engage in agricultural pursuits; second, because it is the guardian of interstate interests and rights, and must intervene whenever necessary to secure peace and harmony between the States; third, because the General Government is interested in the general welfare of all the people in whatever State or Territory they may abide.

The States are interested in all of these questions; first, because the prosperity of the people of each State largely depends upon the prosperity of the agricultural communities existing therein, agriculture being at the foundation of all industries; second, because each State and Territory is especially interested to protect those persons who are engaged in agriculture by the use of streams which have their catchment areas in other States and Territories; third, because each State is interested in preserving friendly relations with all other States.

The districts are interested in all of these questions because upon their proper solution depends the prosperity of each district—directly as that prosperity arises from successful agriculture, and indirectly as all other industries are more prosperous when agriculture is prosperous.

The individual farmers are all interested, first, in securing permanent and unchallenged rights to the waters necessary to fertilize their farms, that they may thus know the extent of their possessions, and may not be compelled to defend their rights in the courts at great cost, and that they may be relieved of the conflict and litigation which are rapidly springing up in all of the arid region.

It is thus that the United States, the several States and Territories involved, the irrigation districts, and the individual farmers are all in common interested in the solution of the problems which have been presented.

It is believed that the patriotism of the people inhabiting the States and Territories of the arid region will lead them to adopt the plan herein proposed in the interest of peace and harmony between the States, for it is a simple, practicable, and just solution of these interstate conflicts. And they will be more willing to take this action now than hereafter when great interests shall have grown up.

But there are other interests which will impel the States and Territories to acquiesce in the measure. The States that make such concessions of the catchment areas yield lands of small value for agricultural purposes, while the States that receive the benefits acquire water-rights of great value to them on their better lands. Nevada must support its agricultural population in its rich, warm, and salubrious valleys from the waters caught in the mountains of California; but it must yield catchment areas in its own mountains, where the lands are of little value for agriculture, to Idaho and Oregon, where they can be used on good lands. California yields mountainous catchment areas to Nevada, but receives in return the right to use the water of the Colorado River in the southern portion of the State, where several million acres of land will ultimately be redeemed thereby, and these lands will be the most productive in the United States. It will also receive important benefits on the north from Oregon.

There are still other reasons why the States will readily acquiesce, existing in the concessions made by the General Government to the States. By the proposed legislation the forests and the pasturage of each district are given by the United States to such districts. These are vast concessions. Under the bill the great forests of the Sierras will be given to the people of California—distributed among the irrigation districts whose sources of water supply are in those mountains.

It is true that there will be a class of men opposed to this legislation by the General Government who will also oppose the agreement by the States. These are the promoters of irrigation schemes—the great corporations that seek to control the waters and the lands. But the farmers themselves and the great body of the citizens of each State will not fail to discover the importance of this plan to the welfare of their people, and it can not be doubted that when the matter is fully understood the States will agree to the measure.

SECTION XXVI.

POPULATION OF THE PROVISIONAL IRRIGATION DISTRICTS.

Should all of these great values relating to the use of the water, the use of the forests, and the use of the pasturage be turned over to the people of the natural irrigation districts which have been described, it becomes important to know whether there are a sufficient number of persons to properly take charge of these affairs and to whom these great interests may be intrusted. Director Powell has prepared a series of maps, each one representing a great river basin, on which he has delineated, in a general way, most of the natural irrigation districts which have been heretofore described, and on this subject he has furnished to the members of the committee signing this report the following statement:

A careful study has been made of the arid region of the United States in which irrigation is dependent upon the utilization of the perennial streams, for the purpose of defining the natural irrigation districts in such a manner that every distinct system of irrigation shall be included in one district. A distinct system is composed of a catchment area and the irrigation works necessary to control the water of that catchment area, and the irrigable lands which the controlled waters will serve. In making a preliminary plan of these districts the provisions of the bill introduced by Senator Reagan, which defines how such irrigation districts should be outlined, has been used as the basis by which the districts have been provisionally delineated. It is not possible in the present state of geographic knowledge to outline all of the districts, and it must be understood that the outlines given on the maps presented to the committee and which appear with its report are only provisional. It is probable that a few of the districts will have to be divided; perhaps others can be consolidated. Especially in Montana and the western portion of the Dakotas are there areas where it is yet impossible to draw with confidence the lines of separation. The provisional districts, one hundred and twenty-nine in number, are presented in the following table. They are named in the main from the principal streams, and are arranged in groups by States, and the columns of the table exhibit the class to which each district belongs, as (1) headwater or (2) river trunk or (3) lost stream, the State or Territory in which it lies, and whether in one or more, and the population.

In many of the districts there are cities, and it has not been possible to differentiate the inhabitants of these cities from the agricultural people of the district in which they are situated, though the bill provides that such cities shall not be included in the irrigation districts.

The population is estimated, not by myself, but by officers of the Census Bureau, who are considering this matter for the purpose of arranging the work of enumeration. In order to distribute the work with approximate equality to the Census enumerators, the small districts they are to canvass are outlined with reference to the present distribution of population, and for this purpose a preliminary and detailed estimate of population is made by the supervisors of the Census. The figures of the table are based on this preliminary estimate.

There are one hundred and twenty-nine districts in the arid region. In the same area there are two hundred and thirty-five counties. In the States and Territories involved there are enough people in each county to effect a county organization, and the average district is nearly twice as large as the average county.

Provisional natural irrigation districts of the arid lands.

Name of district.	Class.	State or Territory.	Population.
Upper Arkansas	1	Colorado	[a] 68,500
Lower Arkansas	2	do	5,000
Fountain	1	do	[b] 20,000
Big Sandy	3	do	5,200
St. Charles	1	do	1,000
Huerfano	1	do	9,000
Apishapa	1	do	1,000
Purgatoire	1	do	[c] 15,000
Two Butte	1	do	2,500
Arikaree	1	do	11,000
Lower South Platte	2	do	22,500
Cache la Poudre	1	do	13,300
Big Thompson	1	do	3,000
Boulder	1	do	12,000
Clear Creek	1	do	13,600
Upper South Platte	1	do	[d] 142,500
Saguache	3	do	4,000
Rio Grande (San Luis Park)	1	do	14,000
Yampa	1	Colorado, Wyoming	3,300
Grand	1	Colorado	23,700
Gunnison	1	do	14,800
White	1	do	2,100
Dolores	1	do	10,200
San Juan	1	Colorado, New Mexico, Utah	15,000
Taos	1	New Mexico	[e] 7,000
San Ildefonso	2	do	[e] 10,000
Chama	1	do	[e] 8,700
Jemes	1	do	[e] 2,000
Puerco	1	do	[e] 6,000
Santa Fé	1	do	[e] [f] 10,000
Albuquerque	2	do	[e] 25,000
Mesilla	2	do	[e] 15,000
Mimbres	1	do	[e] 9,400
Salt River	1	Arizona	10,700
Bill Williams	1	do	300
Little Colorado	1	Arizona, New Mexico	14,300
Upper Gila	1	do	34,300
Lower Gila	2	Arizona	8,000
Colorado	2	Utah, Arizona	3,700
San Diego	1	California	[g] 36,000
Penisquitas	1	do	1,000
San Luis Rey	1	do	6,000
Los Angeles	1	do	[h] 100,000
San Bernardino	1	do	48,000
Mojave	3	do	1,000
Santa Clara	1	do	20,000
Santa Barbara	1	do	5,000
Santa Maria	1	do	11,000
Kern River	1	do	17,000
Tulare	1	do	20,000
Kings River	1	do	7,000
Fresno	1	do	20,000
Merced	1	do	21,500
Stanislaus	1	do	13,000
Tuolumne	1	do	12,000
Owens	3	do	3,000
Amargosa	3	Nevada	3,000
Quinn River	3	Nevada, Oregon	1,500
Humboldt	3	Nevada	19,000
Carson	3	Nevada, California	20,000
Truckee	3	do	[i] 18,000
Walker	3	do	3,000
Lake	3	Oregon	12,000
Des Chutes	1	do	13,000
Malheur	1	do	2,000
Umatilla	1	do	8,000
Grande Ronde	1	Oregon, Washington	5,300
John Day	1	Oregon	10,000
Owyhee	1	Oregon, Idaho, Nevada	3,500
Weser	1	Idaho	5,600
Payette	1	do	4,500
Boisé	1	do	11,000
Salmon	1	do	11,000
Wood	3	do	6,000
Bruneau and Raft River	1	Idaho, Utah	6,000
Lost River	3	Idaho	800
Clearwater	1	do	11,000
Cœur d'Alene	1	do	16,000

[a] Including Leadville and Pueblo.
[b] Including Colorado Springs.
[c] Including Trinidad.
[d] Including Denver.
[e] Pueblo Indians included.
[f] Including Santa Fé.
[g] Including San Diego.
[h] Including Los Angeles.
[i] Including Virginia City.

Provisional natural irrigation districts of the arid lands—Continued.

Name of district.	Class.	State or Territory.	Population.
Snake	1	Idaho, Wyoming	21,100
Bear	1	Idaho, Utah, Wyoming	31,400
Walla Walla	2	Washington	20,000
Crab Creek	3	......do	17,000
Ogden	1	Utah	a36,300
Salt Lake	1	......do	b86,200
Tooele	3	......do	6,000
Sevier	3	......do	22,300
Price	1	......do	800
Beaver	3	......do	12,400
Green River	2	......do	1,100
Fremont	1	......do	1,000
San Rafael	1	......do	400
Virgen	1	Utah, Nevada	5,300
Brown's Park	2	Utah, Colorado, Wyoming	1,000
Kanab	1	Utah, Arizona	1,700
Marias	1	Montana	1,000
Teton	1	......do	500
Sun	1	......do	2,000
Smith	1	......do	4,000
Missouri	2	......do	c25,500
Judith	1	......do	3,000
Deer Lodge	1	......do	d40,000
Jefferson	1	......do	12,000
Madison	1	......do	1,400
Gallatin	1	......do	5,700
Musselshell	1	......do	1,100
Milk River	1	......do	1,600
Yellowstone	1	Montana, Wyoming	8,000
Big Horn	1	......do	5,500
Rose Bud	1	Montana	500
Tongue	1	Montana, Wyoming	3,000
Powder	1	......do	5,500
Clark's Fork	1	......do	e
Knife	1	North Dakota	1,000
Heart	1	......do	7,100
Cannon Ball	1	......do	1,200
Grand	1	......do	1,500
Owl	1	......do	1,500
Little Missouri	1	North Dakota, Wyoming	1,100
Cheyenne	2	South Dakota	8,000
Belle Fourche	1	South Dakota, Wyoming	11,300
South Fork	1	......do	16,000
Sweetwater	1	Wyoming	1,000
Laramie	1	......do	10,000
Green River	1	......do	9,000
Black Fork	1	......do	800
North Platte	1	Wyoming, Colorado	10,300
Platte River	2	Wyoming	7,300
Lodge Pole	1	......do	2,600
Crow	1	......do	f11,000

a Including Ogden.
b Including Salt Lake City.
c Including Helena.
d Including Butte City.
e Unknown.
f Including Cheyenne.

SECTION XXVII.

THE SOLUTION OF THE PROBLEMS.

It is a question of profound importance whether all of these difficulties can be surmounted, whether conflicts can be avoided, whether agriculture in the arid lands can be permanently prosperous, whether the full service of the waters and the largest development of the agricultural industries of the country can be secured, and whether the unearned increment of values can be secured to the farmers. The members of the committee who sign this report believe that there is a simple and effectual way to solve all these problems. The subject of this report is one of great magnitude, for it involves vast interests and pertains to the prosperity of millions of homes now being rapidly established in the arid lands. It is therefore worthy of the most careful consideration of the statesman, for if wise institutions can be established for the regulation of this new industry in the United States, peace and prosperity will be given to millions of people; but if unwise institutions are developed the people will be plunged into conflict and ruin; the lands and waters of the arid West will be aggregated in the hands of the wealthy few and the farmers themselves will be but hired laborers. The members of the committee signing this report feel that a great responsibility rests upon them, and earnestly invoke from their fellow Senators a careful consideration alike of the problems which have been presented and of the solution of those problems which they now set forth.

The members of the committee signing this report have made a long and careful study of the problems presented in the arid lands affecting the industries of agriculture, and through them all other industries, and they have earnestly sought for some wise and just method by which these problems may be solved. They believe that such a method has been found; that the real solution is simple and obvious, and that the method which they propose will, if adopted, secure prosperity and peace to the farmers of the arid lands. This solution may be briefly set forth in the following manner:

It is proposed to have the entire arid region surveyed into natural irrigation districts in such a manner that each one shall have its catchment area and its body of irrigable lands dependent upon such area. It is then proposed to measure the waters of each catchment area for the purpose of finding how much land can be served in each irrigation district. It is then proposed to select the sites for headworks, canals, and reservoirs by which this water is to be controlled and to plan the irrigation works in the interest of the farmers and to estimate their cost. After ascertaining the amount of water and the amount of land which these waters will serve, it is then proposed to segregate and define the irrigable lands, in sufficient quantity, and no more, for these waters to serve, and to select them in such a manner that the greatest area can be irrigated, and that the best lands, as depending upon climate, soil, and subsoil, may be used, and so that the irrigating works may be constructed with the greatest economy. It is proposed, however, to include in such segregated and designated lands all lands that have heretofore been lawfully irrigated or for which irrigating works have been lawfully constructed.

It is proposed further that the designated waters of the catchment area shall belong to the designated lands of the irrigable area, and that the lands in each catchment area designated as pasturage and timber lands shall not be irrigated. This will fix water rights to lands in such a manner that every farmer will know his rights. It is also proposed to fix the sites of diverting works in river-trunk districts in such a manner as to prevent obstructive and improvident rights therein. In this manner it is also proposed to prevent the development of agricultural industries on lands where such industries can not be permanently maintained. It is also proposed to prevent the enormous waste of waters which is now almost everywhere found, by providing that the waters used shall be measured in quantities of water and not in quantities of land irrigated.

To distribute water values among the farmers and to prevent the creation of permanent water rights dissevered from the lands and in the possession of permanent corporations controlling these rights and perpetually taxing the farmers, it is proposed that the farmers may build their works in any of the following manners: First, by co-operative labor; second, by taxing the irrigated lands; third, through the agency of construction companies to be remunerated by the issuance of irrigation district bonds; and, fourth, through contracts with construction companies to construct the works and deliver the waters for a term of twenty-seven years, at the expiration of which time the works shall be the property of the irrigation districts; and it is proposed to properly guard the making of these contracts.

To administer such provisions it is proposed to constitute each irrigation district a body corporate and politic for specific purposes, and for no other, viz, those relating directly to irrigation and those relating indirectly thereto through the catchment areas where the forests and the pasturage are situated. It is proposed that each irrigation district shall have a board of irrigation commissioners to take charge of all matters relating to irrigation for the district. It is also proposed that each district have an irrigation district court, before which all questions relating to irrigation, the protection and use of the forests, and the protection and use of the grasses shall be submitted for adjudication; and it is also proposed that each irrigation district shall have a superintendent of irrigation with the necessary assistants, a superintendent of forestry and the necessary assistants, and a superintendent of pasturage with the necessary assistants. Equipped in this manner for local self-government relating directly and indirectly to irrigation, the districts will be in a condition to control all of these interests and regulate them by local self-government.

It is then proposed to turn over to the authorities of each district the right and duty to regulate the use of the waters of the district on the irrigable lands, the right and duty to protect and use the forests of the district, and the right and duty to protect and use the pasturage of the district in the interest of the people of the district. It is further proposed that the States and Territories themselves shall provide for organization of these bodies corporate and politic by State or Territorial laws, and that the States or Territories themselves shall provide general statutes controlling the use of waters within the limits prescribed by the United States, and controlling the protection and use of the forests and the protection and use of the pasturage—all under general conditions prescribed by the United States.

Cities and towns are growing up in the arid lands which are centers of mining, manufacturing, commerce, and transportation. These must have water for domestic and other purposes, and it is proposed to permit the States and Territories to designate the waters and the catchment areas which are necessary for these places, and to exclude such waters and catchment areas from the irrigation districts.

As all of these measures require action upon the part of the States and Territories themselves, and as concessions must be made by the States and Territories as well as by the United States to these districts, and as some of the natural districts must be situated in two or more States or Territories, it is proposed to obtain the consent and action of the States and Territories to all of those measures as set forth wherein divided jurisdiction may exist or be claimed; and it is not proposed to make the concessions to the districts and States and Territories until they agree to accept the rights and duties imposed, and also agree to make the necessary concessions to the districts themselves.

SECTION XXVIII.

THE NECESSITY FOR AN IRRIGATION SURVEY.

From the foregoing explanation it will be plain that an irrigation survey should be made by the General Government for the following reasons: First, the irrigation districts must be defined; second, the irri gable lands must be defined; third, the sites for irrigating works, as headworks, canals, and reservoirs, must be determined; fourth, the quantity of water in each irrigation district which can be used for irrigation must be determined, in order that the irrigable lands may be reserved in proper quantity, and in order that the works may be planned so as to control these waters; fifth, the works should be planned and the cost of the same determined for the information of the farmers.

The work of the Irrigation Survey, as shown by the Director, is properly divided into three parts: First, the topographic branch of the work, by which the catchment areas, headwork, sites, diverting-canal sites, reservoir sites, delivery-canal sites, and irrigable lands are discovered. Second, the hydrographic branch of the work, by which the streams are gauged to determine the volume of water which can be used for irrigation and which must be controlled in the reservoirs and carried in canals. It has the duty of determining the amount of evaporation from the reservoir sites, so as to discover what loss of water may be sustained through this agency. It also determines the duty of water, or the amount of water necessary to irrigate an acre of land, and it has various other functions relating to the waters. Third, the engineering branch of the work, by which the sites for headworks, the lines of canals, and the reservoir sites are surveyed for the purpose of making plans for such works and determining their probable cost. All of these things the statute directs.

The plan of the Director in organizing the Irrigation Survey, which plan he reported to Congress prior to the act authorizing it, and which plan was adopted by Congress in the act making the first appropriations for the work, appears to be wise, and in all its parts to be necessary to carry out the provisions of the statute. The Director has appeared before the committee and explained the operations of the irrigation work in detail, and he has exhibited many illustrations of the results of the work, and they appear to be of great value, and the survey seems to be conducted with economy.

The survey also seems to be conducted in the interests of the farmers themselves rather than in the interests of water companies. This fact has led to some criticism of the methods and results. In general, the water companies are disappointed because the statute provides for the reservation of the sites for works, including headwork sites, canal sites, and reservoir sites, and prevents their falling into the possession of monopolistic corporations. The statute also provides that the lands which can be irrigated by said works shall be withdrawn from the operations of the desert-land laws, the timber-culture laws, and the preemption laws, so that they can not be acquired thereunder; but it also provides that these same lands can be acquired as homesteads after proclamation by the President. This provision also seems to be obnoxious to companies and individuals desiring to acquire large tracts of land.

Whether these provisions of the statute are wise or not, the Director of the Survey, as an administrative officer, must be governed by them in the administration of the trust imposed upon him by the statute. Congress is responsible for these laws, including the statute of 1888, and those who believe they are unwise should seek their repeal directly by an appeal to Congress and not indirectly by seeking to annul them in destroying the survey necessary to execute them. Believing that the statute of 1888 is wise and for the interests of the people settling in the arid lands, and generally for the good of country, we earnestly recommend the continuation of the survey on the plans already adopted, and further recommend that proper appropriations be made so that the work may be performed efficiently and vigorously.

If the irrigable lands are segregated and the timber and pasture lands held as national reservations for the benefit of the agricultural and other industries of the country, it will not be necessary to extend the Land Office surveys over any but the irrigable lands. In this manner a great saving may be made, amounting to several times the cost of the Irrigation Survey as it is now conducted. Already great areas have been surveyed into ranges, townships, and sections where such surveys will never be needed. It is probable that the amount wasted in this manner would pay the cost of the irrigation survey.

The Director of the Survey was called on by the Appropriations Committee of the Senate to make an estimate of the cost of the irrigation survey, which he did, and such estimate was published with a report of the committee. In that statement the estimate was made that the total cost would be $7,000,000, of which amount $4,000,000 were for the topographic work and $3,000,000 for the remaining portion of the work; and it was further stated that the $4,000,000 for the topographic work would have to be expended for that same work for the geological survey, and if made for the irrigation survey the cost of the geological survey would be reduced to that extent. The work of the Irrigation Survey has now been in progress for two years, and the work actually accomplished shows that the estimate was reasonable and that it will cost no more than the estimate.

SECTION XXIX.

THE SURVEY NEEDED FOR THE SUBHUMID REGION OF THE GREAT PLAINS.

The general characteristics of the subhumid region have already been explained in section III. Its water supply is fourfold. There are running through it some large rivers, notably the Missouri, the Platte, the Arkansas, and many minor streams. A portion of the waters of most of these streams can be used in the subhumid region, and can not be utilized elsewhere; another portion will ultimately be cut off and used in the arid region to the west. The supply of stream waters is therefore limited, and will not serve great bodies of land except in North and South Dakota. The chief source of water supply for this region is to be found in the storage of the storm waters, and these waters are to be stored in small tanks or ponds on the several farms irrigated. The survey necessary to their utilization differs from that necessary for the utilization of the stream waters of the arid region. First, it is not necessary to reserve the sites, as they are small tracts scattered among the farms, and in general each man will own his own tank or pond site. Second, it is not necessary to reserve the canal sites, as they will only be small water-ways constructed on the several farms. Third, it is not necessary to segregate and reserve the land; each farmer can designate for himself the lands which will fall under the tank or pond, and which can be irrigated thereby.

The pump-well water will also be of value to the people, as is shown by the experience in agricultural irrigation in other regions of the world. To discover the geological formations which hold such water a geological survey is necessary. Finally, there are a few districts where artesian waters have already been found, and other such districts may be discovered, and such waters should be utilized, although their volume is small. But to discover the artesian formation a geological survey is necessary. A geological survey proper must necessarily be based upon a topographic survey. Therefore the present geological survey carries on topographic work, and this necessity is recognized in the statutes, and provisions for such work are made in the appropriation bills.

What the sub-humid region needs, therefore, is a geological survey furnishing a topographic map by which the farmers themselves can plan their small irrigation works, which will consist in the construction of small ponds or tanks on the farms themselves and in the digging of ditches to carry this water to the lands. It also needs a geological survey to point out the rock formations into which pump wells and artesian wells may be sunk. This is provided for by the existing statute, which authorizes a geological survey of the region, and thereby furnishes all of the information which can be given to the farmers who settle in the region.

The operations of the Geological Survey in the sub-humid region of the Great Plains were carried on very slowly until the Irrigation Survey of the arid region for the utilization of perennial streams was created. Thereupon the Director of the Survey withdrew a part of the force of the Geological Survey from the arid region and increased the work of the Geological Survey in the sub-humid region, in order to meet the agricultural wants of the people of that region at the earliest possible date. During the past year the topographic survey of this sub-humid region has been pushed with great vigor in two localities, the one in Kansas and the other in Texas. In Kansas an area of 12,000 square miles has been surveyed and the maps constructed, and in Texas an area of 6,000 square miles has been topographically surveyed and the maps also constructed; and the maps of both of these regions were placed before the committee, and the Director explained how these maps were to be used by the farmers, and how the necessary work was being done in this sub-humid region in the interests of agriculture. It is very important that this work should be completed at an early date. The region of country has already been settled from time to time, but the settlers have met with disaster, not recognizing the fact that irrigation is necessary for permanent prosperity. Before these regions are resettled, all of the facts should be known. It is therefore recommended that larger appropriations be made for work in this special region, so that relief may be given at the earliest possible day to these suffering farmers, and that future settlers may be informed of the conditions necessary to success and prosperity. No additional draft on the treasury will be needed for this, as the geological survey is already authorized by law and will be done in course of time. The appropriations should be increased and the length of time for the work shortened.

SECTION XXX.

LEGISLATION RECOMMENDED.

To accomplish these purposes a bill was introduced by Senator Reagan and referred to the Select Committee on the Irrigation and Reclamation of Arid Lands. It is numbered 2837. On a more careful consideration of this bill it is believed that it should be amended, and it will be given at the end of this report in its amended form, and its passage is recommended. The new bill is numbered 3769.

The purpose of the bill is to provide by legislation that all of the public domain which is valuable for agricultural purposes may be distributed among actual settlers who will themselves engage in farming. That these gifts of homesteads to the people may have their greatest possible value, it is proposed that the rights to use the waters of the arid lands shall be attached to these homestead lands and to none others. To make the homesteads of still greater value it is proposed to give to the farmers on the irrigable lands the right to use the forests, that they may protect them from fire and preserve the sources of water supply. It is also proposed to give these same farmers the right to use the pasturage of the grass lands. It is then proposed to turn over the whole subject of irrigation to the farmers themselves that they may construct the irrigating works or cause them to be constructed, and regulate the division of the waters on the irrigable lands in their own way. It is proposed that the General Government shall never be called upon to construct the works of irrigation, and that surveys only shall be made at the charge of the general Treasury.

SECTION XXXI.

ANALYSIS OF THE BILL.

In explanation of the bill the following statements are made:

Section 1 of the bill provides for a survey of the arid lands and their segregation into irrigation districts of three classes, viz, districts of the first class, or head-water districts; districts of the second class, or river-trunk districts; and districts of the third class, or lost-stream districts. It provides also that the boundaries of the districts shall be marked upon the ground, and that topographic maps shall be constructed, and that this work shall be done by the United States Irrigation Survey, which is an integral part of the Geological Survey.

Section 2 of the bill provides for the selection of the irrigable lands in each district, such selections to be governed by the following conditions, to wit: First, the conditions necessary to secure the greatest area of irrigable lands. Second, the conditions necessary, to secure for agricultural purposes the most valuable lands by reason of climate. Third, the conditions necessary to secure the most valuable agricultural lands as determined by soil and subsoil. Fourth, the conditions necessary to secure lands that can be irrigated and cultivated with the greatest economy.

Section 3 of the bill provides that lands already irrigated, or for which irrigation works had been constructed prior to the passage of the act of October 2, 1888, providing for the segregation of irrigable lands, shall be declared and deemed irrigable lands for the purposes contemplated in the bill. This provision is necessary to protect existing rights.

Section 4 of the bill provides that the works constructed in irrigation districts of the second class, or river trunk districts, must occupy the sites designated by the Irrigation Survey, for the purpose of protecting the water-rights of the several irrigation districts, and to prevent the construction of improvident or obstructive works; and it makes it unlawful to construct any other works in such districts. The wisdom of this has been explained as being necessary to prevent conflict between irrigation districts and waste of water.

Section 5 of the bill provides for a division of the waters between irrigation districts by assigning to each the waters of a designated catchment area, and prohibits the use of waters for irrigation on any lands but designated irrigable lands and town-site lands.

Section 6 of the bill provides that whenever any irrigation district, as planned by the United States Survey, shall fall within the domain of two or more States or Territories, the people occupying and cultivating the irrigable lands shall have a right to construct works of irrigation and maintain the same, although they may be situated in another State, and shall have a right to protect and use the forests and the pasturage in the interest of the cultivated lands; and that the right to use such sites, works, forests, and pasturage shall not be obstructed, and that it shall be unlawful to levy any tax on such waters, forests, and pasturage by the State or Territory wherein they are situate, provided that such States give their consent.

Section 7 of the bill provides that all of the lands belonging to the United States in any irrigation district shall remain the property of the United States, except the mining lands, which may be acquired by individuals under the statutes providing for the acquirement of such mining lands, and except the coal lands, which may be acquired by individuals under the statutes of the United States providing for the acquirement of such coal lands, and except such town-site lands as may be selected by the proper persons under the statutes of the United States providing for the acquirement of town sites. It also provides that the irrigable lands may be acquired by individuals through the agency of homestead settlement, as regulated by the United States statutes, in tracts not greater than 80 acres; and, finally, it gives to the farmers of each irrigation district the right to control the waters for irrigation purposes, the right to control the catchment areas for irrigation purposes, and the right to use and protect the forests and the pasturage on the public domain within the district.

Section 8 of the bill provides that every settler on a homestead tract shall have the right to use his proportional part of the water of the irrigation district in which his farm is situate, and shall have the right to use this water when controlled by the irrigating works, by paying his proportional share of the cost of such works; but it leaves it with the State or the districts to determine what this proportional share is, and how and when it shall be paid. This section is necessary to prevent the establishment of local laws that might prohibit settlement on the irrigable lands.

Section 9 of the bill makes it unlawful for any person or corporation to construct irrigation works in any of the districts, except such as are properly authorized.

Section 10 of the bill provides, in general terms, a method by which the irrigation districts may be organized, and requires such districts to provide a board of irrigation commissioners, who shall have general control of irrigation within the district; and to provide for an irrigation court to adjudicate questions relating to irrigation, the protection and use of the forests, and the use and protection of the pasturage. It also provides for a superintendent of irrigation in each district and the necessary assistants, for a superintendent of forestry and the necessary assistants, and for a superintendent of pasturage and the necessary assistants.

Section 11 of the bill provides that it shall be lawful for the commissioners of each irrigation district to provide laws and rules for the use of the waters belonging to the district on the designated irrigable lands, for the use and protection of the forests, and for the use and protection of the pasturage.

Section 12 of the bill provides that it shall be lawful for the States and Territories in which the irrigation districts are situate to provide, by general statutes, for the use of the water in the irrigation districts on the irrigable lands, and for other useful and beneficial purposes. It also authorizes the States and Territories to provide statutes to regulate the construction of irrigating works, under authority of the commissioners of the several irrigation districts, by any of the methods, to wit: First, by the co-operation of the people interested therein; second, by taxes levied on the lands irrigated; third, by the issuance of irrigation district bonds, the interest and principal to be paid by taxes levied on the lands irrigated; fourth, by granting to persons or corporations the right and imposing on them the duty of supplying water for irrigation and other beneficial purposes, through the agency of irrigation works, for a term of twenty-seven years, and by providing that the services of such persons and corporations shall be paid for by the users of the water at just and reasonable rates for measured quantities of water, and not at rates per acre or quantity of land irrigated, and by further providing that at the expiration of twenty-seven years from the beginning of the first service of water the rights and duties of such persons or corporations shall terminate, and all such irrigation works shall thereupon become and be the property of the irrigation districts to which they pertain. The States and Territories are also authorized to pass general statutes relating to the protection and use of the forests, and the protection and use of the pasturage—all to be in conformity with United States statutes.

Section 13 of the bill provides that it shall be lawful for any State or Territory in which irrigation districts are situate, to provide for the organization of a State or Territorial board of irrigation commissioners to supervise and approve all contracts made by the irrigation district commissioners for the construction and maintenance of irrigation works.

Section 14 of the bill makes it lawful for any State or Territory to define the boundaries of any city and to designate the waters to be used in such city for domestic, horticultural, and other purposes, and to exclude such cities and such waters from the irrigation districts.

Finally, section 15 of the bill provides for the consent of the States and Territories interested to this legislation, and refuses the rights and benefits to any State or Territory which fails to give its consent.

SECTION XXXII.

REMARKS ON THE BILL.

It will be noticed that the plan formulated in the bill calls on the General Government for no expenditure but that necessary to complete the surveys; that the whole cost of construction and maintenance of irrigation works is placed upon the several irrigation districts and there placed upon the lands irrigated. It also provides that water rights and land rights shall never be dissevered, and that the irrigation works shall from the first, or after a term of years, be the property of the farmers themselves who are the owners of the land. It also places in the hands of the people directly interested in the matter, namely, the farmers on the irrigable lands, the right to use the forests and the right to protect them from spoliation; and the pasturage lands are also turned over to the districts to be utilized in such manner as they may select. The bill provides all possible safeguards against the aggregation of lands in the hands of individuals and corporations, against the aggregation of water rights by companies, and against improvident contracts with companies for the construction of irrigation works. Finally, it provides a form of government for these districts, with legislative, executive, and judicial functions in harmony with the institutions of the country.

The bill asks and requires the consent of the States and makes it to their interest to give such consent; therefore the plan of the bill can meet with no objection from the most ardent adherent to States rights. And on the other hand it is believed that it will be satisfactory to those who believe in the paramount authority of the General Government.

There are minor provisions in the bill which perhaps are not absolutely essential parts, but which it is believed are important and obviously wise.

It will thus be seen that the plan proposes to relegate the whole subject of irrigation to districts, to be regulated and controlled by local self-government, and proposes that the General Government shall interfere in the matter to the least possible extent. It provides that all of the many complex problems which grow out of this new industry shall be solved by the people who are themselves directly interested, and it takes the precaution to turn over the question to such interested people and to no others. It obviates the necessity for any legislative, administrative, or judicial interference with the subject of irrigation by the General Government, but it does prescribe the district boundaries and it divides the waters among the districts and it segregates the irrigable from the non-irrigable lands. The General Government can not do less than this and do its duty to the people of the arid lands. It can not permit the public domain to be wasted through the acquirement of improvident and obstructive water-rights. It must interfere to prevent neighboring States from being plunged into conflict disastrous to the harmony of the country, and it is in duty bound to devise some means to provide for the protection of the forests and pasturage lands which are now being laid waste. It is believed that all these purposes will be accomplished by the bill if it becomes a law, and that it will insure prosperity and peace to the energetic and patriotic people who are settling on these western lands.

SECTION XXXIII.

THE METHOD OF DISPOSING OF THE WATER-RIGHTS AND THE LANDS OF THE ARID REGION IN THE BILL REPORTED BY THE MAJORITY IS NOT APPROVED.

The majority of the committee have reported and recommended for passage another bill, entitled "A bill to provide for the conservation and use of natural water supplies upon certain portions of the public lands of the United States, and for other purposes," and which is numbered 2104. The members of the committee signing this report dissent from the conclusions of the majority as to the propriety of passing the bill, and deem it their duty to present the reasons causing them to disagree with the majority. The objections to this bill are as follows:

(1) It seems to us to be in the interest of the great cattle companies that pasture their animals on the public domain, and opposed to the interests of the farmers who are making homesteads on the lands.

(2) It also appears to be in the interest of the great irrigation companies rapidly developing in the West, who seek to gain control of the land and the waters alike, and it practically excludes from ownership the poor man who settles upon the land for the purpose of obtaining a home.

Such a result is believed not to be in the interest of the great body of people settling in the country. To show that these conclusions are correct, the bill will be analyzed and its effects pointed out.

Section 1 declares "all natural waters not now otherwise appropriated found upon and within the public lands of the United States lying west of the ninety-eight meridian of longitude west from Greenwich" to be public property, "inalienable from and forever attached to the land for such beneficial uses as the States and Territories in which such waters are situated shall determine." It then goes on to declare that, "subject only to the paramount sovereignty of the United States for such beneficial uses," such waters "shall be placed under the authority of the State or Territory wherein said natural waters flow or are found, whether the same be running streams, lakes, pools, ponds, springs, or other surface bodies of water, or subterranean streams, pools, or underflows, produced by natural seepage and drainage within the areas affected by this act."

If the purpose of this section is to give the States power to control the waters to be used for irrigation within the States, it is unnecessary, as the States already possess and exercise that power. Most of the States of the arid region affirm their right to exercise this power in their constitutions, and most of these constitutions have been accepted and approved by the United States in admitting such States into the Union from the Territorial condition. But it appears that the real effect of this section is to assert the paramount sovereignty of the United States over the use of such waters for beneficial purposes. The clause is manifestly to be thus interpreted. The effect of the clause is made more apparent by an examination of the third section, which is as follows:

> SEC. 3. That access to natural waters within the section west of the ninety-eighth meridian aforesaid, which may be necessary to the direct support of man or *domestic animals*, shall never be denied, but such access to natural waters shall be and remain a permanent right of way, subject to rule and regulation by the State or Territory for such right of way, and for the prevention of trespass, unlawful occupancy, or spoliation in any way.

It appears that the effect of this section is to secure to the nomadic cattle and sheep companies the privilege of using the pasturage on the public lands, by securing to them rights of way to all watering places, "whether the same be running streams, lakes, pools, springs, or other surface bodies of water, or subterranean streams, pools, or underflows, produced by natural seepage and drainage within the areas affected by this act," in defiance of the authority of the States. The first section of the bill, which is declaratory, paves the way to this construction. The interests which this bill thus attempts to foster are opposed to the interests of the great body of farmers who are settling upon the lands. The ranching interests are largely in the hands of great companies operating with foreign capital. In general the owners and employés of these companies which infest the public domain drive their great herds of cattle and flocks of sheep over the land and destroy the pasturage and burn the forests. The flocks of sheep that roam over the mountains of California are destroying the grasses of the great sierra, and irresponsible herders are destroying the finest forests in the world with the fires which they wantonly kindle. To such interests is the bill under consideration dedicated.

Section 5 practically repeals the desert-land laws, the timber-culture laws, and the pre-emption laws, and to the wisdom of this we assent. The bill leaves the homestead laws unmodified, except as follows: It gives to the Commissioner of Irrigation—the incumbent of an office created by the bill—the power to determine from time to time the area of the homestead tract. This appears to us to be a dangerous power to give to one man.

The bill then provides for two classes of irrigation districts. In one class the territory to be included in each district is to be selected and defined by the water company. In the other class the territory to be selected and defined in each case is left to a community already existing, and it provides the means by which the area already irrigated may be increased and new homesteads acquired by settlers in such districts. The water company districts are to be organized under the provisions of the following clause in section 5:

> Whenever the proper authorities of any State or Territory shall present a survey and map to the Commissioner of Irrigation giving the boundaries of the irrigable land in a district which can be irrigated by one system, together with the reservoirs, lines of ditches, and other hydraulic works, and represent to said commissioner that the hydraulic works, including reservoirs, canals, and other improvements, which are for the common benefit of all the irrigable lands in such district, have been constructed and completed in a substantial manner and approved by the State or Territorial authorities, it shall be the duty of said commissioner to cause an examination to be made of such district and the hydraulic works constructed for the irrigation of the same, and if such hydraulic works shall be ascertained by him to be well and substantially constructed and suitable for the irrigation of the irrigable lands in such district, he shall approve the same and transmit to the Commissioner of the General Land Office a certified copy of such survey and map; whereupon the persons who have made lawful claims to any of such irrigable lands shall be allowed to prove up their claims and receive patents therefor: *Provided*, That the applicants for such lands shall have performed the acts required by the law under which the claims were made, but as to desert land claims heretofore made no further proof shall be required as to the desert character of the land or reclamation of the same.

Under this part of the section an irrigation company can construct the necessary head-works on any stream and divert the waters to a tract of unoccupied lands, and the members of the company and other favored and selected persons can file claims to these lands, and when the works are constructed all of these persons can get titles to their lands, but can not irrigate them except by the permission of the company owning the works. Thereupon the company may sell water-rights to the owners of these lands, who mortgage their farms to the company for amounts they can often never pay, and in the end the company will usually become the owner of both waters and lands. The settlers on the public lands will be wholly at the mercy of the water companies.

It will be noticed further that the proposed Irrigation Commissioner is given no authority to disapprove of such works except on the sole ground that they are improperly constructed. He is given no authority to determine whether they are in conflict with rights already established by communities or other companies; is not authorized to examine into the question of the volume of water supply which the works will command, to see whether the lands under the works can be actually irrigated or not. But if good works are constructed he must approve them whether the people on the lands irrigate them or not. To people who have not carefully studied the subject by observation and experience, a stream appears to furnish an almost boundless supply of water. But for irrigation large quantities are needed. On the average in the United States an acre of water a foot deep is needed every year to irrigate an acre of land—10,000 acre-feet to irrigate 10,000 acres of land; and the settlers actually going into the country do not properly understand this, nor do they know how to measure running waters to discover how much they will supply. Experience shows that by reason of this want of knowledge of the quantitative facts, irrigation works are often multiplied upon a stream beyond the necessity to control its waters. The cost of construction is incurred, but the water is insufficient to supply the lands which ought to bear it, and the lands which are actually redeemed are thus made to bear an inordinate expense.

That the effect would be to place the greater part of the irrigable lands of the arid region that are to be watered by streams under such companies is made very plain by the facts which have heretofore been presented in the statements made about the great numbers of irrigation companies already organized for this purpose under State and Territorial charters. But for the law of 1888, reserving sites and lands, almost all of the water rights would now be in the possession of such companies. In fact, in many regions these inchoate and speculative water rights are already far in excess of the water supply, and the effect of this clause of the bill which we are now considering is to confirm all of these charters and speculative rights, and to remove any obstruction to the aggregation of water rights in the hands of a comparatively few companies, most of which are organized on the basis of foreign capital and whose interests are in direct conflict with the interests of the settlers already in the country who are engaged in farming. Nearly every stream the seasonal flow of which is not fully used can be taken onto such districts, and all the water to be stored in reservoirs can be used in this manner; and in the main the companies are already organized to do it, and but await the hoped for action of Congress by which the legislation of 1888 shall be annulled. If the sites now reserved are turned over to the control of the States and Territories, these States and Territories have already disposed of them to companies, and that result is effected by the bill.

That this is the real purpose and effect of the bill is made plain in the report of the majority, in which they state that they will move the following amendment to the bill:

> That so much of the act of October 2, 1888, entitled "An act making appropriations for the sundry civil expenses of the Government for the fiscal year ending June 30, 1889, and for other purposes," as reserves "all the lands made susceptible of irrigation by the reservoirs, ditches, or canals," mentioned in said act, is hereby repealed; so that the reservation in said act shall only include all the land which may, after the passage of said act, have been or may hereafter be designated or selected by United States surveys for sites for reservoirs, ditches, or canals for irrigation purposes. And bona fide claims, made since the passage of said act, to land within the reservation hereby repealed shall not be defeated or affected by said act: *Provided*, That the diversion of water at high altitudes, where all the agricultural crops produced in the same latitude in the valleys below do not mature, shall confer no prior rights to the use of such water as against persons below who appropriate the water to irrigate land more suitable for homestead settlement, unless such diversion shall be approved by the Commissioner of Irrigation.

It has already been shown in Sections XVIII and XXI that speculative rights and charters to nearly all the stream waters of the arid region have been acquired by squatter title and official State filings and charters in defiance of the statute of October 2, 1888, and since that time, and by this amendment it is proposed to directly confirm all of these speculative and charter rights, and to put into the hands of a comparatively few corporations all of the unused waters of the arid region.

It must be further explained that this provision could be used by the settlers themselves, who might go upon the unoccupied lands as colonies and organize themselves into companies to construct the irrigation works had they the capital necessary for the purpose. The provision might thus serve a valuable purpose had not the companies already prevented it by obtaining inchoate charters and rights under local laws. But promoters, tempted by the prospect of large remuneration, have already in most cases, and would in all others, seize upon the waters, and thus the agriculture of more than two-fifths of the area of the United States would fall into the control of such companies.

But there are still small tracts of land situated in neighborhoods where irrigation has already been developed, and provision is made for the settlement of these tracts and their redemption by irrigation in the sixth section of the bill, which is as follows:

> SEC. 6. That whenever, under the authority of any State or Territory, an irrigation district shall have been organized and the qualified electors thereof empowered to levy taxes, charges, or assessments upon public and private lands situated in such district for the purpose of constructing hydraulic works for the common benefit of the irrigable lands therein, the irrigable lands of the United States in such district shall be subject to the same taxes, charges, and assessments as are so imposed upon other public lands and land belonging to private individuals; and persons who shall thereafter acquire title to lands from the United States in such district shall take the same subject to the said taxes, charges, and assessments, which shall be a lien upon such land, the payment of which may be enforced after such title is acquired from the United States in such manner as shall be prescribed by the State or Territory in which such district is situated: *Provided, however*, That before such taxes, charges, and assessments shall be chargeable against the public lands of the United States, or be a lien thereon, the rate and amount thereof shall be approved by the commissioner of irrigation of the United States: *And provided further*, That the United States shall not be liable for such taxes, charges, or assessments.

This section provides for the expansion of the area of irrigation in districts already settled by giving the people who live in such districts the right to construct works and to charge a portion of the cost to the unoccupied lands of the public domain, and making such charges a lien upon the lands inoperative as long as they are held by the General Government, but immediately operative when they pass into the hands of individuals. The settler entering upon such a tract of land could not make the homestead without using the water, and he could not get the water onto his land until he had extinguished the mortgage for a sum including the share of the original cost of the works and the accumulated taxes. If this would not prevent the settlement of such lands it would at least prevent their settlement by poor men. Men of wealth might acquire titles to such lands, but they would usually be unwilling to make bona fide homesteads thereon, and their compliance with the provisions of the homestead act would necessarily be but nominal.

Section 7 provides that irrigation districts may be organized in two or more States and Territories by the agreement and consent of the States and Territories involved, and it further provides, that if any State or Territory does not assent to and approve the organization of such irrigation district the people may still proceed with their organization under the authority of the State or Territory in which the principal body of irrigable lands are situated, but it does not protect the district from unfriendly legislation and the obstructive acts of the dissenting State or Territory, nor does it seem probable that the General Government has the constitutional right to provide such protection.

It may be noticed that the irrigation districts provided for in this bill are not the natural districts for which the bill recommended by the minority provides. Under the bill recommended by the majority, two classes of districts are provided with artificial boundaries. The one includes tracts of land and sites for works where such sites and lands are not already occupied, and the bill virtually puts these under the control of water companies. The second class of districts which it provides relates to regions where settlement is already made and where irrigation is already practiced; and provides that any such district may grow by new settlement on the lands which are mortgaged for works and taxes, and practically excludes poor men from such homestead lands.

SECTION XXXIV.

THE CREATION OF A NEW BUREAU OF IRRIGATION IN THE AGRICULTURAL DEPARTMENT UNNECESSARY AND UNWISE.

Section 8 of the majority bill provides for the organization of a new bureau in the Agricultural Department, at the head of which shall be an officer styled the Commissioner of Irrigation. It also provides for a chief clerk, and for "a sufficient number of engineers, clerks, and other employes to execute such laws relating to irrigation, as have been or may hereafter be passed by Congress, and to perform such duties as shall be prescribed by the Secretary of Agriculture." It seems not to create a new irrigation survey, but only a new bureau, with officers sufficient to determine the proper size of the homestead tract from time to time, to examine and approve or disapprove of certain "taxes, charges, and assessments" against the public lands, and with engineers sufficient to examine the works after they have been constructed by irrigation companies and approve or disapprove of them. But it provides further that "all surveys, maps, and reports relating to irrigation, of record or on file in any department of the Government, shall be transferred without delay to the Secretary of Agriculture." It thus appears to contemplate the discontinuance of the present irrigation survey, though it does not provide for it by repealing its organic act. The purpose of the bill in this respect seems to have been more clearly set forth in the report submitted by the chairman of the committee.

The report presented by the majority recommends that the topographic work be discontinued and that the hydrographic work be given to the Signal Service; but it is silent on the subject of the engineering work. It is perhaps the effect of the bill and the report to discontinue the irrigation survey, and in lieu thereof to create a new bureau to determine from time to time the size of the homestead tract, to examine and approve or disapprove of certain "taxes, charges, and assessments" against the public lands, to examine and approve or disapprove of works, and "to execute such laws relating to irrigation as have been or may be hereafter passed by Congress."

The signers of this report believe that the present irrigation survey should be continued, that the work which it is performing is necessary and useful, and that it is doing the work in the most economic manner consistent with the proper conduct of the work and the accomplishment of valuable results. They therefore recommend its continuation, and urge the importance of making the necessary appropriations to complete the survey without great delay.

An artesian-well survey is recommended, and it seems to be the purpose to place this under the direction of the proposed bureau of irrigation. But an artesian-well survey is in all essential particulars, if properly conducted, a geological survey. Two geological surveys would seem to be unnecessary, a multiplication of organizations for the same function, which would involve increased expense, and rival geological surveys would thus be created. It is probable that the next step undertaken would be to destroy the present organization.

The effect of the bill reported by the majority is not plain in relation to the survey, but in the light of the report it seems probable that the purpose is to connect with the bureau of irrigation a survey to select sites and make plans for works, and an artesian survey to make investigation in relation to subterranean waters, and to do the work in part by a geological survey and in part by the experimental boring of wells. It is also proposed in the report, but not in the bill, to make a hydrographic survey through the agency of the Signal Service. Thus the work is to be divided among three organizations: The topographic survey, under the Geological Survey; the irrigation survey, under the bureau of irrigation, by faulty and enormously expensive methods for the discovery of sites through the agency of trial lines; and the hydrographic survey, under the Signal Service. Under this provision the irrigation survey would in part be a duplicate of the present Geological Survey. Such is the mixed system of administration which the bill and the report together provide. It is believed that the work done in this manner would be inefficient and greatly expensive.

SECTION XXXV.

THE DIRECTOR OF THE SURVEY HAS NOT MISAPPLIED THE APPROPRIATIONS MADE FOR THE IRRIGATION SURVEY.

The following statement, made in the report of the majority is incorrect and unjust:

> Subsequently the whole subject was turned over to the Director of the Geological Survey with general provisions for the classification of the public lands, he having previously prepared a valuable report on the arid lands of the United States. The most important action by the Government in aid of the reclamation of desert lands was the passage of the acts of October 2, 1888, and of March 2, 1889. By the first of these acts $199,000 was appropriated for topographic surveys, and $100,000 for surveys pertaining to irrigation. Of the sum appropriated for irrigation $60,000 was diverted by the Director from that purpose and added to the appropriation for topographic surveys, making the sum of $259,000 for topography and leaving only $40,000 for irrigation.
>
> By the act of March 2, 1889, $200,000 was appropriated for topographic surveys, and $250,000 for irrigation surveys. Of the sum appropriated for irrigation surveys $120,000 was diverted from that purpose by the Director and added to the $200,000 for topographic surveys, making the aggregate of $320,000 for topography, and leaving only $130,000 for irrigation surveys and the office and other expenses incidental thereto. Your committee regard this as a plain violation of the statute and a misapplication of the money.
>
> * * * * * * *
>
> The provision of law authorizing this last appropriation sets forth in some detail the purposes to which it is to be applied, etc. Among those purposes it mentions "the necessary maps." The Director of the Survey has construed the words "necessary maps" to mean topographic maps of the same kind as those that are provided for specificially in the first item of $200,000, and he has applied more than half the irrigation item to that purpose, leaving less than half of the $250,000 for the objects for which it was intended.

It is thus by implication made to appear that the topographic survey for which $199,000 was appropriated on October 2, 1888, and for which $200,000 was appropriated on March 2, 1889, was for the irrigation survey, when in fact, as the act itself shows, these items were designed to be used in making maps for the Geological Survey. The topographic survey made under the appropriation for the irrigation survey was a part and parcel of such irrigation survey, made in the interest of the irrigation survey, and by distinct authority of law. Prior to the creation of the irrigation survey the Geological Survey had been in progress many years, and was making topographic maps in various States and Territories, being authorized to make such maps for geological purposes. The regions where this work was in progress were scattered about the country from the Atlantic to the Pacific, and as it was a geological survey, mining regions were selected for the theater of operations.

When the Irrigation Survey was created by act of Congress, it was not proposed to interfere with or change in any manner the operations of the Geological Survey and the topographic work connected therewith. The work went on in the usual manner, unaffected by the statute creating the irrigation survey. The topographic work still went on in Maine, in Texas, and elsewhere throughout the country. One hundred and ninety-nine thousand dollars was appropriated by the act of October 2, 1888, for these topographic surveys forming a part of the Geological Survey, and $200,000 in the following year, and the work went on as usual thereunder. By some singular oversight, which a glance at the act would have at once corrected, the majority of the committee have concluded that this appropriation was made for topographic surveys connected with the irrigation survey—a mistake which it is impossible to explain. In the same act, viz, the sundry civil appropriation act, there was another paragraph making an appropriation for the work of the irrigation survey of $100,000 in the following words:

> For the purpose of investigating the extent to which the arid region of the United States can be redeemed by irrigation, and the segregation of the irrigable lands in such arid region, and for the selection of sites for reservoirs and other hydraulic works necessary for the storage and utilization of water for irrigation and the prevention of floods and overflows, and to make the necessary maps, including the pay of employees in field and in office, the cost of all instruments, apparatus, and materials, and all other necessary expenses connected therewith, the work to be performed by the Geological Survey, under the direction of the Secretary of the Interior, the sum of one hundred thousand dollars or so much thereof as may be necessary. And the Director of the Geological Survey, under the supervision of the Secretary of the Interior shall make a report to Congress on the first Monday in December of each year, showing in detail how the said money has been expended, the amount used for actual survey and engineer work in the field in locating sites for reservoirs and an itemized account of the expenditures under this appropriation. And all the lands which may hereafter be designated or selected by such United States surveys for sites for reservoirs, ditches or canals for irrigation purposes and all the lands made susceptible of irrigation by such reservoirs, ditches or canals, are from this time henceforth hereby reserved from sale as the property of the United States, and shall not be subject after the passage of this act, to entry, settlement or occupation until further provided by law:
>
> *Provided*, That the President may at any time in his discretion by proclamation open any portion or all of the lands reserved by this provision to settlement under the homestead laws.

When the first appropriation for the irrigation survey was made, the sum was $100,000, and it is charged that of this amount more than one-half has been misapplied by the Director, a charge so baseless that it is difficult to understand how it could be made with sincerity. The appropriation was made to do a number of specified things, and this is one of them "to make the necessary maps." To make maps a topographic survey is necessary—topographic surveying is map-making. That this is the correct construction of the law is made plain by the history of its enactment. The irrigation survey was created by an act approved March 20, 1888. On March 27, just seven days after, the following resolution passed the Senate:

> *Resolved*, That the Secretary of the Interior is hereby directed to report to the Senate what appropriation is necessary to enable the United States Geological Survey to carry into effect the joint resolution "directing the Secretary of the Interior by means of the Geological Survey to investigate the practicability of constructing reservoirs for the storage of water in the arid region of the United States and to re-

> port to Congress," approved March 20, 1888, and the several acts of Congress requiring such Geological Survey, under the direction of the Secretary of the Interior, to classify the public lands and furnish a map or maps showing the various divisions of the public domain suitable for agricultural, mineral, and other purposes; and particularly to segregate the lands susceptible of irrigation where irrigation is required from other lands, and designating places for reservoirs, canals, and other hydraulic works.

By this resolution the Secretary was directed to make estimates for the irrigation survey which should include estimates for "a map or maps." In reply thereto the Secretary transmitted a letter from the Director of the Geological Survey, making such estimates and submitting a plan for the survey. From the plan the following quotation is made:

> To determine for a given stream, or for a given group of streams treated collectively, first, the maximum area of farming land and its most advantageous selection; second, the best selection of sites for reservoirs and their proper size; and third, the best system of head-works and canals, there are three general requisites, as follows:
>
> (a) The construction of an accurate topographic map, with grade curves at such intervals as will properly represent the configuration of the ground.
>
> (b) The determination of the total annual discharge of water from the catchment basin, or where there are more than one, from each catchment basin, and the distribution through the year of that discharge.
>
> (c) An examination of the soils in the area from which, under existing topographic conditions, the selections of lands for irrigation must be made.

This document, which outlines the plan for an irrigation survey, is worthy of an examination. A full and plain statement is made therein of how an irrigation survey should be conducted, and after setting forth the matter fully, the Director closes with the following:

> Impelled by these considerations, I respectfully recommend that an appropriation of $250,000 be made for the first year's work, and would suggest the following clause for the appropriation bill:
>
> For the purpose of investigating the extent to which the arid region of the United States can be redeemed by irrigation, and the segregation of the irrigable lands in such arid region, and for the selection of sites for reservoirs and other hydraulic works necessary for the storage and utilization of water for irrigation, and to make the necessary maps, including the pay of employés in field and in office, the cost of all instruments, apparatus, and materials, and all other necessary expenses connected therewith, the work to be performed by the Geological Survey, under the direction of the Secretary of the Interior, the sum of two hundred and fifty thousand dollars.

It will thus be seen that having explicitly stated that a topographic survey would be necessary, he made estimates for its prosecution in these words: "and to make the necessary maps." It will also be observed that the entire paragraph submitted by the director was incorporated in the statute after he had explicitly and fully explained its purpose, and after his statement had been submitted to the Senate and printed as a public document and referred to the Appropriations Committee.

This would seem to furnish a thorough vindication of the action of the Director of the Survey. He had fully explained that a topographic survey was a necessary part of an irrigation survey; he suggested a clause for the appropriation act which should authorize and direct him to make that topographic survey as a part of the irrigation survey, and the suggested clause was incorporated into the statute.

But the history of this matter does not end here. The Appropriations Committee of the Senate summoned the Director of the Survey to appear before it to explain his estimates, and an explanation was made of this particular thing in language singularly plain and simple, and the statement of the Director of the Survey was published by Congress as a part of the report of the Appropriations Committee as an explanation made by that committee of its reason for recommending the appropriation. The Director explained that he was already making a topographic map of the entire country in obedience to the provisions of the law, and that ultimately, after many years at the rate of progress then made, it would be finished, and that an irrigation survey could thereafter be made at a small expense; but if it was necessary to make the irrigation survey at once, it would be necessary to make a topographic survey in connection with it.

The following quotations are made from the report submitted by Mr. Allison from the Committee on Appropriations, Fiftieth Congress, first session, Report 1814, to accompany bill H. R. 10540.)

By the CHAIRMAN:

Q. Are you through with your general statement?—A. Yes, sir; but I want to speak something about the cost.

Q. That is what we want to hear you upon.—A. To complete the survey as we have been going on, without laying out the reservoirs, without laying out the sites for head-works and canals and so on, would take about $5,000,000. We have expended about $1,000,000, so that it would now take about $4,000,000 to complete that work.

By Mr. BECK:

Q. And what length of time?—A. At the rate we have been going on it would take between thirty and forty years.

Q. With ample means how long would it take?—A. It could be done in ten years.

Mr. STEWART. Is it necessary to wait until you work up all the geological data in order to make the preliminary survey with a view to reservoirs?

Mr. POWELL. No, sir.

Mr. STEWART. That only refers to the local topography?

Mr. POWELL. To the construction of the maps.

The CHAIRMAN. Major Powell is speaking only of the topographical survey.

Mr. STEWART. No, of the geological.

Mr. POWELL. Not of the geological, but the topographical survey which we are conducting over the country.

Mr. STEWART. Can you not vary your survey so that these reservoirs can be located more rapidly than that?

Mr. POWELL. We can, with the necessary appropriations. We could do it in six years if sufficient appropriations were made.

Mr. STEWART. You could locate the reservoirs in five or six years?

Mr. POWELL. Yes, sir; we could make the maps, outline the catchment ba[illegible] and lay out upon the ground the head-works, the canals, and the reservoirs in six years, with sufficient appropriations.

Mr. STEWART. Do you not regard that as the most urgent work?

Mr. POWELL. Yes, sir.

Mr. STEWART. Because then settlement can take place, and the geological part of the work could go on afterwards just as well.

Mr. POWELL. Oh, yes. We are pushing the topography very far ahead of the geology all the time.

Mr. STEWART. Then, if you had the requisite appropriations you could locate the reservoirs and make the surveys for settlement in five or six years?

Mr. POWELL. Yes, but it would take about $5,125,000 to do it.

By the CHAIRMAN:

Q. At the rate of about $1,000,000 a year?—A. That is my estimate.

Q. That would complete the topography?—A. It would complete the topography. I have made a second estimate. I have been working the last three days on [illegible]

Q. It would complete the surveys of the basins and districts?—A. Yes, the catchments.

Q. And locate reservoirs, canals, and so on?—A. Yes, sir.

Q. In other words, the additional cost of this contemplated survey would be about a million and a quarter dollars over and above what you are now doing in the way of topography?—A. Precisely.

The CHAIRMAN. It will cost $4,000,000 to complete this area?

Mr. TELLER. Anyhow.

Mr. POWELL. Anyhow, for topography.

Mr. HALE. And it would take thirty years the way they are doing it now.

By the CHAIRMAN:

Q. Of course topography is the first thing?—A. Topography is the first thing.

Q. It is the essential thing?—A. And the chief cost.

Q. If you run this whole area into a six years' term, you must spend your $4,000,000 for topography, and then the remainder of the work can be done for a million and a quarter?—A. It could be done for a million and a quarter, according to my estimate, and could be done *pari passu* with the other work.

By Mr. HALE:

Q. In round numbers it would cost about a million dollars a year?—A. About a million a year; but we could not use a million this year, because the engineers are not trained yet; they would have to grow.

Thus it was with a full understanding by the members of the Appropriations Committee, and by the chairman of the present Irrigation Committee, who was present at the interview, that this appropriation of $100,000 was made to be chiefly expended in topographic work. It will be remembered that this appropriation was made on the 2d day of October, 1888. On the 30th day of December following the Director made a report to Congress on this subject, which was printed and referred to the Appropriations Committee for their information. It is a document of twelve pages. In it the Director reports fully how he has inaugurated the work of the irrigation survey, and how he is using a part of this $100,000 in topographic work. The following quotation is made from this report:

> The necessary topographic work was placed under the charge of A. H. Thompson. A number of topographers already employed in the Geological Survey were selected as his chief assistants, and the force was largely increased by the employment of temporary field assistants, but no increase of the permanent corps was made. Under the direction of Professor Thompson the following described work has been done:
>
> ### WORK IN MONTANA.
>
> Work was commenced on the Continental Divide at the headwaters of the Columbia and Missouri Rivers early in October, one party surveying on the Columbia River side and another on the Missouri River side. The whole was under the immediate charge of Mr. E. M. Douglas. An area of 2,200 square miles has been surveyed. The topographic features of this country were delineated, the courses of the streams and the sites of all considerable bodies of water were ascertained, and the altitude, position, and general character of irrigable lands were determined. This is a region of abundant perennial streams, and many sites favorable for the establishment of storage reservoirs have been surveyed.
>
> ### WORK IN NEVADA.
>
> Early in November Mr. H. M. Wilson, with the parties under his immediate charge, previously engaged on topographic work in the gold-belt region of central California, was transferred to Nevada, near the headwaters of the Truckee, Carson, and Walker Rivers, and immediately began the work of an irrigation survey. This is a region where mountain waters are in great abundance, but where lands to which they can be economically conveyed are limited in extent. Up to the present time the survey of an area of about 800 square miles has been completed. Work will be continued as late into the winter as the season will permit and resumed early in the spring of 1889.
>
> ### WORK IN COLORADO.
>
> In the latter part of October, and immediately on the passage of the act, a party in charge of Mr. Anton Karl commenced work on the South Platte River. The season was too far advanced to enter the mountain region, so the survey was confined to the foot-hills and the plains extending eastward, embracing the city of Denver and a portion of the great agricultural district of Colorado. About 1,400 square miles have been discovered.
>
> In this region the waters of the South Platte are already employed in the irrigation of many districts, and the entire volume of the river during the irrigating season is utilized in serving the lands for agricultural purposes. The future development of agriculture in this country is dependent partly upon such an improved construction of irrigating works as will prevent waste and loss, but chiefly upon the construction of reservoirs to hold the waters which through the remainder of the year now flow to the sea without performing their duty to agriculture. The topographic work in this region is now suspended, as it can not be economically carried on in the winter, but it will be resumed in the spring.

Early in October a large party, under charge of Mr. W. D. Johnson, was sent to Colorado to operate in the valley of the Arkansas, and work is being prosecuted with vigor. An area of about 1,500 square miles has been surveyed. It embraces some regions which have already been redeemed by irrigation, but which can be further developed by better utilization of the great flow of the Upper Arkansas and by the storage of waters in the higher mountains and the foot-hills. The upper portion of the Arkansas, unlike that of the South Platte, is well adapted to this purpose, as there are many valleys, morainal lakes, and basins that can be economically utilized for storage basins. On the South Platte much of the stored waters must be held in lakes created in the foot-hills and on the plains, while the waters of the Upper Arkansas can be held high in the mountain lands, where in many ways the conditions are more favorable and the engineering problems less difficult.

WORK IN NEW MEXICO.

At the time of the passage of the act above mentioned, parties under Mr. A. P. Davis were at work in New Mexico, making topographic surveys of certain mountain regions. These surveys were on methods adapted to the purposes of the irrigation investigation, and it was therefore only necessary to enlarge the scale and extend the work into districts of irrigable lands. The entire work of the season is therefore available. The region embraced is that drained by the Jemez River and other tributaries of the Rio Grande rising in the Tewan group of mountains. The most northern river of this series is the Chama, which has its confluence with the Rio Grande above Santa Fé. The most southern is the Puerco, having its confluence with the Rio Grande below Albuquerque, and between these rivers the Jemez and other streams join the Rio Grande. At the writing of this report an area in this region has been surveyed topographically having an extent of about 6,000 square miles.

From the above it will be seen that, although the act for the irrigation survey was not signed until October, and the season favorable for surveys in middle latitude was almost past, yet the work was immediately pushed with vigor, so that at the close of the calendar year five considerable tracts of country have been surveyed—one in Montana, another in Nevada, a third in the Platte Valley of Colorado, a fourth in the Arkansas Valley of Colorado, and a fifth in the drainage basin of the Rio Grande, in New Mexico.

After the Director had thus reported to Congress that an irrigation survey needed a topographic survey, had drafted a clause in such a manner as to authorize and direct that a topographic survey should be included in the irrigation survey, and had appeared before the Committee and explained the matter fully, the clause was incorporated in the bill and finally became a part of the act that was signed by the President. Thereupon, in good faith, and in compliance with the law, the topographic branch of the Irrigation Survey is organized and its work is begun, and thereupon the Director reports to Congress what he has done, and fully and elaborately sets forth where and how he is doing this topographic work.

Still this history continues. The Director made a second estimate for an appropriation for the Irrigation Survey, in the same terms in which the first appropriation was made, and once more he was called before the Senate committee to explain his estimates. On this occasion he appeared with samples of his work, a topographic map and plans for reservoirs and canals, and he explained them to the committee, virtually saying, "This is what I am doing with the funds intrusted to my charge." The statement made on this occasion by the director was recorded by a stenographer and incorporated in a report of the committee to the Senate, and printed as a part of that report. (See report submitted by Mr. Allison before the Committee on Appropriations, Fiftieth Congress, second session, No. 2613.)

From a long and interesting statement made by the Director on that occasion the following extract is given:

The CHAIRMAN. Now go back a moment to this map. What will it cost the Government to locate the reservoirs and canals and make the plan for them, which I suppose, in a general way, at least, would be done? They would be located absolutely, so that the men who chose to build these dams would know where to go precisely?

Mr. POWELL. Yes, sir.

The **CHAIRMAN**. If they chose to build a canal it would be laid out for them practically?

Mr. **POWELL**. Yes, sir.

The **CHAIRMAN**. On a map and in the field, would it not?

Mr. **POWELL**. Not in the field.

The **CHAIRMAN**. You would not locate it?

Mr. **POWELL**. With a topographic map, laying it out on the map is laying it out in the field.

The **CHAIRMAN**. Practically?

Mr. **POWELL**. Practically. That is the advantage of a topographic map.

The **CHAIRMAN**. There is a region to be reclaimed practically of 153,000 acres. What would it cost the Government to do that?

Mr. **POWELL**. I dare not make an estimate. I can not make an estimate from that one, because I have made a geological study of that region myself in the field. I knew just what I had to do. I knew where I had to go to make these plans. They were already practically made.

Senator **HALE**. You could do this much more easily and less expensively than in an unknown region?

Mr. **POWELL**. Oh, yes; that did not cost more than $8,000, for I knew all about it from previous study.

Senator **HALE**. You selected this place because you knew it?

Mr. **POWELL**. Because I knew it. I did it in a hurry, so as to have something to show you.

The **CHAIRMAN**. That is, I take it, an illustration of what you propose to do throughout this entire arid region?

Mr. **POWELL**. Precisely.

The **CHAIRMAN**. Having conditions of reservoirs and water?

Mr. **POWELL**. Yes. You asked me for an estimate of what it would cost. I made the best estimate I could last year for the entire country and you published it; but you put into the law much more than I anticipated would be put into it, so that the cost of the work has been increased above my estimate. I did not anticipate that I should be called upon for plans of reservoirs, but only for putting upon the maps the sites. I did not anticipate that I should select the lands in such a manner that they could be designated to the Land Office. As the law stands, I have to go on the ground and discover the land-marks of the old land survey, so as to show what sections are to be reserved, and that has increased the cost of the work. My judgment is that, for the whole region, it will increase the total cost about $1,500,000.

The **CHAIRMAN**. What we propose?

Mr. **POWELL**. What you propose.

The **CHAIRMAN**. And that is a very important thing to do?

Mr. **POWELL**. It is a very important thing to do.

The **CHAIRMAN**. In having these men in the field selecting places for storage and so on, do you also find yourself able to utilize them in carrying on in connection with this work your regular geological survey?

Mr. **POWELL**. So far as the making of the topographic maps is concerned. The maps have to be made for this purpose as they would have to be made for the other, and all the map-making for this work is map-making for the other.

The **CHAIRMAN**. After this work is done would it be necessary to go over the same space in completing your geological survey?

Mr. **POWELL**. Yes, sir.

Senator **HALE**. Which would you naturally go over first?

Mr. **POWELL**. This work now, because they are pressing for it, and there is no reason why it should not go first.

The **CHAIRMAN**. I did not know but that the same men might do both.

Mr. **POWELL**. It must be understood that more than half of the cost is for the map-making, and that is done for both surveys at once.

Senator **HALE**. There you do not duplicate the work.

Mr. **POWELL**. There we do not duplicate it. That is more than half the cost of the whole work. The engineers who make these plans are not geologists, and geologists are not engineers. You can not get the same men to do the geological work and the engineering work.

Senator **HALE**. If a given region that is adaptable to this purpose had been gone over by your geological survey, would not that work really help you in this?

Mr. **POWELL**. That would have given me the maps and given me data which would have greatly diminished the cost of this work, or doing this work first will greatly diminish the cost of the other. It amounts to the same thing either way.

The **CHAIRMAN**. That is the point I wanted to understand; whether the work that you are doing here is not a saving of necessary work in your geological survey?

Mr. **POWELL**. Precisely; it is.

Senator **HALE**. Either way that you work, whichever was done first would help the other?

Mr. POWELL. Whichever work is done first will help the other. The map-making is the first thing in each case, and the map-making is the chief cost.

The CHAIRMAN. Has not the House given you in the bill more money than you need?

Mr. POWELL. I wish to reach that point. There are eight States and Territories where agriculture is wholly dependent upon irrigation, where they raise nothing without irrigation; and there are six other States and Territories where they are chiefly dependent upon irrigation. If you give me $250,000 I can go into six of those States only; I must make a selection.

Senator HALE. You mean there are fourteen States and Territories in all?

Mr. POWELL. Yes, sir.

Senator HALE. And six of those are partly dependent upon irrigation?

Mr. POWELL. Yes, sir. With $250,000 somebody out there has to be disappointed. Their governors, their legislatures, their people are pressing upon me for this work They are petitioning me and writing me, and there is a pressure upon me. With $250,000 I have got to make a selection of six States and Territories and disappoint the other eight.

It ought to be understood why I say I can only go into six States. It seems to me to be important to take up three pieces of work next year and carry them on to such a point that I can exhibit to Congress next year what it means on a larger scale than I have shown here. So I propose on the Arkansas and a portion of the Rio Grande, and on the Walker River in Nevada, to put larger parties than elsewhere in order to get the work pushed in those regions as rapidly as possible. This shown to-day is on a very small scale indeed. I should need for that about $175,000 for those three places. Then I can take the remainder and put it in three or four other States and Territories, and for these I must make a selection for a little beginning, and show that I am trying to do something for them; that is all I can hope for. But with $350,000 I can go into all the States and Territories where irrigation is necessary throughout the region, and also go into California and Oregon. There is very little of California where irrigation is not needed, but I could go into all the States and Territories and into California and Oregon with an appropriation of $350,000.

The CHAIRMAN. Do you find at hand thoroughly competent men to organize these field parties and put them at the work?

Mr. POWELL. I can to that extent. I have been urged very much to make my estimate $500,000, but I said "I can not find the men in one year to do it." I have looked over the matter and I have found where I can get men in addition to what I have, so that I can utilize $350,000.

The CHAIRMAN. You want $100,000 more?

Mr. POWELL. I want $350,000. I have one other thing to ask for in the bill, and that is that the appropriation be made immediately available.

Senator HALE. You want the money to start right on, I suppose; you do not want to wait until July?

Mr. POWELL. I do not want to wait until July.

The CHAIRMAN. You had $150,000. Will not that run you until July?

Mr. POWELL. I had only $100,000. If you will make $30,000 or $40,000 available, that will be sufficient.

Senator HALE. What have you left of the amount Congress gave you in the act of last year?

Mr. POWELL. About one-half.

Senator HALE. You have in hand $50,000 of the appropriation made last year?

Mr. POWELL. Yes, sir.

Senator HALE. That you can use right away, in the spring?

Mr. POWELL. Yes, sir.

Senator HALE. You wish $40,000 more to be immediately available?

Mr. POWELL. If I had from $30,000 to $40,000 more, I could do one thing which is all-important. The season of irrigation was already passed last year before the appropriation was made. The season of irrigation will be largely passed this year before the 1st of July, so that for this new work I will lose the observations to be made during the season of irrigation. I want to employ at once this spring in all the region of country river-gaugers, stream-gaugers, men who are gauging or measuring the amount of flow of those streams between now and the 1st of July, during the season of irrigation. I have money enough to keep all my other force at work.

Senator HALE. You can do this work to better advantage during the season when the streams are used for irrigation?

Mr. POWELL. The stream-gauging ought to be done then. The most important stream-gauging is that which is to be made during the season of irrigation. That is water which is not to be stored at all, you see.

After all this explanation, repeated again and again, explained in the clearest manner and exemplified by producing before the committee the maps actually made, a second item was incorporated in the bill in terms identical with the first, except that the amount was $250,000.

On the 30th of last July the Director submitted to the Secretary of the Interior a report, which report is submitted by the Secretary of the Interior to Congress through the Government Printing Office, as the statute directs. While yet this report is in the hands of the printer there is introduced into Congress a resolution calling for the printing of 20,000 copies of it, and this resolution is ultimately passed by both Houses and becomes a law, and under the resolution the report is printed, and it is now before Congress. This report fully explains the topographic work, the hydrographic work, and the engineering work—all of the operations of the Irrigation Survey under the appropriation of $100,000. Thus a second report for this year's work has been made, and in it is contained an itemized statement for the expenditure of $100,000, less $135 on hand at theexpiration of the year, to be covered into the Treasury. Surely it is a reckless statement that charges the Director of the Survey with any misapplication of this money, and from a long, careful, and patient investigation of this subject, we are fully warranted in affirming that the money has been expended strictly in compliance with the law; that the work has been prosecuted vigorously and economically, and that results of great value to the country have been obtained.

It will be seen from the foregoing statement that the strictures made on the Director of the Survey in the majority report, implying that he has failed to comply with the law in reporting to Congress, are not in accord with the facts. Within three months after the passage of the act the Director made a report to Congress setting forth the operations of the Survey under the organization of the work. Subsequently, on the last day of July, 1889, he submitted another report to Congress setting forth the operations of the Survey under the provisions of the act making appropriations for it, and giving a detailed statement of expenditures, and that report also has been printed and is before Congress. The report was not transmitted directly to Congress, but through the Public Printer, as the statutes direct. *Vide* U. S. Statutes at Large, Vol. 13, 184, an act entitled, "An act to expedite and regulate the printing of public documents, and for other purposes," approved June 25, 1864, of which the following is an extract:

> That hereafter, instead of furnishing manuscript copies of the documents usually accompanying their annual reports to each house of Congress, the heads of the several departments of government shall transmit them, on or before the first day of November in each year, to the superintendent of public printing, who shall cause to be printed the usual number, and, in addition thereto, one thousand copies for the use of the Senate and two thousand copies for the use of the House of Representatives.

SECTION XXXVI.

THE TOPOGRAPHIC WORK OF THE IRRIGATION SURVEY IS NECESSARY AND ECONOMICAL.

The report of the majority also condemns the topographic work of the Irrigation Surveys as being unnecessary for the work contemplated in the statute creating the Survey, and it gives the opinions of sundry persons called before the committee, who thought that the topographic work was useful, but believed that it could be dispensed with, and that the same results might be reached in another manner. But these persons had no definite plans to propose—made no explanation of how the work could be otherwise done, but expressed the vague and general opinion that they could do it better in some other manner which they could not define or state. Other officers of the Survey, who seemed to comprehend clearly all the work prosecuted by the Survey, were able to explain how the work is done, the necessity for all parts of it, the thorough and accurate results obtained by it, and the great economy of the methods devised. But Director Powell himself made a simple and clear statement of the whole matter in a manner that must be convincing to all persons not desiring to destroy the Survey for other reasons.

The following extract is given from the testimony of the Director:

FURTHER STATEMENT OF DIRECTOR POWELL.

The **CHAIRMAN.** Major Powell, the point that the committee desires your views upon this morning is as to the necessity of topographic surveys preceding the engineering surveys for irrigation, the relation of the two classes of surveys, and whether the engineering surveys can be carried on independently of the other, or whether they are necessarily connected.

Director **POWELL.** Mr. Chairman, there are two branches of the subject which I wish to present: First, the plans and methods of the survey, as necessary to carry out the provisions of the statute; and second, I wish to call attention to and review the statutes and the reports which I have made to Congress on calls from the Senate, which represent the needs of an irrigation survey, for the purpose of showing that the wording of the statute and the representations made by me to the Congress prior to the passage of the statute are in harmony with what has actually been done. That is, I wish to show, first, what the irrigation survey should be, What is necessary to be done, and the information required; and second, to show that before the passage of the law I had fully set forth the facts to Congress, and that the wording of the statute calls for the work which has actually been done.

The **CHAIRMAN.** We are not complaining of what has been done. We simply want to know how these surveys are dependent upon each other.

Director **POWELL.** These two lines I would like to be heard upon. First, then, I wish to address myself to the question, What is necessary to be done in an irrigation survey, and how can this be done in the most economic manner? The statute provides, first, that the extent to which the lands can be redeemed by irrigation shall be determined; second, that reservoir sites shall be selected; third, that canal sites and sites of other hydraulic works, such as diverting dams, etc., shall be selected; fourth, that the lands made irrigable by these hydraulic works shall be selected; and, finally, that all of these sites and lands shall be segregated—that they shall be selected on the ground, as I understand it, and be certified to the Land Office, in land-office terms of township, range, section, etc., for the purpose contemplated in the law. In order to accomplish the end a survey had to be prosecuted and a series of discoveries made. These discoveries may be divided into three classes: Those relating to the land—the catchment areas, the sites for diverting dams and canals, the sites for reservoirs, and the irrigable lands. These necessities give rise to the topographic branch of the Irrigation Survey. Second, those relating to the water; that is, it is necessary to determine the amount of water which can be used for irrigation in each hydrographic basin or area drained by one important stream and its tributaries. It is necessary to determine the mean amount of water for the irrigating season in each basin, and also the mean amount of water for the entire year, and it is also necessary to determine the minimum amount in seasons of excessive drought and the maximum amount in seasons of excessive rain-fall. It is also necessary to determine the amount of water required to irrigate an acre of land, that is, to determine the "duty" of water. The necessity for determining all of these facts in relation to water gives rise to the second branch of the Irrigation Survey, that is, the hydraulic branch. Third, those relating to estimates of the cost of dams, canals, and reservoirs. For this purpose the sites of the dams must be surveyed with accuracy and the constructive conditions as to the proximity and character of materials must be studied. The sites of the reservoirs discovered by the topographic survey must be carefully examined and plans for their construction made. The sites of canals, the general routes of which are previously discovered by the topographic survey, must be carefully run upon the ground and marked and the amount of cutting and filling determined and the ground minutely examined for the purpose of discovering its character, whether it be in sand, clay, gravel, or solid rock, as all of these facts affect the cost of the work. Having studied these facts the cost of construction can be properly estimated. These three classes of work all relate directly to the Irrigation Survey. They are all required by the provision of the statute, and no one can be neglected without disobedience to law. The three kinds of work give rise to three branches in its organization, which we call the topographic, hydrographic, and engineering branches.

The topographic survey is the work primarily necessary to the discovery of sites, though it has another use in the hydrographic survey, as will be shown when that point is reached. In investigating this subject for the purpose of determining the best and most economic method of discovering the various sites required, it was decided that a topographic survey was proper. If a specific reservoir site is already known, and the body of land to be served by the waters from that reservoir is already known, the simple problem is to find a way for a canal from the reservoir to the land. Such a survey would need only the work necessary to run a number of trial lines on the ground and then to select the best from these. But the problem before the survey was not to irrigate some one man's farm from some one stream or reservoir site; it was not to irrigate some particular piece of land to suit some particular person; but the problem was to discover all of the reservoir sites, all of the canal sites, and all of the lands that could be irrigated in any given hydrographic basin. How this could be done in the cheapest manner was the question which I had to solve. Having a specific reservoir in sight and a specific body of lands in view, and wishing to take the water from that reservoir to that piece of land, I can run trial lines and find the best route at the rate of about $25 per mile for each of the trial lines; but the final line selected must be run again with great care, the whole ground must be studied, very exact levels must be run, and all the characteristics of the line must be determined, in order that the cost of the canal may be discovered. But in the work of the irrigation survey the reservoir sites, the canal lines, and the lands to be irrigated have all to be discovered—ten, twenty, fifty reservoirs perhaps in one hydrographic basin; scores of canal lines, 10, 20, 50, 100 miles in length. To run many such trial lines over the ground for the purpose of selecting a few would involve great cost. The system of discovering canal lines by a topographic survey instead of by a trial line survey is very much less expensive. Certainly it would not cost more than one-third of the amount. To discontinue the topographic survey and inaugurate a trial-line system would be to increase the cost of the work fully three times. In the same manner the reservoir sites are to be discovered, and their relation to the streams which furnish them water and to the lands which they are to irrigate must be determined. Some of these reservoir sites are in the mountains—the best are there; some are in the valleys and on the plains. They are therefore widely scattered throughout all parts of each hydrographic basin. To discover them by trial lines instead of topographic surveys with contours would be to increase the cost of the work at least three times.

A hydrographic basin may furnish only a half a dozen good reservoir sites, or it may furnish two or three hundred, as the case may be. Some will be small, sufficient for reservoirs to hold 1,000 acre-feet of water; others will be great, sufficient for reservoirs to hold 1,000,000 acre-feet or even 2,000,000 acre-feet of water. One reservoir site may be excessively expensive, another very economic; that is, it may cost $10 per acre-foot of water to store it or it may cost but 10 cents per acre-foot of water to store it. It becomes necessary, therefore, for economy's sake, to select the best sites. In order to do this it is necessary to discover all of the reservoir sites of each hydrographic basin. If I were to select a score of reservoir sites in a basin at random and have these reserved to be used by the people in the future, and it should be found that half, or many, or all of them, were not so good as other sites in the same basin, and that a system of reservoirs could be constructed to store the water for one-half or one-fourth of the cost that would be required in the basins carelessly selected, the whole work would be repudiated by the people; it would be misleading and injurious. It is therefore necessary for me to know in each basin all of the reservoir sites in the basin, that the best may be selected. This means that I must know every valley in the basin.

To illustrate the method of discovering these reservoir sites, I have brought with me the maps constructed by the topographic survey in the upper basin of the Arkansas in Colorado. These are the maps constructed in the field. On examination you will see that they are in contour lines; that the vertical interval from one contour to another in the valley region is 25 feet, in the hill regions 50 feet, and in the mountain regions 100 feet. It is not necessary to do the work in the mountains with the same degree of refinement as in the valleys. For more than twenty years I have been engaged in making topographic surveys in connection with the other work under my charge. During that time I have employed a corps of men of ability and genius, and during that time I have topographically surveyed about a half million square miles of country, on various scales and with varied degrees of refinement. Through the inventive genius of the men who have been employed on this work new methods of survey and new instruments have been devised, so that the whole system of topographic surveying has been revolutionized, and to correspond with it the method of map construction has been greatly developed and improved. The work has been improved in quality and enormously decreased in cost, and gradually other nations of the world are adopting our system.

The topographic survey which we are making in connection with the Irrigatio Survey is in most particulars the same that we are making for the Geological Survey The topographic work necessary for the one is necessary for the other, and we wer making these maps for the Geological Survey before the Irrigation Survey was inaugurated. The cost of the irrigation survey, therefore, was only the cost of what wa additional to the work already in progress. The work of the irrigation survey is, fo the reason I have stated, in the first place a topographic survey, because the sites fo the works and lands are to be discovered, and it is the cheapest and best way of discovering them. In the maps before you you will see that the topographers have discovered forty-three reservoir sites and marked them upon the maps. They are colore in blue. The contour lines are colored in light red, as you see, and the reservoir site are determined by the contour lines. Each site represents a valley basin, and in general terms the height of the dam, the size of the basin, and its capacity are reveale by the maps which the topographers have constructed. From these about twelve o fourteen have been selected by the engineers as being, all things considered, the mos eligible. The twelve or fourteen must be surveyed with greater care for the purposes already indicated, that is, to determine the cost of construction and to mar them upon the ground. That is the work of the engineering branch of the survey In the same manner these maps reveal the general lines of the canals. They show for example [indicating on the map] that the water from this reservoir can be taken along this line to this body of land. The map reveals other lines by which it can b taken, and shows that this one is the best, and the engineers have selected it and have actually run it upon the ground and obtained the facts necessary to estimate it cost.

When called upon by a resolution of the Senate for a plan for these surveys, and by the Appropriations Committee for an estimate of cost, I selected and recommended this method of prosecuting the work, because I believed it would be the most economic; and I estimated the cost of the topographic work, in addition to what had already been done in the country, to be about $4,000,000. In making this estimate I took into view the fact that already work had been done under the general appropriation for the Geological Survey, and that that work would not have to be done again I further estimated that to determine the amount of water in each hydrographic basin that could be used for irrigation and the amount of land which could be irrigated thereby would cost an additional sum of $1,500,000; and, finally, when it was decided by the committee that the sites should be surveyed for the purpose of estimating costs and of segregating the lands and reporting them to the Land Office as reserved under the provisions of the act, another $1,500,000 would be necessary, making in all for the irrigation of the arid lands the sum of $7,000,000. But this estimate was based upon the consideration that the work should be done in the manner which I have pointed out. If this cheap and comparatively accurate topographic method developed in the survey had not been known, and had the old methods of topographic surveying been in vogue, I should then have had to decide whether it was cheaper to make the discoveries of sites by the old method of topography or by the system of running trial lines; but having developed a more economic topographic method, it was only necessary to decide between this new method and the trial-line system; and the new method is by far the cheaper and in every way the more satisfactory; for, having done it, the entire work can be published and submitted to the people—not as the opinion of men engaged in the work, but as facts determined by instrumental survey —and presented by simple contour lines on maps, so that they can see for themselve all the facts and conditions.

Senator Jones. What is the scale of those maps?

Director Powell. One inch to 1 mile. That is the field scale. We do not publish on that scale. It is reduced to 2 miles to 1 inch for publication.

The Chairman. Right in this connection let me make an inquiry. You have got these drainage basins mapped. Now, suppose an engineer should go into one of these drainage basins with such maps as you have, would it not be necessary, in order to do accurate work, to follow up the stream and work carefully over this ground again, to determine where to locate his reservoir and canals?

Director Powell. No, sir. I will come to that.

The Chairman. Then could not an engineer, with the boundaries of the drainage basin indicated, go into the drainage basin and make accurate surveys and locations; or even if they were not indicated, could he not determine the boundaries of the drainage basin and do the mere engineering work with a view of practical work

Director Powell. No, sir; the engineer——

Senator Jones (interposing). This dotted line on the outside indicates the watershed. [Pointing to map.]

Director Powell. The dotted line is the catchment area. That shows what will feed this reservoir. [Indicating on map.] I will come to that in the latter part of my statement. I want to answer the chairman. An engineer who should go in there without the topographic map would have to select the site. If he went in to select the site he would have to select it by running trial lines, and to run trial lines would cost three times this. Now, when he comes to this reservoir the engineer surveys it, but not all this catchment area. Instead of surveying the area outlined here he surveys this area, the dam site itself only, and surveys it in a minute manner. The topographic survey has found the reservoir site and the catchment area. The engineer has all the facts. Now, the engineer who goes in there runs a more careful line to find the amount of water that reservoir will hold and the length and height of dam necessary, and that is all he has to do.

Senator JONES. In order to make an accurate reservoir is it not necessary to run those minute lines?

Director POWELL. Certainly.

Senator JONES. Before the people can go in and occupy the lands these lines have to be run?

Director POWELL. Yes, sir, those in that little basin; but we have saved him all that work [indicating on map], and have done it in the cheapest possible way.

Senator JONES. This work of setting apart and getting the areas is pretty much done all over the country, is it not?

Director POWELL. No, sir; nowhere in the United States except where I have made surveys.

Senator JONES. Have you not had the engineering work in certain cases precede your topographic surveys?

Director POWELL. Yes, sir, I have, and that I wish to refer to. On the passage of the act the people of the western region were exceedingly anxious to have results. In the general study of this subject for the twenty years in which I have been engaged, and during which Mr. Gilbert, my first assistant, has been engaged, I knew of very many sites; they did not have to be selected. I knew that Providence Lake was a site; I knew that Utah Lake was a site; I knew that Hope Valley was a site; I knew that a number of localities were sites; but I did not know all, only a small number. I set the engineers at work on places which I already knew, in order that I might meet a local want at the very earliest day; but still they had in each of those cases to run trial lines, and the money expended in those unnecessary trial lines, if I could have had the topography of the sites which I already knew, would have paid 50 per cent. of the cost of making the map. If I had had a topographic map even of the sites which I already knew I could have saved enough in the running of trial lines to have paid 50 per cent., or one-half, of the cost of the map, and that has been demonstrated over and over again on the Arkansas and on other rivers. The greatest waste which I had in that manner was in Nevada. The engineer who went there ran unnecessary trial lines, as the chairman knows. He was the first man to raise an objection to this work; he organized the movement against the topographic work and wasted money in running unnecessary trial lines.

The CHAIRMAN. When an engineer runs his trial lines for his ditch he must be governed by something besides topographic maps, must he not?

Director POWELL. No, sir. Suppose that I have selected the reservoir and the land. That had to be done first. Now I want to know how I am going to get the water from that reservoir to that land?

The CHAIRMAN. Can you select the land before you know definitely where the ditch is to be located?

Director POWELL. I can with a topographic map; otherwise I have got to run trial lines, either one or the other. Without that map I must run trial lines. To make selections by running trial lines is to increase the cost of the work three times.

The CHAIRMAN. Can you select with sufficient accuracy to enable people to locate on the lands?

Director POWELL. I can.

Senator MOODY. In making these topographic maps you run these lines, do you not?

Director POWELL. Yes, sir. I run them with plane tables by methods which we have developed in the Survey. To explain it would require a long trigonometrical statement. Let me further say that in addition to the discovery——

Senator MOODY (interposing). Right here let me ask, can you run a line with such accuracy as to enable the engineer to follow any line without himself running levels and lines in the usual way with transit and levels?

Director POWELL. Suppose that we have a reservoir at one point, and some land at another point, 10 miles away. I can say from the topographic map that the best line that can be made from that reservoir to that land must run along that hill and meander down that valley, and down that hill, through that valley, to that land——

Senator MOODY (interposing). You could do that with the eye.

Director POWELL. And having done that, the engineer ultimately runs over that ground, and from the reservoir site to the lands, for the purpose of doin gone other thing. The statute demands that we shall furnish an estimate of the cost. The engineer has to go over the ground and determine the nature of the soil, the nature of the excavations which will be required, what amount of cutting there must be in one place, and what amount of filling in another place, and so on, in order to get at the cost of constructing that canal; but the site of the canal is selected from the map, without any trial lines whatever. I have in my office, Mr. Chairman, three classes of men——

Senator **Reagan** (interposing). That is the same method that is observed where a preliminary survey of a railroad is made, the details being attended to afterward?

Director **Powell**. The first thing is to make the selection, as we would in the case of a railroad survey, by trial lines, or by topographic surveying, ultimately selecting one, and then make an accurate survey of it. I have adopted the method of discovering the sites which is the cheapest of all. But, Mr. Chairman, the topographic work is an important part of the irrigation survey for other reasons than those already explained, and such reasons are even more potent. The amount of water furnished by a hydrographic basin must be discovered. If a reservoir is to be constructed it must be known how much water can be furnished it annually before its size and the character of its works are determined. To select the lands to be irrigated I must know how much water there is to serve and how much water each acre of land will require; that is, the amount of water and the duty of water. In general, there is more land than the water can serve. Only one-eighth or one-tenth of the country can be irrigated, because there is not enough water to irrigate more. I must find out how much water can be got to serve that land. How would I do this? This was the most difficult and complex problem presented to me when the survey was inaugurated. How could we gauge all the rivers, creeks, and brooks of two-fifths of the area of the United States—all the waters flowing in the streams of that region—in order that works for their control and use might be constructed and lands for them to serve might be selected? There is a vast number of these streams, as will be seen by a review of the entire ground. To gauge one stream means what? It means that we have to discover the velocity of the current, which varies from shore to central line and which varies from top to bottom, so it becomes necessary to determine the velocity of the current in every part of the cross-section of the stream, because the flow is not uniform, it being greater in the center and less at the sides and bottom, but exceedingly variable for the different forms of cross-sections. Supposing it to be gauged in this manner on one day of the year, that night a rain falls and the stream is enlarged, the entire conditions are changed, the cross-section is larger, and the velocity of the current is greater. So it changes from hour to hour and from day to day, rising with the rains and falling with the droughts.

To find out how much water flows down the stream during the year it is necessary to find out how much water flows in that stream at every stage of its volume, from the lowest water to the highest water. This is done by the use of current meters. Then it is necessary to employ a river-height gauge to determine how high the water is at each hour of trial, and having discovered how much water flows at each stage and how much time it remained at each stage, we are able to determine the total flow of the year. But some years are dry, other years there is great rain-fall; so the streams vary from year to year, and their volume in minimum years must be determined, and their maximum volume, and their average volume from year to year. To gauge the flow of each river and brook in the manner which I have indicated would require an enormous outlay of money, so great that when I studied the problem, as I did before the survey was organized and before it was authorized by Congress, I reached the conclusion that the work could be done in another and cheaper manner, and in a manner altogether more satisfactory. I reached this conclusion after a very careful study of the subject myself and after having submitted it to other gentlemen associated with me. The same conclusion was reached by all the gentlemen except one; that was Captain Dutton. The plan was to make a topographic survey of the catchment basins which should determine with reasonable accuracy their area, with reasonable accuracy their declivities or slopes, and to gauge a few of the streams in the manner which I have indicated, and to find therefrom under varying topographic conditions and varying altitudes and varying rain-falls, the amount of water which could be derived from each square mile of the territory of the basin.

Permit me to make this plain by the use of an illustration which will serve well for that purpose and better than a long discussion of the subject by which the scientific methods might be elaborated. Suppose I wish to know how much water there is running annually from the roofs of the houses of Washington. Shall I put a water-spout on every roof and gauge each one for every day in the year and for a series of years in order to get the mean annual flow? Such was the plan advocated by some of the engineers, but such was not the plan adopted by myself. Now, suppose I gauge the amount of water which falls from the roofs of a dozen houses in Washington, or even a less number, so as to get a good fair average of what every square yard of roof surface will deliver during the year. I can then easily determine how much water a square yard of roof surface will furnish during a year; and having found that a yard of surface, for example, on a general average, will furnish a yard of water 30 inches in depth during a year, I have the means of determining the amount of water which any roof in the city will afford by simply measuring that roof. This is certainly a very much simpler and just as satisfactory a method as to put a current-gauge on every water-spout of the city. To do the work of the survey by gauging all the streams would cost an unknown sum, but certainly not less than $10,000,000. So I determined to gauge a few typical streams and measure their catchment areas; that is, to determine the extent of catchment area and to base the computations of water supply upon the factors thus developed and from the factors derived from the measurement of rain-fall. But it is necessary not only to measure the superficial area of the catchment basin, but also to determine the declivity or slopes of the ground by which the water would be gathered into streams and delivered to the irrigating works. The necessity for determining this element can be very simply explained.

The CHAIRMAN. The hydrographic survey is different from the topographic, to some extent, is it not?

Director POWELL. No, sir. A hydrographic survey is a topographic survey, but something more is added. A hydrographic survey determines the areas by a topographic survey. I was trying to explain that in my illustration of the roofs of the houses. I have to measure the roofs of the houses, from which the area of the roofs, the catchment area, is determined. It is the method of determining the areas which supply these basins. But there is another thing——

The CHAIRMAN (interposing). You have to approximate the area of the basin, do you not?

Director POWELL. It is not sufficient to approximate the area. It is necessary to determine the declivities. That is a problem which seems very simple when it is stated; but you will find that we have to determine the slopes of all the hills for the purpose. Suppose the rain falls over a district of country that is level, or nearly level, in that arid region, no great quantity of that water will flow into a reservoir. It will be gathered up so slowly into pools that it will all evaporate. But suppose it is like that of the Hassayampa, of which the dam has just been swept away. Then all the water which falls upon the catchment area, after the soil is once saturated, will immediately be gathered into the reservoir. It is a region of steep declivities. Here is the source [indicating on the map]. Here is Mount Tritle; here are four great mountains encircling the basin. When a great storm comes on those mountains the water rolls down into the basin. They sometimes have storms in that western country which will give 2 inches of rain-fall in two or three hours. The Hassayaupa dam drained a mountain declivity of 325 square miles of nearly naked rock. When the big storm came it only required seven or eight hours by my computation to bring the maximum supply of water against that dam. The maximum supply of water against that dam was 6¼ acre-feet per second. There was that much water coming down every second for nearly an hour. Provision had to be made for it, and the declivity had to be known in order to construct the work properly. It was not only necessary to provide a proper way to dispose of the surplus water when it came, but also to know how much water could be stored there. If it had been a flat country there would have been no need to make a dam there, for no water would come down; but it being a steep country, a vast amount of water could be collected.

Now to make my illustration from housetops complete, suppose that the flat housetop is covered with a great thickness of sand, so that all the rains falling thereon are absorbed and finally evaporated by the sun. Then from such tops no water can be caught in the spouts. Suppose that others have varying declivities, and that the greater the declivity the less the amount of sand, until some are so steep that no sand will remain on them. The steep roofs will deliver all their water. Now similar conditions are found in the natural slopes of every drainage basin of the West. Some regions are so flat and sandy that the waters all evaporate, and nothing can be obtained from them; others are so steep and rocky that almost the entire rain-fall is discharged into stream-channels. It is wholly a question of declivities, and we are therefore compelled to determine these declivities. We want areas of catchment basins and declivities of catchment basins. To get these we make a topographic survey, in the cheapest manner that it can be done to be useful to properly solve the problems. The plan, therefore, is to measure drainage basins and determine their areas and declivities, to see what water they will shed in the streams; then gauge a few typical streams with accuracy, and with these facts—and some collateral ones which need not be here explained, as that would complicate the subject too much for simple statement—we have the data necessary to plan the works to control the water, so that it can be put upon the land.

On this subject the opinion of the Superintendent of the Coast and Geodetic Survey, who is an eminently practical, scientific man, and familiar with such survey methods, was asked, and the following letter has been received in reply:

UNITED STATES COAST AND GEODETIC SURVEY,
Washington, D. C., April 28, 1890.

SIR: I am in receipt of yours of yesterday, asking my opinion of the propriety of making a topographic survey as the basis of hydrographic and engineering work in connection with the irrigation survey of the arid lands now in progress, and whether in my judgment the plan thus far pursued is, on the whole, wise. In reply, I have the honor to submit a brief statement of my views upon the subject, as follows:

The vast extent of this irrigation scheme, together with the fact that it is the evident intent of the Government in its organization and prosecution that the interests of the whole people are to be conserved, and that no particular portion of the arid area is to be favored above any other portion, gives to the investigation that broad and general character which not only justifies but requires its prosecution in accordance with the well-recognized principles of research.

Considered from this stand-point, it seems to me impossible to avoid the conclusion that a topographical survey or reconnaissance of the whole area under investigation is a necessary preliminary to the wise and economical expenditure of money in engineering operations.

The interests at stake are so extensive that the method of investigation employed should be one which would result in the discovery of the truth, the whole truth, and nothing but the truth. A topographical survey or its equivalent is alone adequate to this. If it were simply desired to ascertain if a particular tract of land was susceptible of irrigation by the utilization of a particular stream, or whether a particular basin might be used as a storage reservoir, a less exhaustive and less expensive method might well be chosen. But it is assumed that the scheme contemplates the discovery and indication of all lands susceptible of irrigation, the location of all proper sites for reservoirs, and especially the selection of the best of these, economy and efficiency being considered; in a general way it should reveal all competing lines for diverting water by canals and discriminate among them. In short, the exploration should be of such a character that nothing of value could escape it. A trial line of levels answers a definite question in a perfectly definite manner, but the information which it yields is of two dimensions, while that furnished by topography is of three. It is quite probable that in the prosecution of the work results of immediate practical value would be reached more quickly by ignoring the general principles which should control it, especially in parts of the country where some topographical information is already at hand, but while, in such localities, the engineer may do well, he can have no means of knowing that he might not have done better, unless, indeed, he should extend his examination until it becomes equivalent to a topographical survey, in which case it will become vastly more expensive.

A topographical survey is equivalent to an infinite number of lines of leveling of an accuracy depending largely on its cost. When executed in sufficient detail and with proper skill the limit of its accuracy depends upon the constancy of the dimensions of the sheet upon which it is represented, and it satisfies nearly every requirement of the most elaborate engineering operations. Again, it may be very cheap and only roughly accurate, exhibiting only in the most general manner the principal features of the country. A survey of the first type would be very expensive, but would leave little to be done by the expensive methods of the engineering parties, while one of the latter type or none at all would leave everything to the engineers, who must, if their work is exhaustive, make the equivalent of a topographical survey by methods relatively very costly. Between these two extremes of maximum expense lies a mean of minimum cost, in which the end is reached through a preliminary topographic survey of sufficient accuracy to reveal all of the irrigable lands, the available reservoir sites, diverting canals, etc., thus locating and restricting the operations of the engineer. This is, as I understand it, the plan proposed and adopted by the Director of the Geological Survey, and in my judgment it is, on the whole, wise.

Yours, respectfully,

T. C. MENDENHALL,
Superintendent.

Hon. J. H. REAGAN,
United States Senate.

SECTION XXXVII.

THE HYDROGRAPHIC BRANCH OF THE IRRIGATION SURVEY SHOULD NOT BE TURNED OVER TO THE SIGNAL SERVICE.

In the majority report it is proposed to transfer the hydrographic branch of the Irrigation Survey to the Signal Service, but the bill is silent on this subject. How the work ought to be done is not stated. The following is the recommendation made in the report:

> OBSERVATIONS NEEDED ON CLIMATOLOGY.
>
> The Secretary of Agriculture must deal with the climate, the soil, and the products, and employ a large force to collect and diffuse information with regard to all matters pertaining to the production of crops and the cultivation of vines and fruits. The Agricultural Department is particularly charged with collecting and diffusing information with regard to modes of cultivation and fertilization of the soil. Irrigation is a great fertilizer, and the proper application of water to the soil is a matter of the first importance to farmers. This relates to agriculture and not to geology.
>
> In addition to the purely engineering work connected with irrigation, it is necessary to know approximately the amount of water discharged from each drainage basin, in order to estimate the quantity of land that may be irrigated; and it is also of importance to know the maximum discharge in time of great floods, in order to make ample provision in strength of works and extent of waste weirs to avoid accident. This branch of the service is called hydrography, and it is the subject least understood in the arid regions. Since it has been determined to transfer the Weather Service Bureau to the Agricultural Department, the employés of that bureau, and the army of volunteer observers connected therewith, can collect without any material additional expense to the Government all the information necessary on this subject. No other department of the Government is prepared to perform this service without an independent corps of observers. In a very short time the employés of the Weather Service Bureau will be able to do all that is required in measuring the streams and observing the climatic conditions with but slight supervision.

If an irrigation survey is not to be made under authority of the General Government, if no topographic map is to be constructed, if the head-work sites, canal sites, reservoir sites, and irrigable lands are not to be segregated, if plans for the construction of the works are not to be made and the cost of the same determined, if the real work of the irrigation survey is to be discontinued, the general observations made in relation to climate by the Signal Service may go on as they are with propriety; but if a hydrographic survey is to be made by the Signal Service, or by any other organization, a topographic survey is necessary for it. It is true that the volume of water carried by the streams in detail can be determined by another method, that is, by direct gauging; but, as shown by the Director and by all those persons who seem to have been competent to discuss the subject, and who have appeared before the committee, all persons who have had definite plans for the work, to make a hydrographic survey by direct gauging would be enormously expensive, and if made would be less valuable than if accomplished by the simple, practical, and inexpensive method recommended by the Director.

If the hydrographic survey is to be made by the Signal Service, its present officers in the field can not be utilized for this purpose; they must be at their stations to make observations on temperature, winds, rains, and barometric pressures from time to time during each day. Their stations are in the cities, not out in the mountains where reservoirs are to constructed and on the banks of streams distributed all over the arid lands. It is possible that this suggestion was not intended as a measure to be adopted, for it was not incorporated in the bill, but appears only in the report, and that the object of placing it there was that it might be used to destroy the present survey.

It is suggested in one paragraph of the report of the majority that it is proposed to have an irrigation survey in the Agricultural Department. Such suggestion is contained in the following paragraph:

> The committee, believing that irrigation pertains to agriculture and not to geology and other subjects under the charge of the Director of the Geological Survey, and differing from the Director as to the mode of conducting such matters as relate to irrigation, have provided for the transfer of the Irrigation Survey to the Agricultural Department, and the appointment of a Commissioner of Irrigation in that Department.

It also provided in the bill recommended by the majority that in addition to a Commissioner of Irrigation "there shall also be appointed by the Secretary of Agriculture, on the nomination of the Commissioner of Irrigation, a sufficient number of engineers, clerk, and other employé to execute such laws relating to irrigation as have been or may hereafter be passed by Congress."

If the effect of this paragraph is to transfer the work of the present Irrigation Survey to the Agricultural Department, it transfers it all—topographic, hydrographic, and engineering.

The effect of the bill referred to will be the transfer of the Irrigation Survey with all its present functions from the Interior Department to the Agricultural Department, or to stop all topographic, hydrographic, and engineering investigations, and to have only an artesian-well survey, of which mention will hereafter be made. Considered in the light thrown upon the bill by the report, it seems possible that the intention is to secure the latter effect. The effect of the bill is to turn all lands and waters over to irrigating companies and wealthy men, and to give the ranchmen access to all waters. An engineering survey which shall locate on the ground the headworks, canals, and reservoirs, and make plans for such works and compute their cost, should not be made in the interest of irrigating companies. The report and the bill must be taken together, and the practical effect of the two must be considered, and this may be stated in the following manner:

(1) The nomadic ranching companies shall have the right of way to all waters in the arid lands, that they may destroy the pasturage and burn the forests, and perpetuate for an indefinite time the conflict between actual settlers and themselves.

(2) The great tracts of irrigable land now unoccupied along the major streams shall be turned over to the control of irrigating companies, indirectly through the acquisition of the water rights and by making the farmers subservient to their interests, or directly by their ultimately acquiring possession of the lands.

(3) The lands found in the neighborhood of districts already irrigated shall be acquired as homesteads by wealthy men, able to pay the enormous mortgages which the bill places upon them.

(4) To secure all this, it is necessary to destroy the Irrigation Survey and practically annul the provisions of the legislation already enacted, by which the sites of the irrigating works are selected and reserved for the ownership and use of the people, by which the irrigable lands are selected and reserved for homestead settlers, and by which the settlers are furnished with plans for works or informed of their cost; and this is consistent with the theory that these should all be turned over to corporations.

SECTION XXXVIII.

THE TWO BILLS ARE DIAMETRICALLY OPPOSED IN THEORY, PURPOSE, AND EFFECT.

The bill of the majority makes the arid lands the theater of wild speculation, and is opposed to the interests of the people, and is not in harmony with the sentiments of the people. The bill of the minority provides that these lands and waters shall constitute a sacred trust, to be administered in the interest of the people who are seeking to make homesteads thereon, and that they shall have the lands, the waters, the forests, and the pasturage.

Under the provisions of the majority's bill companies operating with foreign capital will build the works and organize immigration bureaus, as they are now doing, and the vast value given to these lands by putting water upon them will fall into the hands of promoters and speculators. Under the provisions of the bill formulated by the minority the lands will be held by the General Government, the irrigable lands to be transferred severally by small tracts to actual settlers, and the timber lands and pasturage lands to be held as a perpetual reservation to supply water, lumber, and pasturage to the farmers on the irrigable lands.

The bill of the majority devotes the arid region with its waters and lands to the use and benefit of such men and companies of wealth as shall first seize upon them and build up a system of large land holding in the hands of great companies, to whom the occupants of the land must be serfs. The bill of the minority, if enacted into law, will devote this great region with all its magnificent possibilities to the establishment of American homes.

SECTION XXXIX.

DIRECTOR POWELL DOES NOT SUGGEST THAT IRRIGATION SHOULD BE CONTROLLED AND THE WORKS CONSTRUCTED BY THE GENERAL GOVERNMENT.

The majority make the following statement in their report:

> The passage of this bill, it is believed, will enable the bona fide settlers and land owners to develop the arid region by their united efforts. It will give full play to the enterprise of the pioneers of the West. It avoids, as far as possible, Government interference, and frees the Government from the enormous expense which would be involved if the United States should undertake the supervision and control of this vast region as suggested by the Director of the Geological Survey.

It can not be doubted that the effect of the bill "will give full play to the enterprise" of the promoters of irrigation schemes, and it does avoid, as far as possible, "Government interference" with the acquisition of water rights for irrigation by monopolies. The statement of the majority, quoted above, implies that the Director of the Geological Survey recommends that "the United States should undertake the supervision and control of this vast region." No word of such recommendation appears in the statements made by the Director to the committee and published with the two reports. On the other hand, the Director has clearly expressed his opinion that it is wise to turn over the entire control of the arid region, by natural irrigation districts, to the people of such districts, the whole subject of irrigation to be controlled by these people under the statutes of the several States and Territories involved. On this subject the Director has a long record, beginning with the publication of his report on the arid lands in 1878. From that time to the present he seems to have consistently recommended the policy which he now urges. While traveling with the committee during the past summer through the arid lands, he carefully and elaborately set forth this plan in many public addresses to constitutional conventions and other bodies of men, and we challenge the production of any paragraph or sentence which the Director has uttered or written, either directly or indirectly, recommending that the works should be constructed by the Government, or that it should interfere with the question of irrigation in any manner except by surveys and by the organization of natural irrigation districts, and by turning over to the farmers of these districts the waters, the forests, and the pasturage, to be protected, controlled, and used under State laws.

SECTION XL.

NO DELAY IN THE OPERATIONS OF THE IRRIGATION SURVEY IS CAUSED BY THE OPERATIONS OF THE GEOLOGICAL SURVEY.

In the report of the majority the following statement appears:

> It also prevents the delay which would be occasioned by waiting for the expenditure of many millions of dollars in geologic and topographic surveys and in paleontologic, chemical, and physical researches under the Director of the Geological Survey, and also avoids the embarrassment which would be imposed upon irrigation by charging to it the expenditures made by the Director of the Geological Survey for other purposes.

This paragraph is based upon a misapprehension of facts which it is impossible to explain. It is not proposed by the Director nor by any other person of whom we have knowledge, nor is it contemplated in the existing statutes, that the work of the Irrigation Survey shall wait on the work of the Geological Survey or on paleontologic, chemical, and physical researches carried on in the Geological Survey. The Geological Survey goes on independently of the Irrigation Survey. The Geological Survey will derive great benefit from the Irrigation Survey because the maps constructed for the Irrigation Survey can be used for the Geological Survey. These maps have to be made for geological purposes. They also have to be made for Irrigation Survey purposes, and it matters not to statesmen whether they are made primarily for the one purpose or the other. They must be made for both purposes, and the expense of the topographic work must be provided for from the Treasury, and will be provided even if the Irrigation Survey be discontinued, and there will be no saving to the Government if it is discontinued. We are therefore unable to understand the meaning of these words: "And it also avoids the embarrassment which would be imposed upon irrigation by charging to it the expenditures made by the Director of the Geological Survey for other purposes."

SECTION XLI.

THE EFFECT OF THE ACT OF OCTOBER 2, 1888, ON THE DISPOSAL OF THE PUBLIC DOMAIN IN THE ARID LANDS.

The act creating the Geological Survey, approved March 3, 1879, provided for a classification of the public lands. It was therefore the basis of the present Irrigation Survey. Under these provisions the irrigable lands, the timber lands, the pasturage lands, the mining lands, and the coal lands were delineated, such being the classes recognized in the laws relating to the disposal of the public domain by the General Government. March 20, 1888, the following joint resolution enlarging the functions of the Geological Survey was passed:

> Whereas a large portion of the unoccupied public lands of the United States is located within what is known as the arid region and now utilized only for grazing purposes, but much of which, by means of irrigation, may be rendered as fertile and productive as any land in the world, capable of supporting a large population, thereby adding to the national wealth and prosperity;
>
> Whereas all the water flowing during the summer months in many of the streams of the Rocky Mountains, upon which chiefly the husbandman of the plains and the mountain valleys chiefly depends for moisture for his crops, has been appropriated and is used for the irrigation of lands contiguous thereto, whereby a comparatively small area has been reclaimed; and
>
> Whereas there are many natural depressions near the sources and along the courses of these streams which may be converted into reservoirs for the storage of the surplus water which during the winter and spring seasons flows through the streams; from which reservoirs the water there stored can be drawn and conducted through properly constructed canals, at the proper season, thus bringing large areas of land into cultivation, and making desirable much of the public land for which there is now no demand; therefore be it
>
> *Resolved by the Senate and House of Representatives of the United States of America in Congress assembled,* That the Secretary of the Interior by means of the Director of the Geological Survey be, and he is hereby, directed to make an examination of that portion of the arid regions of the United States where agriculture is carried on by means of irrigation, as to the natural advantages for the storage of water for irrigating purposes with the practicability of constructing reservoirs, together with the capacity of the streams and the cost of construction and capacity of reservoirs, and such other facts as bear on the question of storage of water for irrigating purposes; and that he be further directed to report to Congress as soon as practicable the result of such investigation.

Again, on October 2, 1888, the following act was passed, in a clause of the sundry civil appropriation bill:

> For the purpose of investigating the extent to which the arid region of the United States can be redeemed by irrigation, and the segregation of the irrigable lands in such arid region, and for the selection of sites for reservoirs and other hydraulic works necessary for the storage and utilization of water for irrigation and the prevention of floods and overflows, and to make the necessary maps, including the pay of employees in field and in office, the cost of all instruments, apparatus, and materials, and all other necessary expenses connected therewith, the work to be performed by the Geological Survey, under the direction of the Secretary of the Interior, the sum of one hundred thousand dollars or so much thereof as may be necessary. And the Director of the Geological Survey under the supervision of the Secretary of the Interior shall make a report to Congress on the first Monday in December of each year, showing in detail how the said money has been expended, the amount used for actual survey and engineer work in the field in locating sites for reservoirs and an itemized account of the expenditures under this appropriation. And all the lands which may hereafter be designated or selected by such United States surveys for sites for reservoirs, ditches or canals for irrigation purposes and all the lands made susceptible of irrigation by such reservoirs, ditches or canals are from this time henceforth hereby reserved from sale as the property of the United States, and shall not be subject after the passage of this act, to entry, settlement or occupation until further provided by law:
>
> *Provided,* That the President may at any time in his discretion by proclamation open any portion or all of the lands reserved by this provision to settlement under the homestead laws.

The effect of this act was to reserve the sites for irrigating works until Congress should finally decide upon some method of disposing of them to the people. It also required that all lands made susceptible of irrigation should be reserved from disposal by the General Government, except under the terms of the homestead law after proclamation by the President. As the survey was required to present plans for the utilization of all of the stream waters of the arid region and to designate all of the lands susceptible of irrigation by such waters, and to reserve sites for the works and the lands which could be irrigated, the effect was to repeal the desert land law, the timber culture law. and in part the pre-emption law, and to put all the irrigable lands under the provisions of the homestead law for disposal after proclamation by the President. This effect is produced in the following manner: Those acquiring lands under the desert land act were required to irrigate such lands, but the sites for controlling the waters and the lands that were irrigated were withdrawn from its operations. It was therefore practically repealed. Those acquiring titles to lands under the timber-culture act were required to cultivate timber on such tracts. To do this it is necessary to irrigate them, but as the sites for irrigation works and the lands irrigated were withdrawn from the market, except under the provisions of the homestead law, the timber culture act was practically repealed. In the same manner the pre-emption laws were repealed so far as they applied to irrigable lands, as all lands which could be irrigated by any of the stream waters of the arid region were withdrawn from its operations and placed under the operations of the homestead act only. But there yet remains a method by which timber lands and pasturage lands can be acquired under the provisions of the pre-emption laws. But irrigable lands—actual farming lands—can not thus be acquired. The practical effect of the statute, therefore, is to repeal all methods of disposing of the lands for farming purposes in the arid region except only the method by homestead settlement.

In the Congressional debates which immediately preceded the passage of the act of October 2, 1888, it appears that the purpose of the act was to prevent the monopoly of the sites for irrigating works and of the lands irrigated thereby, and this result is secured by the legislation. The waters on the public domain in the arid region can not now be monopolized by individuals and corporations, and the lands can not be acquired in large bodies as heretofore. This is made more plain when the effect of the desert land laws, timber culture laws, and pre-emption laws, combined with the homestead laws, is fully understood. Under the desert land laws an individual could acquire title to 640 acres, under the timber culture laws to 160 acres, under the pre-emption laws to 160 acres, and under the homestead laws to 160 acres, making in all 1,120 acres. It was thus that large holdings were aggregated. The individuals acquiring titles to large tracts of land in this manner which they could not possibly irrigate with their own means, were compelled to mortgage them, and through the agency of these mortgages the titles of these lands are aggregated in the water and land companies, and in many cases, as has already been shown, the individuals acquiring titles to lands were but the agents of the companies themselves, through which the titles were acquired to be transferred to the great land-holders. The history of the administration of the Land Office for the past eight years is instructive on this point. Sometimes the contracts between the individuals acquiring titles and the companies were so apparently fraudulent that many of these entries have been overthrown; yet probably the greater amount stand.

It is believed that the legislation thus accomplished was wise, and in the interest of homestead settlers on the public domain and opposed to the interests of land and water companies, and we disagree with the majority in recommending its repeal. The proper course now to be pursued by Congress is to complete this legislation by providing means by which the sites for irrigating works selected by the General Government may be turned over to the proper persons—the farmers themselves engaged in agriculture, and the new settlers who are to acquire homesteads. Such additional legislation is incorporated in the bill recommended by the minority. It is also believed to be unwise to dispose of the pasturage lands and timber lands to individuals, but that such lands should remain as permanent reservations in the hands of the General Government, to be used as catchment areas for the waters of irrigation needed on the irrigable lands. Provisions for this purpose have been incorporated in the bill herein recommended. Finally, it is believed to be unwise and unjust to make valid the unlawful claims to sites, waters, and lands which speculators and companies have sought to obtain since the passage of the act of October 2, 1888.

SECTION XLII.

EXPERIMENTAL BORING FOR ARTESIAN WATERS UNWISE.

The majority have formulated another bill, and defend it in their report. This is a bill authorizing the Department of Agriculture to investigate the extent to which artesian and other subterranean waters can be used in irrigating the Great Plains, and already an appropriation of $20,000 has been made for this purpose on the recommendation of the majority. It is further proposed in this second bill under consideration that an appropriation of $350,000 shall be made for this purpose. If it is the intention to bore artesian wells to supply the farms of the plains with artesian waters in basins already known, the amount of the appropriation is wholly inadequate. If the appropriation were exhausted in boring wells in artesian basins equal to the average in the world, the area irrigated thereby would be less than three thousand acres. If it if proposed to discover artesian waters in this manner - and that seems to be the correct interpretation—then a geological survey, based upon topography, is necessary, and it should precede all experimental sinking of wells. Perhaps this is the new irrigation survey proposed by the majority, as they appear to deem it unwise to have these investigations relate to any other source of water supply than those mentioned. In fact, it would seem that they expect that the plains can be irrigated by artesian waters. In the United States 8,000,000 acres of land are irrigated by streams, and less than 6,000 acres by artesian wells. There are a thousand artesian wells in Utah, but they irrigate less than 2,000 acres of land, as shown by the printed testimony. No wheat fields, no corn fields, no farms or fields of any character are irrigated from this source anywhere in the United States, or in fact anywhere in the world.

In North and South Dakota there are already many artesian wells, perhaps in the aggregate about 1,000. With four or five exceptions they furnish small amounts of water, and leaving out these phenomenal wells, they would not irrigate 5,000 acres of land if used only during the irrigating season. The non-seasonal flow of these fountains might be stored, and the possible area of irrigation would be increased thereby. But most of these wells are not in the region where irrigation is necessary. The phenomenal wells are in the sub-humid belt where irrigation is needed, and could they be multiplied to a great extent a supply of water would be obtained sufficient to irrigate important tracts of land. Great wells like those at Woonsocket and Aberdeen have been discovered in other regions of the world, but the great flow which they first afforded was not maintained. It has been found by experience that such wells sooner or later exhaust their sources, and that if multiplied the original wells decrease in the volume which they afford. To what extent the artesian formations of the sub humid and arid portions of the Dakotas can be depended upon for a supply of water for irrigation, is unknown, and can only be revealed by careful geological investigation. This source should not be neglected; it may prove to be of some importance, especially for the irrigation of small tracts. In the sub-humid and arid region of Nebraska, Kansas, and Texas there has also been much experimentation with artesian wells. Most of the experiments have been failures, and the few wells found afford a very small supply of water. The geologists of Kansas and of Texas agree with the Director of the United States Geological Survey that it cannot be expected to obtain any great supply of water for irrigation from these sources.

The people of a portion of North Dakota, South Dakota, and Kansas are suffering great hardship by reason of a famine caused by the lack of rain for the last two or three years. Their farms are burned up, and it is proposed to give them relief by encouraging them to bore for artesian wells and obtain waters for their fields in this manner. But the experience of the world shows that the cost of such waters usually prohibits their use in general agriculture, and that they are used only on lands of great value for the cultivation of gardens, orchards and vineyards, and for domestic purposes. Yet the people in these same regions have a vast source of water in the perennial streams which roll across the plains and in the storm-waters which are gathered on their hills. But the majority practically refuse to have the attention of the farmers called to these great supplies, and are unwilling to have a survey made by which the facts can be demonstrated to the people, lest this vast source of wealth should fall into the hands of the people rather than into the possession of water companies. Shall the people of North and South Dakota, who are now suffering the pangs of famine, be still further deluded, and induced to devote their last energies to search for water where it can not be found in quantities sufficient for their relief, that they may ultimately lose their mortgaged lands and be driven from the country, and that thus new theaters for speculation may be opened when the years of abundant rain-fall come?

The following statement made by Director Powell puts this matter in a clear light. (See pages 87–94 of Vol. IV of the report of the special committee of the Senate.)

Senator CASEY. The one thing we and our people desire to know is, what is the extent of the artesian basin underlying that country; they care nothing for the topography of the country, because their hopes and their courage are dependent on what they ascertain in regard to the water that may be obtained. Now, as this is a question of expense, and the money to be appropriated for the purpose has to be granted by Congress, we want to make the expense involved as trifling as possible until we ascertain those essential facts. Therefore I suggest that perhaps an expensive topographical survey may be dispensed with until we know the facts about the water. Would not that be the better plan? Mr. Chairman, would not that strike you so?

The CHAIRMAN. We will discuss that after hearing all the facts.

Senator CASEY. It was by way of discussing it that I have stated what I have.

Director POWELL. If the artesian waters are to be discovered in such a manner that we may predict something of them—so that we can say to the people, "Bore here and you will get water," or "Do not bore there because you can not get water"—that would be of value. To do that a geological survey based on topography is the cheapest and the quickest method. If we go into that country and write books about guesses as to how the strata lie, about the sandstone and the limestone here and there, without having determined definitely where they lie and at what depth they lie, and as to their character, whether they be pervious or impervious to water, but go in with a general statement to the people that it seems to be a good country for the boring of artesian wells, and if it should afterwards turn out that it is not a good country for that purpose, our reports would be of no practical value. Unless we should be able to say positively "Bore here and you will succeed; if you bore there you will fail," the reports would be of no practical value.

In order to be able to say to the people, "You can do this and you can not do that," you will require a map based on a survey. Geology is expressed in topographic features. The map-making collects and arranges these facts of geology in a manner the most economic. All sound geology is based on topography. No good conclusive geologic work is done in the world without this basis.

The CHAIRMAN. In passing through that section of the country the committee took all the testimony that it could get regarding the condition and the character of the rocks. Suppose now that the United States should make a reasonable appropriation for additional wells to determine the extent of that basis, and an intelligent man, a geologist if you please, were to diligently inquire and make a careful record of what had been discovered—of course your experimental wells would determine in other places—might you not with one or two intelligent men to observe and record what has been done and with the Government making some more wells determine with considerable certainty, so that the people might see where they could sink wells, so as to be making a practical move?

Director POWELL. We can take the artesian basins that we know of. Some of these basins are pretty well discovered and defined, as I have said before. We can say to the people as to certain places, "Bore here" or "Bore there."

There are other places where the artesian basins are not well known, but experiments have been made in them. There are others it is probable now entirely unknown. We know that there are some artesian basins, but we do not know their outlines. One man bores in one place and gets no water. The money of the man who gets no water is therefore lost. To trace the outline of that basin and be able to say to the people "You can bore and get water, but if you bore 1 or 2 miles away you can not get water"—that we can not do until we have studied the geological structure.

The CHAIRMAN. Yes, but that takes a good deal of time. The people are on the ground, and they are boring wells. Their hope is predicated on the prospects of getting water. My idea is to aid them in what they are now doing by collecting the facts as to the penetrations——

Director POWELL. That we are doing.

The CHAIRMAN (continuing). Doing that carefully—ascertaining the levels at which they will have struck water, formulating the information as fast as possible, and giving them all the knowledge available; and then, under an intelligent man, having some Government money expended in boring other wells to relieve them of the experimental expense. I have received I suppose twenty or thirty letters from enterprising men in that section, and one from a gentleman in New York, the other day, who said that he owned some land there and wanted to sell it to settlers· He wanted to know what information there was to be had as to the developments that had been made there in artesian wells, and what the Government could do or would do. It occurred to me that it would be well if you could have somebody who was a good geologist to classify what has been done, without waiting for the topography—without waiting for the general geological survey; simply to classify what well-sinking has been done; and then to let some chances be taken, without speaking with absolute certainty, but giving them all the facts as to where water is found. They will not want to wait until you have done all your work, so as to be able, as you say, to speak positively. They want to do something right away. The people are there and want immediate relief.

Senator CASEY. Will you be able to determine the limits of that basin without the experimentation?

Director POWELL. No, sir; not fully.

Senator CASEY. Is it not better to immediately proceed with the experimentation to ascertain the expanse of those basins instead of waiting for the topographical survey that will involve considerable time and expense? The very fact that the Government is taking an interest in this matter will be of great value to the people of that country. Their courage will be greatly aided. As to a topographical survey, the average citizen knows nothing of it. If he sees a hole being bored in the ground he knows what that means; he knows that it means business. The more important part of the country to water is the uplands, away from the river. What the people desire is that they shall know whether they can have water. Coming over this country, for instance toward the Red River, they will want to know whether they can get water, and at what expense. Can not that be ascertained by experiment, and can not the other work be followed up as inaugurated? That is to say, can not the beginning of the work be the boring of experimental wells?

Director POWELL. The work which is to be done there can be considered from two stand-points. It can be considered from the stand-point of what will be known when it is finished, or it may be considered from the stand-point of its progress—what will be known in the stages of its progress.

While the topographical work is going on, as I should work, the geological work is going on, the experimentation is going on; and the geological work is confirmed, as it is going on, by the experimentation. And when it is finished we will know the whole thing; but we will only know parts, as we finish the work in parts, as we go along. But as we go along the work will be developed *pari passu*.

Senator MOODY. The people who have sunk these wells are not scientific people, but mere well-diggers. The information which they have obtained they have not preserved.

The CHAIRMAN. Some of them have.

Director POWELL. We have more facts than they dream of.

Senator MOODY. They have not the facts which would enable them, or enable a scientific man, to determine the strata and the extent of the basin and all that. Of course you are aware that right here on the banks of the Missouri River, the very southernmost point of South Dakota, they have several wells. We know the fact, of course, that they were obliged to go only from 450 to 650 feet, according to the elevation on which they started, to strike that basin which brings the water to the surface with force, and of course we know the fact, for it is a familiar one, that the pressure there is from 60 to 80 pounds to the square inch. The other day they struck a well at 760 feet at Huron. They had to go 900 feet elsewhere. They got a well at Redfield at about 1,100 feet, and so on. They had to go as far as 1,300 feet on the divide between the Jim River and the Missouri River.

Here is a quartzite stratum along the eastern side of North and South Dakota. That red quartzite which they call jasper, sometimes granite, they have attempted to go through, but they have never found any water at any depth that they have gone through that. So we call that the "rim," or the "rim rock." No experiments have passed over the Missouri River, or over the divide; in fact they have not got quite on the divide.

Now, the query is whether it would not be advisable to put a force into the field at once for the purpose of making a fairly good survey to show what area of this country can be utilized for irrigation—to experiment with this water—to see for example whether there is anything in the water which would be detrimental to crops.

The CHAIRMAN. I think the water is very good.

Senator MOODY. And then to dig experimental wells over west and across along the Missouri. When we get across into the western part of the country we know there is plenty of surface water, and people are using the surface water for irrigation; they are constructing ditches in this region of country. On of these ditches is 25 miles long. But going farther north, into the western part of North Dakota, we do not know how much use can be made of the waters. What we want is that these people already there on the ground—600,000 people are located there—may know where they can get water. The farmers will have to depend upon bringing water to the surface to furnish moisture either in the atmosphere or upon the lands, because there comes sometimes a series of years in which they do not have sufficient rain-fall.

Senator CASEY. And four-fifths of the people are farmers and directly dependent on their farms.

Senator MOODY. Now, as Senator Casey has said, what these people want is courage. The courage of conviction is what they greatly desire, and if the Government will give them sufficient money to dig experimental wells they will take care of the rest.

Senator CASEY. But their courage must be built on that which is palpable to their eyes. They can not be expected to look upon this question from a scientific standpoint at all.

Senator MOODY. They want results.

Director POWELL. But what shall the people be given courage to do, to bore wells where they will ultimately fail? or to bore wells where they will meet with success? Suppose they are advised to bore wells on barren ground; the first failure of that kind would react, and all courage would be lost. I do not wish to give the people courage to lead them on to failure, to waste their energies in seeking disaster.

Senator MOODY. Will not the expenditure of a few thousand dollars there by the Government absolutely determine the question as to where that artesian belt exists and where to bore?

Director POWELL. Artesian water can be discovered in part by experimentation and in part by tracing out the formation of the ground.

Senator MOODY. And one must go with the other, you think, or ought to go with it?

Director POWELL. Yes, precisely. The geological examination without the experimentation will more or less be futile. The experimentation without the geological examination will be wasted. That matter has been up before Congress again and again, and appropriations have been made for Texas and Colorado. Fifty thousand dollars has been expended by the Government and thrown away, and yet there are artesian waters in that State. But the wells were bored without the examination of the geological structure and were not placed where the water was to be found.

Senator **MOODY**. Is it not practical with a comparatively small appropriation or expenditure for you to put into that country a corps of engineers and others right at once?

Director **POWELL**. I have estimates sent to the Secretary for each of the Dakotas of $50,000, with the idea that the work there was pending, that it was necessary, and that they wanted the work done at the earliest possible day.

Senator. **MOODY**. Fifty thousand dollars for each of the Dakotas?

Director **POWELL**. Yes.

Senator **MOODY**. Is that enough?

Director **POWELL**. I have asked for $50,000 each for North Dakota, South Dakota, Nebraska, Kansas, and Texas, to be used in this work. With that amount of money I propose to take up, first, the study of the artesian waters and storm waters. My judgment is that the storm waters will be most valuable. I want to be frank with you. I think the people are mistaken, but the people believe in the artesian wells and I am going to meet them.

Senator **CASEY**. And the population lies where the storm water is not available without very great expense, such as the tapping of the Missouri, or something of that kind.

The **CHAIRMAN**. Oh, no.

Senator **CASEY**. I am living in that region and am familiar with it.

Director **POWELL**. My idea is that the people are looking to the artesian waters, and I should push artesian examination first; but I believe that it will be but a small resource, and that the great resource will be in the storm waters and river waters.

Senator **CASEY**. The experimentation is different in our case, because there are facts that exist from which you may proceed, and the examination of the basin should be from what is known outward.

Director **POWELL**. Yes; you have artesian basins but how much water will they supply is the vital question.

Senator **CASEY**. That is a different thing from an examination in a country where no well has ever been discovered.

Director **POWELL**. Already we have facts in relation to the two Dakotas upon which we can proceed with a great deal of confidence about the artesian waters. There has been sufficient study of the geology and sufficient experimentation to make a basis from which to start.

Senator **CASEY**. The confidence of the country with regard to the James River Valley itself is established; but the notion exists in the minds of the people that when you have left the particular formation which makes that valley (of which they know nothing, but which they suppose is the formation inclosing the valley) they will not be able to get water. They have not the courage to expend money for wells there. If the Geological Survey will ascertain that the basin is not confined to that particular valley, experiments will go on by the people in all directions, but they must have some one thing to give them that courage.

The **CHAIRMAN**. Suppose that, taking the places that are known, experimental wells were sunk outside, where the probabilities are great, but where people are not willing to make the experiment, the Government money would not be wasted, would it?

Director **POWELL**. Some would be wasted and some not.

The **CHAIRMAN**. If where you succeeded and gave courage then private enterprise would take hold of it; even if you did waste some money the information would be valuable. By sinking the well the formation would be discovered as you went down. What would be the average cost of these wells?

Senator **MOODY**. The well at Redfield, complete, 1,050 feet in depth, cost $3,100.

The **CHAIRMAN**. What did the well at Huron cost?

Senator **MOODY**. That will cost more, although it is not quite so deep.

Senator **CASEY**. That well at Jamestown cost $7,000. But there is nobody who knows just what a well is going to cost.

The **CHAIRMAN**. I should like to get at a general average, to see how much money is necessary to accomplish any useful purpose.

Senator **MOODY**. Mr. Holt, whom you met at Huron, I suppose, gave the matter a great deal of attention, from the fact that he has had the management of a farm mortgage company there. He told me that they had received an offer from a responsible company to sink thirty-five wells in that region of country for $35,000.

The **CHAIRMAN**. What would be the average depth of those wells?

Senator **MOODY**. The average depth would be about 800 feet.

The **CHAIRMAN**. If they went to the higher lands they would have to dig deeper wells?

Senator **CASEY**. That would be relatively more expensive. I saw Mr. Holt and other people at Huron quite late in the season, and the people on the ground were quite doubtful as to whether it could be done at that price. So that I think that you will need to reckon on these wells costing $5,000 each, taking the average of the country up and down.

Senator MOODY. Possibly, if you reckon on the divide, that may be so.

The CHAIRMAN. Major Powell has got $250,000 for the plains.

Director POWELL. Yes; if the work is to proceed on the theory that the basins are to be discovered by the boring of wells, then the appropriation should be larger. If you want immediate results and want to proceed on the theory that the investigation must be made by experimentation, the appropriation should be larger and it should be expected that much of it would be wasted.

Senator CASEY. That could not be avoided.

Director POWELL. With that understanding we can go ahead experimenting.

Senator MOODY. If every experiment was to be a success we would not want you to make any experiment. We would make it ourselves. It is for the very purpose of determining absolutely that it is no longer an experiment that we want this done.

The CHAIRMAN. The situation out there is very pressing.

Director POWELL. If you will give me sufficient money, I can, within one year, put a corps of geologists and engineers boring on the plains, but it must be understood that much would be wasted, and when the work is finished not a very great supply for agricultural purposes will be given. The amount of water to be obtained from artesian wells is very small, but what there is will be of value.

Senator MOODY. That is what we want.

Senator CASEY. That is what we want so far as North Dakota is concerned.

Director POWELL. Many of the wells bored would be failures; others would be successes. A double corps would be needed—a corps of engineers and a corps of geologists.

The CHAIRMAN. There is a vast population there now that are suffering, and the Government can afford to give them courage, if it is possible to do so. If it could relieve them at once and stop their sufferings it would be a great blessing to that country, for it is really suffering. There are 600,000 people there and they have lost their courage. They want immediate knowledge in order to give them courage. They are a vigorous and active people and only want encouragement.

Senator CASEY. They want the knowledge that the Government is taking an interest in this matter. They want it in a palpable form.

Senator MOODY. Of course we know the existence of this rim-rock. I believe you call it Sioux quartzite?

Director POWELL. Yes.

Senator MOODY. It is a formation by itself. Of course we know there is a little outcrop of that quartzite on the Jim River, which is not very material, and there is nothing of it as you go west. The limit of this artesian basin west has never been found. In other words, it has never been a total failure to find the artesian basin. So we think, or at least we hope, that the proper investigation by scientific men—by the men that you will be able to send out—would supply sufficient facts, so that it would hardly be an experiment to dig a well.

The CHAIRMAN. How much of an examination would it be necessary to make to examine the Missouri River as to where it could be taken out, etc.?

Director POWELL. If any ordinary appropriation is made we will be able to do that next year.

The CHAIRMAN. I do not mean a general survey, but to ascertain the particulars?

Director POWELL. I understand. The single fact could be determined easily; it is a question of levels.

Senator MOODY. The situation of the country is such, that after getting out of the influence of the Jim River you have to take the water from the Missouri. You can not climb this ridge.

The CHAIRMAN. Oh, no. That is the thing we want investigated.

Senator CASEY. The bulk of the population of North Dakota lies east of what is known as the Coteaux.

The CHAIRMAN. Are you through with your general statement, Major Powell?

Director POWELL. Let me say just one word more, Mr. Chairman. If I beg for thorough work, which will not ultimately lead to disappointment, I want you to understand my motive in the matter. We can do work that will be valuable to the people at once, in some cases, but in many cases it would bring disappointment. If we are hurried in doing it, instead of doing it in a careful, scientific manner, many people will fail and will say, "We have failed because we followed the recommendations that were given." We know of three artesian basins in the Dakotas: That on the Red River has been carefully surveyed. Its supply of water is limited; but it is in a region of country where irrigation is not necessary. Farther west there are two other basins, imperfectly known; one of them gives no evidence of being of great value; the other gives evidence of being one of the finest basins in the world and is worthy of the most thorough examination; and yet we can not hope for a great supply of water for irrigation from it. Water for towns, villages, gardens, ranches, and even for powers, may be obtained, and perhaps some small amount of water for farming purposes; but artesian waters are always limited, and excessive boring destroys them. The great basin of the Dakotas should be utilized to its fullest extent, but it must not be tapped beyond that or the whole thing will collapse. That has been the experience of many artesian basins; and it seems to me that it would be wise to direct the attention of the people more to the storage of storm waters. There are many portions of the Dakotas where this can be done advantageously and cheaply. Yet I do not wish to discourage the use of artesian waters to the utmost extent of the supply.

The principal supply of artesian waters in the two Dakotas is from the Dakota sandstone. All the great wells are found in it. We do not have to discover that sandstone; we know its extent throughout the country, but we do not know how much water it will yield. We do know that the supply is limited, that it can not be great; that it will be impossible to multiply wells indefinitely; and we do not know but that this source has been drawn upon nearly to its limit. Should I say to the people that this sandstone is found from north to south throughout the Dakotas and from the ninety-seventh meridian westward nearly to the Rocky Mountains, and that you can in most places find artesian waters in it—which is a fact—it would give the people courage to bore, and many wells would be immediately sunk, and the probabilities are that the supply would soon become exhausted and all existing wells destroyed. What we want to know is to what extent this source can be drawn upon and when the boring of wells into it must be stopped. But what is still more important, we wish to discover whether there are any other water-bearing formations. All this can be determined in the most speedy and most economical manner by a geological survey based on topography and by an occasional experiment to verify the inferences of the geologist. The geologist is able to say that such and such rocks and such and such districts will not afford artesian waters. His first conclusions are therefore negative, excluding certain rocks and certain districts. Then he discovers other districts where the character of the rocks and the geological structure give probabilities that artesian waters may be found, and these probabilities must be tested by experimentation.

And finally, Mr. Chairman, I wish to be understood as expressing the opinion that when all the artesian waters are discovered and all utilized, there will still not be a sufficient amount of water for the region of country of which we have been talking, extending along the plains from our northern to our southern boundary, greatly to affect the industries of agriculture. Artesian waters have always been and must be inadequate to meet the wants of irrigation, except here and there for gardens, orchards, vineyards, and for stock purposes. The great fields of Dakota can never be cultivated by artesian waters. To encourage the hope for success in this direction, on any scale adequate to the needs, is to give the people a false hope that will lead them to disaster. I know that the people see streams of water bursting out of the ground here and there, impelled high into the air, and in times of drought these are beautiful scenes. I know that they have reached the conclusion that there is a lake of water underground, and that rivers flow beneath their feet, and that they have but to tap these sources to receive an abundant supply. But I also know that these opinions are groundless; that the waters which they obtain are only those which percolate through porous sandstone from a long distance away, and that the supply is exceedingly limited. I know that the sandstone in which it is found is widely spread, but I dare not tell them of its extent lest they be tempted thereby to spend vast sums of money in vain, and reach still worse results by destroying the fountains already developed. It is my opinion that the resource is not exhausted, that some more wells can yet be successfully sunk into the Dakota sandstone, but to what extent it is safe to go on as they have begun I dare not say until a proper examination is made. I am not willing to deliberately face the facts before me and encourage the people as you desire. Is it wise to encourage the people to gamble for water with the dice loaded against them?

JOHN A. REAGAN.
A. P. GORMAN.
JAMES K. JONES.

A BILL to provide for the irrigation of the arid lands of the United States, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Secretary of the Interior, through the agency of the Irrigation Survey, shall cause the arid lands of the United States to be topographically surveyed and platted into irrigation districts by hydrographic basins, so that one hydrographic system, embracing all of the interdependent waters and lands in relation to irrigation, forest protection, and pasturage protection, shall be included in each, in manner to wit:

First. Wherever it is possible, each irrigation district shall consist of the area drained by the headwaters of a great river, or by one small river and its tributaries, or by a large creek and its tributaries, and it shall include all the lands embraced therein and that are or can be irrigated thereby, and all such headwater districts shall be known as irrigation districts of the first class.

Second. Wherever it is possible, all other lands not included in any irrigation district of the first class, and that lie along any river and belong to the hydrographic basin of such river, shall be divided into districts in such a manner that each district shall embrace all of the irrigable lands belonging to one irrigation system, dependent upon one system of head-works and canals, together with all other lands of whatever nature belonging to the drainage of that portion of the river embraced in said district; and this shall be done in such a manner in each case that the sites for the diverting dam or dams, reservoir or reservoirs, and other head-works, together with the main canal or canals, and all branches thereof, and the section of the river along which it lies on one or both sides, and all lands drained into the river along such section on one or both sides, as the case may be, not embraced in any irrigation district of the first class, and forming the catchment area of such district, shall be included within said irrigation district; and such districts shall be known as irrigation districts of the second class.

Third. That wherever creeks drain contiguous areas and run into valleys or plains, where they disappear or are lost by being discharged into the sands, and thus do not have natural outlets into other streams, they may be thrown by groups of contiguous basins into irrigation districts, or may be attached to other irrigation districts and form constituent parts thereof for the purposes contemplated in this act; and such districts, constituted solely of isolated drainage basins, shall be known as irrigation districts of the third class.

And the boundary of each district shall be determined, with all its meanders, and marked upon the ground; and the topography of each irrigation district shall also be determined by surveys, and maps shall be constructed of the same, appropriately representing such boundaries and such topography.

SEC. 2. That it shall be the duty of the officers of the United States Irrigation Survey to select, define in land-office terms, and designate on the maps the irrigable lands in the irrigation districts provided for in this act; and the lands selected shall be such as can be irrigated by the canals and irrigating works planned and reported by the survey and by the irrigating works already constructed and used for that purpose; and wherever in any topographic basin there is a greater area of good and available irrigable lands than the waters are competent to serve, the lands most favorably situate for irrigation shall be selected, as governed by the following conditions, to wit:

First. The conditions necessary to secure the greatest area of irrigable land.

Second. The conditions necessary to secure the most valuable lands for agricultural purposes by reason of climate.

Third. The conditions necessary to secure the most valuable agricultural lands as determined by soil and subsoil.

Fourth. The conditions necessary to secure lands that can be irrigated and cultivated with the greatest economy.

SEC. 3. That all lands which were irrigated in any irrigation district provided for in this act prior to the passage of the act of October second, eighteen hundred and eighty-eight, providing for the segregation of irrigable lands, and all lands for which irrigation works had been constructed, in whole or in part, prior to the passage of said act, are hereby declared irrigable lands for all purposes contemplated in this act; but this provision shall not be construed to authorize the use of any water for irrigation not legally appropriated; and all lands designated by the United States surveys as irrigable lands, whether belonging to the United States or to other parties, are hereby declared irrigable lands for the purposes contemplated in this act.

SEC. 4. That it shall be the duty of the United States Irrigation Survey to designate the trunk sections of the rivers and large creeks of the irrigation districts, and to determine and locate the places on such trunk sections where dams for irrigating canals may be constructed, and the sites within such irrigation districts which may be used for irrigating reservoirs, and the routes which may be followed for the construction of canals taking water from such designated trunk sections, all in such a manner as to protect the water rights of the several irrigation districts and to prevent the construction of improvident and obstructive works of irrigation; and it shall be unlawful for any person or corporation to construct, in any of the irrigation districts provided for in this act, any dam, reservoir, canal, or other hydraulic work for irrigation purposes taking water from designated trunk sections upon any site or route not selected and designated by the United States Irrigation Survey for such purposes.

SEC. 5. That all running waters, perennial or intermittent, in the irrigation districts provided for in this act, shall be divided among such irrigation districts in the following manner, to wit:

First. In any irrigation district of the first class all of the waters running therein may be used for irrigation on the lands designated as irrigable lands, and on the lands of town sites; but waters shall not be used for irrigation on the lands of such irrigation districts not thus designated as irrigable lands, or which are not town-site lands; and waters shall not be taken from designated trunk sections except at such places as are designated for that purpose by the United States Irrigation Survey.

Second. In any irrigation district of the second class all of the waters falling thereon may be used for irrigation on the designated irrigable lands and on the town-site lands, and all the waters running in the trunk sections of such irrigation districts may be used on the designated irrigable lands and on the town-site lands; but waters shall not be used for irrigation on the lands of such irrigation districts not thus designated as irrigable lands and town-site lands; and waters shall not be taken from such trunk sections except at the places designated for that purpose by the United States Irrigation Survey.

Third. In any irrigation district of the third class all of the waters falling on or flowing in such irrigation district may be used for irrigation on the designated irrigable lands and on town-site lands; but waters shall not be used for irrigation on the lands of such irrigation district not thus designated as irrigable lands and town-site lands; and waters shall not be taken from designated trunk sections except at such places as are designated for that purpose by the United States Irrigation Survey.

SEC. 6. That whenever a catchment area, in whole or in part, or the reservoir or reservoirs, dam or dams, or other head-works or canals of any irrigation district, as planned by the United States Irrigation Survey, lie within the boundaries of another State or Territory than that to which the chief body of irrigable lands belong, the people of the irrigation district whose lands are irrigated thereby shall have the right to enter upon the lands where such waters, sites, and works are situate, for the purpose of constructing, maintaining, and protecting the same, and for the purpose of protecting and using the forests and the pasturage thereon; and it shall be unlawful to levy any tax on, or establish any obstruction to the use of, such waters and such forests and pasturage by the State or Territory wherein they are situate; but the jurisdiction over such waters, sites, and works, for the purposes contemplated in this act, shall belong to the irrigation district owning and using the same: *Provided*, That the State or Territory wherein they are situate shall consent to the same as hereinafter provided.

SEC. 7. That all the lands belonging to the United States in any of the irrigation districts provided for in section one of this act shall remain the property of the United States, except as herein provided, to wit:

First. Any lands designated and segregated by the United States surveys as irrigable lands may be acquired by individuals in tracts not greater than eighty acres under the provisions of the United States statutes for the acquirement of homesteads.

Second. Any mining lands in such irrigation districts may be acquired by individuals under the statutes of the United States providing for the acquirement of such mining lands.

Third. Any coal lands lying within such irrigation districts may be acquired by individuals under the statutes of the United States providing for the acquirement of such coal lands.

Fourth. Any town sites that may be selected in such irrigation districts may be acquired by the proper persons under the United States statutes providing for the acquirement of town sites.

All other lands in the irrigation districts are hereby declared to be public lands, to remain the property of the United States, and to be held for the use and benefit of the people of the irrigation districts as forest lands and as pasturage lands, and as catchment areas or sources of supply for the waters to be used in the irrigation district for irrigation and for other beneficial purposes; and such forests and such pasturage may be used by the people of such irrigation districts under the conditions and restrictions hereinafter provided; and all sites for reservoirs, canals, dams, and other hydraulic works designed for irrigating purposes which may be selected by the United States Irrigation Survey shall remain the property of the United States, to be used by the people of such irrigation districts, under the conditions and restrictions hereinafter provided.

SEC. 8. That the owner of any tract of land designated as irrigable land, acquired by homestead settlement, with title inchoate or perfected, or the owner of any tract of land designated as irrigable land acquired in any other manner, shall have the right to use any waters for irrigation belonging to the irrigation district in which his tract of land is situate not otherwise used and appropriated, and shall have the right to be served from any irrigating canal properly located for that purpose by the payment of the proper part of the cost of the construction of the irrigating works upon which his supply of water is dependent, such amount to be determined by the commissioners of the irrigation district who are hereinafter provided for, in compliance with the statutes of the State or Territory to which such irrigation district belongs: *Provided*, That such payment may be extended over a term of years at the discretion of said commissioners, or under the provisions of State or Territorial law.

SEC. 9. That it shall be unlawful for any person or corporation to construct dams, reservoirs, canals, or other hydraulic works for irrigation purposes in the irrigation districts provided for in this act, except such as are authorized by the commissioners of the irrigation district, in conformity with the general statutes of the State or Territory in which the irrigation district is situate and in conformity with the laws of the United States; and no person or corporation shall acquire the right to appropriate and use water for irrigation in any of said irrigation districts except as provided in this act.

SEC. 10. That it shall be lawful for the qualified voters of any irrigation district, as provided in section one of this act, to organize themselves into a body corporate and politic, with powers to sue and be sued, and right to use a seal, for the purposes contemplated in this act, by providing:

First. For a board of irrigation district commissioners of not less than five persons, who shall be elected by the qualified voters of the irrigation district, and who shall constitute the legislative body of the irrigation district to enact laws and rules relating to the use of the waters of the district for irrigation and other purposes, and relating to the use and protection of the timber and fire-wood of the district, and relating to the use and protection of the common pasturage of the district, subject to and in compliance with the statutes of the State or Territory in which such irrigation district is situate and in conformity with the laws of the United States.

Second. For an irrigation court to adjudicate questions that may arise under the laws and rules of the irrigation district relating to the use and distribution of the waters of the district, the protection and use of the timber and fire-wood of the irrigation district, and the use and protection of the pasturage of the irrigation district, and to provide for appeals from such irrigation court to higher courts of the State or Territory.

Third. For a superintendent of irrigation, and for the necessary assistants, as engineers and water-masters.

Fourth. For a superintendent of forestry, and for the necessary assistants, as foresters.

Fifth. For a superintendent of pasturage, and for the necessary assistants, as herders, should they be deemed necessary.

SEC. 11. That it shall be lawful for the commissioners of each irrigation district to provide laws and rules for purposes, to wit:

First. For the use of all the waters falling within the catchment area of the irrigation district, for the irrigation of the lands of the irrigation district, and for other useful and beneficial purposes, and for the recovery, by drainage and other hydraulic methods, of all the waters used in irrigation, and for other public purposes, and for determining how and where they may be reused within the irrigation district on the lands designated as irrigable by the United States Irrigation Survey: *Provided*, That such regulations shall be in conformity with the general statutes of the State or Territory in which the irrigation district is situate and in conformity with the laws of the United States.

Second. For the use and protection of the timber and fire-wood of the irrigation district, in conformity with the general statutes of the State or Territory in which it is situate and in conformity with the laws of the United States.

Third. For the use and protection of the pasturage of the irrigation district, in conformity with the general statutes of the State or Territory in which it is situate and in conformity with the laws of the United States.

SEC. 12. That it shall be lawful for any State or Territory in which are situate any of the irrigation districts authorized in this act to provide by general statute for the purposes herein named, to wit:

First. For the use of the waters of such irrigation districts for service on the lands selected and segregated as irrigable lands by the United States, and for other useful and beneficial purposes; and, further, for the construction of irrigating works under authority of the commissioners of the several irrigation districts by any of the methods, to wit: First, by the co-operation of the people interested therein; second, by taxes levied on the lands irrigated; third, by the issuance of irrigation-district bonds, the interest and principal to be paid by taxes levied on the land irrigated; fourth, by granting to persons or corporations the right and imposing on them the duty of supplying water for irrigation and other beneficial purposes, through the agency of irrigation works, for a term of twenty seven years, and by providing that the services of such persons or corporations shall be paid for by the users of the water at just and reasonable rates for measured quantities of water, and not at rates per acre or quantity of land irrigated, and by further providing that at the expiration of twenty-seven years from the beginning of the first service of water, the rights and duties of such persons or corporations shall terminate, and all such irrigation works shall thereupon become and be the property of the irrigation districts to which they pertain.

Second. For the use of the timber and fire-wood of such irrigation districts for domestic, mining, and other purposes, and that the users of timber and wood for such purposes shall pay to the commissioners of any irrigation district from which timber or fire-wood is taken an amount sufficient to cover the expense of the maintenance of the forestry organization in such irrigation district, and not more than twenty per centum of the same added thereto; and all revenue derived from the sale of timber and fire-wood by the commissioners of any irrigation district shall be used, first, for the maintenance of the forestry organization of the irrigation district; and, second, for the construction and maintenance of irrigation works. And the forest areas from which such timber and fire-wood are taken shall be designated by the commissioners of the irrigation districts in such manner as they may deem wise for the protection and advantage of the sources of the water supply for irrigation, and for the protection and permanence of reservoirs and other works of irrigation: *Provided*, That the administration of such statutes shall be relegated to the irrigation districts.

Third. For the use and protection of the pasturage of such irrigation districts: *Provided*, That the administration of such statutes shall be relegated to the irrigation districts.

SEC. 13. That it shall be lawful for any State or Territory in which are situate any of the irrigation districts provided for in this act to provide by statutes for the organization of a State or Territorial board of irrigation commissioners, to consist of not less than five persons, for the purpose of supervising and approving all contracts made by the irrigation-district commissioners for the construction and maintenance of irrigation works, when provision is made to pay for such works by the issue of irrigation-district bonds, or when contracts are made with persons or corporations for the construction and maintenance of irrigation works for a term of years, and such contracts or bonds shall not be valid without the approval of the State or Territorial board; and it shall be the duty of said State or Territorial board to disapprove said contracts or bonds whenever it shall appear that the amount stipulated to be paid by the irrigation district for the construction of irrigation works is excessive and more than sufficient for the economic construction of such irrigation works, or when such works are not properly planned to serve the purposes for which they are intended, or when proper provision is not made for the prompt and complete payment of the interest and principal on bonds or other obligations of the irrigation district.

SEC. 14. That it shall be lawful for any State or Territory to define the boundaries of any city or town in such State or Territory, and to designate the waters to be used in such city or town for domestic, horticultural, and other purposes, but not for agricultural purposes, and to exclude such cities or towns and such waters from the irrigation districts and from the operations of this act, and to regulate by general statutes the conditions under which waters may be used on town sites segregated from the public lands or laid out on other lands.

SEC. 15. That the provisions of this act relating to the organization of the irrigation districts as expressed in sections ten, eleven, twelve, and thirteen shall have no force or effect, and the benefits and privileges of the act relating to sites for reservoirs, dams, canals, and other hydraulic works for irrigation purposes, and to the protection and use of timber and fire-wood, and to the protection and use of pasturage shall not accrue in any State or Territory until such State or Territory shall have performed the followings acts, to wit:

First. It shall be incumbent upon such State or Territory to provide by general statute for the organization of such irrigation districts by the election of commissioners, and for the organization of irrigation courts, and for the election or appointment of a superintendent of irrigation and water-masters, a superintendent of forestry and foresters, and a superintendent of pasturage, in compliance with the provisions of this act.

Second. It shall be incumbent upon such State or Territory to provide by general statute for the use of waters for irrigation and other purposes, relegating its administration to the several irrigation districts, and such statute must be in conformity with the provisions of this act.

Third. It shall be incumbent upon such State or Territory to provide by general statute for the use and protection of timber and fire-wood, relegating its administration to the several irrigation districts, and such statute must be in conformity with the provisions of this act.

Fourth. It shall be incumbent upon such State or Territory to provide by general statute for regulating the use and protection of pasturage, relegating its administration to the several irrigation districts, and such statute must be in conformity with the provisions of this act.

Fifth. It shall be incumbent upon such State or Territory to provide by general statute for the condemnation, relocation, or re-adjustment of improvident or obstructive water rights whenever any water right is declared improvident or obstructive by the commissioners of any irrigation district, and such statute must be in conformity with the provisions of this act.

Sixth. It shall be incumbent upon such State or Territory, by joint resolution of both branches of its legislature, to grant the rights and accept the duties conveyed and intrusted by this act; and whenever the governor of any such State or Territory shall have submitted to the President of the United States such joint resolutions and such general statutes as are nominated in and required by this act, then, if the President of the United States shall find that the requirements of this act are fully and properly met, he may make, and is hereby authorized to make, his proclamation setting forth the fact that the requirements of this act have been properly fulfilled by such State or Territory, and that the several irrigation districts therein are authorized to proceed with their organization, and are entitled to all the rights and subject to all the duties expressed and implied in this act, and thereupon the provisions of this act embraced in sections ten, eleven, twelve, and thirteen shall have force and effect as law.

INDEX TO MINORITY REPORT.

Abstract of minority report, 95.
Act of October 2, 1888, effect, 168-171.
Arid lands, total area, 95, 100.
    redeemable, 95, 101.
    can not all be reclaimed, 96, 167.
    how to select the best, 96, 108.
    valuable when irrigated, 96, 109.
    naturally fertile, 105.
Allison, Senator, quotations from report concerning a topographic survey, 152.
Argument showing that a topographic survey was ordered by Congress, 149-157.
Artesian wells, boring without geological survey unwise, 99, 171-176.
Artesian waters always of insignificant amount, 99, 101, 171-174.
Bill of majority of committee, 98.
    in the interest of great cattle companies, 98, 143, 167.
    in the interest of great private irrigation companies, 98, 143, 167.
    analysis and criticism, 143-148, 167.
Bill of minority of committee in full, 178-182.
    abstract, 97, 98, 140.
    general effect, 98, 142.
Bureau of Irrigation in Agricultural Department, unnecessary, 98, 148.
California, processes of irrigation, 103.
Casey, Senator, makes inquiries concerning artesian wells, 172-176.
Cattle companies, consolidated into syndicates, 106.
Claims, Federal, for damages, 96, 117.
Corporations getting control of land and water, 96, 117-[illegible]9.
Colorado River, international conflict, 111.
Columbia River, international conflict, 111.
Forest lands, extent, 96, 105.
    should belong to settlers, 96, 105.
    varieties of, 105.
Geological survey, a second not necessary, 99, 167.
Homestead, small size expedient, 96, 109.
Hydrographic branch of survey should not be turned over to Signal Service, 99, 165, 166.
International conflicts concerning water rights, 96, 111.
Interstate conflicts about water, 96, 97, 112, 113, 130, 131.
Irrigable land, limited in extent, 107.
    best must be selected, 107.
    great importance of selection, 107, 108.
Irrigation, practical work not to be done by Government, 97, 120.
    to be done by the people, 97, 120, 121, 167.
Irrigation districts, how bounded, 97, 121.
    mapped by the United States Geological Survey, 97, 121.
    land, pasturage, timber, and water go together, 122.
Irrigation survey, total cost for the whole country, 97.
    should go forward, 99.
    survey, necessary for the settlers, 136-138.
Irrigation, cost per acre, 120.
    when perfect, consumes all the water, 102.
Irrigation sites, should be reserved by General Government, 99, 169.
    districts, population, 132-134.
    their functions and government, 134, 136.
Irrigated land, area under cultivation, 102.
Kansas, suffering from drought, 102.
Mendenhall, T. C., alleges the economy and necessity of a topographic survey, 164.
Mexico, conflict of water rights with United States, 111.
Moody, Senator, makes inquiries about artesian wells, 172-176.
North Dakota, suffering from drought, 102.
Pasturage lands, extent, 96-105.
    should belong to settlers, 96-106.
Powell, Director, justified in making a topographic survey, 150-154.
    does not hold that irrigation works should be built by the General Government, 99, 167.
    statement concerning topographic survey, 158-163.
    on artesian wells in the Dakotas, 172-177.
    holds that irrigation should be done by the people of irrigation districts, 99.
    believes in great utility of storm waters, 101.
    furnishes maps of arid region, 102.
Prince, Gov. L. Bradford, of New Mexico, furnishes list of corporations, 119.
Pump-waters, as source of irrigation supply, 101.
Reagan, Senator, bill (No. 3769) for irrigation survey, 97, 98, 140.
    analysis of bill, 140-142.
Reservoirs, 115.
Rio Grande irrigation district, mapped and described by Powell, 122-129.
    insufficient water for farmers, 111.
South Dakota, suffering from drought, 102.
Stewart, Senator, understood in 1888 that a topographic survey was intended, 152.
Storm-waters, as source of irrigation supply, 101.
Streams, as source of irrigation supply, 101, 103.
Subhumid region, area and character, 95, 96, 102, 103, 138, 139.
Survey for irrigation, expense of total, 97.
Topographic survey, according to law, 99, 149-157.
    according to plan submitted to Congress, 99, 149-157.
    economical, 99, 157.
    necessary, 97, 99.
    report made in 1888, 153.
Water waste can be avoided, 95, 103, 104.
Water supply, sources, 95, 100-102.
Water, how to divide, 96, 115.
Water in streams, value, 112.
Water rights, obstruction, 96, 110.
    international conflicts, 96, 111.
    interstate conflicts, 96, 97, 112, 113, 130, 131.
    speculative should be extinguished, 96, 114.
    conflicts between communities, 113.
    existing must be maintained, 114.
    in few hands, 117, 119.
Wells, artesian, 99, 101, 171-176.

REPORT

OF THE

SPECIAL COMMITTEE

OF THE

UNITED STATES SENATE

ON THE

IRRIGATION AND RECLAMATION OF ARID LANDS.

VOL. I.—THE NORTHWEST.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1890.

VOL. I.

THE NORTHWEST.

SOUTH DAKOTA.
NORTH DAKOTA.
MONTANA.
EASTERN WASHINGTON.
EASTERN OREGON.
IDAHO.

IRRIGATION AND RECLAMATION OF ARID LANDS.

WASHINGTON, D. C., *April* 8, 1889.

The committee met pursuant to call of the chairman.

Present: Messrs. Stewart (chairman), Allison, Hiscock, Plumb, Gorman, Jones of Arkansas, and Reagan.

The resolutions forming the committee and prescribing its functions were read, as follows:

IN THE SENATE OF THE UNITED STATES,
February 14, 1889.

Resolved, That a select committee of seven Senators be appointed by the President of the Senate, to be known as the Select Committee on Irrigation and Reclamation of Arid Lands, whose duty it shall be to consider the subject of irrigation and the best mode of reclaiming the arid lands of the United States, and that said committee shall have leave to sit during the recess of the Senate, and shall report to the Senate at the meeting of Congress in December next what legislation is necessary for such irrigation and reclamation; and the committee may employ a clerk who shall be paid six dollars per diem out of the contingent fund of the Senate.

Under the foregoing resolution the President *pro tempore* appointed Senators Stewart, Allison, Plumb, Hiscock, Gorman, Reagan, and Jones of Arkansas.

IN THE SENATE OF THE UNITED STATES,
February 25, 1889.

Resolved, That the Select Committee on Irrigation and Reclamation of Arid Lands, appointed under authority of a resolution of the Senate of February 14, 1889, is hereby authorized in pursuing the investigation in said resolution ordered, to hold its session and to take testimony at any place in the United States, and to employ a stenographer and a messenger; the expenses of such investigation to be paid from the contingent fund of the Senate. The committee is also authorized to cause its proceedings and the testimony taken before it to be printed from time to time as it may see fit, exclusively for its use. Any subcommittee appointed by said committee may exercise the same powers as the full committee.

On motion of Senator Hiscock, the committee adjourned to meet at St. Paul, Minn., August 1, 1889.

THE TWO DAKOTAS.

ST. PAUL, MINN., *August* 1, 1889.

The committee met pursuant to adjournment.

Present: Messrs. Stewart (chairman) and Reagan; also, by invitation of the committee to take part in its proceedings, Director J. W. Powell, of the Geological Survey.

The CHAIRMAN. The committee meets here for the purpose of hearing what the delegation from Dakota may have to say with regard to that country.

The object of the investigations to be made by this committee is the ascertainment of facts touching the peculiar conditions of the different sections of the arid country, with a view to legislation in the future. As there are several gentlemen here from different parts of Dakota we would like to have each one of them, or as many as may be able, to speak with reference to their localities; stating what water-supply facilities they have; what is the general topography of their sections; what they have done in the way of irrigation, and what is the necessity for it, giving their reasons therefor.

REMARKS OF E. V. SMALLEY, OF ST. PAUL, MINN.

Mr. Chairman and gentlemen, the chairman of our Chamber of Commerce, Mr. Bishop, was not able to be here this morning, and he has directed me to offer to the committee the use of this chamber, as has been already done by the secretary, and to express to you in a few words the very cordial interest we feel here in St. Paul in the work of this committee. It was with great satisfaction we learned that you had selected this city for the place of your first meeting and point of departure through the West.

St. Paul's trade relations extend over the whole northern part of what is known as the arid belt; that is to say, we have a direct interest in the development of the entire region from here to the Pacific coast, a great part of which will be the scene of your labors and researches.

Fortunately our own State of Minnesota is not in need of irrigation, and heretofore we have never regarded Dakota as a region where irrigation was essential to the production of crops. But in recent years, as these gentlemen from that region will tell you, a sentiment has grown up there, through necessity, in favor of increasing its water supply by means of artesian wells.

When you get west of Dakota you come to Montana, which is entirely a region where the rain-fall must be supplemented by irrigation, if successful farming is to be carried on. Beyond that the whole of the

Territory of Idaho, which we also regard as within our trade region, must be classed as a country suitable for irrigation, with a considerable portion also of Washington Territory.

Now, gentlemen, I shall detain you only to say that in the development of this country St. Paul has a great and growing interest, and we desire also, when we can, to second your labors and to assure you of our hearty interest in them. It was with pleasure we heard that the National Government had taken up this work of inquiry by the appointment of a committee so thoroughly competent to deal with the subject, and we trust that something more may come out of its labors than the preparation of a report. We have hope that the gentlemen of this committee will second the efforts of the people in these new States, and that the General Government will give to that people some model systems of irrigation; that they may show what it is possible to do on a large scale with some of the great rivers that now run waste to the sea.

STATEMENT OF A. W. BURT, OF HURON, BEADLE COUNTY, DAKOTA.

Mr. Chairman and gentlemen, I appear before you as a representative of Beadle County, in central Dakota, having been sent here by the county commissioners of that county to present to you the question of sinking artesian wells for the purposes of irrigation. That question is one of great importance to the people of Dakota.

I first went to Dakota in the fall of 1881, and moved there to live in the spring of 1882. At that time there was little or no settlement in that country.

During the winter of 1880 and 1881 there was in that country what might be called abnormal snow—an extraordinary deposit of snow. That snow melted and filled all the lake beds and low places with water. During the summer of 1882 we had rains frequently—heavy rains. I know that, because I was out on my claim in a tent, and we got wet nearly every day.

Every summer, from May until along in July, we had copious rains, which replenished those low places on the face of the prairie. Then we had plenty of moisture. I was enchanted with the country, because I saw that everything grew luxuriantly. That season what little crops were there, what little matured, were good, and the vegetables of every description grew to mammoth size. We are all well satisfied that the soil of that Territory is very fertile, and that the possibilities of its production has not been ascertained.

In 1883 it was a dryer season, still we had plenty of moisture on the surface and we had good crops. The summer of 1884 came, and it was dryer still; and since that time it has continued to grow dryer until the supply of water which we had obtained in 1881 and 1882 became exhausted.

Thousands of men went into that country in 1882 and 1883 and made their homes there. I had followed a professional life for a good many years, but I sought rest from its exhausting demands, and what wealth I have in all this world is now in farming interests in that country, and what I now tell you I have seen, experienced, and know.

The soil of Dakota is a black soil from 16 to 20 inches thick. Underneath it through that section of the Territory—central Dakota—lies what may be called red clay, hard and almost impervious to water. Therefore, when the water falls upon the surface of the earth it is kept on this subsoil; so that when the rains are over vegetation may draw from this supply. The only thing is to get the water into the ground. When I went to Dakota artesian wells were not thought of. I think the first discovery made in that direction was by the railroad companies, who dug wells to supply their trains with water.

Mr. Chairman, you say that you wish to know facts. We of Dakota dislike to have our country referred to as an arid country. We have always insisted that we had one of the grandest countries in the world, yet to-day, while still clinging to that belief, we must admit that the farming of that country is substantially reduced to a question of luck. It is this way: In the west or northwest you will see the clouds rise. You have 200 acres lying out. A shower seems to hover in the sky. After two or three seasons you will watch that threatening shower with as strong an interest as you would a little child that might come into danger, in the hope that it may come across your farm and give you water on your wheat. I mention that to show the feeling of every man in that country who has crops in the ground upon which he is relying for subsistence.

The crops that we raise in Dakota are wheat, rye, barley, potatoes, all kinds of vegetables, and oats. We have some snow in the winter time, but we have not had a heavy fall since 1882. The vegetables and grain start well in the spring, because there is sufficient moisture. If in the month of May, after the crops begin to draw on the soil, we could have some moisture to open the land we would not have any fear that we would have perfect crops. So that the application of water to the land at that time of the year would be beneficial to the crops. We often start our plows when the wheat is off the stubble. Last fall the ground was very dry and we plowed it and it lay there, and the wheat and the oats never sprouted during all the fall; but I believe that if artesian-well water or reservoir water could have been put upon that land and allowed to lay on the subsoil during the winter, there would have been sufficient moisture to have perfected the crops of small grain without further assistance.

I am not here to advance theories; I am no civil engineer; I understand nothing about the systems of irrigating, but I will say to you that as you go from Sioux Falls, which I understand you are to visit, up through Huron and Jamestown, on your way westward out of the Sioux Valley on to the table-lands, which you will find lie in long wavy rolls like waves of the sea with high ridges running in various directions, sometimes the points of those ridges coming together, there you will find places for artesian wells from which miles and miles of land may be filled with water.

Senator **REAGAN**. Be good enough to state to us the extent to which artesian wells have been obtained in Dakota.

Mr. **BURT**. I was about to proceed to that. In 1885 the city of Huron, which at that time had the Holly water works system of supplying water, came to the conclusion that they would sink an artesian well. They had been induced to do this on account of the well at Miller, 40 miles away, and one at Hitchcock, and another at Groton. The well at Huron was completed in September, 1886. I have here a statement showing the different formations through which the drill passed when that was sunk. It is as follows:

Huron artesian well sunk during the month of September, 1886

	Formation.	Feet.	Depth.
1	Yellow clay	13	13
2	Blue clay	76	89
3	Gray shale	151	240
4	Hard iron rock	2	242
5	Sand	5	247
6	Hard sand rock	2	249
7	Gray shale	175	424
8	Hard sand rock	10	434
9	Gray shale	15	449
10	Brown shale	101	550
11	Sand rock	41	591
12	Gray shale	101	692
13	Brown lime	10	*702
14	Sand rock, white	50	752
15	Hard sand rock	10	762
16	Sand rock, white	40	†802

* This came to cap of water-bearing rock.
† Second flow.

Then went down 61 feet deeper through hard sand rock and gray lime but stopped, as appropriation gave out, and as sufficient water for all purposes was found it was considered wise not to go deeper. The flow of this well is 1,400 gallons per minute. When closed there is a pressure of 170 pounds to the square inch.

ALEX. MCINTOSH,
Water Commissioner, City of Huron.

HURON, DAK., *June* 13, 1889.

When this well was completed and the water put in motion, confined in the pipe, it went straight out of the pipe into the air nearly 100 feet. The pressure was 170 pounds to the square inch. The water from that well is as clear and pure as the water which flows from the springs in the Vermont hills and mountains. It is wholesome water. I use it in my family, and others do. It takes kindly to vegetation also. I am now using it in town on trees of various kinds, upon white clover, upon red clover, upon timothy and other grass, upon crops and vegetables of various kinds, and even on house plants. Pot plants flourish under its application. The well at Miller, 40 miles west, has a double flow. I do not know the pressure of that well. They have not yet utilized the pressure. The well has been sunk, but they are not running it, because they have not the means to inaugurate a system of water-works.

There is a well 140 miles north of Huron, at Hitchcock, said to have a pressure of 200 pounds. That well runs a grist and feed mill. Besides that they have a lake a little west of the town which at one time was half a mile long and 80 rods wide. That lake afforded a large amount of evaporation and made things look cheerful. A gentleman complained of that lake because a portion of it came on three acres of his land. He commenced suit against the town, he being one of 300,000 in Dakota who objected to water. He enjoined the town from proceeding. I defended the town. Of course I did not suppose he could get more than nominal damages. The result of the suit was that this lake was lowered and the water was turned from this man's land and allowed to proceed in another direction. The farmers on the other side of the town had "caught on," if you will allow the expression, and had the water sent out over their farms. The water runs some 7 miles after having done duty in the grist mill and lands in a little place called Wall Lake, and 30 rods each way from the stream you can see the difference in the grass from that which is beyond that distance.

I wish to mention one thing further in this connection. In the spring of 1882 I went out on my homestead and staid there until I could see growing 100 acres of wheat, which I had assisted with my own hands in putting in. In the spring of 1882 when we went out in the morning to see about our stock or after our oxen and horses we would have to wear rubber boots, because it would wet our leather boots through in a short time. But this summer I venture to say that there has been no morning since the first of July that I could not step out in that grass in my stocking feet and not be seriously inconvenienced.

Our belief in that country is that if we can fill up those ponds and low places with water so that we can have evaporation it will materially help humidity. We believe that if we could have a sufficient number of wells to supply the water we could raise trees without any trouble, because we find the trees grow finely under it. Hundreds of thousands of dollars go East every year for coal which comes to Dakota, goes into the grate, and out of the chimney in smoke with no compensating return from it. It is a dead investment because used for cooking purposes and heat. But send those streams out over those prairies and down those runs, and we could raise trees for our fuel and thus save a heavy drain upon the country.

I am aware that there are a great many theories upon the subject of irrigation. They say that moist winds come from Japan and strike the Rocky Mountains and there become condensed because of the frigidity that is up in those mountains. While it is possible that those vapors and currents of moist air are arrested by that process, still we have some compensating circumstances to consider. The moisture may not come to us in the form of vapor, but may it not come down through the crevices of those rocks and subterranean passages in an inexhaustible supply of water? Whatever may be the theory of those who think that this water may become exhausted, if we can get what is there we would ask that you give us that. We have gone to that country to develop it, to add to the riches of this mighty nation, and we ask that we be properly assisted, that we may be able to raise our wheat and grain in such quantities and at such reasonable prices that no man may have a corner on his neighbor's daily bread.

The **CHAIRMAN**. To what extent have you explored this artesian belt? How wide apart are your wells at different points?

Mr. **BURT**. There is one at Miller, 40 miles west; one 20 miles north; two at Aberdeen; one at Groton, and then our well.

The **CHAIRMAN**. Do these wells of which you speak follow the line of the river, or are they anywhere across the plains?

Mr. **BURT**. Across the plains. There is one more point, Highmore, which stands upon the Missouri and James River valleys.

The **CHAIRMAN**. Have not wells been sunk that failed, that did not strike the belt?

Mr. **BURT**. Not that I know. Over the divide, still going toward the Missouri, there is a flowing well.

The **CHAIRMAN**. Then, at all points where they have sunk the wells sufficiently deep they have struck water?

Mr. **BURT**. Yes. So well satisfied are the business men of Huron about water that when they make a contract with any one to sink a well they do not ask about water.

Senator **REAGAN**. What is the depth of those wells?

Mr. **BURT**. The well at Highmore is 1,552 feet. That stands upon the summit of the divide between the James and the Missouri River valleys. The depth of our well I have stated. I am not able to give the depth of the other wells. In order to show the power of this well at Huron, I desire to submit to the committee a photograph taken in July last of the streams of water from the hose used for fire purposes. Upon the back you will find some memoranda which may interest you. I have had hard work many times to convince eastern people that there was not some artificial power behind that water. But this photograph represents the stream as it comes from the bowels of the earth by natural forces. That block [indicating on a photograph] is about three-quarters of a mile from the well. Water is forced through the main. We have never had any trouble about it. There never has been any cessation of that pressure. For one year we kept the fires banked at the Holly water-works for fear that the well might go back on us; but it has never failed, and now we do not watch it.

The **CHAIRMAN.** Has there been any decrease in the volume of the water from any of those wells?

Mr. **BURT.** Not that I know. At Aberdeen there are two wells 150 feet apart, and the sinking of one did not affect the other.

The **CHAIRMAN.** As I understood you in reading the list of the different layers through which the drill passed you gave sandstone as the rock carrying the water.

Mr. **BURT.** White sandstone.

The **CHAIRMAN.** Is it all cross-grain?

Mr. **BURT.** They tell me it is porous like a sponge.

The **CHAIRMAN.** What was the thickness of that layer? I believe you gave it as some 60 feet, did you not?

Mr. **BURT.** I do not remember the figures—40 feet, I believe.

The **CHAIRMAN.** Do you know what was the thickness they met with in that water-bearing rock in the other wells?

Mr. **BURT.** I do not.

The **CHAIRMAN.** Whether it maintained a uniform thickness or not?

Mr. **BURT.** I do not know.

Senator **REAGAN.** In boring these wells have you come across coal or illuminating gas?

Mr. **BURT.** As to the coal, we have not. When they drill through this rock it becomes powder, and as it is necessary to fill the hole with water they follow it down with a pipe and work the drill inside, and whatever comes up is ground so fine that unless you are specially looking for coal you would not notice, though you might pass through it. The men who sunk this well were not thinking of coal, only of water, and no observation was made. In this connection I would like to say that if the Government desires knowledge of the geology of that country it could find no better way of ascertaining the formation of that soil than by sinking wells. I believe that it will be discovered in time that coal is in certain portions of that section of the country.

Director **POWELL.** I believe you have mentioned seven artesian wells in your section of country, the deepest of which is 1,500 feet.

Mr. **BURT.** That at Highmore is 1,552 feet.

Director **POWELL.** In what direction is the general drainage at the surface?

Mr. **BURT.** The general direction of the flow at the surface is on the east side of this divide of which I spoke. There it all flows toward the James River, and on the west towards the Missouri, and there is a general lay of the country sloping in that direction. There are little runs and low places, little hollows that run back into the country 40 or 50 miles and flow down across the prairie, and after awhile they grow deeper and deeper when you come into the vicinity of the river where all this drainage goes. Those places are innumerable all over that valley.

Director POWELL. The general drainage is eastward into the James River?

Mr. BURT. Yes.

Director POWELL. The deepest well is 1,552 feet, and about 800 feet down near the valley of the James?

Mr. BURT. Eight hundred feet.

STATEMENT OF JOHN R. WILSON, OF DEADWOOD.

Mr. Chairman and gentlemen, it is proper I should say I am not a delegate to this meeting. I am here by courtesy of your committee and of the committee that was sent here by the Farmers' Alliance, of Dakota.

I have here some statements made by responsible parties in the section of the country in which I live. These statements are in the shape of letters, and while only portions of the letters relate to the subject which you are investigating, yet I submit them for your inspection.

I reside in Lawrence County, at Deadwood, in the section known as the Black Hills. It is the area of country lying between the forks of the Cheyenne River, in southwestern Dakota, embracing six or eight million acres of land. It is that portion of the country ceded in the Indian treaty of February 28, 1877. It is a country that up to within the last few years was more widely known for its mining resources than for its agricultural interests. But to-day the agricultural and stock interests of the Black Hills are in the ratio of 4 to 1 of its mining interests.

We have in that section a belt, 156 miles long and from 30 to 40 miles wide, of rough, mountainous country, and that is known as mineral land, yet at the same time is covered by vast forests of pine timber. All through those hills are beautiful parks that are very productive, and that are utilized for agricultural purposes. Generally the rain-fall about the hills has been sufficient for agricultural purposes, and farming has been reasonably so for the home markets.

I desire to submit first some arguments as to the necessity for irrigation in Dakota, and in doing so shall read the statement of a gentleman named Samuel Cushman, an insurance agent, who engaged in loaning on farm lands, he being a resident of Colorado for eighteen years, a gentleman of wide experience and perfectly familiar with the country:

> During my residence in Colorado, from 1860 to 1878, I watched the steady and substantial progress of irrigation with more than ordinary interest. Three years ago I had an opportunity of witnessing the remarkable advance in the business since 1878. I was informed in Denver by capitalists that irrigation securities, especially the older ditch companies, that were selling all the water they could furnish, were the best in the market, being regarded as safe, profitable, and likely to be still more profitable. At my last visit to Colorado I saw an uncultivated 160, as dry and barren as in the old days, right in the midst of cultivated and well-watered farms. On the natural ground there was the same old tufts of bunch-grass, 12 to 18 inches apart, and on the bare spaces between the same old cactus was crawling, while just over the fences were the finest crops of clover, alfalfa, timothy, wheat, oats, etc., I ever saw in any country. The change was due to water alone, no manure or fertilizer of any kind being required on that rich soil that lacked nothing but water.
>
> I have been a resident of Deadwood since 1878, and for eight years have been doing insurance, and for the past five have been in the farm-loan business. My business has taken me over a considerable portion of the agricultural country surrounding the Black Hills on the north and east. There are no farming lands in the whole sec-

tion that are not or would not be more valuable for irrigation. Those lying adjacent to the hills receive more showers, and in an average year raise an average crop. Twelve or fifteen miles from the hills the showers are light, and at 25 or 30 miles they amount to nothing. There, on as rich soil as can be found in the world, the crops come forward with the spring showers and rain, and up to the middle of June look well; then they begin to burn up with the drouth and frequently are not worth harvesting. In some of these localities farmers have taken out short ditches, enough to cover a portion of their farms. Crops under the ditches are wonderful and repeat the Colorado experience. I know of no part of Colorado where there is greater need and greater demand for irrigation canals than on each side of the Belle Fourche River. It can not fail, in my judgment, to prove a highly profitable enterprise to take the water of the Red Water and distribute it over the thousands of acres of rich but arid lands lying beneath the canal survey.

Now permit me to call to your attention a map of that country, showing the land that will be open to settlement, the Indians being willing, by the act of the last Congress. [Exhibiting map.] That [indicating] is the land, the part which is colored light. The section of the hills in which I live is the section between the two forks of the Cheyenne River. I am personally acquainted with a great deal of the land lying between the Missouri and the Cheyenne Rivers, and also with that portion of the Indian reservation to be open to settlement and lying north of the Cheyenne River. I see in the hall a resident of St. Paul, Mr. Blakely, who can give you a better description of that land than I can; but, in my judgment, no finer piece of land can exist than that is.

The CHAIRMAN. What are the hopes for obtaining water there?

Mr. WILSON. From my knowledge of the country it is impossible to utilize the Cheyenne River for that purpose. The river there lies deep within its banks, and to construct ditches and dams is impossible. When Major Powell visits that country he may be able to give the committee more information than I can. I simply call it to your attention to show the area of country that can be benefited by irrigation. The General Government owns that land, a large extent of it, and it should make these experiments there. By so doing it will enhance the value of that land very much. Unless something be done to secure irrigation in that country farms there will be valueless.

The Star and Bullock Stock Company owns land lying in the Belle Fourche. The secretary of that company writes:

> We have a very great interest in this matter, in that we own over 2,000 acres of land under the line of the proposed ditch and are engaged in farming and stock-raising. A bountiful supply of water is absolutely necessary to the success of our business, and the experience of the past ten years satisfies us that the proposed system of irrigation is essential to the successful cultivation of this entire valley. There can be some 30,000 or 40,000 acres covered by the proposed ditch and a very large portion of this land is of the best quality. In our stock business and the farming operations connected therewith we shall require from 500 to 700 inches of water annually, and there is no question but that with the rapid settlement of this section which will speedily follow the location of this ditch there will be a demand for all the water obtainable and that land values will very greatly increase. Every acre of tillable land that can be irrigated is fairly worth $10 per acre, and when it is actually covered by the ditch will be readily worth $20 per acre.

I have a statement here which Major Powell will verify, to the effect that to irrigate an acre of land it requires a foot of water over the land to be irrigated.

The CHAIRMAN. A foot deep is 12 inches deep over the area to be irrigated?

Mr. WILSON. Yes. I will read an extract from a pamphlet prepared by the Arkansas River Land and Canal Company:

> Experience proves that the amount of water needed during the cropping season, when irrigation is required, is equivalent to 30 inches deep upon the land if all ap-

> plied at once, or that 1 cubic foot per second, flowing night and day for one hundred days, will irrigate 80 acres of land. The well, the wind-mill pump, or even the ever-flowing artesian well, which suggest themselves, are thus seen to be entirely inadequate for even small farming, and the only method is by canals and ditches.
>
> The very high price obtained for garden and field products caused the first settlers to construct ditches that would cover a few farms along the stream, which could be cheaply made. Usually this was done by co-operation, each farmer taking his team and doing a certain portion of the work. The success of these first attempts finally attracted the attention of capitalists, and it was found that the water paid as great a revenue as the land, and the two were necessarily joined.
>
> When the Greeley colonists built their main ditch, a water right for 80 acres of land cost from $75 to $100. Now, twelve years later, the same right would sell for more than $1,000. This right must bear its proportionate share of the expense of superintendence and repairs, usually in smaller ditches of about 40 cents per acre per annum. When capitalists construct the larger canals, covering larger tracts of land, they generally decline to sell water rights, but sell to each farmer what he requires, at a stipulated price per acre for each year. This price has increased gradually ever since the custom has prevailed. One dollar per annum per acre was for a time the usual rental for water; now there are few if any ditches which do not receive $2, and some even more than that. By the laws of the State the first ditch constructed has a priority to the water appropriated, and no canal tapping the stream nearer its source can divert the water of the older ditch. The laws provide for measurement, proof of quality, and date of appropriation, so that there may be no controversy as to whom the water right fairly belongs. Every equitable safeguard which experience suggests is made to protect the rights of those who invest in these enterprises.
>
> The people of the State are fully alive to the importance of utilizing all the water of the mountains on the farm, in order to be able to supply the home markets, and prevent, as much as possible, the outflow of money for bread-stuffs, vegetables, fruits, etc., which now goes to other States to so large an extent.
>
> In the last three years several very large canals have been constructed, many miles in length, and covering large bodies of land hitherto producing only the meager pasturage of the plains. One of these, which has cost nearly $1,000,000, will irrigate about 65,000 acres of land. The canal, which is 82 miles long, covers very much more land than it is capable of furnishing water for, and so great is the competition that parties are paying from $9 to $25 an acre for the privilege of obtaining water at an annual rental which will probably pay a net interest on the investment of 10 per cent.

I have also a letter from Mr. A. D. McPherson who represents a bank with footings of over $1,000,000 and a surplus of $225,000. He says:

> Irrigation is just as legitimate as the business of farming itself, inasmuch as its very object is to make the farmer who partakes of its benefits almost absolutely certain of reward for his labor, and to make that reward much greater by greatly increasing the productiveness of his land. Therefore, the irrigating canal is the handmaid of the farm, and when judiciously used must produce results very beneficial to the owners.
>
> I have been familiar with the tract of country which it is proposed to cover with the irrigating canal under consideration for the past twelve years, and the statements made as to the quantity and quality of the farming land within the area named are fully borne out by the facts.

Mr. Selbie, the cashier of the Merchants' National Bank, writes as follows:

> It is proposed to consolidate the present ditches taken from the Red Water and greatly increase their capacity. A large amount of excellent farm land is under these ditches and requires water to make it productive. This district lies outside of the rain belt in the hills, and, without water, is of no value except for pasture; but with water magnificent crops can be raised with certainty.

The area of country spoken of is nearly 1,000,000 acres of land, and there is no water on it except that which flows from the streams in the hills. Reservoirs could be established in the hills so that it might be used later; but where to establish them would have to be determined by surveys, and that can be accomplished only by national aid.

I have also a statement made by a farmer who has worked in the Belle Fourche Valley, and every word stated by him is, to a certain extent, applicable to that whole extent of country. His statement is in the form of an affidavit, and it is as follows:

TERRITORY OF DAKOTA,
Lawrence County, ss.:

Andrew H. Snyder, being first duly sworn, deposes and says that he resides in the Belle Fourche Valley, in Sec. 14, T. 8 N., of R. 5 E., and has resided there for nearly ten years past; that the land in that valley is of a most desirable character, and when there is plenty of rain produces splendidly; that affiant and his two brothers have 640 acres of land in that vicinity, and are engaged in farming; that they have raised three fair crops out of ten planted, and have done better than most of their neighbors; that if they could have had water for irrigation they would have raised a good crop every year, and in the years that it rained he could have raised much better and heavier crops with irrigation; in this affiant's opinion irrigation is absolutely essential to successful farming in this valley, and that in a very few years nearly every farmer below the ditch would use the water for irrigating. I would consider my land better worth $20 per acre if covered by water than $10 as now located; that, in my opinion, there would be a demand for every inch of water that could be brought onto this valley.

Affiant further says that very recently, in connection with his neighbors, he had a survey made for the purpose of locating a ditch and taking water from the Belle Fourche for the purpose of irrigating this section, but found it impracticable to get the water from the Belle Fourche on this valley; but it can very easily be brought from the Redwater; that unless irrigation is arranged for, affiant says he will do but little farming hereafter, and will sell out as soon as possible when he can get his money out of his property; that affiant and his brothers would require irrigation for 300 to 400 acres each year.

ANDREW H. SNYDER.

Subscribed and sworn to before me this 27th day of July, A. D. 1889.

[SEAL.]

S. M. HOUGHTON,
Notary Public.

Here is another affidavit made by a gentleman named A. A. Chouteau, who says:

TERRITORY OF DAKOTA,
County of Lawrence, ss.:

A. A. Chouteau, being first duly sworn, deposes and says that he has been a resident of Butte County, Dak., for the past ten years, and is well acquainted with the lands in the Belle Fourche Valley and surrounding country; that the said valley contains from thirty to forty thousand acres of land which are susceptible of irrigation, and specially adapted for it within a distance of 24 miles eastward from Minnesota; that from his personal observation, extending over a period of ten years, he can state that the farmers who have been able to irrigate their land have uniformly raised large crops every year, and that the others have raised good crops only during the wet years, that is to say, about one year in four; and that even in the wet years the irrigators have produced far larger and better crops than the others; that many farmers have determined to quit trying to raise grain unless there is a prospect for a water canal to be extended to cover their lands. I believe that an extension of the water canal will double the present value of the lands which shall be brought under the canal, because it will insure a large and certain annual crop of all grains and grass, and the crops of all kinds will average more than double the quantity which can be produced without irrigation.

Affiant further states that he is the owner of 500 acres of land under the water canal, and will require between 200 and 250 inches of water, which he intends to purchase from the water company.

A. A. CHOUTEAU.

Subscribed and sworn to before me this 27th day of July, 1889.

[SEAL.]

S. M. HOUGHTON,
Notary Public.

I have one more letter, which I wish to call to your attention, a letter written by a Mr. Martin, of the firm of Martin & Mason, also president of the Merchants' National Bank. He says:

There are thousands of acres of very fertile lands in the Belle Fourche and in the valleys of its tributary streams that require irrigation to secure regular and abundant crops. Without irrigation the lands do not produce good crops, except for an occasional season when the rains chance to be sufficient for the requirements of the soil; and such seasons have been very rare in the past ten years.

This has been attracting the attention not only of the people throughout the hills and the whole country lying west of the Missouri and the hundredth meridian, but it is going east of that; and I have heard Major Powell himself express some surprise to find that the people of eastern Dakota were asking for irrigation and storage. Here let me call the attention of the committee to an article which appears in the Redfield Dispatch. Redfield lies in the eastern portion of Dakota, in a country that was always supposed to have been abundantly supplied with rain. This article is very short and I will read it here.

> Though it may not be necessary to irrigate the lands in Dakota every year in order to raise big crops, it has been demonstrated repeatedly that a reasonable amount of rain at a critical period in the growth of wheat and other crops would have doubled the yield, and in some instances turned an absolute failure into a bountiful crop. In view of these facts it is well enough to go about getting the water on hand to use it if it is necessary.

Aberdeen is the next town lying above Redfield; and at Aberdeen they have also an excellent flowing well. The News on the 11th of July had the following, which I read:

> S. M. Gibbs, a resident of Riverside Township, was in the city last evening on his way home from an extensive trip through Arizona, New Mexico, Utah, Colorado and southern California. He left Brown County the 1st of June, and has been putting in his time investigating the irrigation system of the above-mentioned States and Territories. A reporter had a few minutes' conversation with Mr. Gibbs, during which the latter was profuse in his expressions of the beneficial results of irrigation and the success sure to attend it if taken up in Dakota. In the sections which he passed through, the water supply comes largely, of course, from rivers and mountain streams, but on several occasions he had opportunity to inspect large tracts of land which were supplied by artesian wells alone and which were practically deserts before reclaimed by means of the moisture drawn from the bowels of the earth. At Riverside, California, he found the main supply came from the wells and the Gage system of water works, and here the results had been simply magnificent.
>
> * * * * * * *
>
> Whenever he had opportunity Mr. Gibbs consulted with practical engineers with reference to this work in Dakota: Their plan is to sink the well at the highest point on the land sought to be irrigated; here a large basin is formed, the water in which will be several feet deep. From this the ditches may extend, following the elevations and rises in all their various crooks and turns and so placed that the water may be run from either side onto the tracts devoted to crops. Temporary dams can be put in and the water handled with practically the greatest ease and convenience. Mr. Gibbs saw corn-fields in Kansas where the crops reached to the top of his head, the growth of which, so far as moisture is concerned, has been regulated if not entirely by the farmers themselves, who obtained their water supply by means of extensive ditches from the Arkansas River.

Such extracts show the feeling of our people on the subject of artesian wells. There are other articles and correspondence from prominent papers which I leave with the committee, asking leave to read the following from the Deadwood Weekly Pioneer of July 18, 1889:

> The experience of the farmers in the Black Hills counties of Dakota during the past ten years has fully established the fact that fair average crops can be raised every year without irrigation, and that by reason of superior soil better crops have been raised here than in many other localities where the rain-fall has been greater. While this is true as a rule, there are certain localities where irrigation is to a large extent almost essential to the certain growing of large crops. Such is the case with the valley of the Belle Fourche, than which no finer body of land exists; a rich, deep sandy loam, which ordinarily, without an artificial water supply, raises a fair crop—yet of such a character that where irrigation has been tried the results have been almost wonderful and not excelled in any section. The effect is not only felt upon the grain crops, but upon the hay and grasses, small fruits, and especially trees of all kinds, both native and cultivated, which will soon give a different appearance to the face of the country. Even in the most desirable localities, where good crops are the rule, without irrigation, very much larger and more uniform yields would be the result if a system of irrigation were introduced.
>
> * * * * * * *
>
> Very many of the smaller valleys in this district are already covered by ditches, the result of the co-operation of the farmers living along the small mountain-streams,

but it remains for something more than local capital to turn the waters of the Belle Fourche upon the fertile valleys adjacent and thus open up what will in a very few years prove to be the garden spot of the West; the Egyptian fields of Dakota.

I ask leave, also, to present to the committee certain papers intended for business purposes in promoting the construction of irrigation works named in them. I have indicated the portions which state facts that bear on the inquiry this committee is making, and ask that, if approved of, they be incorporated as part of my statement. These papers relate to a canal in process of construction in the Black Hills. Under date of July 26, last, the engineer writes:

> I surveyed and laid out both the Choteau and Harrison dicth, and the Red-water ditch. The first mentioned, if I remember right, is nearly 3 miles long, and has a grade of 3.2 feet to a mile, or a hundredth of a foot to a rod. The Redwater ditch has three hundredths to 2 rods for the first 3 miles, then the grade is heavier for several miles. The Redwater ditch carries, at present, from 2,500 to 3,000 inches of water, all of which is used along its line for irrigation. A great deal more could be sold if the ditch had a greater capacity. The Redwater River, from which these ditches are taken, flows from 8,000 to 10,000 miners' inches of water when at its lowest. It has a good fall and low banks, so that ditches can be taken from it easily at nearly any point.
>
> Three or four miles below where the Redwater ditch is taken out, is the confluence of the Belle Fourche and Redwater Rivers. The Belle Fourche has a much longer water-shed than the Redwater, consequently it is more liable to high water and freshets. In the dry season it affords only a small quantity of water, while in the wet season it is a large river. It runs deep within its banks, and being subject to extreme high or low water, it is very difficult and costly to take a ditch from it. It has only about 7 feet fall to the mile.
>
> The Redwater River is not subject to the extremes in high and low water as the Belle Fourche. It has a more even flow, being more of a mountain stream, and flows several times more water than the Belle Fourche at the time water is needed for irrigation. All the water of this river could be sold to the farmers for irrigating, if a ditch or canal were built large enough to take all the water out of it. Such a ditch, if extended 30 or 35 miles, would cover several thousand acres of as good farming land as there is in this or any other country. This land is at present, all or nearly all, located and proved up on, but the greater portion is unproductive because the farmers are discouraged, trying to raise crops without irrigation; while those who can get water from the ditches now in operation try to increase their acreage each year. The land is very productive under irrigation, yielding from 30 to 50 bushels of wheat per acre, and other cereals in proportionately large quantities.
>
> A canal 16 feet wide, on a grade of 3.2 feet to the mile, would flow 6,000 inches of water. It would not be necessary to build it with an even capacity the entire length, as the flow would be less at the lower end on account of the water let off for irrigating along the line. When a suitable place was determined from which to build the proposed canal, the line could be surveyed and staked off in sections of, say, 100 rods each, and cross-sectioned, so as to calculate the number of cubic yards of earth to be removed, and contracts let all along the line which, when done, should be approved by the company's engineer before it was accepted as completed. There are no great obstacles or difficulties in the way of building such canal. It can be done cheaply, and will be permanent when made, as there will be very few flumes along its line. After the first year or two it will not require much work to keep it in repair, and the demand for water will always be increasing. The first few years the ditch would be in operation, as I have before stated, it will cost more to keep it in repair than when it is settled and stanch. The demand for water will also increase so that the percentage of profit will ever be on the increase. There are to-day from fifty to one hundred farmers living under the line of the proposed canal, who are anxious to get from 50 to 100 inches of water each, and who would no doubt help to build the ditch by taking part of their pay in ditch scrip or stock that a company building said canal would guarantee to take in pay for the use of its water.
>
> The land below the line of this proposed canal has a gentle slope toward the river, so that it is peculiarly adapted to irrigation in that respect. The valley is about 3 miles wide, and, on a rough estimate, I should say there was 20,000 acres of land that could be irrigated by a ditch extended from Redwater River on the south side of the Belle Fourche Valley, 25 to 30 miles long. There would be no trouble to sell the first year 6,000 inches of water at $1.50 per inch for the season.

From the other business paper, relating to the project referred to, I submit the following:

We have had several preliminary levels and surveys run, and are now more definitely informed as to the situation than at that time. Upon examination we find that the great bulk of water in the "Belle Fourche" River comes from the "Redwater" River, and that it is much more feasible to tap this latter stream than the Belle Fourche. That a ditch or canal can be constructed and the water of the "Redwater" or, practically, all of it, now available, say 8,000 inches, taken out at a point some 3 miles above its confluence with the Belle Fourche River, and carried a distance of about 25 miles, and cover nearly 30,000 acres of land, two-thirds of which is desirable agricultural land that can be irrigated by this canal in the course of two or three years.

The expense of securing the prior rights to the water, and constructing the ditch, would hardly exceed $50,000, and the income in 1890, from land already under cultivation, would be about $5,000. This, we think, beyond question, would increase $2,000 to $2,500 per annum, until the limit of the ditch was reached. This, in our judgment, will be about $15,000 per annum and likely more.

The irrigating season lasts five months at the outside, though really two months covers the heavy work. During the five months a canal properly organized would require an active business agent and manager to make contracts and collections, at, say, $150 per month; also one foreman, at $80 to $100, and two laborers, at $40 each, or $330, and, say, $20 per month for sundries; making a total for the five months of $1,650, and for the seven months, one man (part of his time) at $30, or even less, say, 200, while office expenses of all kinds would hardly exceed $600 per annum, thus making a total expense of about $2,500 per annum, of 5 per cent. of the capital $50,000.

This would be independent of construction cost, to be invested. The office work would increase with the greater demand for water, but nothing in comparison with the increased income. While the expenses of the first year would likely be at least 50 per cent. of the income, the second year it would be less than 40 per cent., and the third less than 30 per cent., and so on until it would reach a minimum of about 20 per cent.

Land that to-day without irrigation is worth $5 to $10 per acre will more readily sell for $10 to $25 under the proposed canal. There are several thousand acres of this land (a rich, sandy loam, desirable in every way, except water), that could now be bought for $5 to $10 per acre, and which would pay a big profit inside of three years, and meantime pay good interest from rentals whenever water is put upon it.

The valley of the Belle Fourche River, below the mouth of the Redwater River, for a distance of 30 miles eastward is about 3 miles wide, and peculiarly adapted by nature for irrigation on account of its grade and the incline of the plateau or bench lands towards the river. The valley is sparsely settled, and much of it unoccupied at present, but with an assured artificial supply of water by means of irrigation the valley would soon become thickly populated and the demand for water far greater than the supply obtainable. One ditch has been in operation for some years, but under a co-operative management, not calculated to be successful. A small portion of the land has been cultivated for some years, with fine results as to the quantity and quality of productions, the wheat weighing 61 pounds and over to the bushel, oats weighing from 36 to 41 pounds to the bushel, barley and rye in proportion. The root crops are magnificent and the potatoes command the highest price in every market. All small fruits yield abundantly; strawberries and raspberries grow wild, while the adjacent lands to which the ditch has not been extended are to a great extent uncultivated. The principal water supply is from the Redwater River, which has a fall for the last 5 miles of its course of 25 feet to the mile, and carries about 15,000 inches of water, of which 8,000 could be appropriated and utilized. The first 22 miles of the valley contains some 30,000 acres of land on the south side alone which can be brought under the line of a canal, which is sufficient to consume all the water which can be carried to it. A canal for irrigating, water-power, and domestic purposes can be constructed down the south side of the Belle Fourche valley, the supply being drawn from the Redwater River, with a capacity to irrigate 16,000 acres, at a cost of construction not to exceed $3.50 per acre of the area to be irrigated; that is, to irrigate 16,000 acres will cost $53,000 or less. The line of the canal will pass through one village on the projected line of a railroad, which is situated on a plateau 50 feet above the Redwater River, thus permitting the canal to furnish a grand water-power for manufacturing, town use, and other purposes. The sale of the water for irrigation on 16,000 acres at a rental of $1 per acre will produce a gross yearly income of $16,000, equivalent to 30 per cent. per annum gross on the capital invested in the canal alone.

The capitalization or cost varies according to the distance of the supply of water and the difficulties encountered in the construction of canals. In some places it has reached as high as $40 per acre of the area to be irrigated. The "seventy-six" canal at Fresno supplied 20,000 acres at a capitalization cost of $6 per acre. In Colorado it has been estimated that the cost of canal construction is from $5 to $6.25 per acre of the area to be irrigated.

Originally the cost of the water required to raise a crop depends upon the capital required to construct the works and canal, but as the land continues to be cultivated and larger areas are brought under cultivation the price of the use of the water increases, so that the value of the "water right" grows constantly, and a purchaser at a later date must pay a proportionate advance for an interest in the water.

The average cost of rented water for each season in the dry regions of the United States is from $2 to $6 per acre; in Italy and France from $2 to $7 per acre. The lowest water rent paid by consumers varies from $1 per acre in Utah to $1.50 per acre in Colorado and $2 per acre in Kansas.

The conditions as to climate and kinds of products raised in the irrigated parts of Colorado and the irrigable parts of Dakota are practically alike, so that results which have been obtained in Colorado can also be obtained in Dakota, with the further advantage of possessing better soil. A part of Butte County, Dak., is in the "dry region," where irrigation can be practiced with success for the certain production of large crops. All kinds of grain, vegetables, and fruits can be raised there which are raised in northern Illinois and Iowa. The soil is rich and deep, and the finest No. 1 hard wheat and other cereals have been raised for the past seven years.

I do not know of anything further that I can do or say, except to give to the committe the benefit of my twelve years' experience in eastern and western Dakota. In my judgment, unless a survey is afforded by the General Government, much of the land that is open to settlement will not be settled, and it will remain in its original condition.

The **CHAIRMAN**. Has the cutting of timber made any difference in the moisture of that region—that is, has it affected the streams?

Mr. **WILSON**. I can not say as to that. Large quantities of timber have been cut, but it is in that particular section where rain is not used. The water supply has decreased for several years. We have no floods now. The mountain streams which ran through Deadwood several years ago nearly devastated the town, but we have had no floods for several years.

The **CHAIRMAN**. Have you any data showing the rain-fall in that section?

Mr. **WILSON**. I think it is about 25 inches a year—that is, I so understand the figures. There is a gentleman here who has the data. The station at that time was located at Deadwood, which is in the mountains, and which is higher. The rain-fall is greater there than through the lower districts of which I have been speaking.

Senator **REAGAN**. Have there been any attempts at boring artesian wells in the Black Hills country and west of the Missouri River?

Mr. **WILSON**. No. The only country settled west of the Missouri is the Black Hills. There they have some systems which will irrigate a portion of the land. These artesian wells have been built only in the cities where there is a co-operation of capital. It would be impossible for farmers to go about constructing these wells. Experiments can be made only by capital. When the fact of irrigation by means of artesian wells has been established, then the farmers may co-operate.

The **CHAIRMAN**. Have you any irrigating ditches in that vicinity at the present time?

Mr. **WILSON**. We have.

The **CHAIRMAN**. Can you state where those ditches are, and approximate the amount of land which is under irrigation in that region?

Mr. **WILSON**. I can, generally. On the headwaters of a stream, carrying about 20 to 25 inches of water, and in its lowest season 10 and 12 inches, there was a ditch built by the farmers which at first was 9 miles in length and which has since been extended 9 miles further, making 18 miles in all. That ditch covers about 5,000 acres of land. About a week ago I went to the bluffs overlooking this valley, and along the line of the ditch the fields were magnificent in appearance, yielding large crops, while above it was a barren waste, the stream marking the line between poverty and plenty. That stream originates in the mountains some 30 or 40 miles distant, and there you may store a good deal of water—from 25 to 30 inches of water. There are numerous places where reservoirs could be erected and the supply of water increased from 10 to 30 inches, and the amount of land to be irrigated from twenty to sixty thousand acres. They have about 5,000 acres under irrigation now, and the value of a farm under that ditch is from two to three fold greater than a farm that can not be irrigated. I know of land better than that which was under that ditch, and it was abandoned because the parties could not live upon it.

The **CHAIRMAN.** Is that the only ditch of which you know?

Mr. **WILSON.** On the Spear Fish you will find a number of private ditches along the stream. There is no organized company for constructing these ditches; but a few farmers will build a ditch to cover their land, taking out a sufficient amount of water for their own purposes. In that valley I should say there are from three to six thousand acres of land irrigated in that way, and the value of that land is from two to three fold greater than land not irrigated. I know a farm there selling as high as from $20 to $40 an acre, and it was made valuable by reason of irrigation. There is no reason why if artesian wells could be made a success, the value of the land in the valleys of Dakota should not be run into the millions of dollars.

Director **POWELL.** Have you computed the relative cost of securing the use of a given amount of water by artesian wells and by storage?

Mr. **WILSON.** No; but I can say to the committee——

Director **POWELL.** Suppose that it would take an acre of water 12 inches deep to irrigate an acre of land for a season; you might get that water in some regions by boring for it and it would cost so much; or you might get it by storing the surplus water which falls in that territory when irrigation is not necessary. Then the practical question for the farmers of Dakota more than for the rest of the country is to know whether that acre of water 12 inches deep will cost more one way than it will another. I wish to know whether you have considered the question of the difference of cost of storing water and of boring for it.

Mr. **WILSON.** I have looked at it in this way: To ascertain the cost of irrigating the land generally and then comparing the value of the land irrigated as compared with land not irrigated. The estimated cost of constructing irrigating ditches, taking that as a basis first, will run from $5 to $25 an acre. To irrigate 160 acres of land will cost from $800 to $2,500; and in portions of Colorado they are paying a bonus of from $5 to $10 an acre for the privilege of buying water. They pay there the value of the land every year for the privilege of buying water.

The **CHAIRMAN.** Would you not be satisfied at the present time for the Government to make a survey, and estimate what is necessary to be expended to accomplish irrigation in the different portions of the country? Do you not think it would be best to ascertain what we have before expending any money?

Mr. **WILSON.** I am afraid some of the gentlemen before you would be in their graves before relief would come from legislation on the part of the General Government if speedy action were not taken. We take it that this committee is friendly to this enterprise, know the benefits to be derived from irrigation, and that you will urge the matter upon

Congress. These gentlemen have told you what has been accomplished by artesian wells; but they are for domestic uses in the cities. Now, why should not the Government make a trial on its own land? It would take but very little money.

The **Chairman**. Suppose Congress should come to the conclusion that artesian wells would be the best scheme for reclaiming these lands, would it be necessary for the Government to do more than ascertain the extent of the artesian belt by sinking experimental wells?

Mr. **Wilson**. That in my judgment would be feasible if our people were as far advanced as they are in the older States.

STATEMENT OF JOHN J. CUSHING, OF ASHTON, SPINK COUNTY.

Mr. Chairman and gentlemen; I am here from Ashton, Spink County, Dakota. We now consider ourselves a part of the United States, and as such entitled to all the rights and benefits pertaining to the people of a free republican government, which rights and benefits include appropriations.

The wealth of any country depends upon the production of that country. In Dakota Territory, the best calculation for the last two years places the loss at $25,000,000 a year from the failure of its water supply; and that is a loss to the whole country also. We are in one of the most singular portions of the United States, a belt extending from the Gulf of Mexico to Hudson Bay. It is evident that something should be done to improve that country. Nature has done its work, and now we want a little art applied. We have what we believe to be an inexhaustible supply of water underneath the surface of the earth. I have taken pains to investigate annually the precipitation in the different parts of the Territory. I find that the annual precipitation for the Territory as determined by 29 points of observation from July, 1875, to December, 1886, has amounted to 22.35 inches. Of these 29 points 15 have fallen below 20 inches while 14 have run above that. Taking the points along the James River valley, in which I live, it being the most thickly settled portion of our Territory, and we find at Huron, which is the only point in our county where observations have been taken, that the average precipitation annually is 23.65 inches. The country around Huron is comparatively level. We are situated below the Coteaux.

The **Chairman**. By that, you mean a range of hills?

Mr. **Cushing**. Yes. The Coteaux are situated east of the James River and west of the Missouri River, and some distance from each. Now, Webster, a place on the east side of the James, in Day County, is surrounded by small lakes. There are a good many small bodies of water around that town. At Huron there are no bodies of water to afford surface evaporation. The precipitation at Webster is double what it is at Huron, and that to my mind indicates that rain-fall is affected by evaporation.

I have here a map of Spink County, on which I have marked in red ink the natural water-courses which are dry, and the natural lake beds which are dry, showing the drainage system in our county. In this county, at Ashton, we have an artesian well; at Redfield we have one; at Frankfort we have one.

The **Chairman**. When you strike the first flow, what is the character of the water?

Mr. **Cushing**. The formation is almost the same as the other, but it is a narrower stream of water. The contractor told me that when he struck water at Redfield his drill dropped down apparently 925 feet in the quicksand or an open place. At Frankfort after they had completed their well they were experimenting with it, showing the people the pressure they had, and they closed the well up. At that time the pressure of the water burst the pipe, which is a 6-inch pipe, down some 600 feet below the surface. The water ever since at that place where it burst the pipe has been coming up outside the pipe, bringing the soil with it, and for that reason the water is sometimes thick and muddy. It comes up with the same pressure, and they have been obliged to abandon the well for domestic purposes. This water runs into a small ditch along the railroad down to the James River 2 or 3 miles below. I was there two or three weeks ago and I noticed the vegetation along this small ditch, and for at least 12 rods on each side of the ditch the vegetation is nearly four times as large as it is outside of that distance.

Now, I do not think we really need what is called surface irrigation. We need what I should term sub-irrigation. We have a subsoil about 2 feet from the surface, which is almost impervious to water. The subsoil during the winter of 1879 and 1880, when we had deep snows in the Territory, was thoroughly filled up. At that time all the rivers and small streams were filled with water For two or three years after that, 1881, 1882, 1883, and 1884, these streams were evaporating, and we had good falls of rain and good crops; but the rain-fall has been growing less, and to-day those streams and lake-beds are entirely dry. The evaporation has totally dried them up, and, of course, we get no benefit from surface evaporation.

What is to be done? I believe that the Government should take hold and place artesian wells at convenient points in this James River Valley, and run water into these old water-courses and lake-beds, fill them up, and give us a good supply of surface evaporation.

I brought with me a few samples of grain to show to the committee what we can do in Dakota. These two samples of wheat [exhibiting] are the result of irrigation. Here is a sample of the general run of wheat [exhibiting] which is the result of no irrigation. These two samples of oats [exhibiting] are the result of irrigation. The wheat and oats which have received the benefits of irrigation are 4 feet in height, with the heads ranging from 12 to 14 inches on the wheat and 12 to 13 inches on the oats. The wheat which has not received the benefits of irrigation stands about 14 inches high, with heads about an inch long and with but few kernels in them. Now, when I speak of the results of irrigation I mean this: These two samples of wheat are the result of what is termed in our country "sub-irrigation." Last winter there was a little snow, very little. This snow settled in low places and along the fences, and such places where it would stay until it made quite large banks. This snow thawed in spring and filled the subsoil with water. This wheat was grown on low places, and has never received any more water than that sample of low wheat which was grown about 5 rods from the other. This soil on which the large samples were grown received a thorough soaking in the winter, and you see the result.

I believe if we can get these artesian wells—get the Government to bore them, we can apply the water to our soil. We could run the water through the sections of land, and it would percolate through the soil. During the winter we could throw up little embankments around our farms, and turn this water on to them, and thus give the soil a thorough soaking. This could be done by one man from one well in a very few days, and then another could take the water and fill up his land. Could this be done, though we might have no rain in the summer, we could raise good crops of wheat.

The artesian wells in our country have been sunk by the cities and have not been applied to irrigation. There are three at Aberdeen, and each one has about the same force, and there has been no considerable difference in the flows or the force of those three wells. A gentleman from Aberdeen informs me that while they were taking their water for the sewerage system the water was run off onto a piece of land, about 40 acres, low enough for water to flow on. There were 60 acres too high for the water flow on. Not a piece of grain grown on the ground which was overflowed received a drop of water this spring until the 20th of June, and they have 40 bushels to the acre from that land. The 60 acres which did not receive the benefit of this water will not give 3 bushels to the acre; it is practically worthless. There are in our country quite a number of wells, but as yet none of them have been applied to the purposes of irrigation.

Director POWELL. How long have you lived in the James River valley?

Mr. CUSHING. Nine years.

Director POWELL. How many of them have been successful years for agriculture?

Mr. CUSHING. About three.

Director POWELL. How many of them practical failures or total failures?

Mr. CUSHING. About three—what we might call total failures—about one-third the time.

STATEMENT OF MORRISON EAGER, OF HURON.

Mr. Chairman and gentlemen, I own several thousands of acres of lands in Dakota myself, and I am imbued with the idea of irrigation. I live at Huron. This is the fourth or fifth crop I have raised and I have not had a failure yet. But I must say that 5 miles from me the crop is a failure; but that is for want of irrigation. Why it is that the people of James River Valley do not irrigate I can not see.

At Jamestown there is a well 800 feet deep; one 600 feet deep at Yanktown, the mouth of the James, and one 802 feet at Huron. You can get a flowing well at, perhaps, 400 feet. I know of flowing wells varying from 375 feet to 800 feet; but where the water flows without any great pressure. At 802 feet we struck sandstone. Now, I can show two wells within a mile or two of this well, that is at Huron, where there is a continual flow, but no pressure at from 400 feet to 700 feet. The first one was soft water and the second was hard water. This sandstone is practically 40 or 50 feet in thickness. Were we to go into the third sandstone what would we find? As steam is to water, so gas is to make the pressure of these wells. I maintain that the Trenton rock or third sandstone will show what this pressure of water is in the James River. The second flow is hard water, impregnated with gas, and at Miller they can set it on fire. Gas, I maintain, is the power behind this water, and that the force is not by water seeking its level. The chairman asked whether it ever happened that no water was found. At Salem the contractor in sinking a well struck granite, and the parties paid him his contract price although he abandoned the work without getting water, because he struck granite—the backbone of the earth.

Highmore is the highest point on the James River and the Missouri. If you go further west or further east, it does not make any difference you will find this artesian belt of greater force than at Highmore. That is the case at Miller, 35 miles west. Proportionately as you range the James River Valley you will strike water at 802 feet, and at 1,552 feet, as there is a rise in the land between Huron and Highmore.

STATEMENT OF WALDO M. POTTER, OF LA MOURE.

Mr. Chairman and gentlemen, I do not purpose taking much of your time, but I feel desirous of impressing upon the members of this committee the importance of some action by the General Government touching the needs of Dakota. And to show you how general that sentiment is I will read you my commission here. It was issued by the board of county commissioners of La Moure County, which is in the James River Valley, about in the center, between the Missouri and Red Rivers.

Now, I need not take your time to speak of the situation to any great length, because it has been dwelt upon here already. The same condition of things, so far as the lack of rain is concerned, exists where we are as farther south. I say there is a lack of rain at the right time to insure the growing of crops. But I wish to call your attention to what our commissioners have stated to our county. Here [exhibiting] is a map very elaborately drawn to show the surface of the county. This shows where, six years ago, Bone Hill Creek in the northern part of the county, Bear Creek on the eastern border, and Cottonwood Creek in the center, each extending through several townships, were considerable streams, but are now almost dry.

The CHAIRMAN. What amount of water is in the James River?

Mr. POTTER. There is a very small amount. Six years ago sloughs nearly impassable by teams were scattered in a majority of the townships, but they are now all dry. The twin alkali lakes, 3 miles from the town of La Moure, nearly 2 miles north and south, and from 10 to 12 feet deep, now one is dry and the other nearly so. Cottonwood Lake, 1 mile long and one-half mile wide, 9 miles southwest of La Moure, is now a shallow pond 6 feet lower than it was five years ago. This is about all the surface water except the James River in the entire 1,152 square miles of county. The James River has been only a shadow of its former self most of the time during the present season. The disappearance of these ponds has been gradual, more or less from year to year, in the face of the generally received theory that cultivation of the land increases rainfall. Probably the cultivation of the surface has one effect—to arrest the falling water before it reaches the water courses. At the same time it is evident that the supply has diminished, and that our farmers have been suffering more and more, from year to year.

What is true of La Moure County in these three respects is also true of nearly all the present occupied portion of the two Dakotas. I have here letters from other counties, written since the formation of your committee. I was appointed by the county board of commissioners to meet you gentlemen, and I entered into correspondence with other counties in the Territory, and I find the same sentiment, the same disposition, everywhere as to the needs of Dakota.

We think that the General Government should initiate this movement, and that it is feasible. I do not know that there is any part of Dakota, of either of the Dakotas, east of the Missouri River where artesian wells are not feasible, because in Yankton county they have about 30 wells at a depth of 600 feet, with a pressure of from 60 to 70 pounds to the square inch, and the depth increases as you go north. But wells are in existence over the whole distance, over a surface of nearly 400 miles north and south, and about 200 miles east and west. There are wells at Huron, at Aberdeen, farther north at Jamestown, at Groton in the Red River Valley. If there were any doubt about it, it would be there. At that place there is a well 528 feet deep which flows a thousand gallons a minute. There are several wells in Cass County, in the region of Fargo; two wells which show their practicability.

Here is an extract from a newspaper, the Hope (Steel County) Pioneer of July 19, 1889, with reference to the waste water of an artesian well:

> The result of the waste water from the Hitchcock artesian well is that on either side of the ditch for a distance of from four to six rods the yield of grain will be from 50 to 100 per cent. better; that all the ground that was flooded in the spring by the water from the ditch will yield from 25 to 50 per cent. more grain; also that the grain is green and that the head is filling plump to the tip, and that the dry weather and hot winds have not affected it in the least.

The feasibility being settled, we now come to the necessity of it. It seems to be absolutely certain that we must have some moisture in order to keep up agriculture in Dakota. I can state some facts in regard to our own county, of people who have abandoned their farms. I know neighborhoods where several farmers have abandoned their farms after they had broken up the land because of a continual failure of crops. One of our county commissioners left our county. He said that he brought several thousand dollars into that county but could not stay. He was a temperate man, a German, and he was close-fisted, and he said he was compelled to go because his crop had failed from year to year. The showers that come into Dakota are spasmodic—intermittent. Sometimes one man will have a good crop while his neighbor will have no crop at all, and that is owing entirely to the lack of moisture. It is that fact which has to-day created that unrest, doubt, and discouragement which are prevailing characteristics of the grain-growers of Dakota. Dakota is a great country; it has great possibilities; there is no soil that is richer. In my experience I know of none that is so rich. We have a fine climate. I lived a large part of my life in the State of New York and ten years in the State of Iowa, and I give the preference to Dakota. The eight years that I have lived in Dakota have been the best eight years, so far as continued good health is concerned, of my life. We lack but one thing, and that is moisture, and on that account the majority, I should say all, the farms are heavily mortgaged, and we think the General Government ought to give us assistance.

The CHAIRMAN. Is there much public land in your region?

Mr. POTTER. Not in our region. In the last statement of our commissioner it appeared that the Government owned 21,000,000 acres of land not entered, but open to entry. I do not recollect the statement as to survey. But the fact was that there were 21,000,000 acres open to entry.

The CHAIRMAN. In North Dakota?

Mr. POTTER. In both the Dakotas. This was the report of the Territorial immigration committee—21,000,000 acres subject to entry and 10,000,000 acres to be added from the Sioux Reservation.

According to the best light that I have been able to get on the subject, and I have written letters to each of the receivers of the land offices and received replies principally thus: The General Government has received, in round numbers, from North Dakota alone, $7,529,400.

The CHAIRMAN. That is principally from pre-emption entries?

Mr. POTTER. Very largely from homesteads, because homesteads very largely have been turned into pre-emptions. I suppose it is a fact that more than one-half of the money that has been paid into the General Government has been paid in there by farmers who turned their homesteads into pre emptions, because they wanted to borrow money. They had been disappointed in their crops, and they would borrow money and pay the General Government $1.25 an acre in order to get money. Therefore, a large amount of this has gone into the Treasury from that source. But from South Dakota, Aberdeen and neighborhood, $7,000,000; and I was told by a receiver of the Huron office that he received $3,000,000 during his term of office, and I estimate $10,000,000 more from the southern offices, making in the neighborhood of $20,000,000 paid into the national Treasury from the settlers of Dakota. Under these circumstances and the extent of the discouragement under which the people of that country suffer, we think the General Government ought to be liberally disposed toward them. I do not expect any large appropriation from the General Government in the way of sinking wells, at least at the start, but I do expect that this committee will recommend that Congress grant a liberal appropriation for surveys and investigation in regard to what can be done for the advantage of the two Dakotas in that respect; that the General Government will send experts who understand the business, who have made it a study; men who will thoroughly investigate the matter, and perhaps make some experimental trials in regard to these artesian wells.

Senator **REAGAN**. Have you made any estimate of the probable cost of sinking artesian wells?

Mr. **POTTER**. No; I have had no experience; but I believe the expense has been from $4,000 to $6,000. If this work is entered upon with the best appliances for doing the work, it could be done by wholesale more cheaply than in these isolated localities.

STATEMENT OF L. R. CASEY, OF JAMESTOWN.

Mr. Chairman and gentlemen, I will endeavor to set an example of what you seem to desire—brevity.

Representing the Farmers' Alliance of North Dakota, I desire to express for myself and for them the exceeding gratification we have felt that in the great work you have undertaken Dakota has not been omitted.

I was appointed by the constitutional convention, now convened at Bismarck, a messenger to deliver to the committee at this point a memorial drawn by the convention and passed by it. I can only report to the committee that it has not reached me by this morning's mail, which is just as well, as the committee will get it when it arrives at Bismarck.

Data have been presented to the committee, which are general in their character, pertaining to the different wells. It is not necessary for me to present additional data. In North Dakota we have two wells, in Ellendale and Jamestown, both of excellent character, of which you will get definite information. Here [indicating on the map] is Devil's Lake, due north from Jamestown, and in the James River Valley, James River turning off at a given point. Here is Devil's Lake City on the north side of the lake. A well has been recently put in successful operation there, of which I know very little.

The **CHAIRMAN**. Has that lake any water in it now?

Mr. **CASEY**. It has a large body of brackish water. It has no defined outlet. It is full of fish and of great depth in the middle.

The **CHAIRMAN**. If fish can live in it, it could be used for irrigation purposes.

Mr. CASEY. Undoubtedly. [Indicating on a map.] James River comes off in this direction. The Cheyenne River has its source a few miles from the James.

The CHAIRMAN. Is that lake lower than the surrounding country?

Mr. CASEY. Yes; it is lower than the surrounding country.

The CHAIRMAN. It can not be made a reservoir?

Mr. CASEY. No, although it lies 100 feet higher than Jamestown; possibly by cutting channels it could be used.

The CHAIRMAN. Is there much of a ridge between it and the James River?

Mr. CASEY. Yes, a high ridge. I do not know the figures. I have inquired for a map showing the topography.

The CHAIRMAN. If that lake could be turned down southward [indicating] it could be made to contribute to the James River?

Mr. CASEY. No; the level of the James is above.

The CHAIRMAN. You might turn other water into it.

Mr. CASEY. Possibly the Cheyenne.

The Cheyenne, at first parallel with the James and near it, continues its course farther east, then like the James flows nearly south, but after about 100 miles, turns about to the north, joins the Red near Fargo, and finally its waters go into Hudson's Bay, while those of the James go to the Gulf of Mexico.

In many places in the Red River Valley water is obtained at a depth of 200 or 300 feet, without pressure, and with slight overflow. Greater depths have not been satisfactorily tested. There is a deep well at Grafton, but I have failed to receive a report of it. I know the water is salty. Let me mention that the first flow of water at Jamestown, 1,300 feet down, was salt. It was piped off, and the water finally got 1,500 feet down has a mere trace of salt in it.

Shallow artesian wells such as I have referred to have not generally been of value for irrigation. The water from some of them is injurious to vegetation, and none of them give sufficient supply. It is the water from great depth—from what we suppose is the true artesian basin—that is valuable. That at Jamestown yields 375 gallons a minute and it comes through a 3-inch pipe at the bottom. It has a pressure of about 90 pounds. Such artesian water has not been extensively applied to irrigation. The wells are generally in the towns. It has been used in a small way successfully and grass under its influence grows luxuriantly. The people are confident of its suitability to irrigation.

I desire, if the committee please, to present some considerations, in addition to those already presented, as to why we may fairly and boldly claim that the Government shall to some extent aid us at this time in the direction of irrigation.

Farming in Dakota was begun in 1875 by a few venturesome parties in the Red River Valley, but it was 1878 before confidence was established in Dakota sufficient to induce emigration to North Dakota. In ten years (from 1877 to 1887) the population of Dakota, as a whole, increased from less than 100,000 to something over 600,000. Of that population North Dakota in 1877 had not more than 20,000. In 1887 it had about two-fifths of the whole. The basis of that large emigration to North Dakota was the great success of cropping lands, and the emigration to the country was almost entirely east of the one hundredth meridian.

That success continued until 1883. During that summer the precipitation was deficient. For the year it was about as usual, but while in other years there had been good rains in June or July, that season it was not so. And in every year when there has been such lack crops have not been so good.

I will give you one illustration. In the year 1886 there had been scarcely any rain-fall in the first part of the season in North Dakota. The crops were languishing, and discouragement began to come over the people. On the 3d day of July there was a copious rain, lasting fifteen or twenty minutes in the James Valley, and in all the Red River Valley three hours. The farms in the Red River Valley that had been cropped eleven years without rest, the reports show, gave larger crops that season than ever before, and it all turned on that great rain of the 3d day of July, which we regard as one of the most potent arguments in favor of irrigation. Because with irrigation water can be applied at the critical time.

In 1884 and 1885 two impressive facts dawned upon the settlers in the country: First, that the rain-fall was capricious and could not be depended upon; and second, the other fact that prices were gone. Previous to 1882 the average price of wheat had been from 95 cents to $1 per bushel. If we had that price for wheat we would take our seasons good and bad and compete with every other section; but when our prices are reduced to from 50 to 70 cents a bushel, we find it impossible to get ahead.

The CHAIRMAN. Have the people of Dakota made any effort to ascertain what caused the low prices?

Mr. CASEY. Oh, yes; I understand your theory. The people have given attention to this fact. All the commercial history of the world from the beginning has shown that supply and demand determine values. The supply had increased enormously in the United States. In 1885 the wheat raised in the United States was double that raised sixteen years before. The population had not increased in the same ratio. India came into the field, South America had come in, and this competition was added to that of Russia, and the world was asked to take more wheat than it ever had before. That is our argument; you may have a different one. That is a sufficient answer to the question.

The CHAIRMAN. That is an answer; but India should not have come in.

Mr. CASEY. You have had South Dakota presented to you. The average rain-fall is 25.7 inches at Huron, and at Bismarck, in North Dakota, 19¼ inches. So that if South Dakota has a rain-fall of 27.5 inches, North Dakota, varying from 10 to 20 inches in its various parts, certainly has the greater need of irrigation. The fact has been brought out to-day, and it is undisputed, that a farm with the ordinary rain-fall for irrigation purposes is worth double a farm without the ordinary rain-fall, and that an irrigated farm will deliver three times the crop of one not irrigated. I know of an instance in the Gallatin Valley where a test was made on a farm of 160 acres. From that land 100 bushels of wheat per acre were taken, and the owner made a profit of $2,500 on his 160 acres.

These, then, are some of the main considerations with which we present our case to the committee, and which I apprehend will be the case which we shall carry to the law-makers and to the Government, and we think a proper case in view of the fact that twenty millions of cash has been paid into the public treasury for lands in Dakota. This Territory is filled with a sober, industrious, and frugal people, who have put into and upon the soil their entire possessions, and in no place in the United States has this proposed redemption of arid land been applauded and admired more than in Dakota. I have heard it spoken of everywhere with the greatest enthusiasm. There is no word against it, and the people know that this great movement has behind it men of ability, men of character—trusted representatives of the United States, who are capable of pushing it through.

But it can not be concealed that they view with apprehension the enormous competition contemplated in the proposed irrigation of arid lands, now practically without farming population, and they feel justified in demanding at the hands of Government consideration for the 600,000 in the two Dakotas already established on their lands and in their homes.

STATEMENT OF C. W. HALL, OF DICKEY COUNTY.

Mr. Chairman and gentlemen, like everybody else who has considered this subject, I have my ideas of what can be done in Dakota, and those ideas I wish to lay briefly before the committee for its consideration. I believe the problem of irrigation should be well considered, and that it should be considered by experts who are capable of going into all the details of the proper methods for supplying and distributing the necessary water. But there are two methods which have been known to the world for all time of supplying irrigation—one, the oldest, by means of reservoirs, by storage. We have on our western border a water surface which I have roughly estimated to be 50 miles in width by 450 miles in length. In our county this water surface in range 66, I think, takes up nearly one-half the rain. In ranges 67 and 68 it takes up nearly the whole, and then runs 30 or 40 miles beyond the Missouri, rising all the way. But this surface is not even; it is intersected every few rods by valleys which are only separated by dome-shaped ridges. These run all the way up the country, and are the beds of certain lakes and sloughs which are generally more or less full of water; this year they are mostly dry. The openings to those valleys are gulches which could be dammed by masonry, and it is easy for an engineer to estimate how much water a year those reservoirs would be capable of taking up and storing.

The CHAIRMAN. In flood time is there much water running down those ravines?

Mr. HALL. Yes. In 1882 and 1883 there were weeks when we could not ford them.

The CHAIRMAN. How is it now?

Mr. HALL. There was a little freshet in the spring on account of the rain and snow.

The CHAIRMAN. Then there would not have been much water to store?

Mr. HALL. Not much.

The CHAIRMAN. In any other year were they as dry as this year?

Mr. HALL. No; this is the dryest year we have had for eight years. But I was going to speak of the second method of irrigation—the artesian wells—the system which has been talked of here to-day. That system could be put in operation in connection with the other, and we could have those reservoirs stored with water the year round.

The CHAIRMAN. Have you ever considered the question whether or not you could take out the main rivers—for instance, the Missouri River?

Mr. HALL. There is a storage-shed to the Missouri River the other side of the divide.

The CHAIRMAN. How high is that?

Mr. **Hall.** The center of that is 200 or 300 feet above the Missouri; not so high above the Missouri as above us.

The **Chairman.** If it is higher what would be the difficulty?

Mr. **Hall.** It would be a pretty big canal. I will leave that subject. At Ellendale there is a well 1,087 feet deep. It has a 6-inch bore, and cost about $5,000. It has a pressure of 125 pounds to the square inch. It started at 80, and has since run up to 125 pounds. That well is like the others that have been described here. The water is found in the sand rock, which for a time disintegrates and pours up large quantities of sand; the flow is increased as that passes away.

The **Chairman.** To what depth did they bore into the rock? Of what thickness is this water-bearing strata?

Mr. **Hall.** I have not the figures in regard to that. I can send them to the committee.

Oakes put in a well; and Frederick, 12 miles south of us, has contracted for one at $3.25 a foot, and we will have that completed this fall.

The **Chairman.** Do you know whether any engineers have taken the altitude of the Missouri to see the difference?

Mr. **Hall.** Mr. Aikley has, but I have not his figures. I have the figures of Jamestown and Bismarck, if you want them.

The **Chairman.** What are the figures of those places?

Mr. **Hall.** The altitude of Fargo on the North Pacific road is 903 feet; of Jamestown, 1,395 feet, and of Bismarck, 1,668 feet.

The **Chairman.** That is 300 feet difference.

Mr. **Hall.** It is nearly 700 feet across the Territory from Fargo to Bismarck.

There are one or two other things which I wish to mention. My acquaintance with this part of the country commenced in August, 1881. In that year the condition of the country was very much the same with regard to dryness that it now is. The Cottonwood was dried up, and only some of the lakes remained full. In 1881 and 1882 there was an immense fall of snow, and the next spring the country was full of water and the crops were the best that were ever known in that section. All through the valley of the James there was a good yield of wheat—24 to 25 bushels per acre was a moderate crop. The yield went as high as 42 bushels. Dews were heavy, and the country generally seemed to be favorable to farming. But since that time the country has dried up. T. W. R. Emery, who had a large farm in Dickey County, sunk $40,000 in wheat farming. He never had a crop that paid expenses in four or five years, and he was a man who deserved well. My father sunk $16,000 in La Moure County. But all this country, not only from my own observation but from the observation of military men who told me about it, is liable to cycles of rain. At times the whole country will get wet through, and then it will gradually dry up. On Devil's Lake, covering some 60,000 acres, the steam-boats run across, and it is not as low to day as it was twenty years ago.

We are proud of Dakota, and we are bound to stay there if it is possible to do so. We know that we have there as rich soil as there is in the world. We have land that we wish to sell to people from other sections of the country, and we do not wish the idea to go out that will lessen the value of those lands. But unless something be done to help Dakota other than Americans will have to go there—people who can live on comparatively nothing and feed themselves. The question will be with any one who wishes well of this project, not what will be done, but what can be done. I believe that if the Government of the United States can not afford to make appropriations for Dakota as it makes appropriations for other States for their harbors, for sea-walls and coast defenses; if it can not appropriate money for our State as it does for scientific investigations of the fish culture, it can lend its credit to build a system of water-works, and we will pay a reasonable rent to have it in our county, and other counties will do the same. In closing, it should be said that the Government of the United States owes Dakota a good deal of money in a moral point of view.

STATEMENT OF N. J. LOWTHIN, OF GRANT COUNTY

Mr. Chairman and gentlemen, I live in the eastern part of South Dakota, on the west side of the Coteaux, on what is termed the divide between the Whetstone and the James Valleys. The Sioux River has its rise in those Coteaux, and through all the valley are two general streams which are known as the Whetstone and Yellowbanks, with numerous branches, all of which are dry. There are lakes in that valley which in former years were high and had a surplus of water in them. To-day they are very low, and the rain-fall since the lakes have commenced to dry up has grown less every year. In 1882, as has been stated, we had plenty of rain and abundant crops was the result. I think we could have some artesian wells sunk in those Coteaux.

The CHAIRMAN. Have you any streams of water that could be turned into the lakes?

Mr. LOWTHIN. No; nothing but the actual rain-fall. I do not know of any other supply.

The CHAIRMAN. You have not sunk any wells there?

Mr. LOWTHIN. No. They attempted it in Grant County, but I think they struck granite.

The CHAIRMAN. Sometimes there may be overlying granite that is drawn up by volcanic disturbances; but when you come to the regular granite there is no artesian well possible?

Mr. LOWTHIN. They do not attempt to drill through it. I do not think there is any other source for us except the supply from those lakes.

The CHAIRMAN. The lakes are dry now?

Mr. LOWTHIN. They are not completely dry, but they are very low.

The CHAIRMAN. Would there have been sufficient water had it all been drawn off this year?

Mr. LOWTHIN. Yes.

The CHAIRMAN. What difficulty is there in the way of drawing it off; what you want is a tunnel, a deep cut?

Mr. LOWTHIN. I do not think we would have to cut very deep.

The CHAIRMAN. Those waters in the lakes do not belong to any one?

Mr. LOWTHIN. No.

The CHAIRMAN. The first means would be to get those waters out?

Mr. LOWTHIN. Yes.

The CHAIRMAN. Then if you do not have enough for your purposes you should try some artificial mode; but the probability is that you will have plenty of water every year. How much water have you there now; how deep and how wide is it?

Mr. LOWTHIN. Some lakes are 10 feet deep, some less.

The CHAIRMAN. What area does the water cover?

Mr. LOWTHIN. Some 40 to 50 acres. There is a chain of small lakes there.

The CHAIRMAN. Has the land a clay subsoil?

Mr. LOWTHIN. Yes. The Pumice-stone Lake is quite a body of water, of a pretty good depth. In the southern part of the county the crop is poor, but in the northern part the crop is very good.

The CHAIRMAN. You want to survey to ascertain how much of the water in those lakes you can utilize.

Mr. LOWTHIN. Yes. That, I think, should be the first thing done—ascertain what can be done, and then the Government can do whatever it may deem proper to assist us.

STATEMENT OF C. E. GRIMM, OF NEWARK, MARSHALL COUNTY.

Mr. Chairman and gentlemen, I represent the district of Marshall and Broad Counties. That district forms part of the north line of South Dakota. The lakes border the eastern part of our county.

The CHAIRMAN. Have you examined those lakes?

Mr. GRIMM. Yes.

The CHAIRMAN. Is there a good deal of water in them now?

Mr. GRIMM. I saw them about two years ago, and a number of them which are now dry had water in them. There is a number of coulées in our county, and in the spring there is a little water running in them.

The CHAIRMAN. Suppose you were to dam those lakes, could you not benefit a good deal of the land?

Mr. GRIMM. Those coulées or ravines are something like 2 to 5 miles in length, and there has once been a good deal of timber on them. Some of them are 2 miles in length, and some of the banks are 100 feet high. Those hills are higher than the surrounding country, and if the water in those coulées could be increased by a flow from wells, we could get enough water to irrigate a large country. Still lower down the valley there is a strip of what we might call heavy land, and there is where the suffering has been this year; there was no water to reach the subsoil, and the poor sample of wheat which was shown here this morning is good wheat compared with that produced in that country. Then to the westward of that is a strip of country where the crops are considerably better. There the water is nearer the top of the ground. We can reach well water from 10 to 12 feet deep. If you were to sink a well 15 feet deep, it would be almost impossible to pump the well dry. And then, on this flat ground, I understand they have struck water at 75 feet, so that they have made splendid wells in that country. Right up the lower end of this valley of which I am speaking, they have an artesian well a little less than 1,000 feet deep, and the pressure from that well is 125 pounds to the square inch. Then they have a well at Andover, another well at Webster, and another at Columbia, in the James River Valley.

In the winter of 1880 there was much snow in Dakota, and there was water from the melting of that snow that staid from 1881 to 1882, and wheat went up as high as 50 bushels to the acre. That proved to me that with a favorable season we could have a large crop any year. But in the spring, as a general thing, we have not enough water to reach our subsoil, and what little we have is dried up by the hot winds which pass over the country in the summer. I think the bad effect of these winds could be obviated by surface water. But as we have no dews and no surface water, we can not raise our stock or farm products, and our country must be either a stock or farming country. Unless something be done the people must dispose of their stock and make a change. A large number will dispose of their farms under the hammer. Three wells to a township would give sufficient surface water for that country, and we could raise good crops every season. We know that Congressmen generally live on the best in the land, and it is said that Dakota raises the best flour in this country; so that Congressmen, for their own interest, should look at this thing as we do. We do not wish to make more money than we can well take care of; but we do wish to make enough to pay our taxes and honest debts. We can raise stock cheaper than any other section of the country, and there is no land in the world that has better soil, soil better adapted to cultivation, and we do ask that Congress grant us such relief as our needs require.

STATEMENT OF G. S. PERRY OF DOUGLAS COUNTY.

Mr. Chairman and Gentlemen, I think the ground has been pretty well covered by those who have preceded me, and I shall detain you only a few minutes in presenting the views we entertain in our part of the Territory.

I live in Douglas County, in the extreme southern part of South Dakota. When I went to that country in the winter of 1881 we had an abundance of water, and during the summer of 1882 we had as good crops as I have seen in any other country. In the early part of the season we had a good deal of water in our streams. There were four or five that we could not cross. As I have said, during that season we had as good crops as I have seen in any of the States, and I have lived in Iowa, New Hampshire, Maine, and Colorado. I do not think that the crops of any of those States could come up to the crops that we had in 1882. I do not think there was a night during that summer but what we had dews, and these streams of which mention has been made were running full of water; but this season our crops are poor.

In the early history of the county we had 16 bushels of wheat to the acre, and corn 45 bushels to the acre. That was our crop. But soon these streams were without water, and wagon-roads were made all through them. It is my opinion that unless something be done for our relief the country will soon be depopulated. Why, in Davidson there is not one piece of land in five that is inhabited to-day, the people being driven out because of want of water.

The CHAIRMAN. Is there any supply in that county except from artesian wells?

Mr. PERRY. No.

The CHAIRMAN. But you have artesian wells there?

Mr. PERRY. Yes; at Campbell they have artesian wells and at Plankington.

The CHAIRMAN. What pressure of water did you get there?

Mr. PERRY. At Plankington 140 pounds to the inch. Then you go south to Tyndall, and there is a well 600 feet deep. That has a pressure of 122 pounds to the inch. That flows on the surface, the water going into the Missouri River. Parties living adjacent to this well at Tyndall entered suit against the town because of this water running over their land, but before they got the suits into court and under headway they withdrew them, seeing the advantage the water was to them. This surface water from that well makes the land on which it flows worth $25 an acre, while the land this side is not worth more than $8 to $10 an acre.

The CHAIRMAN. Are the banks of the Missouri deep at that point?

Mr. **Perry**. Yes; there are high banks there, and timber lands until you get to Yankton.

The **Chairman**. How high have you been?

Mr. **Perry**. Only to Pierre I will say in regard to the wells at Yankton that the best well is 165 feet deep, and has a pressure of 140 pounds. They have eight or nine wells there, and one is on the Missouri River, where they are carrying on one of the largest brick manufactories, and all the water is derived from this well, driving the machinery and everything else. There is another matter to which I wish to call your attention, and to which there has been no allusion so far, and that is that from fifty to seventy-five parties having tree claims are compelled to ask an extension of time to carry out their contract with the Government. This is on account of the dry weather in those counties. If wells could be sunk at the heads of Choteau Creek and two other creeks in that neighborhood, it would make each one of them flowing streams. They are only 6 to 12 miles apart, and we might get moisture from them which would assist us materially. But we are poor and not able to get the money to get on and make the experiments.

STATEMENT OF G. E. PURLEY, OF MINNEHAHA COUNTY.

Mr. Chairman and gentlemen, I live in the Sioux Valley, and I am the only representative from that section. Our county is economically managed, and it is out of debt. The Big Sioux has grass growing in its bottom, with but little water in it.

The **Chairman**. Where does it head?

Mr. **Purley**. In Codington County.

The **Chairman**. I see here (referring to a map), that there are a great many of these small lakes therein. Do they drain into the Sioux?

Mr. **Purley**. They are not drained. Some of them are dried up. It appears, on the map, as if there were a little lake here [indicating], and one here [indicating], but those places are where we get our good grass. They were lakes and streams in earlier days, but there is no water in them now.

The **Chairman**. There is water in the Sioux that could be brought back upon the land?

Mr. **Purley**. But there is not enough in the dry seasons. Here is a statement of the rain-fall in our last growing season. I got it from the president of the Agricultural College. It is $4\frac{430}{1000}$ inches. We got the idea that Brookings was getting more water than we were. We could see the clouds move around us, and we found that at the same time they had four inches of water and over, we had only two. Mention has been made about this snow-fall of 1881 and 1882. I have lived in Dakota since 1876 and I have noticed this feature in the change of wind currents: They come from the northwest. The start of oursnow-fall was a blizzard from the northwest. The water from that snow went into the ground and filled it up so that we could not plow our fields that fall. Then, during the same winter, we had southeast winds that gave us more snow, and the water from that went into the land. But during the last three years the wind has come directly from the south and the north, and it has been without this moisture. We felt a little delicacy at first at being classed as an arid country; but we are not the first to say we want rain. But the rain grows less all the way from the Alleghany Mountains to the one-hundredth meridian. The average fall is less when you get to the one hundredth meridian, where it is not enough for the crops. But there is no use in rebelling against nature or your country because there is not enough rain-fall, for irrigation is the beginning of civilization. When we get educated to it, we will find people leaving rain-fall countries and seeking irrigation lands, and we need not be ashamed of it.

When I went to South Dakota, in 1880, the country was new. There was not a post-office in our county, nor a railroad. I sought information from every available source as to the condition of the country. There were signs of drouth, and my friends back East said they could see between the lines of my letters that I was a little uncertain whether it was a place to live in or not. The lakes throughout South Dakota that summer were dried up. There is a lake in the northeast portion of my county—Lake Brant. It covers probably two sections of land. That was dried up, and teamsters used to go over it and cut their timber. East of the line of the railroad there was a lake called Preston, and that was dried up. The northwestern people built their railroad across there. The grass on the prairies burned off about the middle of last July, but on the 14th of August there was a heavy rain, and the grass all grew up again. The season of 1879 had been dry, but I think not so bad as that.

In the winter of 1880–'81 there was a heavy snow-fall. The winter was a very hard one, and it kept up until the 18th of April. That was the first thaw that we had, and then the snow went off just as fast as snow could go, and all the lakes were filled with water. Preston Lake was so full the railroad company had to lay its track around it. Lake Brant was filled with water. The seasons of 1881, 1882, and 1883 were very productive.

The CHAIRMAN. How large is Lake Brant?

Mr. PURLEY. It covers about two sections of land.

The CHAIRMAN. Is there water in it now?

Mr. PURLEY. Yes; the water in it now is about a foot deep. I learned from an old stageman that it was dry in 1870, and in 1872 or 1873 the subdivisions were made by the Government, and at that time it had water in it. This shows that these dry seasons are periodical. In the seasons when those streams were full of water we had rain. But whether that was the result of the water being in them or a coincident, I would not say. It may have been both.

The CHAIRMAN. It is time that you were having a change of season.

Mr. PURLEY. Yes.

The CHAIRMAN. When the good season comes will you give up or will you keep up the fight?

Mr. PURLEY. Solomon says there is no remembrance of past things. But I do not think there is much danger of this being forgotten. There have been no seasons but what we have had dry spells; but some of them are not so disastrous as others. There has not been one of those dry spells but what the farmers would be alarmed. But the rains would come before the crops were killed.

The CHAIRMAN. When you have a good winter and the rain fills the ground above down to the hard soil, and it is well saturated, will the dry spell hurt you?

Mr. PURLEY. No.

The CHAIRMAN. The moisture will carry you through the season?

Mr. PURLEY. Yes. Last fall had the ground been well saturated, with what rain we had this summer we would have had a fair crop. There is no question about that.

The **CHAIRMAN**. You have here a most favorable feature—the condition of your soil is such that after a while less water will do.

Mr. **PURLEY**. Yes. There are several farms where there has never been an entire failure. For instance, there is Mr. Cass's farm, northeast of Huron. He has never missed a crop. He made the statement that anywhere within the area of his land where good crops were raised he could dig down 8 to 12 feet and invariably find water. Many farms there are the same way. I maintain that if we can have some means by which we can irrigate in the fall, after the harvest is over, and once in June, we can get along very well without any more irrigation. Once will suit us. If we can sink artesian wells and anchor the pipes so that the water may be kept in the wells we would have no trouble in that country. But there is the difficulty—the anchoring of the pipes; they are blown out of the ground.

The **CHAIRMAN**. Why not let the water flow into a reservoir?

Mr. **PURLEY**. We do not want to use that land for a reservoir; we do not want the water to go down to the James. If the water is in natural places it is too low; we want it up high.

The **CHAIRMAN**. Can you not locate your wells on high places?

Mr. **PURLEY**. That might be done in many cases. I think that would be a very good idea. Water naturally percolates through the soil. It has been explained here that the James River Valley has a depression of about 500 feet on each side. I have the figures from the engineers of the Northwestern Railroad. You will see from the map that Pierre is nearly west from Huron. The land at Pierre is 150 feet higher than at Huron.

In 1883 on the lowlands the moisture was left, and on my farm there was a hay field of 60 acres on which there was grass 9 inches long. In 1882 I saw potatoes on the scale that weighed 4 pounds, and a single cabbage head that weighed 40 pounds. But I do not propose to go into details, because the ground has been already covered. When you go to Huron there will be some statistics furnished you.

Now, what is to be done in view of the evidence that has been presented here this morning? If the Government will send out promptly and sink a few wells under the guidance of an engineer—there is no necessity for an extended survey—and show the people how this can be done, it will give confidence to them. They will see that there is a reward to follow which will justify the expense to be incurred in the work. If the Government will do this, gentlemen who are in the money-lending business will see that there is a way for their loans to be paid, and those who have to borrow money to sink wells will have confidence that they can pay their debts. There will be no difficulty in sinking those wells. Our people are not a people to contract debts without making provision to pay them. They want to see their way, and when once they do, they will roll up their sleeves and go to work.

STATEMENT OF E. D. DRAKE, OF MINNESOTA.

Mr. Chairman and gentlemen, I am a citizen of Minnesota. I believe Minnesota has been wholly excluded in this discussion. While it is a fact that southern and eastern Minnesota have as perfect a return of rain-fall as any place on the earth, yet we sometimes suffer for want of rain. I have lived in this State for 25 years, and I am acquainted with northwestern Minnesota, northwestern Iowa, and southwestern Dakota. The agricultural land of Minnesota, around a circle of 100 miles, is the best body of farming land on the face of the earth. That is a pretty bold statement to make; but I think I am correct. I am sorry that the committee is to part from us in the night; because were it otherwise the committee would see that my statement is true.

But there are seasons when we could double our productions by artificial means. I have been farming some 10 or 15 years and I have planted out trees to more than the value of $50,000. I have spent much money in planting trees.

And right here let me call attention to this latitude, exposed to the winds of the western prairies—winds that in summer and winter come over an unbroken prairie for 500 miles. There a good rain-fall is all lost. But where trees are it is different, and the effect is shown in the grass and wheat and corn. These trees change the direction of the winds, and induce moisture. I have measured crops of corn from my farm as high as 57½ bushels to the acre. I have this year 30 bushels of wheat on a comparatively thin soil. And then my observation has been confirmed by some of my friends from Dakota, and by the chairman of the committee, to the effect that where we have water in the winter in these basins all over our territory we need very little rain during the year. I have cut good, soft, nutritious hay in those places. A farmer who resides within 25 miles of this city said that he sowed a crop of wheat and harvested it without a single drop of rain; the winter snows going off late in the spring gave him the necessary moisture.

I do not wish to detain the committee, but I trust it will incorporate in its report a recommendation that the introduction of trees should be inaugurated as a means of inducing moisture for purposes of agriculture, particularly in that portion of the country which the Government owns. We have given millions of prairie acres, a very great portion of them to naturalized foreigners, who have filed their declarations of intention and taken a farm. We have given freely and required nothing. Had the Government reserved a portion of that land, or attached a reasonable condition with regard to the planting of trees, we should have had a different condition of things in this whole northwest territory. We would have gotten rid of these blizzards and modified our climate with regard to rain and evaporation. Let Congress consider and pass an act upon the subject of planting trees, and let the beneficiaries do the work. If this can be done it seems to me that it will accomplish as much as can be accomplished by irrigation, and even more.

COMMUNICATIONS FROM DAKOTA PEOPLE.

By direction of the chairman, the following communications were filed:

Messrs. D. C. Pierce (chairman), I. Rockaffow, A. S. Whipple, B. A. Rogers, and A. L. Jones, a committee of the Farmers' Alliance, write under date of Ipswich, S. Dak., July 10, 1889, as follows:

> In response to a letter from your committee addressed to C. A. Soderberg, secretary of the Dakota Farmers' Alliance, we the undersigned having been appointed a committee for that purpose by Alliance No. 120 of Edmunds County, beg leave to offer the following facts in relation to the water supply of this county, and ask for them a favorable consideration by your committee.
>
> Edmunds County lies near the center of Dakota Territory, on the eastern slope of the "Coteaux du Missouri," having an elevation at the west end of about 1,200 feet, and at this place (Ipswich) about 400 feet above the James River Valley at Aberdeen. The surface is varied from very rolling and stony in the west to gently rolling in the

eastern, and nearly level and free from stone in the central part. The soil is very rich and produces abundantly when sufficiently moistened.

It has no natural water supply except the melting snow of spring which is carried off by creek beds about a mile apart which empty into the James River. These creeks become dry soon after the snow is gone, no water remaining in the county except a few pools, which are dry by the middle of summer. These creeks average at this point when at full flow about 30 feet wide by 2½ feet deep and have a strong current, thus carrying off an amount of water which if it could be retained in the county would greatly increase the rain-fall and furnish an adequate supply for agricultural and stock purposes.

The rain-fall has varied a great deal during the past six years (the time since the first settlement of the country), but one year (1886) having been sufficient to insure a full crop, while the present year is lacking in rain to the extent of almost a total failure of crops. The present drought, however, is partially attributable to a very light snow-fall last winter, as there was not enough to start a flow of water in the creeks. No record of rain-fall has been kept, but it might be set down about thus: 1886, 18 inches; 1887, 13 inches; 1888, 12 inches; 1889 (to July 1), about 3 or 4.

Ipswich has a 6-inch artesian well, depth 1,270 feet, flow 200 gallons per minute, pressure 70 pounds. Water-works and village well supplied.

The most practical way, in our opinion, to increase our water supply would be—

First. To construct dams across the creek beds mentioned, at least one on every section. These need not be expensive. In many places a large amount of water could be retained by a small dam. A few small dams were constructed by individuals last year, but, as we had so little snow last winter, they were not filled this spring. Although the people believe generally in the advantage of these, they are too poor to build them alone, having invested all their surplus in buildings, teams, and tools.

Second. Artesian wells, located at such points as would accommodate the most people, surplus to flow into the creeks to supply the ponds below. At many points these wells in the future could be utilized to run factories, mills, creameries, etc., as their pressure often reaches 175 pounds. The rental of power would pay for the wells.

Third. As a means to secure the construction of dams and wells we need Government aid in the way of bounty, or exemptions, or any other appropriation that will secure the end.

We do not know what power your committee may be clothed with, and therefore may be overstepping our privileges in this communication; if so we hope it may not detract from what good might come from it with better information.

The people—numbering about 5,000—are mostly American and of the better classes, well up in intelligence and education, and they have labored honestly and faithfully to develop this country and make themselves homes, and are worthy of your consideration, but the heavy odds against which they have had to work has covered them with debts and many are discouraged; and only help of the kind we hope you can bring will save us from the shame of many abandoned homes.

Under date of Dickinson, Stark County, N. Dak., July 24, 1889, a committee composed of the following citizens, James G. Campbell, N. C Sunsmer, R. J. Turner, Timothy Cuskelly, H. L. Dickinson, John A. McGregor, C. H. Klinefelter, sr., Ed. R. Bonney, Jos. T. Scott, A. Hilliard, and Smith Hilliard, forwarded the annexed paper.

To the special committee of the United States Senate appointed to investigate and report on the matter of irrigation of arid lands, etc.:

GENTLEMEN: The undersigned, citizens of Dickinson in Stark County, North Dakota, respectfully represent for your consideration that there is a large tract of land west of the Missouri River in North Dakota, east of the Bad Lands and bordering on the Little Missouri River. This tract comprises several large counties, some of them having territory enough to make each of itself a fair-sized State. Three of these counties, Morton, Stark, and Billings, are organized, and all of them are more or less settled with permanent settlers, having large tracts of land in cultivation. This whole country is undulating, with a good rich soil, capable when sufficiently watered to raise crops of wheat of from 20 to 30 bushels per acre, and from 50 to 90 bushels of oats. Since the settlement of these lands there have been a few seasons when the rain-fall was sufficient during the growing season to show the capabilities of the soil and climate as above stated; but while there have been a few such years the majority have suffered from severe drought during the months of May, June, and July, more especially June. This has led to repeated crop failures, impoverishing farmers, unless rich enough to have live stock to rely upon, and thus retarding improvement and discouraging settlement. There are several small streams in this region, but the conformation of the county is such that irrigation from the streams does not seem to be practicable. Artesian wells generally distributed might be made to water large tracts directly, and indirectly the whole region by increasing the humidity of the atmosphere and thus increasing the rain-fall. In this whole region the only incorporated town or city is Mandan on the bank of the Missouri River. All the other towns are mere villages and hamlets, and the settlers are generally poor. This being so the conditions are not favorable for expending money by way of experiment in boring for water. In all that region there is no well of that kind. If it were once established that water could be had in that way in abundant supply at a moderate depth, then we think that private and corporate enterprise would in time supply the country in the manner indicated with water enough to make it one of the most fruitful regions of the United States.

In view of the foregoing we respectfully request your committee to examine and consider the natural conditions and capabilities of the region referred to, and, if deemed proper by you, that you recommend that one or more experimental wells be sunk at Government expense at such point or points best calculated to make a fair test of what may be accomplished in supplying sufficient water by that means to irrigate this country.

Mr. S. Patton, under date of Dickinson, N. Dak., July 28, 1889, writes as follows:

I have just received a copy of Hon. William M. Stewart's letter to the Farmers' Alliance, from which I learn that the Senate Committee on Irrigation will visit this country early next month. Our agricultural department is engaging in a noble work. We have a superior soil, and the topography of the country is favorable to irrigation. Our farmers are not able to make artesian wells, and our streams are deficient in water in a dry time, and have not enough fall to enable us to get the water out of their deep channels. We have much greater need of irrigating wells than near the mountains in Montana, where the great fall of the mountain streams and melting snows give good facilities. Our rain has been deficient three seasons out of six. This is the dryest we have had. Most of our early crops are a sad failure. We have had at my place but 2.74 inches of rain this month:

	Inches.
June	0.82
May	2.77
April	.79
March	.17
February	1.07
Total for five months	7.56

We have had but 8.46 inches since last August, and had it not been for the surplus carried over deep in the soil from the heavy rains of last year, no crop could have been made.

I can answer a few of Mr. Stewart's inquiries:

(*a*) The extent of arid area in dry seasons embraces our whole country.

(*b*) Above find rain-fall for the past 11 months, our rain-fall during the growing season in good seasons is from 8 to 15 inches; that is an average of 11½ inches.

(*c*) We have no irrigation, and no means of irrigation; no streams available for dams or reservoirs.

(*d*) Dakota is too dry in fall and winter for trees, and many die from drought.

LA MOURE, LA MOURE COUNTY, NORTH DAKOTA.

The following papers were also filed by the chairman of the committee:

ACTION OF BOARD OF COUNTY COMMISSIONERS.

July 13, 9 o'clock a. m. Board of county commissioners in session. Full board present.

Mr. W. M. Potter appeared before the board and invited attention to the importance of an artesian-well system.

On motion the following resolutions were passed:

Whereas experience has demonstrated the lack of a sufficient supply of moisture to insure growing crops, and also an evident increasing tendency in the same direction and from year to year; and

Whereas the sinking of artesian wells, in various portions of Dakota, affords satisfactory evidence of the existence of vast reservoirs, or inexhaustible currents of water, beneath the soil, which may be utilized by the construction of such wells to flood present and open new water-courses; to create reservoirs; and to irrigate large quantities of agricultural lands; and

Whereas it is believed that such an increase of surface water will exert a beneficial effect upon rain and snow falls, and thus afford assurance of an ample supply of moisture for agricultural needs: Therefore,

Resolved, That it is the judgment of this board that public attention should be turned to artesian wells as a resource against the evils now being suffered for lack of rain supply, with a view not merely to county but to State and national assistance in meeting the exigencies of the situation.

Resolved, That we respectfully and earnestly invite the attention of the committee appointed by the Senate of the United States to investigate as to arid lands, to the needs of these northwestern plains, and to the necessity of supplementing the efforts of exhausted settlers with the strong hand of the General Government.

On motion the chairman was instructed to appoint a committee of three to confer with other county committees and the Senatorial committee on arid lands in relation to artesian wells for water supply for Dakota.

The chairman appointed the following persons on said committee: Waldo M. Potter, W. E. Brewer, and G. R. Fralick.

A correct copy.

Attest:

G. R. FRALICK.
County Auditor.

STATEMENT ACCOMPANYING THE COUNTY MINUTES.

The map sent with this paper, represents sloughs and water-courses where water was abundant six years ago. They are now entirely dry, except the James River and two little lakes.

The county contains thirty-two townships, 1,152 square miles, is centrally located between the Missouri and Red Rivers, rolling prairie, and is divided north and south by James River.

Its condition as to surface water.—Six years ago Bone Hill Creek, in the northern part of the county; Bare Creek, on the eastern border, and Cottonwood Creek, in the center, each extending through several townships, were considerable streams; now almost entirely dry. At that time sloughs nearly impassable by teams were scattered in a majority of the townships. These are now all dry.

The twin Alkali Lakes, 3 miles from the town of La Moure, covered nearly 2 miles north and south, and were 10 to 12 feet deep. Now one is dry and the other nearly so.

Cottonwood Lake, 1 mile long and one-half mile wide, 9 miles southwest of La Moure, is now a shallow pond, 6 feet lower than five years ago. This is about all the surface water, except the James River, in the entire 1,152 square miles of the county.

The James River has been only a shadow of its former self most of the time the present season.

The disappearance of these sloughs and ponds has been gradual—less from year to year—in the face of the generally received theory that cultivation of the land increases rain-fall.

What is true of La Moure County in these respects is also true of nearly all the present occupied portion of the two Dakotas.

I. *Feasibility of an artesian-well system.*—Wells are now in operation scattered over 300 miles north and south and 200 miles east and west. Irrigation believed to be practicable to a large extent.

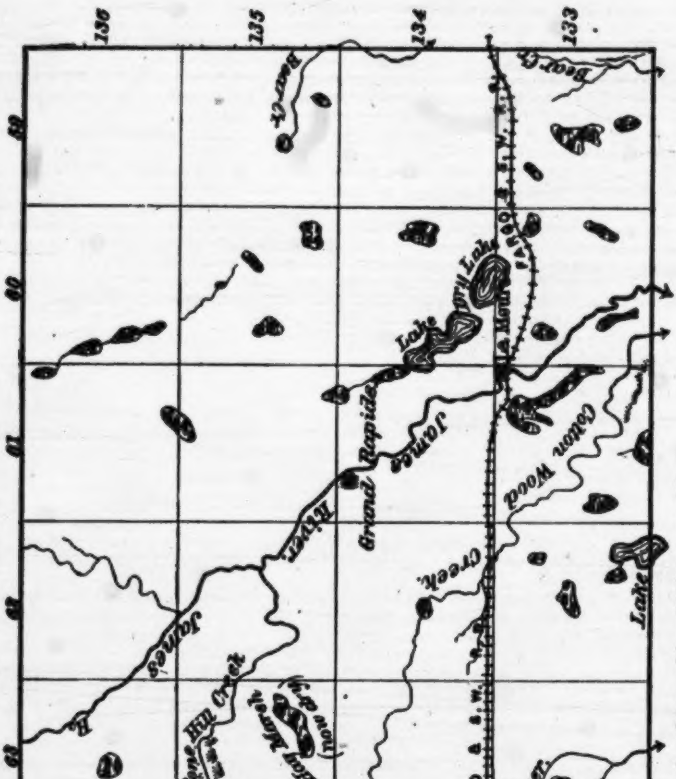
II. *Necessity.*—Seasonable rain-falls more uncertain, and growing less for a series of years. Drying up of water-courses, sloughs, and lakes. Deficient crops.

III. *Need of Government help.*—The bulk of Dakota people are poor; heavily in debt; lands, crops, and chattels mortgaged; result of decreasing crops and low prices. Bonding and taxation to inaugurate a system of artesian wells, with whatever risks there may be of success, would seriously burthen their resources.

IV. *The General Government should open the way.*—About $20,000,000 already paid into the United States Treasury by Dakota settlers; 20,000,000 acres yet to be occupied, in addition to 10,000,000 expected from the Sioux Reservation. Better water supply necessary to encourage immigration. A return of 5 to 10 per cent. of what has been realized would suffice.

V. *Great natural fertility of the soil will justify the expenditure.*—Thirty to 40 bushels of wheat per acre have been raised in favorable seasons. For lack of moisture 10 bushels is all that can be expected this year, and thousands of acres have been plowed up. Irrigation would doubtless insure 30 to 50 bushels.

La Moure County, North Dakota.


136
135
134
133
59
60
61
62
63
64
65
66
Bear Cr.
Bear Cr.
Lake
Dry Lake
La Moure
Fargo & S.W.
Grand Rapids
James
River
Cotton Wood
Creek.
Lake
James
R.
Bone Hill Creek
Hay Marsh
(now dry)
Fargo & S.W.
River
Maple
Edgeley
Lake Bed

32 Congressional townships, 1152 square miles.

VI. *Investments in Dakota show the courage, character, and enterprise of her people.*—

Assessed valuation, 1888		$161,420,974
South Dakota		$91,381,072
North Dakota		$70,039,902
Post-office revenues		$500,000
Expended for schools in 1888		$1,051,327
Number of church societies		1,000
Railroad facilities:		
North Dakota	miles	2,100
South Dakota	do	2,400
Aggregate banking capital		$11,747,440

VII. As agriculture underlies all Dakota prosperity everything for the future depends upon its encouragement. With adequate water supply great prosperity is assured. Without it all is in peril.

RECEIPTS OF DAKOTA LAND OFFICES.

North Dakota.

Fargo	$3,257,776
Grand Forks	2,921,000
Bismarck	640,000
Devil's Lake	710,624
	7,529,400

South Dakota.

Aberdeen	$1,867,881
Yankton	1,094,944

Huron, Mitchell, Watertown, and Deadwood, estimated about $10,000,000. Total, about $20,000,000.

COMMUNICATIONS FROM CITIZENS AND ARMY OFFICERS.

STATEMENT OF J. E. LABRIE, OF DOLAND.

DOLAND, DAK., *July* 23, 1889.

To Hon. Wm. Stewart, chairman, and others, of the United States
Senate Committee on Irrigation, sitting at St. Paul, Minn:

GENTLEMEN: The people of Spink County, Dak., comprising 1,512 square miles of land and containing 15,000 population, have suffered for four years from a shortage of crops on account of insufficient supply of moisture. We have an unfailing supply of water at a depth of from 900 to 1,000 feet below the surface, which rises through the artesian wells now in operation with a force of 200 pounds to the square inch; we have a country that is traversed by innumerable dry water-courses, and interspersed with numerous dry lake beds; we believe that if these water-courses and lake beds were filled from the subterranean fountains the evaporation would tend to produce more rain, heavier dews moisten the atmosphere and temper the hot south winds which destroy our crops; without artificial means for producing moisture we must struggle against failure; with artesian fountains feeding the dry water-courses and lake beds we are confident that we shall become the greatest grain and stock producing country on the continent; we believe that Dakota, robbed of a large portion of her school fund, long deprived of her political rights and with no hope of Government appropriations except in this direction, should be liberally dealt with on this question by Congress; we ask that Congress appropriate sufficient money to sink artesian wells along the James River Valley at the head of dry water-courses and lake beds so as to fill them with water.

To the end that the people of our county may obtain information on this subject, I have appointed the bearer, John J. Cushing, of Ashton, to wait upon you in conjunction with the committees from the other counties of the Territory.

I have the honor to be very respectfully,

J. E. LABRIE, JR.,
Chairman Board of County Commissioners, Spink County, Dak.

STATEMENT OF JOHN J. CUSHING, OF ASHTON, DAK.

The water question is creating a profound interest in our new State.

We have a soil equal, if not superior, to any in the United States for the production of all kinds of cereals, but the absence of sufficient rain-fall at the periods when most needed has become damaging to us, and from a production of 62,000,000 bushels of wheat in 1887 we declined to 37,000,000 in 1888, and according to a recent estimate of the commissioner of immigration we shall come down to about 20,000,000 bushels this year.

As the United States produces more wheat than it can consume, and we therefore are heavy exporters of wheat, seeking to become strong competitors of India and Russia in this branch of commerce, the loss to this country in a commercial sense on the shrinkage in this one commodity in the last two years has been nearly $50,000,000.

Can the people of this Republic submit to a loss of $25,000,000 annually in this one industry on the ground that an internal improvement to protect and build up the same would be local? Can the General Government fail to recognize that the improvement which we propose asking for will increase the production of wheat here in a comparatively short time from 20,000,000 to 100,000,000 bushels, and cheapen the cost of production correspondingly with the increase? With cheap land and plenty of moisture Dakota can compete with any country in the world in wheat raising.

We have the land and have paid the General Government many millions of dollars for it. This money is being used to deepen harbors and water-ways for, we might say, the local benefit of commercial centers; to build custom-houses and post-offices to suit the metropolitan architecture. May we not reasonably ask for a return of a portion of the money which we have so bountifully contributed?

Why this absence of rain-fall, and what remedy can we apply? That the absence of rain-fall is directly traceable to the absence of water-courses and lakes, and resulting surface evaporation in some portions of our State, I think may be established by careful examination of the meterological reports of the different localities.

Taking the reports from July, 1874, to December, 1886, we find that the mean annual precipitation for the whole Territory, as established by the record of twenty-nine points of observation in all parts of the Territory, was 22.25 inches. This does not include a large portion of country west of the Missouri, where the rain-fall was light, and would have reduced the general average below 20 inches.

Out of the twenty-nine places fifteen fell below 20 inches, while fourteen were above that mark.

Taking the James River Valley, it being the most thickly settled portion of our Territory, as the subject for comparison, with Huron, Yankton, Alexander, and Webster as the points of observation, we find the mean annual precipitation during that period as follows: Huron, 23.65; Yankton, 28.43; Alexandria, 30.54; while at Webster it reached the amount of 44.61.

We have only to examine the map to furnish sufficient account for the increased precipitation of the other points over Huron. At Webster, where the greatest precipitation occurs, there are numerous small lakes furnishing the surface evaporation. At the other two points their location between the Missouri and Sioux Rivers furnish the explanation; while at Huron there is an absence of lakes or water-courses, and all places similarly located—which is the case with most points in the James River Valley—are similarly affected.

Let us examine the summer rain-fall. From April to September, both inclusive, at the same twenty-nine points, and over the same period, from 1873 to 1887, we find the mean average monthly rain-fall for the whole group to be: April, 2.50; May, 3.20; June, 3.64; July, 3.10; August, 2.65; September, 1.59. Sixteen points fall below the average for April; seventeen points fall below the average for May; sixteen points fall below the average for June; eighteen points fall below the average for July; fifteen points fall below the average for August; and eighteen points fall below the average for September.

Let us now examine the same four points in the James River Valley over the same period. We find the average rain-fall at each point for each month during the fifteen years was as follows:

Point.	Apr.	May.	June.	July.	Aug.	Sept.	Total.	Mean average monthly.
Huron	2,60	3.34	3.68	4.25	3.37	1.43	18.67	3.11
Yankton	3.25	4.24	4.42	3.71	3.05	2.93	21.60	3.60
Alexandria	3.86	3.47	4.20	5.26	3.20	1.18	21.37	3.56
Webster	4.87	6.18	7.24	6.30	2.53	3.18	30.30	5 05

The above shows the effect of surface evaporation on our rain-fall. Now if this will increase our rain-fall from an average of 3.11 to 5.05 inches per month, and our annual precipitation from 23.65 to 44.65 the benefits would be incalculable to our country. The effect would be beneficial to our climate, would enable us to grow trees, would swell the volume of the Missouri River, and make of the James a river of the first class below navigable.

How are we going to bring about this increased rain-fall? By creating lakes and streams throughout the entire length of the James River Valley, the evaporation from which will bring us the precipitation here and in the adjoining States.

We have underlying the whole valley a subterranean lake, fed from a fountain far above the level of the valley, which we believe is inexhaustible. The depth ranges from 600 to 1,500 feet, and when the fountain is tapped the water rises to a height of 100 feet and has a pressure of 175 pounds to the square inch. It is estimated that the amount of water flowing from a 6-inch well is 3,500 gallons per minute, or 210,000 per hour, or over 5,000,000 every twenty-four hours from one of these wells; it becomes, then, a mere matter of calculation to ascertain how many wells we need to fill up our lake beds and dry water courses.

I have here a map of Spink County, on which I have marked in red ink the dry lake beds and water courses in this county, from which it can be seen that with artesian wells at the head and along the water courses we should have as finely a watered county as could be found anywhere; the old lake beds would fill up, the water would percolate into the subsoil, and, coming out to the surface, would give us rains and dews. In this county, at Ashton, we have an artesian well; at Redfield we have one, and at Frankfort we have one.

The people of Dakota are enterprising and will do all they can to solve this question, but they are poor at this time and believe that Congress should take hold of the matter at once, without delay, and go so far as to sink large wells at the head of and along the dry water-courses and in the vicinity of dry lake beds.

It is not expected that Congress will go into the business of irrigation, but merely to fill up these old water courses as they originally were. The people of Dakota will then take hold and do the rest if wells are needed for mechanical or irrigation purposes.

How much is it going to cost the Government to do such work as we desire? It is estimated that these wells can be sunk for $1,000 each. A sufficient number should be sunk to accomplish the end sought. If one hundred were required in each county in the artesian well belt of both North and South Dakota, it would require an appropriation of only $4,000,000, but there are many counties where but few would be required. What we want is an appropriation of somewhere near that amount, placed at the disposal of the Bureau of Geological Survey at once, require that Bureau to proceed with all dispatch possible, and make a survey and sink such number of wells as shall be deemed necessary.

Can the Government afford to refuse so paltry a sum—equal only to about one-sixth of the amount lost every year to the country from a failure resulting from the absence of this improvement?

Gentlemen, we ask your aid in this matter; we ask you to come and see our beautiful country.

STATEMENT OF V. HAVARD, ASSISTANT SURGEON U. S. A.

The arid lands of the United States, especially those which form such a large part of our territory between the 100th meridian and the Sierra Nevada, may, for our purpose, be classed under two heads: Valleys, bottoms, and flats of alluvial formation and more or less capable of irrigation, and high plains or table lands where irrigation and therefore cultivation are out of question. The latter form the great bulk of the lands under consideration, and therefore the problem how to utilize them, how to make them productive, is one of very great interest. Their enormous extent is at once appreciated by realizing that they form the greater part of Texas, New Mexico, Indian Territory, Idaho, Utah, Nevada, and Southern California, with much of Wyoming, Colorado, Nebraska, and Dakota. These plains and table-lands are destitute of timber, and their treeless condition, giving them a bare, monotonous, and often dreary aspect, has fostered the impression that their soil does not contain the elements of vegetable life, an impression which has been demonstrated to be quite erroneous; it is in fact more or less fertile, and as a rule covered with herbaceous vegetation.

The treelessness of the western plains and prairies is due to causes in which the productive capacity of the soil is not involved. True, barren, irreclaimable sandy deserts are quite rare in the United States and of limited extent. Thus Dr. Sereno

Watson, in his classic work on the botany of the Great Basin of Utah, the worst part of the American Desert, says: "No portion of this whole district, however desert in repute and in fact, is destitute of some amount of vegetation, even in the driest seasons, excepting only the alkali flats, which are usually of quite limited extent. Even these have frequently a scattered growth of Sarcobatus or Halostachys surmounting isolated hillocks of drifted sand, compacted by their roots and buried branches. It has often been noticed that sandy tracts of most unpromising aspect showed unexpected fertility under the action of water.

The prairies of Dakota, Nebraska, and Montana are famous for their nutritious and self-curing grasses, which form a close and continuous sod. West of the Rocky Mountains the conditions of vegetable life are less favorable (greater heat and smaller rain-fall); the grasses seldom form an unbroken sod, but generally grow in isolated bunches. Here, says Prof. J. T. Rothrock, "the indigenous grasses, though somewhat localized in their distribution and seldom forming a dense sward, are exceedingly nutritious, and stock will make long marches, having no other food. Among them we may specially allude to the various 'bunch grasses' of Colorado, *i. e., Eriocoma, Festuca*, and *Poa*, and more notably still the *Bouteloua*s of southern Arizona, where without much distinction all are called 'Grama.'

"The staked plains of Texas and New Mexico, which have been so often described as dreary expanses of sand, are mostly covered with excellent grass, and in places are fast becoming well stocked with cattle and sheep. At one station in the southern staked plains (less fertile than the northern) I observed nine species of grasses, including four of Grama, round about our camp."

Utah is not a promising agricultural land. There no crop is possible, except with irrigation, and pasturage is confined to the mountains. Yet the well-known botanist, Marcus E. Jones, expresses himself with some enthusiasm about the potential fertility of that Territory: "If Utah has had such a luxuriant flora in times past, and now possesses so many beautiful and useful plants where there is sufficient moisture to support them, what is to hinder its becoming a paradise again? Nothing but water. The soil is rich, and the climate is magnificent—unexcelled in this country. The cañons supply much water, and have wrought great changes in the appearance of many valleys. There is scarcely an alkaline flat or plain in Utah that does not have a natural reservoir beneath it of sweet water, ready to flow the moment it is tapped. The time is not far off when the bed of the ancient lake from one end of Utah to the other will be covered with waving grain and groves of thrifty fruit trees."

The foregoing remarks tend to show that the so-called arid lands (plains and mesas) of the "Great American Desert" are not sterile. By far the larger proportion produce grass of excellent quality. They form vast natural pastures, which under proper management are capable of subsisting herds of stock vastly outnumbering the former legions of the now extinct buffalo. All they need is water; truly an imperative need, but not beyond the reach of well-directed energy. One may travel day after day in western Texas, New Mexico, and Arizona over plains and mesas carpeted with fine and nutritious grass, which, as is well known, cures itself and retains its qualities throughout the winter; yet, owing to the absence of springs, streams, or wells, this grass is entirely inaccessible and unavailable to cattle and sheep. Drinking water for stock is then the great desideratum. We may assume that there is a sufficient rain-fall over the territory in question for the supply of all the stock which the available grass can support. It ranges, I should estimate, from 10 to 25 inches annually.

Rain falling upon uncultivated soil, especially if covered with a dense sod, as in the prairie States and Territories, does not penetrate to any amount into the subsoil, but runs off into ravines, arroyas, and cañons, and is soon drained away; stream-beds ordinarily dry become raging torrents, which soon again subside, and the much-needed water has passed away and is practically lost. It is an interesting fact worthy of note, that under such conditions—namely, scant rain fall and slight penetration—the grass should grow so well, often so luxuriantly.

If the surface crust be broken up and the soil cultivated more or less deeply, then the rain penetrates with facility to the subsoil where it is held in reserve, and the farmer is surprised at his ability to raise crops where the apparent aridity of land and climate had long delayed the trial of cultivation. From this fact of the greater usefulness and availability of rain falling upon tilled soil has arisen the belief generally entertained in the West, that the yearly rain-fall has increased of late. Careful comparison of statistics by competent observers has shown that there has been no such increase; if any, it is very slight, and more rationally accounted for by the greater care in collecting and measuring now exercised by the Signal Corps.

From what precedes it is not to be inferred that rain-fall with cultivation is sufficient to make farming remunerative over much of the "arid lands." Such farming, without irrigation, is, west of the Missouri River, fairly successful in Dakota, Montana, and Wyoming, but entirely precluded west of the mountains.

The question arises how the water required for stock on the prairies, plains and table-lands of the "American Desert" is to be procured. In two ways: By wells and by reservoirs. Wells must overflow (artesian wells), or else the water must be pumped. Artesian wells are common in some of the basins of California, Utah, etc., but hardly to be expected on high lands, where water is most needed; there we must depend upon wells from which the water is pumped. The trials made in sinking wells upon many districts of the "arid lands" have been encouraging; wells are bored and good water struck at variable depths in many unlikely places. Thus, where the Texas Pacific Railroad crosses the Staked Plains an abundance of good water was obtained at several stations within 40 or 50 feet of the surface. On the contrary, at Marfa, Tex., a station of the Southern Pacific Railroad, standing in the midst of immense level prairies, a "drive" well had to be sunk to the depth of 1,200 feet before good and abundant water could be obtained. This well now supplies not only the railroad locomotives, but also the whole town, which is a flourishing county seat. "Striking" water under these circumstances is mainly a question of depth, which in its turn is governed by that of expense. As wind of various degrees of velocity is always blowing over the Western plains, wind-mills will afford a certain, cheap, and efficient motor to work the pumps.

Reservoirs in the shape of tanks or lakes are for the purpose of collecting and retaining rain-water; their establishment is simply a question of expense, and is, I think, practicable almost everywhere. However level a plain or prairie seems to be, it is always scarred by gullies and ravines leading to stream beds, and it is in these ravines or in the valleys into which they open that the tanks or lakes should be constructed. In hilly or mountainous regions advantage should be taken of cañons or other natural reservoirs. There, and wherever practicable, the tanks should be in twos, that is, each collecting tank should have a corresponding tank at a lower level; the rain-water is collected in the first, and later, as it becomes clear, decanted by a system of sluices into the lower.

The many streams, large and small, which drain the arid country between the 100th meridian and the Sierra Nevada are characterized by great width of alluvial bottom and the crookedness of their ever-changing channels—necessary peculiarities of streams which overflow with each rainy season and always hold a large proportion of earthy matter in suspension.

As already stated, the rain, unable to penetrate the hard crust of uncultivated soil, is shed off, carrying with it whatever soil it succeeds in detaching and disintegrating; the result follows that all the streams of the "American Desert" are yellow or red with mineral matter held in suspension. The Rio Grande, immediately above its junction with its main tributary, the Rio Conchas, rolls liquid mud in summer, and is some- times designated with justice Rio Puerco. The many Rio Colorados or Red Rivers of that region testify by their name to the same fact.

Much of this suspended matter is deposited along the course of the streams, and gradually adds to the width and depth of the valley bottoms. These bottoms are formed at several levels; some are periodically covered by high water, others are only flooded in exceptional years, and still others have never been covered within the memory of old settlers. Their fertility is very great and well-nigh inexhaustible. The lower bottoms often yield abundantly without irrigation, the spring overflow, if not too violent, being taken advantage of to start the crops and fertilize the ground.

Irrigation gives agriculture the degree of certainty and exactness of a scientific industry. The farmer reaps as he sows, in accordance with his labor and his skill; he is no longer dependent on the amount and distribution of the rain-fall, and a prolonged drought will only give the more value to his assured crops. He, however, avails himself of whatever rain may fall, bearing in mind that rain-water contains fertilizing elements often wanting in river-water.

In a warm climate, such as that of most of our "arid lands," with an abundant supply of water on good soil, the processes of vegetable life are exceedingly active, so that growth is rapid, and several successive crops are possible during the same year. It is a fair general estimate that irrigated land produces twice as much as the same quality of land in a region where rain-fall is deemed sufficient.

The only navigable rivers which to a slight extent penetrate the "American Desert" are the Rio Colorado, the Upper Missouri, and the Yellowstone. Since the advent of railroads navigation has practically ceased on these streams, so that, as far as it is concerned, it would not matter to what extent their tributaries or their own waters were directed from their courses for the purpose of irrigation. As a matter of fact, however, most of the water thus used in irrigation finds its way back to the river-beds, so that streams show but little, if any, diminution of volume; it follows that not only is navigation not endangered, but the water supply of the populations settled below the irrigated area is not practically diminished.

Most of our Western rivers have periods of overflow, but, unlike that of the Nile, this overflow is too irregular as to duration and extent to turn it to practical advantage on any large scale. It is utilized on the Upper Rio Grande and on the Lower Colorado, and it may be that, by the proper construction of ditches and dikes, its utilization could be very much extended.

Irrigation is only applicable to valleys and connecting bottoms or flats. The water is generally derived from the main stream or its tributaries, dammed or not, as the case may require. It often happens that the tributaries have a greater slope than the main stream, so that their waters can be made to reach the desired point at much less cost. Water can also be derived, but necessarily on a small scale, from artesian wells and springs. It would also be possible, specially in mountain districts, to irrigate from tanks or artificial lakes built in cañons or ravines, wherein water from rain or small streams is collected. For purposes of irrigation mountain streams are particularly advantageous, as their waters can be utilized in the valleys on which they debouch with very little work. In this connection, attention should be called to the great value of timber on the mountains which feed such streams. Whether timber increases the rain-fall is uncertain, but there is no doubt as to its beneficial effect in retaining the precipitation and equalizing its outflow, so that throughout the year the streams run with an even, steady current, seldom becoming raging torrents and never entirely dry.

The adaptability of rivers to irrigation depends very much, other things being equal, upon their rate of fall; thus, the Missouri falls less than a foot per mile, the Yellowstone 1¾ feet, while the Rio Grande falls nearly 3 feet per mile. It follows that the difficulties to overcome in using the waters of the Rio Grande are much less than would be met in tapping the former streams. We find irrigation commonly practiced along the Rio Grande and on many of its tributaries, while it has hardly been begun on the Yellowstone, and is probably impossible on the Missouri.

From observations made at my last station (Fort A. Lincoln, Dak.), and my present one (Fort Buford, Dak.), I am able to offer a few remarks on the practicability of irrigation on the Upper Missouri and the Yellowstone.

The valley of the Upper Missouri is bounded by two lines of bluffs, and the river runs its tortuous course between them, washing the base of the bluffs alternately on one side and the other, so that large areas of irrigable alluvial bottom-land are seldom seen. The length of the "bottoms" inclosed in the turns of the river seldom exceed a mile or two; therefore, a canal of several miles in length would have to be raised over the high banks of the bluffs.

I have computed (taking Lewis and Clark's estimate of distance), that the fall of the Missouri River between the mouth of the Yellowstone down to Omaha is almost exactly three-quarters of a foot (.76) per mile. The minimum height of irrigable land above the river level (at low water when irrigation is most needful) is 12 feet, therefore a canal of at least 16 miles would be required if it followed the curves of the river, and only 10 or 11 miles if perfectly straight. In practice, we may say (making allowance for fall) that on the Missouri, any irrigating canal will be at least as many miles in length as the land to be irrigated is feet above the water level. As few irrigable bottoms have a greater area than 1 or 2 square miles, it would seem very unprofitable (even supposing there were no serious obstacles to overcome) to dig a canal of such great length for the accomplishment of such small result. We must also bear in mind the great rise and fall of the Missouri, causing a difference of level of at least 15 feet, and it will be safe to conclude that the irrigation of the Missouri Valley by means of canals tapping the river is out of question, even with the most liberal aid from the Government.

The only practicable way, in my opinion, in which the many alluvial bottoms of the Missouri could have the benefit of irrigation is by means of pumps and tanks, the pumps to be worked by steam or wind. One wind-mill and tank would easily supply all the water required for the irrigation of several hundred acres of land.

The current of the Yellowstone is much more rapid than that of the Missouri. Between Glendive and the mouth of the river, at Fort Buford, the fall is 1¾ feet per mile, more than double that of the Missouri. Above Glendive, the fall is still greater and much land could doubtless be profitably brought under irrigation either from the main stream or some of its tributaries. Work is now in progress to bring the waters of Tongue River to the flats of Miles City.

The Lower Yellowstone Valley is bounded by bluffs on the east side, but is broadly open on the west side, where it extends up-stream for many miles uninterruptedly, and here is an exceptional opportunity for the application of irrigation on a large scale. It is estimated that the available lands for the purpose range from 1 to 4 miles in width for a distance of 30 or 40 miles above the mouth of the river. These lands are from 8 to 30 feet above the average stage of water, and not subject to overflow; the lower (those nearest the river) are covered with scattered clumps of cottonwood and willow, and almost always by the characteristic gray sage-brush of this region (Artemisia cana), which is indicative of a rich soil; the higher are prairies already occupied by many settlers, and in propitious years yielding fair crops under cultivation.

The Yellowstone is not subject to the same extreme rises and falls as the Missouri, and therefore its average level is more constant. I estimate that the length of canal required to bring water upon the above lands, so as to make it available from a point

35 miles above the mouth of the river, would be from 12 to 15 miles. Thence down to the mouth the canal would follow the natural slope of the valley along the upper edge of the lands supplied. There are but few obstacles to overcome, yet such a large enterprise, it is needless to say, can only be undertaken by a company with large means and with liberal Government aid.

To conclude, we may ask in what particular lines should Government help and intervention be specially directed so as to be most effectual. These, in my judgment, are as follows:

1st. In thoroughly and immediately protecting the forests now remaining upon all national lands, with a view to the continued usefulness of the streams fed by those lands.

2d. In investigating the number of mountain streams which can be canalized or dammed; to what extent and in what manner, so as to make them available in arid valleys and basins.

3d. In determining the depth at which water in all the districts of the American Desert can be obtained.

STATEMENT OF ARTHUR WILLIAMS, FIRST LEIUTENANT THIRD INFANTRY, U. S. ARMY, FORT MEADE, DAK.

In a full sense, the term arid lands embraces not only true deserts and tracts which depend absolutely on irrigation for the production of crops, but also lands on which, in the absence of irrigation, the crops would be in danger of being lost or impaired. The definition of arid lands given in our statutes (Sec. 2, act March 3, 1877), therefore, does not include all arid lands. For instance, the grain crops in Bare Butte Valley, Dakota (near Fort Meade), in absence of irrigation, are liable to failure from drouth one year out of five, while with irrigation crops of the cereals, superior in quantity and quality to the best that can be produced with the natural supply of water, are, barring hail, almost certain. I am credibly informed that in some cases settlers who have attempted to locate in this vicinity, and who had no facility for irrigation, have become discouraged by failure of crops, and have abandoned their claims.

The accompanying table compiled from the records of the Post hospital at Fort Meade, to which, through the kindness of Dr. W. C. Shannon, Post surgeon, I have had access, exhibits the rain-fall in this section during the past five years:

	1884-'85.	1885-'86.	1886-'87.	1887-'88.	1888-'89.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*
May	8.58	.64	.57	2.72	4.14
June	.48	3.39	.45	1.76	5.50
July	1.20	1.52	3.68	4.46	2.64
August	2.30	3.22	1.50	4.25	3.70
September	.23	.28	.40	1.10	.00
October	.98	.74	.40	.40	.25
November	.53	.42	1.60	.24	.16
December	.89	.17	.72	.36	.17
January	.32	.32	.56	.00	.29
February	.23	.67	.20	1.29	.85
March	.52	.88	.76	.75	.12
April	1.22	2.17	2.12	.10	2.64
Total	17.48	14.42	12.96	17.43	20.46

Average annual rain-fall 16.55 inches.

The deficiency of precipitation in the months of June and July, 1884, will be noted, also that in the month of May of that year over one-half of the average rain-fall of the section occurred.

It is, I believe, well established that most soils when supplied with a sufficiency of moisture, provided the thermal conditions are not unfavorable, may be made to produce agricultural crops. Even the volcanic ashes of Ætna are planted with vines to a height of 3,000 feet, and the sands and gravel of portions of the Sahara have become fruitful on being watered from artesian wells. (The Earth Modified by Human Action; G. P. Marsh, pages 150 and 481.)

Assuming that most of the arid lands of the United States can be reclaimed and rendered valuable for agricultural purposes, provided they can be watered, it remains to be considered how the necessary water is to be obtained.

By statute, the "waters of all lakes, rivers, and other sources of water supply upon the public lands, and not navigable, shall remain and be held free for the appropriation of the public for irrigation, mining, and manufacturing purposes, subject to existing rights." (Sec. 1, act March 3, 1877.) These, together with the waters that can be withdrawn from beneath the surface or from the atmosphere, constitute the fund available.

The bad lands and other such broken and forbidding surfaces, it would seem, can never be put to any agricultural use, except perhaps grazing, yet by the use of wells, storing of rain and snow-waters in gorges, etc., sufficient water might be obtained in places to render the cultivation of garden vegetables and small fruits practicable and to promote the growth of grasses. Experiments could easily be made by the Government, and might be repaid with unexpected and good results.

Such deserts as are not only deficient in rain-fall, but also have no streams running into or through them, present great difficulty. If they occupy a sufficiently low level, as in the case of the Colorado desert, water may be introduced from the ocean bed or lakes, or the whole or a portion of a river may be diverted into it, or the conditions may be favorable for obtaining water from artesian or ordinary wells. By the introduction of ocean waters the result would be attained indirectly, the idea being to provide the agricultural water by means of evaporation and subsequent precipitation from the atmosphere. Such a project is necessarily in the nature of an experiment; much more so, I think, than is the sinking of artesian wells. From the character and magnitude of all of the enterpries named I believe engineering experts should determine the best course to be pursued.

When the areas to be watered occupy a high level, water, if obtained at all, must be raised from streams or lakes by mechanical appliances or be drawn from artesian wells. Here, too, engineering skill and judgment will be required.

Where, as in portions of California and Nevada, streams of considerable size sink in sand or gravel, it may be advisable to construct artificial channels to keep the water on and conduct it over the surface; or perhaps ordinary or artesian wells can be employed to advantage. Here, again, engineering investigation should determine the best method of accomplishing the desired object.

The simplest form of irrigation is that of conducting water from streams by means of ditches, a dam of some kind being usually constructed to increase the "head" of water. This is the method generally resorted to in reclaiming lands under the act of 1877.

The manner of applying water to crops is a subject which, I understand, it is not intended I should touch upon. The Department of Agriculture, through its skilled agents, is well fitted to suggest the best methods, depending on the character of the surface, nature of the soil and of crops, the peculiar meteorological conditions, etc.; and farmers will be led by self-interest to avail themselves of such valuable assistance.

In many instances, I think, the manner in which water is appropriated is open to objection. When one or more settlers find a small stream emerging from the hills, and so conduct it that the entire body of water can at any time be made useful, it would seem that nothing better could be done. Still, if the demand is not for a continuous and full supply of water, but only a supply at a particular season, or a variable supply, unless reservoirs are employed to be drawn from according to actual needs there will be waste, inasmuch as by judicious storing a larger area could be benefited.

Whenever the whole or a portion of any stream is diverted, there is a liability to waste, although the fact may not be suspected by the persons appropriating the water. Moreover, the distance from which water must ordinarily be conveyed, in order to bring it to the level of the land to be irrigated, renders ditching costly. Individual settlers, if poor, frequently find it impossible to secure a supply of water, and when settlers along a valley unite in making a water-ditch for the common benefit bickerings and disputes are liable to arise and even where accord exists, it can hardly be expected that any effort will be made to benefit any but the best and first selected lands. The fact also must be kept in view that selfish interests operate to induce avaricious settlers to make it difficult for their poorer neighbors to improve their lands, so that they may be willing to part with them at a low price. I believe it would be good policy for the Government to construct the main irrigating ditches in all valleys of considerable size; for example, in the valley of the Big Horn in Montana. It would be a matter of engineering to determine the points from which water should be taken, and to locate ditches where they would do the most good.

There is another matter which I think of importance:

In all portions of the United States there is some rain-fall. The annual precipitation varies according to reports from a very few inches in the Colorado region to the extreme of several feet in other portions of the country. We have therefore to deal with all conditions, from that of almost absolute aridity to that of almost excessive humidity. Moreover places with the same average annual precipitation may vary greatly as to the general laws controlling its distribution throughout the year.

Further, the peculiarities of surface—flat, sloping, basin-like, etc., nature of the soil and subsoil—whether absorbent or otherwise, chemical characteristics, the depth of impervious strata, the action of dry or moist winds, and meteorological conditions generally, as well as differences of altitude and latitude, produce effects which greatly modify the results obtained from the same amount of precipitated moisture, although similarly distributed.

It may therefore be necessary in some sections to provide for irrigation throughout the whole year; in others during certain seasons only. In some places a small but regular supply of irrigating water is demanded; in other places a large supply for a very brief period may suffice. I believe it may be safely stated as a general rule that in sections where irrigation is advisable, economy of water-supply is absolutely necessary.

Even where large rivers are available as a source of water supply, if a larger quantity is diverted into canals or ditches than is necessary to supply the area to be watered, the volume in the river channel proper is unduly diminished. The trees, if there be any along the margins, will languish or die. The local evaporation will be much greater, owing to increased surface and diminished velocity of the waters, and although it is true that the diverted waters will, for the most part, be restored to the valley by drainage and the precipitation of the evaporated moisture, there is in such cases almost a certainty that some districts will be benefited at the expense of others. This objection is made more significant when the waters of the stream are needed for other than agricultural purposes.

In the case of small streams, where the supply is either irregular or intermittent, or where the demand is transitory, it is, I think, apparent that a treasuring up of the water in suitably situated reservoirs, from which it can be distributed according to requirements, would be useful.

By means of such reservoirs very considerable areas might be benefited; whereas if the waters are not stored they may be insufficient for any useful purpose. It might also be well to consider whether the waters accumulating from rains and melted snows in gorges among hills and mountains might, if held in reservoirs, be made useful for irrigation.

I am of opinion that reservoirs in connection not only with flowing (artesian) wells, but also in connection with water pumped by means of wind-engines from ordinary wells and low surface waters, will ere long become an important factor in irrigation.

Wells as a means of irrigation deserve, I think, more attention than they have yet received in this country. Artesian borings undertaken by the Government have been few in number, and although they are becoming numerous in connection with other industries they have as yet received scarcely any notice in agriculture. That they would prove useful in irrigation is scarcely doubtful, judging from the success that has attended their use by the French Government in Algeria. The cost of sinking such wells, combined with the doubts that exist as to their proving successful, has thus far deterred individual enterprise. In some localities which are deficient in rainfall at certain critical seasons, ordinary well-water can be reached at moderate depths. Where it can be so obtained in sufficient abundance it might be pumped by means of wind-engines, which have been brought to a high degree of perfection and which can be obtained at a moderate cost, and stored in reservoirs for use when needed. This method is open to individual enterprise.

Besides, by furnishing water directly to it, the wants of the soil might be supplied in a measure, and a very material one, by decreasing evaporation and inducing atmospheric precipitation. Two ways by which evaporation may be diminished deserve special attention; the first the use of wind-breaks, the second extraordinarily deep ploughing.

The arid and semi-arid regions are as a rule treeless and exposed to the sweep of dry winds, and from the effect of radiation of heat, combined with other causes, these winds are of constant occurrence. They gather up the moisture from the soil and growing plants very rapidly. The planting of trees and of hedges is undoubtedly the best means of providing wind-breaks. Wherever irrigation ditches are employed trees and hedges should be planted near them.

Deep plowing is an agency for preserving moisture in the soil which, I think, is not sufficiently understood, and consequently is not fully appreciated. Where it is resorted to the rains and snows that fall sink beneath the surface and are held there, as if in a reservoir, to be drawn upon when most needed. Farmers who have tried deep plowing in this section are advocates of it as a safeguard against the effects of drought.

With regard to inducing precipitation, I believe that although trees may not actually increase the amount of rain-fall, they assist in its equable distribution. By means of their foliage they discharge into the atmosphere moisture drawn from lower depths than are reached by agricultural crops. They thus supply what might otherwise be claimed and taken from the tilled areas.

The whole subject of irrigation is one of such national importance that I believe it, together with the kindred and equally important one of forestry, should be under Government control and supervision. As many as possible of the citizens of the United States should own a portion of land in fee. Attachment to the soil is one of the best guaranties of patriotism. If wealthy individuals or corporations be the only ones who can successfully provide means of irrigation, large portions of the public lands that should furnish homes for hundreds—perhaps thousands—will sooner or later be monopolized. Should unskillful or wasteful methods of irrigation be adopted the agricultural area and population will be less than they should be, and the national wealth will be curtailed.

The streams and lakes, together with the subterranean and aerial waters, which belong to the public, are proper subjects for national control, and in my opinion should not, by any legislation or lack of legislation, be permitted to fall into the hands of monopolies. The farmer should not be compelled to purchase his water supply from either individuals or corporations, as is the habit among miners. It seems to me that the Government could easily take the whole matter of irrigation into its own hands, have engineering skill determine the best methods for the different localities, construct the canals, ditches, and reservoirs, sink artesian wells, plant and maintain trees for public use, etc. The appropriation of public money for the improvement of the public lands, it seems to me, would be as wise an expenditure as that for the improvement of rivers and harbors. Besides, the cost of such improvements could be refunded to the public treasury by charging an increased price for the land; or, indeed, a small charge might be made to farmers for use of water, in order to defray the expense of construction and maintenance of the means of supply, which would be cheerfully paid.

STATEMENT OF GEORGE W. H. STOUCH, CAPTAIN THIRD INFANTRY, U. S. ARMY, FORT SNELLING, MINN.

My knowledge of the matter is only general, such as one would obtain in casual observation during service in the West. While so serving, particularly in southwestern Kansas during the years from 1866 to 1871, I found that as soon as work on new railroad lines commenced and settlements which followed sprang up, great climatic changes took place; rains followed the plowing of the ground and planting of trees. Later on, in traveling over country which, during my service there, was almost arid and sterile, I found vegetation well developed, and settlers raising corn and grain in abundance without artificial irrigation.

During my service in Montana, from 1877 to 1888, I found similar climatic changes followed the construction of railroads; and the turning up of the ground by the farmer's plow. Irrigation here, however, was generally resorted to, and large valleys apparently sterile were made to produce the best of crops by the use of the water from the numerous mountain streams in that country. In this manner a large part of the water in the creeks and rivers was taken from its natural course, spread over the cultivated tracts and evaporated. This appeared to increase the rain-fall and it was apparent that the shower region, which when I first went to Montana extended only along the heavily wooded mountain ridges, gradually descended lower until it was common to have abundant showers in the valleys along the water courses. During two seasons in the fertile Bitter Root Valley in Montana, good crops were raised consequently, with but little artificial irrigation; and lands along the foot-hills, a few years before considered worthless, are broken now and sown in wheat. I believe that all of our arid lands can be reclaimed by settlement.

The committee adjourned to meet at call of chairman.

SOUTH DAKOTA DIVISION.

SIOUX FALLS, S. DAK., *August* 2, 1889.

The committee met pursuant to call of the chairman.

Present, Messrs. Stewart (chairman) and Reagan, also Director Powell.

The **CHAIRMAN**. The committee is here for the purpose of obtaining information. We wish to know how the farmers are situated in this country with regard to a supply of moisture for agricultural purposes, what the deficiency is in that respect, what means they have of supplying that deficiency, whether by artesian wells, the storing of water, taking out of rivers, etc. We would like to have gentlemen now here from all sections of the State make statements covering the situation in their localities.

STATEMENT OF C. R. WESCOTT, OF DEUEL COUNTY.

Mr. Chairman and gentlemen: In the northeast corner of the proposed new State of South Dakota we have many lakes scattered here and there. Our rain-fall is from 22 to 25 inches during the year. On account of these lakes, as we believe, there is a little more evaporation and rainfall. In the southern part of Grant County, the adjoining county on the north, they have artesian wells at 42 feet deep. There the water has flowed above the ground 1½ feet. I think that can be indefinitely increased. These wells are thought to be fed by waters that gather in the Coteaux range, 4 or 5 miles south. As you go further from these coteaux or hills the depth at which you find water is greater, 125 feet, and rising above the ground to about the same height.

The **CHAIRMAN**. How is it with regard to the lakes? On what stream are they; into what do they discharge?

Mr. **WESCOTT**. Into the Sioux River. A great portion of the year they are entirely hemmed in by land. This season there has been no outflow at all.

The **CHAIRMAN**. Do they dry up in the summer?

Mr. **WESCOTT**. No.

The **CHAIRMAN**. Is there any water in them now?

Mr. **WESCOTT**. Yes.

The **CHAIRMAN**. The practical way would be to lower the lake and build a dam, and thus increase the amount of water.

Mr. **WESCOTT**. That could be done to some extent, but the banks are so low it can not be increased a great deal.

The **CHAIRMAN**. What do you mean by that?

Mr. **WESCOTT**. I mean that the ditch which drains the water at this point is so wide that a dam could not be built.

The **CHAIRMAN**. You could build an embankment upon it to some extent, could you not?

Mr. **WESCOTT**. Yes.

The **CHAIRMAN**. A dam a few feet high, if you have surface, makes a good deal of water.

Mr. **Wescott**. Yes; that is true.

The **Chairman**. Are there a good many lakes emptying into the Sioux River?

Mr. **Wescott**. In my vicinity there are six; in Grant County, just beyond, they have quite large lakes.

The **Chairman**. And they all empty into the Sioux River?

Mr. **Wescott**. Lake Kampeska empties into the Sioux.

The **Chairman**. What amount of area is covered by these lakes that form the source of the Sioux?

Mr. **Wescott**. I do not know.

The **Chairman**. Do you know the amount of water-shed that supplies the lakes?

Mr. **Wescott**. No.

The **Chairman**. There has not been any attention given to that subject?

Mr. **Wescott**. They may have been, but not within my knowledge.

The **Chairman**. You do not need much irrigation where you live?

Mr. **Wescott**. We have not suffered as they have in some other parts of Dakota.

Senator **Reagan**. What is the distance from the bed of those lakes to the river?

Mr. **Wescott**. One hundred miles.

Senator **Reagan**. How far would you have to descend the river before you would come to a channel where a large body of water might be collected?

Mr. **Wescott**. Not more than 15 or 18 miles before you would strike a large body of water.

Senator **Reagan**. Have you any idea of the relative elevation of that country and this?

Mr. **Wescott**. In my vicinity it is 175 feet higher. It is 1,900 feet above Lake Michigan in my part of the county; but what it is right east I can not say.

STATEMENT OF WILLIAM COOK, OF MARSHALL COUNTY.

Mr. Chairman and gentlemen: I am from the northeastern part of the Territory. There are no lakes in our county, but we have some artesian wells there. There are lakes east of us, on the Indian reservation, and Marshall County is partly in it.

The **Chairman**. Have you suffered any from drought?

Mr. **Cook**. We have not very much until this year. We have usually rain enough during the season, if it could be regulated—if we could get it at the right time of the year. But the showers are local. Some parts of the county suffer from drought while other parts have rain. In the eastern part of the county it is hilly, and the lakes are in near proximity. There they do not appear to suffer from drought as they do in the valley.

The **Chairman**. Have you done any irrigating in that part of the county?

Mr. **Cook**. No, none at all.

The **Chairman**. Then you do not know what effect it would have to turn the water onto the land in that section?

Mr. **Cook**. No, I do not.

The **Chairman**. You have not seen any experiments tried in that direction?

Mr. **Cook**. No.

Senator **Reagan**. Have you any artesian wells in your part of the State?

Mr. **Cook**. Yes; two in our county, and in Brown County several.

Senator **Reagan**. Of what depth?

Mr. **Cook**. From 700 to 1,200 feet, I believe.

The **Chairman**. Do they discharge a good deal of water?

Mr. **Cook**. Yes; from 25 to 200 pounds pressure.

Senator **Reagan**. Are you informed as to the cost of constructing an artesian well?

Mr. **Cook**. No, I am not prepared to speak on that point—to know just what the cost of a well would be. The cost of one of the wells there and the laying of the mains, a well a thousand feet deep, was $4,000.

STATEMENT OF C. A. HOULTON, OF DOUGLAS COUNTY.

The **Chairman**. In what part of the State is Douglas County?

Mr. **Houlton**. In the southeastern part.

The **Chairman**. Have you suffered any from drought there?

Mr. **Houlton**. Yes; we think we have.

The **Chairman**. What streams are in your county?

Mr. **Houlton**. There is a small stream that runs through our county called Choteau Creek.

The **Chairman**. How is Choteau Creek supplied?

Mr. **Houlton**. This year we have not had running water any time during the season until the last rain, no water running in that creek until last fall. It usually rains in the spring until the latter part of June.

The **Chairman**. Is there any river in your county from which you could take water over your land?

Mr. **Houlton**. I do not think there is any short of the Missouri.

The **Chairman**. The Missouri would have to be taken out some ways above to take your county in. But you all suppose that to be an impossible enterprise.

Mr. **Houlton**. Yes; for the people in Douglas County it would be.

The **Chairman**. I am speaking of it as an engineering enterprise. I do not suppose you people would be able to do it now. Have you tried artesian wells in your county?

Mr. **Houlton**. There are none there.

The **Chairman**. How much have you suffered this year; to what extent have the crops suffered; what proportion raised a good crop?

Mr. **Houlton**. Take the grass, and it does not amount to anything this year; take the small grain, and it will probably be from a third to a half crop throughout the county.

The **Chairman**. I understand from the papers you passed a memorial asking for assistance in sinking artesian wells; you had some discussion on the passage of that memorial, did you not?

Mr. H. W. **Eddy**. Yes.

The **Chairman**. Was there a discussion of the reasons for presenting the memorial?

Mr. **Eddy**. It was not necessary for that, for we all knew them without discussion; each one understands just what the other thinks about that matter. This memorial was gotten up among ourselves, and it was not necessary to discuss the reasons for it.

Mr. **Houlton** (continuing). If there were a line of artesian wells across the county we feel it would give us more rain-fall. There are two creek beds running across the county from north to south; the east creek is east of the center and the other west of the center, and they run parallel.

The **Chairman**. They do not rise in any flats or lakes?

Mr. **Houlton**. No; nothing but rolling hills.

The **Chairman**. Have you a dam there?

Mr. **Houlton**. There is a reservoir to hold water in the creek.

The **Chairman**. In a short creek you can not store much water; you want flat land, and then your dam produces some effect. But my experience is that in the tops of the mountains there are lakes where the water can be kept back; but yours are short creeks.

Mr. **Houlton**. They are 20 miles long.

The **Chairman**. Your idea is that there should be artesian wells at the head to supply them with more water.

Mr. **Houlton**. That is my idea.

The **Chairman**. You have not taken out any water to test what you could do by irrigation?

Mr. **Houlton**. There is none to take out; when we need irrigation there is no water in the creek.

STATEMENT OF S. S. PECK, OF HAMLIN COUNTY.

Mr. Chairman and gentlemen: Our county is just where the headwaters of the Sioux River are. The county of Coddington contains the large Lake Kampeska. Of that I can not say much. I have been there, and I think it is practical to make a very extensive reservoir at Lake Kampeska, and a large supply of water can be held there. But in the spring, when we have rain, down comes the water, and in a couple of weeks it is all gone, and the balance of the season we are without water. Even the Sioux River dries. But sometimes it will be 10 or 15 feet deep. The fact is there is nothing to stop it. We have too little when we want it, and too much when we do not need it.

One-twelfth of Hamlin County is water. We have not suffered from drought until this year. We feel that the reason is that we have not the effect of those large bodies of water. But there is a difficulty to contend with. There is a large amount of water in the spring, and it keeps evaporating and leaves a large portion of the surface in such a condition that it becomes unhealthy. If those lakes were dammed, it would answer the purpose of keeping a quantity of water there. These lakes lead into the Sioux River in the end; but a number of the creeks would furnish us water for our stock.

We have three streams, not as large as the river, running through that county, which are susceptible of having large reservoirs made upon them. The water being so regulated, we could have water furnished the whole summer through. It could be all retained in these reservoirs and let off as wanted.

The **Chairman**. What is the area occupied by the different lakes that supply the Sioux River?

Mr. **Peck**. One-twelfth of our county. It is composed of eighteen townships, and over one-twelfth of our county could have water. This year we have not suffered from drought to the extent that I find in most every other place; and yet, if reservoirs were built we could have the use of that water. We have not suffered to any great extent for water there.

The **CHAIRMAN.** Is that true all the way down the river? Would it not be an advantage to take it out and spread it upon the land below?

Mr. **PECK.** Most undoubtedly, and upon our land. If the water could be retained in Kampeska—that which runs away past us in the Sioux River—it would irrigate our land down, 10 miles on each side of the Sioux River, for 20 or 30 miles. I have not seen the river, and I do not know anything about it.

The **CHAIRMAN.** Is it not possible that you would have reservoir surface enough if these lakes were so dammed that you could handle the water in them? If you could store it in reservoirs, would you not have water enough from the Sioux River on both sides?

Mr. **PECK.** Yes. I have had some little trouble with those reservoirs in the country I came from. We had reservoirs at one time, but the streams were all blocked and the water got off so slowly that it kept our rivers up all through the season. There was no want of water then. After we cleaned up the creeks all the water ran off in a few weeks, and we had to build dams. But now we have it in perfect control. Now the river is in good condition. I know how that was; I have seen it. But locally we can not furnish the money.

Senator **REAGAN.** There has been no effort by private or corporate enterprises to do anything for themselves?

Mr. **PECK.** No. There is not sufficient capital there. It could not be managed by private capital. Some who were to be benefited by it would stand off, and that would prevent all of us—they would just stand still, and that would balk the whole thing. That is the way we feel. If we could have those lakes dammed we could have plenty of water to irrigate our land. There was a remark made by one of the gentlemen to the effect that if he could wet his land and thoroughly soak it in the fall he could raise a crop. I fully appreciate that.

The **CHAIRMAN.** Some of the gentlemen who gave us information at St. Paul said that in some of the localities where they resided they had rich alluvial surface, and 2 or feet underneath a bed of clay that preserved the water. Does that pertain to this country here?

Mr. **PECK.** I will tell you what I have seen in connection with my own farm. I have a large bed of clay, and I retain every drop of water that I get—the clay holds the water. You can dig down here in most places that I have seen, get into the clay and fill it with water, and it will evaporate—not run away.

The **CHAIRMAN.** That is a most favorable circumstance. By means of it a ditch along the side of the hill will irrigate a farm without spreading the water over it. Your irrigation is going to be a very easy matter. If you have a ditch running above your land where you have a clay foundation you can irrigate the land very cheaply, if you have rolling land.

Mr. **PECK.** That is the kind of land we have.

STATEMENT OF DAVID HALL, OF ONEIDA, SULLY COUNTY.

The **CHAIRMAN.** What has been the condition of things in your county?

Mr. **HALL.** Well, as a general thing, it has been very dry there. In our county we have never succeeded in raising a good crop of grain, on account of the drouth in June.

The **CHAIRMAN.** Have you tried irrigation?

Mr. **HALL.** No.

The **CHAIRMAN**. What means have you for irrigation?

Mr. **HALL**. None, only from the Missouri River, and, of course, that would be very expensive and could only be done by large capital.

The **CHAIRMAN**. The Missouri is down deep.

Mr. **HALL**. There are bluffs.

The **CHAIRMAN**. Above the water what is the average height of those bluffs?

Mr. **HALL**. I should judge about 100 feet.

The **CHAIRMAN**. I mean to get back to where you would have the range of level land.

Mr. **HALL**. From the river to level land back it is about a mile and a half or two miles.

The **CHAIRMAN**. That would be an elevation of how much?

Mr. **HALL**. Not more than 50 feet above the Missouri. I do not know; I am making a guess at it.

The **CHAIRMAN**. The bluffs are higher than the land back of them?

Mr. **HALL**. Yes.

The **CHAIRMAN**. Is there a large area of land back there?

Mr. **HALL**. Yes.

The **CHAIRMAN**. Extending how many miles across?

Mr. **HALL**. Almost across to the James River. Between the James River and Missouri River there is an elevation; but it is not hilly as a general thing; it is mostly level land.

The **CHAIRMAN**. If the river could be taken out and run in a canal on that ridge between the two, it would serve to irrigate both sides, would it not?

Mr. **HALL**. Yes, I think it would.

The **CHAIRMAN**. You say you do not raise crops there when it is dry?

Mr. **HALL**. Not sure crops. But I have not had an entire failure. Our average in that county, of wheat, has not been more than 9 or 10 bushels, I should judge, to the acre.

The **CHAIRMAN**. Are you able to raise vegetables—all-round crops?

Mr. **HALL**. Yes; and corn. I have good success with corn, because we always have a wet harvest. This is my seventh year there.

The **CHAIRMAN**. It rains in July and August?

Mr. **HALL**. In July and August we always have it wet. In June and fore part of July we need the rain most for the grain, and we do not have it.

The **CHAIRMAN**. You have no streams except the Missouri that could be utilized?

Mr. **HALL**. No.

The **CHAIRMAN**. There are none between here and Bismarck going into the Missouri that could be utilized?

Mr. **HALL**. I could not say. I was never through there.

Senator **REAGAN**. Is the Missouri navigable where you speak of?

Mr. **HALL**. Yes.

The **CHAIRMAN**. It is a thousand miles above here?

Mr. **HALL**. About 1,250 miles.

STATEMENT OF I. R. SPOONER, OF KINGSBURY COUNTY.

Mr. Chairman and Gentlemen: My county is in the eastern part of Dakota. Lake Preston is the post-office. It is 75 miles northwest of this point on the headwaters of the Vermillion River. A portion of the eastern part of our county is covered by the lakes which are practically the headwaters of the Vermillion. The outlets are now drying.

The CHAIRMAN. Is there any water in the lakes now?

Mr. SPOONER. Yes. There is water in Lake Thompson, which is 65 miles long and about a mile and a half in width. Lake Henry is 2½ miles in diameter. Preston Lake is 2 miles long. Lake Whitewood is 10 miles long and 2½ miles in width.

The CHAIRMAN. What would be the cost of getting water out from there?

Mr. SPOONER. At present it would require considerable cutting, but the facilities for storing water are good. In 1881 the outlet of Lake Henry flowing into Lake Thompson and from there down into the channel, which leads into the Vermilion, was full of water, and also in 1882 for nearly half a season.

The CHAIRMAN. There was water enough fell to raise it a good deal higher had there been a dam to save it?

Mr. SPOONER. For instance, Lake Henry, 2½ miles in diameter, would have covered a third more area and would have risen 5 or 6 feet. Lake Thompson would have covered probably an area one-fourth more and would have risen 2 or 3 feet. That is a rough estimate.

The CHAIRMAN. Do you usually have a series of dry seasons? If you had only one dry season you might store the water and save it for a season or two and keep filling the lakes, and then, when the dry season comes, be prepared for it.

Mr. SPOONER. One season our lakes were dry with the exception of Lake Henry and Lake Thompson. The others were full. That was in 1880 and 1881, from the deep snow. The snow blew in and filled them. They were not filled by rain-fall; but the rain-fall replaced the evaporation and kept them up until the dry season, which occurred four years ago in our part. Our county is on this side. The east part is covered by these lakes. This season the eastern part of our county has 40 per cent. of wheat crop, probably 50 per cent.; 80 per cent. of corn crop; and 30 of oat crop. The western part has no crop at all, none probably worth mentioning. The slough, which we call the Vermilion, and one lake in the northern part of the county—Spirit Lake—are in the dividing part of the county, twenty-four townships north and twenty-six townships east—it is impossible to make an exact division.

The CHAIRMAN. Have you this same substrata of clay?

Mr. SPOONER. Yes, the characteristics of the soil are the same. Wherever you dig down you come to clay.

STATEMENT OF H. W. EDDY, OF CANOVA, MINER COUNTY.

Mr. Chairman and gentlemen: I am going to speak of the dryest place on earth—Miner County, Sanborn County, Hand County, and McCook County, which are very much alike.

The CHAIRMAN. In what part of the Territory is your county?

Mr. EDDY. Fifty miles north of here. You will go through it when you go north.

The CHAIRMAN. As we go to Huron and Jamestown?

Mr. EDDY. It reaches clear through to Huron, and it is all very much the same kind of country. We have no lakes at all; but there are lake-beds. They appear to be everlasting lakes in the wet part of the year; but they dry up.

The CHAIRMAN. Have you any stream?

Mr. EDDY. There is one on the western border and one west of that. The water runs continually in them. But last year there was no water in them three months in the year.

The CHAIRMAN. If you had reservoirs at the head could not a ditch be brought around to supply you with water?

Mr. EDDY. If there were water we could get the ditch.

The CHAIRMAN. The topography of that country is all alike?

Mr. EDDY. Yes; if you go on a level you will not see a hollow until you get onto it. It is a level county, not flat but level, and you can see the little towns 10 or 15 miles distant. We have been dry four years; but this is the driest season of them all. We have in Miner 15 per cent. of wheat perfected this year. No wheat is better, and our corn crop is only about 50 per cent.

The CHAIRMAN. Have you thought of any method of getting moisture?

Mr. EDDY. No.

The CHAIRMAN. Have you tried artesian wells?

Mr. EDDY. We have artesian wells in the western part of Miner County. You put a 2-inch auger down 25 or 30 feet and the water gushes up through a gas pipe. The farmer has plenty of water for his stock, etc., but not sufficient for irrigating purposes. It would take many of those small wells for that purpose. What large wells would do we have never tried. There are in Miner County, the western part, some three hundred of those wells, and Sandborn is still better off with them.

The CHAIRMAN. You say there have been no experiments tried with large wells in that section?

Mr. EDDY. No; there is one at Huron, but I think there are none south of that until you get to Plankington. Mitchell, farther south, has one.

The CHAIRMAN. Are you on the James River?

Mr. EDDY. No; we are 3 miles east of it.

The CHAIRMAN. Are you familiar with that river?

Mr. EDDY. I have seen it frequently, the lower part of it.

The CHAIRMAN. You have followed it up?

Mr. EDDY. No; I have not noticed it since I lived in the country, since 1882. The first three years we had an abundance of rain, and after that the showers would rise in the northwest. They would make a little spot no larger than a man's hat, and then they would slip by, and go by the lakes and by the James River and leave us out in the cold. Whether there is anything in the power of the lakes and the river to draw these clouds I do not know; but they go there and leave us. You have asked a number of times whether we have tried irrigation. I never saw soil that would jump so when it had a little moisture. I raise plenty of potatoes and garden stuff, and when we have moisture we have an Eden.

STATEMENT OF HENRY NEILL, OF MILLBANK, GRANT COUNTY.

Mr. Chairman and gentlemen: Our county is 125 to 150 miles north of here. We are located on the coteaux, or hills, and have a slight incline toward the Big Stone Lake. Those ridges are nearly a thousand feet high. They have innumerable streams that verge toward, and quite a number of streams that run into, the James and Missouri Rivers. In the northern part of our county we have gone down 300 feet and struck granite—failed to get artesian wells. But in the center of that county we have artesian wells. There a farmer will bore 8 or 10 feet with an augur and get a well, and the water from it will rise above the surface. But those wells are not strong; they are not used for irrigation purposes.

But I think the problem of irrigation would be very greatly aided by a series of artificial dams on the streams in our county. We are usually troubled with a very dry season in May and June, which is the time for crops. The balance of the year we could get along very well. All those streams are supplied by the snow that melts in spring, and if the water could be retained in them irrigation would be materially aided. The problem with us is to retain the overflow. We have propositions before the Government with regard to damming Big Stone Lake, and there have been some reports made on the subject. But the Government will not take the question of irrigation into account; it is simply concerned about navigation. But I trust this committee will take into consideration the question of damming our lakes and rivers.

STATEMENT OF H. A. HUMPHREY, OF FAULKTON, FAULK COUNTY.

Mr. Chairman and gentlemen: Faulk County is on the north line of the two States of Dakota,and the whole county lies within the area or scope of the James River Valley—the west valley, near the divide between the James and the Missouri Rivers. The lakes that we have are drained in twenty-four hours. But there are some streams that could be utilized; they, however, are comparatively few within the area where we could derive any benefit from them.

I was born in northern Illinois, and have lived in Iowa; they are the richest agricultural districts in the United States. But I never saw a soil that will produce equal to the Dakota soil if it has water. When we have water we have the crops, but in late years we have not had the water; there is no water above ground, and the only way for us to do is to get it from below. When I came here there were lakes and streams all over the country, and there were dews every summer, and every blade of grass was loaded with moisture; up to 10 o'clock or 11 o'clock in the day it was like wading in water; but that is not the case now.

The CHAIRMAN. You have in your section the same clay substrata that there is in other parts of the Territory.

Mr. HUMPHREY. Yes; we call it clay, but I doubt very much whether it is clay after all. It is clay until you get down to the blue clay. The subsoil is somewhat of the nature of a soil that is filled with what people call marl; but that does not get any moisture all the way down.

The CHAIRMAN. It holds moisture?

Mr. HUMPHREY. Yes; but the moisture disappears; we have none on the top of the ground. If we had reservoirs we would have rain and dews from evaporation.

STATEMENT OF WILLIAM STODDARD, OF BROWN COUNTY.

Mr. Chairman and gentlemen: The famous James River runs through the center of our county, but we can not get water enough from that to do us any good. I have thought that four or five artesian wells at any place in the James River Valley would supply as much water in the summer time as the James River. My remarks would be similar to those of Mr. Humphrey in regard to artesian wells. That is the system we shall have to enter upon if upon any system of irrigation; because we can get artesian wells at almost any place in this valley, which is 250 miles long and 50 miles wide.

There has not been one season since the settlement of Dakota when moisture was not needed. In our county we have had very few that you might call failures; but, as I say, there has been no season when we did not need moisture. The last two or three seasons we have had failures—one-third of a crop—while if we had a system of irrigation we could have had our usual crop of 20 bushels to the acre. We have to go from 800 feet to 1,000 feet to get water, and then we can get a stream of water almost any size. Six inches is the largest we have in the county or that portion of the State. I have forgotten how many barrels that will flow an hour. But at Groton they have a ditch 5 feet wide and 2 feet deep—a pretty fair stream. If we had the capital to go on and sink artesian wells we have no doubt they would prove successful.

This is the first season that there has been much talk on the subject of artesian wells, simply, I suppose, because this is our first failure. But there would be no difficulty, in my opinion, in getting artesian wells. I have my views about irrigation. Near the city of Aberdeen, at which place you have been invited to stop, some water was accidentally left in a ditch last fall. We have had no rains since harvest last year, and very little this summer. Right near this ditch an acre of land is good for 40 to 50 bushels, but beyond that the balance of the field seems to be a failure. I speak of this to show what irrigation will do for us.

STATEMENT OF H. HOLE, OF HURON, BEADLE COUNTY.

Mr. Chairman and gentlemen: I have a somewhat different idea of this irrigation question from those expressed here this morning. I have gone to the trouble to examine the irrigation question in Colorado, Wyoming, Utah, Idaho, and Montana. I find there it costs $20 an acre to irrigate, for the reason that they have to dam their streams and bring the water for miles—a great many miles—at great expense. When we found artesian wells possible in our valley, it struck me that we had right at our doors what the people of those States and Territories had to bring from great distances. My idea is that an artesian well on every section will irrigate that section of land; and to construct the well it will cost $2,500. The flow from a well of that kind will cover 640 acres of land 2 inches deep every 24 hours. Estimates have been made by parties who are experts, and they say that there is no question that a well costing $2,500 would irrigate one section of land; and the plan would be to irrigate with the same care and the same survey and ditches that they have used in Colorado and Utah and the other irrigating States. They would in that way, and at a cost not to exceed $6 or $7 an acre, irrigate the land, while in the other States and Territories it costs about $20 an acre. If this land were irrigated in that way, it would add much to its value, equal to that in the other States and Territories—$20 an acre. Yes; I believe in the James River Valley, within the artesian basin, the lands can be, by a system of irrigation such as I suggest, increased in value $20 an acre. In this Terrritory the question of dams will be eliminated when you come to get at the fall of the river. There is no fall in these rivers that will ever furnish water by the dam-reservoir system. And even if the water could be furnished, it would be no better water and would cost a good deal more. On every farm we have the water, and all you have to do is to bore a hole and let it come up.

And you can irrigate by the natural gravity of water. The pressure of these artesian wells is about 170 pounds to the square inch—some of them going as high as 200 pounds. The rain-fall here is about as mentioned—22 to 28 inches. That ordinarily would be enough to make a crop, but the winds dry up the water and the evaporation is very rapid.

But give us ten days' irrigation, and we can assure 40 bushels of wheat to the acre. Now, every year we expect crops and have the best prospects for them, but the dry winds come and dry up the soil. I think that the artesian will be the cheapest water-power that can be had in the world, as you will see when you examine the artesian wells at Huron, Aberdeen, and Redfield. There they use the artesian power to run the machinery about the city.

Senator **REAGAN**. What is the size of the well at Huron?

Mr. **HOLE**. It is a 6-inch well, with a pressure of 175 pounds to the square inch.

Senator **REAGAN**. Do you know how deep that well is?

Mr. **HOLE**. Nine hundred and some feet. That well cost in the neighborhood of $4,000; that was just one well—an experimental well. We have an offer to put down an 8-inch well for $2,500 within a few miles of our town.

STATEMENT OF C. L. WOOD, OF RAPID CITY, PENNINGTON COUNTY.

Mr. Chairman and gentlemen: Pennington is one of the counties of the Black Hills—a southwest county. Other southwest counties are Fall River County—that is the southwest corner county of North Dakota; and then, passing along the Wyoming border, comes Custer County, Butte County, Meade County, which is east of Lawrence—six in number. They represent the organized country in South Dakota west of the Missouri River. This country is all surrounded by the two forks of the Belle Fourche and the South Cheyenne, coming together about 40 miles north from Rapid City. The east half of that Territory is agricultural country, and the west half is in the mountains and is a mining country. We have a number of streams that put out from the mountains, and each stream runs straight through to the Cheyenne River. The streams in their order are the Redwater, Spearfish, Whitewood, Elk Creek, Box-elder, Rapid Spring Creek, Battle Creek, and French Creek. These creeks are practically parallel, and on an average of about eight miles apart. They are practically of the same width. For instance, a small portion of Rapid Valley is under irrigation. The valley of the Spearfish is also under irrigation. But the streams having their source in the mountains are dry on the plains, with the exception of the Spearfish, and, of course, can not afford to supply water for irrigation purposes.

The **CHAIRMAN**. Are there any facilities for storing water in that vicinity?

Mr. **WOOD**. There are good facilities for storing water. All those lakes burst out of a gap. The gap is always in the outside range. Inside the outside range there are generally large basins, which could be used for the storage of water. I think each stream is supplied with two basins which could be used as reservoirs. By damming across the gaps you could form large reservoirs at the back.

The **CHAIRMAN**. There is a good deal of water in those streams which in the spring runs to waste?

Mr. **WOOD**. Large volumes pass out during the spring, with the exception of the Rapid and Spearfish.

The **CHAIRMAN**. What is the effect of irrigation there?

Mr. **WOOD**. Since my residence in that county, twelve years, we have had three summers of extreme drought; but in those valleys where irrigation is possible and is pursued the crops were as good during this dry season as at any other time. There the soil is productive, and the wheat crop averaged 60 to 70 bushels to the acre. I have seen 60 to 70 bushels taken off an irrigated field, while there was a complete failure above the ditch, although there is no difference in the character of the soil. Then, this year where we have had plenty of rain and the irrigation ditches have not been used there is no difference in the crops. So that proves that there is no difference in the productiveness of the soil.

The **CHAIRMAN**. What is the distance that can be irrigated by these streams?

Mr. **WOOD**. Sixty miles north and south and 40 miles west. It can all be irrigated. These rivers come together on the east side, and the divides are capable of being supplied with canals, so that all of them could be utilized.

The **CHAIRMAN**. You think there are storage basins where the water could be held back?

Mr. **WOOD**. I think that such is the case.

The **CHAIRMAN**. Have you in your section this subsoil of marl or clay that has been described here?

Mr. **WOOD**. It is in the divides, but the valleys seem to have cut through that or depressed it. In the valley the immediate subsoil at an average of 10 feet would be gravel, but on the divide there would be no gravel but a stratum of clay 6 feet in depth. But the streams that do not run dry, the Rapid and Spearfish, have not a sufficient volume of water to irrigate more than the land included in their valleys; they could not furnish enough to go over the divides.

The **CHAIRMAN**. Does not a large percentage of that water run out in flood time?

Mr. **WOOD**. Yes; a great volume comes down; but they are considerable streams at all times, though the volume is not more than enough to furnish the valleys through which they pass.

Senator **REAGAN**. State what is the average price of farming land in that country.

Mr. **WOOD**. Unimproved land is from $8 to $10 an acre; some lands are higher than that, but that would be about the average.

Mr. **R. J. HINTON** (Irrigation Engineer, U. S. Geological Survey, with the committee as expert). What would be the value of Government land as compared with that?

Mr. **WOOD**. I think the Government land would not be far from the value I have named.

STATEMENT OF C. H. VAN TASSEL, OF SANBORN COUNTY.

Mr. Chairman and gentlemen: I am from the southern part of the Territory. I have not noticed that any of these gentlemen have stated that the crops have been affected by the flow from these artesian wells.

In my county they get these shallow wells from 75 to 115 feet. I noticed a few days since where one of these wells, which flows through a 2-inch gas-pipe into a ditch and then onto a lake-bed a half mile away, that on each side of that ditch for about 30 or 40 rods back the crops of both wheat and oats were good, and that on the same field, farther away, there was no crop at all; it was all burned out.

In the western part of the county, in the village of Letcher, there is a deeper well. That well has a depth of 600 feet, and it was obtained at a cost of $2,200. It is now about six or seven months since that well was sunk, and it has created a lake there in a natural lake-bed or depression covering perhaps 100 acres, and then there is an outflow which extends for about 7 or 8 miles to the James River. I noticed this season that in the vicinity of that lake, that depression, where the outflow is clear to the James River, they will cut grass from 1½ tons to 2 tons per acre on each side of the stream, while 80 rods away the prairie would have burned out at any time within the last three or four weeks. I am acquainted with much of the country known as the James River Valley, and while it is a level prairie there are in it numerous lake-beds or depressions covering from 40 acres to a section, any of which could be filled by an artesian well. They have hard-clay bottoms, and from them the water could be carried off by irrigation ditches.

The **CHAIRMAN.** Have you ever seen an artificial ditch running along the side of a hill, and can you say how that would affect the land below?

Mr. **VAN TASSEL.** I have not in this country. The water will percolate through the soil to the clay subsoil that is below, but it does not percolate through that at all.

The **CHAIRMAN.** Have you noticed the effect of this percolation through the soil from a ditch along the hill-side?

Mr. **VAN TASSEL.** In this natural ditch of which I spoke, from the well in Letcher Township, the effect is shown in the grass. I have not noticed the effect where the ditch is near any cultivated crop. But in that one place I noticed that it affected the grass for nearly half a mile. I noticed it in the city of Yankton. There they have two artesian wells, and the waste water from the city well affects vegetation for 40 or 50 rods from the waste ditch. There would be no trouble at all any place through what is known as the James River Valley country in obtaining reservoirs, because there are natural sites in the shape of those depressions and lake-beds. They will hold the water without any trouble.

The **CHAIRMAN.** You have been a surveyor all through this country. Suppose you had the water of the Missouri out on the table-land a few miles back from the river at any point above here, would there be any difficulty in the way of running it down by means of a canal?

Mr. **VAN TASSEL.** No; the natural lay of the country would be suitable.

The **CHAIRMAN.** How far up?

Mr. **VAN TASSEL.** To the head of navigation—Fort Benton.

The **CHAIRMAN.** Are there any opportunities for taking out the Missouri River?

Mr. **VAN TASSEL.** I believe there is no feasible way.

The **CHAIRMAN.** Have you ever looked at it with that view?

Mr. **VAN TASSEL.** No; not with that view.

The **CHAIRMAN.** How far out on the Missouri would you have to go before you would have rock bottom?

Mr. **VAN TASSEL.** There is rock bottom in numerous places, but not very extensive. For instance, there is a chalk-rock bottom a few miles above Yankton, but it extends only a few miles. There is no place that I now remember where the rock bottom is very extensive for any distance up and down the stream.

The **CHAIRMAN.** Is there any place where there is a firm reef and where you could take the water out?

Mr. **VAN TASSEL.** Not to any extent.

The **CHAIRMAN.** Have you noticed any place where there is a reef of rocks, a dike, where you could start from without any great expense?

Mr. **VAN TASSEL.** There is none this side of Fort Buford.

The **CHAIRMAN.** How far would that be by the line of the county?

Mr. **VAN TASSEL.** In the neighborhood of 700 miles.

The **CHAIRMAN.** 700 miles by land?

Mr. **VAN TASSEL.** Yes.

The **CHAIRMAN.** Would it go all the way through good country were it taken out?

Mr. **VAN TASSEL.** Yes; nearly all the way.

STATEMENT OF V. T. McGILLICUDDY, OF RAPID CITY, PENNINGTON COUNTY.

Mr. Chairman and gentlemen: I would like to make a few remarks with regard to the Black Hills country and a part of the Sioux Reservation that is to be opened up to settlement.

I suppose you gentlemen are aware of the fact that the only moisture which we get in this region is from the Gulf of Mexico and the region of the Great Lakes. We get none from the Pacific Ocean, for the reason that the Rocky Mountains reach above the cloud line in altitude, thus cutting off moisture from the Pacific Ocean. Every mile that you go out of the Black Hills the more the rain-fall diminishes, and so the people have to depend on irrigation. This portion of the Sioux Reservation which will be opened up to settlement, 16,000 miles in extent, is remote from the Black Hills moisture. The land there is very fertile generally, but I apprehend the difficulty will be the want of rainfall, except near the Missouri. The nearer you get to the Missouri the more rain-fall there is. Like the Black Hills, the river increases rainfall and dews. But the only future I can see for anything like reliable crops on that reservation will be from irrigation by means of artesian wells.

The **CHAIRMAN.** No experiments have been made there for the purpose of ascertaining whether there is an artesian belt?

Mr. **MCGILLICUDDY.** It is an Indian reservation. Part of it is called the Bad Lands; no agriculture is possible on them. At the same time there are valleys that will prove fertile if we can get water on them.

The **CHAIRMAN.** Are there no streams running through the Bad Lands?

Mr. **MCGILLICUDDY.** There is very little water on the Sioux Reservation. There is a strip of country, 5,000 square miles in extent, running through to the Missouri, that will be opened up to settlement. There the altitude is higher than it is here.

The **CHAIRMAN.** Is there any vegetation there?

Mr. **MCGILLICUDDY.** There is vegetation—buffalo grass. The grass is rich, and 4 or 5 feet in depth.

The **CHAIRMAN.** Is there much timber?

Mr. **MCGILLICUDDY.** Very little, except along the lakes.

The **CHAIRMAN.** You have been living in the Black Hills country. What has been the effect of cutting timber off the banks of the streams?

Mr. **MCGILLICUDDY.** I think it reduces the amount of water in the streams.

The **CHAIRMAN.** How are they doing in that country; are they saving the undergrowth, the brush?

Mr. **MCGILLICUDDY.** The mining companies have been cutting off the timber for mining purposes, and they have not spared it. The law requires that nothing under 8 inches shall be cut. The mining companies do not respect the law, and they do not clean up the small brush. It catches fire, and in the fall that causes the undergrowth to burn.

The CHAIRMAN. Have you thought of a way of remedying that—I mean by legislation?

Mr. MCGILLICUDDY. We have laws enough if they were carried out; but the laws have not been carried out.

The CHAIRMAN. If instead of secret agents suppose men from these timber districts were appointed—not to sell the land, but to regulate the cutting of timber—could anything be accomplished?

Mr. MCGILLICUDDY. These timber agents sent out by the Government are spies. They make secret reports, but the local land officers can take no cognizance of these things.

The CHAIRMAN. Do you not think it would be better to have the local land offices responsible?

Mr. MCGILLICUDDY. Yes; if the people living there were responsible it would be better. There is a great amount of timber cut off the Black Hills.

The CHAIRMAN. Timber that is necessary for agricultural purposes? What I have reference to is regulating the cutting of timber so as to preserve the undergrowth, and to have the dead timber taken away to prevent fires. That is not done now.

Mr. MCGILLICUDDY. No, you will find large regions of timber where fires have been. These have gotten into the growing timber. Sometimes it is set afire by lightning and sometimes by carelessness. In the dry season, when there is a drought, the farms on the upper benches have turned out better than in the valleys, and as an explanation of this we find that in sinking a well at 10, 15, or 20 feet you strike water. That water remains the year round, which proves that when you get upon these benches there is an impervious strata 10 or 15 feet below the surface, and above that a gravel loam. If that water remains the year round it must be held by a basin, and this water at that depth keeps rising up through the dry season. But when you get over the rim, down into the valleys, the water is not held, but slides under the creek beds and flows out of the country. So that those bench-lands are being taken up. But I apprehend that the settlers who in the first place come into the Sioux Reservation will have to suffer. There are some 11,000,000 acres to be taken up.

The CHAIRMAN. There ought to be accurate information furnished before they go there. It is pretty costly going there to fight this case.

Mr. MCGILLICUDDY. I particularly urge that something be done in the way of artesian wells in that portion of the reservation, because the first comers can not sink wells 200 feet to try the experiment.

A copy of the following memorial was presented on behalf of the State constitutional convention:

To the Congress of the United States:

The constitutional convention of the State of South Dakota, duly assembled, would respectfully represent to your honorable body that it has been demonstrated that within the limits of South Dakota there exists what is known as an artesian basin or system, but that its extent has not been fully determined, and that a desire is being generally expressed by the people of South Dakota that the matter be investigated and the extent of the system fully determined, and its availability for the purposes of agriculture and manufactures be determined.

Now, therefore, the said convention would respectfully memorialize your honorable body and request you to appoint at the earliest time a commission for the purpose of making and with power to make a thorough and complete geological and hydrographic survey of this State, including the mineralogical formation of the Black Hills and the artesian basin of South Dakota, and that you make the necessary appropriations therefor.

[Signed by the officers of the constitutional convention.]

SIOUX FALLS, S. DAK., *August* 2, 1889.

The committee met at 7 p. m.

Present: Messrs. Stewart (chairman) and Reagan, also Director Powell.

STATEMENT OF W. F. SMITH, OF MADISON, LAKE COUNTY.

The CHAIRMAN. Do you need irrigation in your county, and if so, how do you think it can be obtained?

Mr. SMITH. We do need irrigation. It can only be obtained from artesian wells.

The CHAIRMAN. Have the crops suffered in your county for want of water?

Mr. SMITH. They have suffered somewhat. However, we have a fair crop in our county.

The CHAIRMAN. Is there any stream running through your county?

Mr. SMITH. No.

The CHAIRMAN. How are you situated with reference to the James River?

Mr. SMITH. We are 50 miles east of the James River and 24 miles west of the Sioux River.

The CHAIRMAN. Have you tried the experiment of artesian wells?

Mr. SMITH. No, sir; we have never tried them.

The CHAIRMAN. So you do not know whether you have water there or not?

Mr. SMITH. We do not know whether we have water underneath us or not.

The CHAIRMAN. Where are the nearest wells?

Mr. SMITH. Twenty-five miles west of us. They are not very deep wells, however.

The CHAIRMAN. You are east of the ridge?

Mr. SMITH. We are east of the center.

The CHAIRMAN. At about what elevation in that neighborhood is the center above the two rivers?

Mr. SMITH. I do not know that I can answer that question. I would not undertake to guess at it.

Mr. HOWE. It is not very high—perhaps about 50 feet.

STATEMENT OF H. J. PATTERSON, OF MADISON, LAKE COUNTY.

The CHAIRMAN. What is your occupation?

Mr. PATTERSON. I am in mercantile business at Madison.

The CHAIRMAN. Is it a fact that you need irrigation in your county?

Mr. PATTERSON. We have a considerable amount of land in our county that is affected more or less every year by the drought. The county has been affected by it this year. It has always seemed to me that it would be an advantage to us if we could have irrigation.

The CHAIRMAN. Have you ever had any examples of the results of irrigation in your county?

Mr. PATTERSON. No, sir; only as we might see it along the line of the little brooks throughout the county. It can be seen that the grain and grass are more thrifty in those locations.

The CHAIRMAN. There are no ditches, are there, turning the water onto the land?

Mr. **PATTERSON**. None whatever.

The **CHAIRMAN**. What is the character of the soil in your locality?

Mr. **PATTERSON**. It is a black loam.

The **CHAIRMAN**. What underlies the soil?

Mr. **PATTERSON**. Gravel; when we get down 3 or 4 feet we find a gravel bed for the most part. Sometimes we strike blue clay.

The **CHAIRMAN**. No wells have been dug in your part of the county?

Mr. **PATTERSON**. No wells have ever been dug in our county. These gentlemen here have done more than anybody else in order to see if they could get a well, but they did not succeed in getting one.

The **CHAIRMAN**. How deep did they go?

Mr. **PATTERSON**. About 300 feet deep, I think, or perhaps 330 feet. I think there is water there if we could get at it.

The **CHAIRMAN**. What makes you think there is water there?

Mr. **PATTERSON**. Because west of north from us they have artesian wells which they dug at 100 feet, more or less. The surface of the land seems to be about the same all the way through.

The **CHAIRMAN**. Is there any appearance about your locality of this quartzite that you have here?

Mr. **PATTERSON**. No, sir; there is none of that in our county.

The **CHAIRMAN**. There are no streams, you say, from which the water could possibly be obtained?

Mr. **PATTERSON**. There are none in our county.

The **CHAIRMAN**. Are there any streams running along there that could be diverted into your county?

Mr. **PATTERSON**. I do not think so, unless they could divert the James River.

The **CHAIRMAN**. But there is not water enough in that for every purpose, is there?

Mr. **PATTERSON**. No; nothing that would materially help in a dry season.

STATEMENT OF S. W. JACOBS, LAKE COUNTY.

The **CHAIRMAN**. How far from Madison do you reside?

Mr. **JACOBS**. About 3 miles south of Madison, Lake County.

The **CHAIRMAN**. Tell the committee what you know regarding the needs of your county in the matter of irrigation, and how you think irrigation can be obtained.

Mr. **JACOBS**. The knowledge that I have has been gotten from other parties. Parties that have bored more artesian wells than any others in Dakota say that we should be able to get water there, according to the stratification of the earth. There is water to the north and west of us, and also to the south of us, underground. We are in the line of the granite formation. In Salem, water has been found just on the top of the rock. They cut through the rock at another place and struck water—very fine water.

The **CHAIRMAN**. How deep did they go?

Mr. **JACOBS**. The first trial was about 600 feet, and I believe the last trial was 800 feet or 900 feet.

The **CHAIRMAN**. That is, they cut through this quartzite?

Mr. **JACOBS**. Yes.

The **CHAIRMAN**. How much water did they get when they cut through that?

Mr. **Jacobs**. They got a good well. They did not get a flowing well at either Salem or the other place, but they got an ample supply of water.

The **Chairman**. It was a pumping well, was it?

Mr. **Jacobs**. Yes.

The **Chairman**. A pumping well will not do much towards irrigation, will it?

Mr. **Jacobs**. No; but if they got good water at that depth, they should get a flowing well by going deeper.

The **Chairman**. But they do not always get that?

Mr. **Jacobs**. Not always; but there is 30 feet of water in the lake.

The **Chairman**. Why do you allow 30 feet of water to remain in the lake if you want water for irrigation around the country there?

Mr. **Jacobs**. Because it costs too much to get it out. The banks of the lake are 25 feet high.

The **Chairman**. Is that the full height?

Mr. **Jacobs**. That is about the height. Madison is about 3 miles northwest of us, and there is a range of hills between Madison and the ridge.

The **Chairman**. How does it discharge when it is full?

Mr. **Jacobs**. It runs through the Skunk River, and from that into the Sioux, and past Sioux Falls. Lake Hermann is west of Madison. It is a small lake and is a trifle higher than Madison, but not very much.

The **Chairman**. It seems to me that would be a very good reservoir if you could dam the water up.

Mr. **Jacobs**. You would have to elevate it in some shape to get it into the surrounding country.

The **Chairman**. It will not run either way?

Mr. **Jacobs**. It would run from this little creek that we call the Skunk River. It has to run through another lake before it comes to that.

The **Chairman**. Is there not some country to be irrigated before this chain of lakes is reached?

Mr. **Jacobs**. There are hills on both sides.

The **Chairman**. All the way?

Mr. **Jacobs**. All the way.

The **Chairman**. And it comes into the Sioux River?

Mr. **Jacobs**. Yes. Wherever the land has retained the water the crops havê been good, but when the water could not reach it of course they have been poor.

The **Chairman**. The lake is not high enough to get water from it to your land at all?

Mr. **Jacobs**. No; and during this time of the year there is no outlet to it. In the early part of the year, when the water is high, there is an outlet.

The **Chairman**. How far from you did they bore a well and strike this quartzite?

Mr. **Jacobs**. At Brookings, which is about 25 miles straight north from here.

The **Chairman**. Then your place is between that point and this?

Mr. **Jacobs**. Yes, just about, but a trifle west.

Mr. **Hinton**. Has anybody ever suggested, in your region, that that chain of lakes could be made useful for general irrigation purposes? The lakes run above you a considerable distance all through those counties, do they not?

Mr. **JACOBS**. But the range of hills on each side of them would be so high that without an immense amount of water dammed up you could not use it. You would have to force the water up. If you could get the water beyond the range of hills adjoining the lake on each side, it could be used to advantage.

STATEMENT OF F. G. YOUNG, OF MADISON, LAKE COUNTY.

The **CHAIRMAN**. Have you given any thought to the question of getting more moisture in your region?

Mr. **YOUNG**. Although our crops have not been complete failures for the last three or four years, still I know they would have been greatly benefited by an increased amount of moisture. The only feasible, or even possible, way that we could get water for irrigation would be by means of artesian wells. I am not sure whether there is a possibility of that. One point that would incline me to believe that there is, is the nature of the subsoil. Although it has been stated here that it is a gravelly subsoil, I know there is a great deal of difference as to its imperviousness to water and the clay subsoil of Wisconsin. The depressions here keep their water through long-protracted seasons of drouth; they would not retain it in Wisconsin, with yellow clay subsoil; that is, the clay that has not a very deep subsoil here has running through it a shallower stratum of a very compact marl, and that is quite impervious to water.

The **CHAIRMAN**. That holds the water?

Mr. **YOUNG**. That holds the water well.

Senator **REAGAN**. How far is that from the surface?

Mr. **YOUNG**. I should say 3 or 4 feet. I have dug post-holes and dug a well there where they found this marl, and it was in the upland too; so that it is not confined to the depressions alone, although I suppose there are some knolls or hills where it would not be found. I think our main point is to find out whether artesian wells are a possibility with us at an expense within our reach, and should we ascertain that it is, to use that system with a series of ditches for irrigation. We have, however, large lake-basins there. I should think if dams were constructed systematically they would retain the superfluous moisture such as we had in the winters of 1880 and 1881, and that the waters might be led off by the outlet; so that if dams were used there are several streams that could be made available for irrigation.

The **CHAIRMAN**. Does the water remain long enough so that sufficient would be retained in the wet season to be used in the dry season?

Mr. **YOUNG**. I think so.

The **CHAIRMAN**. So that if you had had a dam constructed 5 or 6 years ago, the water would not have evaporated so much but that you would have water enough left for this year?

Mr. **YOUNG**. That is my opinion.

The **CHAIRMAN**. What is the average amount of rain-fall in your county for the last two years?

Mr. **YOUNG**. I have no figures.

The **CHAIRMAN**. Have you any idea how much it was this year?

Mr. **YOUNG**. About 23 or 24 inches, perhaps. As a matter of fact however, our county has been more favorably situated this summer because of its moisture than the county just west of us—indeed than a whole strip of counties. Then, too, our county has a greater water area. Perhaps the larger amount of water-covered area is the cause of our having received a larger amount of rain-fall.

The **CHAIRMAN.** You have no means of knowing where this quartzite belt extends through the country, except these developments above here?

Mr. YOUNG. I have not made any survey, of course, and do not know.

The **CHAIRMAN.** It comes to the surface here?

Mr. YOUNG. Yes.

The **CHAIRMAN.** Does it come to the surface anywhere else north of here?

Mr. YOUNG. I think it does, some miles northeast of here. I am something of an amateur in geology, and have read somewhat in that science; and it seems to me that the outflow of the molten mass through an extended fissure——

The **CHAIRMAN.** I do not think it was ever a molten mass. I think it was a sedimentary mass.

Mr. YOUNG. Then it was surely metamorphosed by extreme heat.

The **CHAIRMAN.** We do not know that that is so. There was probably some action of gases that operated upon it.

Mr. YOUNG. I have not any data by which to determine whether it would interfere with our getting water for irrigation.

The **CHAIRMAN.** It appears to me very much like sedimentary rock, and I do not think there was any fire action about it. It is pretty expensive drilling through that to get water.

Mr. YOUNG. Yes, it is.

STATEMENT OF E. H. JACOBS, OF MADISON, LAKE COUNTY.

The **CHAIRMAN.** What do you say as to whether irrigation is needed in your county or not?

Mr. JACOBS. I do not know that I could say anything more than the other gentlemen have said, excepting about the character of the soil. I started a well.

The **CHAIRMAN.** Tell us what you went through, in digging that well.

Mr. JACOBS. We struck yellow clay at about 3 feet. We found that that yellow clay was some 50 feet deep; we then struck a blue clay that went down about 100 feet further. After that there was a white and yellow clay as far as we went. We went down some 330 feet, and did not strike anything but clay all the way along.

The **CHAIRMAN.** Where did you sink the well?

Mr. JACOBS. A mile north of Madison.

The **CHAIRMAN.** I wish you had put that well down about 1,000 feet. We would like to know something about the character of the ground there.

Mr. JACOBS. If I had gone down 1,000 feet I believe I should have flooded the whole town. [Laughter.]

The **CHAIRMAN.** You did not strike any of this quartzite that they have here?

Mr. JACOBS. No, sir; we did not strike a stone of any kind.

The **CHAIRMAN.** Do you think you were in the range of that, so that you would be likely to strike it?

Mr. JACOBS. I do not know anything about that. I had confidence that I should get water before I should strike that.

STATEMENT OF W. E. HOWE, OF MADISON, LAKE COUNTY.

The **Chairman**. What have you to say, if anything, on the subject of irrigation, and the need of it in your county and in your section of the country generally?

Mr. **Howe**. I do not know that I can add very much to what has been said by the other gentlemen. We have a soil there that is very productive if a proper amount of moisture could be had. Instead of raising 10 bushels of wheat to the acre, we could raise 25 bushels, and all the way up to 40 bushels, I think. I have seen irrigation as it was practiced in the western country somewhat.

The **Chairman**. What part of the country did you see it in?

Mr. **Howe**. I saw it up in Montana. The soil in our county is very variable. Mr. Jacobs has told you what he struck on his farm. If he had been down on my farm, south of Madison, he would have struck gravel almost immediately. Gravel presents itself down a foot or two; at least, so far as I have dug down that is the case. He would have found gravel and coarse sand. The subsoil is underlaid 4 feet with this solid cement or marl formation. Four feet further down he would have got another stratum of those, and he would have to go through them with a pick. I have not been down more than 10 feet.

The **Chairman**. That marl substance will hold the water, will it?

Mr. **Howe**. Yes; it is the worst thing in the world to have around. The water will go down through the subsoil and through the gravel to that marl and then run right off through any opening it might reach.

The **Chairman**. That may be a bad thing for a town, but it is a good thing for a farm.

Mr. **Howe**. You are quite right. If you could get in our locality a good snow-fall or an extreme amount of rain, it would fill up that place and would last four years.

The **Chairman**. Do you know any way of irrigating that country except by artesian wells?

Mr. **Howe**. No way that I know of doing it on any extensive scale, except by artesian wells. The water would have to be raised either by wind power or some other power before it could be utilized.

The **Chairman**. You have seen irrigation practiced. Do you not think that in this country, with this marl underneath the soil, a ditch or stream on this side-hill would sub-irrigate for a considerable distance?

Mr. **Howe**. Yes; I think that would be very good for irrigation. If a man could fill his farm up it would last him for three years, very nearly. That soil acts like a sponge. We had, three or four years ago, a rain-fall lasting for pretty nearly six weeks, and we had a great harvest as a consequence, because the subsoil had taken up so much water the previous winter.

Adjourned.

ON TRAIN, NEAR HURON, *August* 3, 1889.

The committee met pursuant to call of the chairman.

Present: Messrs. Stewart (chairman) and Reagan; also Director Powell.

STATEMENT OF C. B. McDONALD, OF DE SMET, KINGSBURY COUNTY.

The CHAIRMAN. What experiments have been made with artesian wells in your county?

Mr. McDONALD. None.

The CHAIRMAN. What is the condition of crops this year in your county?

Mr. McDONALD. In the western part of the county the crop is a total failure. In the northeastern corner there is a fair crop, and in isolated sections there is a good crop.

The CHAIRMAN. Those are the sections, I suppose, in which there is most moisture?

Mr. McDONALD. Yes, sir.

The CHAIRMAN. Where is the nearest artesian well to your place?

Mr. McDONALD. At Huron.

The CHAIRMAN. Are you on the divide between the Sioux and James River?

Mr. McDONALD. We are. We are in the James Valley.

The CHAIRMAN. Is there much of an elevation between the Sioux and the James?

Mr. McDONALD. Yes; there is a pretty high point.

STATEMENT OF L. L. BANCROFT, OF MANCHESTER, KINGSBURY COUNTY.

The CHAIRMAN. Where is Manchester?

Mr. BANCROFT. Nine miles west of De Smet.

The CHAIRMAN. Have you anything to say in addition to what Mr. McDonald has said with regard to your county and the need of irrigation there?

Mr. BANCROFT. Nothing in particular, only that we would be glad to ascertain whether we can have a good supply of water there. Our crops in part of the county have been very small; we have had hardly a piece of a crop, even; we have had some corn.

The CHAIRMAN. Have you had some recent rains here?

Mr. BANCROFT. Yes, sir.

The CHAIRMAN. At what time did you have the first rain?

Mr. BANCROFT. I believe about the 6th or 7th of July. About two weeks after that we had another rain, and we have had quite a number of rains since that time.

The CHAIRMAN. The rain did not come, however, in time to save your small grains?

Mr. BANCROFT. No; one man on 12 acres of land got 24 shocks of grain. The grain is shrunken very much. In the northeast part of the county, however, there is some fair grain.

STATEMENT OF J. D. PEIRSON, OF DE SMET, KINGSBURY COUNTY.

The CHAIRMAN. What have you to say in addition to what has been said by these other gentlemen in regard to your county and its need of irrigation?

Mr. PEIRSON. I do not know that I have anything in particular to add to what has been said except that our crops were saved by a local rain through the northern part of Kingsbury County, along about the 1st of June. Our crops would have been a total failure if it had not been for that rain. North of that the crops have been a total failure, and also south. I am a cattle dealer, and have been all over the county, so that I know the condition of things pretty well.

The CHAIRMAN. Is there anything peculiar in your section of country with regard to the rains?

Mr. PEIRSON. The tendency of the storm I have spoken of was toward the northeast. It was between Spirit Lake and Lake Whitewood and Lake Thompson. Between those places the crops were good, and southwest of those places the crop was an entire failure. Then further on—northeast of this line—the crops are a failure. I have been over the section repeatedly.

The CHAIRMAN. How far up the Missouri River have you been?

Mr. PEIRSON. I have been up as far as Fort Benton.

The CHAIRMAN. Have you ever contemplated the possibility of at some future time having a canal very high up on the Missouri River, and bringing it down here?

Mr. PEIRSON. I have not, sir.

The CHAIRMAN. What would be the effect here of a canal, having plenty of branches, so that there would be a sufficient supply of water for this country about here?

Mr. PEIRSON. It would be a very great thing for this country. Our country here has a number of ravines running through it, so that if we could have it well supplied with water the ravines would distribute the water thoroughly.

The CHAIRMAN. You have never practiced irrigation at all in this neighborhood, by digging ditches to bring the water on the land?

Mr. PEIRSON. Not that I know of.

The CHAIRMAN. What is the character of the soil in this section?

Mr. PEIRSON. It is a black loam, from 12 to 24 inches deep, underlaid in most sections by clay; In some small parts of the country, perhaps a mile wide, our coteaux are underlaid with gravel and sand; you can then go down from 20 to 40 or 50 feet, when you strike blue clay.

The CHAIRMAN. This blue clay holds the water that you get, does it not?

Mr. PEIRSON. Yes, sir; it holds the water very well. Two or three years ago we had quite a number of wells that were from 15 to 18 feet deep, and those wells have now gone dry, and many farmers can not get sufficient water to feed their stock. Many of them have been marketing their cattle, on account of the scarcity of water.

Senator REAGAN. Has there been an unusual absence of rain in this part of the country for a number of years?

Mr. PEIRSON. There has been an unusual absence of it in the last three or four years.

Senator REAGAN. What is the topography of the country that you speak of; are the lakes in low depressions, or are they pretty well up?

Mr. PEIRSON. Spirit Lake is on the divide between the two rivers; it is as high as any point about here, I think.

Senator REAGAN. How about the other two lakes?

Mr. PEIRSON. They are on the same level very nearly, but a little lower.

Senator REAGAN. Are they higher than the valley at large?

Mr. PEIRSON. Yes, sir; our country is a little undulating, and these lakes are in the low places. There are outlets to most of them, but on account of having so small an amount of rain they have run down below the outlet, so that these lakes are dried up.

Senator REAGAN. All around these lakes are the crops pretty good?

Mr. PEIRSON. Yes, sir.

The CHAIRMAN. Could you not use those lakes to some extent by damming them and keeping water in the ditches?

Mr. PEIRSON. Yes, if we had the accommodations for holding the water.

The CHAIRMAN. In the wet season could you not do it to some extent?

Mr. PEIRSON. Perhaps we could to some extent; but we haven't any reservoirs to hold the water. Seven years ago we had water enough to fill up all these lakes, and for the next two or three years we had an abundance of crops.

STATEMENT OF J. B. MACDONALD.

The CHAIRMAN. What have you to say to the committee with respect to the subject of its inquiry as affecting the section of country about here?

Mr. MACDONALD. I simply wish to speak of the desirability of some kind of survey or investigation here to satisfy the people that irrigation by artesian wells is practicable. I am satisfied that our counties here are amply able to carry on a system of irrigation after they are once convinced that it is practicable and that the water can be had. During the first two or three years of settlement here the people had excellent crops of every description, but the last two or three years the crops have been almost a total failure. If the Government would give us experimental wells or some means of knowing how to get wells it would encourage our people very much to carry on the work themselves.

The CHAIRMAN. I would like to see some experimentation done, but the Government of the United States is hardly prepared to go on with a system of digging wells. We do not know what they can do in the future, but we are now trying simply to get the information, and perhaps we may afterwards be able to get some wells dug.

Adjourned.

HURON, S. DAK., *August* 3, 1889.

The committee met, pursuant to call of the chairman.

Present: Messrs. Stewart (chairman) and Reagan; also Director Powell.

STATEMENT OF LEWIS McLOUTH, OF BROCKING.

The CHAIRMAN. What is your position, Mr. McLouth?

Mr. McLOUTH. I am president of the Dakota Agricultural College and director of the United States Experimental Station. Both are located at Brocking, east of this city. With your permission I will read a paper I have prepared on "Irrigation by means of artesian wells."

The CHAIRMAN. Go on.

Mr. McLOUTH. The valley of the James River, from Yankton on the south, to Jamestown on the north, is more than 300 miles long, and, reckoning it 40 miles wide, it covers an area of more than 12,000 square miles—over 7,000,000 acres.

The soil is very deep and fertile, and the surface is so even and unbroken that almost a continuous furrow could be plowed from Yankton to Jamestown. It is a safe estimate to make that 99 per cent. of this entire region is arable land. It is destitute of timber, except occasional strips along the channel of the river. Few living affluents flow into this river from source to mouth, and the volume of water seems hardly to change for hundreds of miles of its sinuous course.

Nearly all the land in this valley is occupied and much of it is under cultivation by an industrious and frugal class of farmers, while thrifty cities have been founded and are growing up along the banks of the stream and at the various railroad centers. The unplowed lands are covered with exceedingly nutritious wild pasture grasses, and the crops of wheat have heretofore almost rivaled in quality and amount those of the famous Red River valley of North Dakota. The soil is also well adapted to the growth of barley, oats, and rye. Corn, especially in the south half of the valley, has been found to grow and ripen well, while potatoes, turnips, and other root crops grow luxuriantly, as in all parts of Dakota.

With favorable climatic conditions this valley might become as productive as any in the world, and support a dense and thrifty population. The climate is salubrious and invigorating. The winters are cold, but not long, and the almost continual sunshine of summer, made more active and intense by an average elevation above sea level of near 1,400 feet, brings forward vegetation with great rapidity and luxuriance.

Although trustworthy meteorological observations have not been made for this region long enough or in places enough to give absolutely reliable data, the best information obtainable indicates that 20 inches per annum is about the usual rain-fall, and that three-fourths of this amount falls during the five growing months of April, May, June, July, and August. The remaining five inches is made up by the scanty later fall rains, the earlier spring rains, and by the snow-fall of winter.

When the 15 inches of summer rain-fall is properly distributed through the growing months good and abundant crops are assured; but when, as during the present season, the scanty average is diminished, or when, as last year, it is bunched into April and May, while June and July, with their hot south winds, are almost rainless, then the growing grain is parched and withered and only yields half a harvest.

The region is so far west that the return trade-winds from the southwest come to us robbed of their watery vapor by the high mountain ranges over which they have passed, and about the only supply of rain is that which is brought to us from the Gulf of Mexico by the return trades, deflected far to the west by the heated plains that skirt the eastern slopes of the Rocky Mountain system.

It is probable that no modification that man can effect with the earth's surface or its coverings can ever change these fundamental climatic conditions. The controlling causes are so radical, are so dependent upon the great continental contour and relief, and upon the very form and motions of the earth itself, that man is utterly impotent to effect any change whereby the watery precipitation can ever be greatly increased in the remoter western regions east of the mountains.

There has been general talk about the effect of tillage and tree planting to increase the rain-fall; but the most careful observations have given no evidence thus far of any such increase.

But while man's work is probably unavailing to procure any measurable increase of rain or snow, still his modifications of the surface conditions of the earth are by *no means* powerless to work such changes in his climatic surroundings as shall better fit them to his wants, his comfort, and his convenience.

The tough original turf of the prairie is almost impervious to water, and sheds the rain-fall almost like a thatched roof, so that the water that falls upon it runs right off along the "draws," and temporary streams soon become dry again. But when these prairies are plowed the loosened and porous sod takes up and holds a supply of moisture to bud vegetation.

These blacked plowed fields also in late winter and early spring draw and absorb the rays of heat from the sun, and thus melt off the snows and absorb the water, while the unbroken prairie is still covered with a white mantle of snow.

The plowing doesn't increase the rain-fall any, but only tends to hold and distribute it, to feed the springs and streams more slowly but longer.

The growth of such crops as wheat and corn upon the cultivated prairie shades the ground and holds back the moisture by preventing rapid evaporation.

Trees do the same still more completely, and will also in time check the dry hot winds from the south, as well as the blizzards from the north.

All of these agencies, while not increasing the rain-fall, tend to distribute it more evenly throughout the growing season, and to husband and utilize it more completely.

That this change is being effected is well enough attested by the fact the blue grass is working its way westward year by year with the advance of settlement, and supplanting the original bunch prairie grass. The blue grass requires a more continuous and regular supply of moisture than the original prairie grass that can thrive on the arid soils.

With these we need ask bountiful mother nature for nothing more. If we can have water the trees will come quickly; if we can have the trees they will protect our water supplies from waste and distribute the vitalizing summer showers throughout the growing season.

But since the dawn of historic times men by their own means have been able to water dry and arid regions by the devices of art and so convert deserts into gardens. Rivers—ordinary rivers—have usually been the sources of this artificial water supply, but in this wonderful new West men not only think new thoughts, but nature manifests herself in wonderful new ways.

All over this belt of country first referred to, 40 miles wide, west of this Little James River, and for a longitudinal distance of nearly 400 miles nature seems to have provided a water supply unlike any ever heard of before. Hundreds of artesian wells all along this valley, wherever sought, from Yankton to Jamestown, attest the presence of a subterranean water supply seemingly inexhaustible in quantity, and at a depth below us varying from 500 to 1,500 feet; whence its source nobody can tell. At Jamestown this strange water supply is found to be near 200 feet below the sea level, at Huron it is more than 400 feet above that level, and at Yankton still higher. Thus while the James River flows to the south, this great underground stream seems to have its descent in the opposite direction. The wells that tap this great reservoir flow with a force that varies from a pressure of 50 pounds to the square inch to 200 pounds. The power is used to run electric light dynamos, brick machines, mills, factories, printing presses, etc. Some of these wells yield, through a 6-inch tube, the enormous amount of 4,000 gallons of water, or more than 125 pounds, per minute.

Neither the pressure nor the amount of flow seems to diminish with the multiplication of the wells. In the city of Yankton, two years ago, there were fifteen of these wells, and thirty within a radius of 20 miles, and yet no cessation nor diminution of flow. Now, naturally enough, it occurs to the mind of every thoughtful man, especially when his fields are parched and his grain is withering, whether this inexhaustible subterranean reservoir of water may not be made to supply the lack of rainfall.

An easy arithmetical estimate shows that one of these wells, yielding 500 cubic feet of water per minute, would supply enough in a year to flood 20 square miles to the depth of 6 inches. Or, in other words, if the yearly flow of one of these wells could be saved in reservoirs and drawn out at pleasure, it could be made to increase the summer rain-fall of 15 inches to 21 over an area of 20 square miles of land, while the supply could be so regulated as to remedy the defects of nature.

Much of the region under discussion is so level that irrigating ditches could be carried long distances and made to serve wide areas. In other places the numerous dry lake-beds would serve as natural reservations, from which it could be drawn by irrigating ditches, or pumped by abundant, inexpensive wind power. A thousand of these wells would easily water this entire valley and convert its area into a most luxuriant garden. Not 6 inches of water, but 1 or 2 of them, just at the right time, when summer showers fail, would be sufficient to insure certain and abundant crops.

The money value of a single quarter-section of land, by such a supply of water, would at one advance from $1,600 to at least three times that sum, an advance amply sufficient to cover the cost of the well. The added value of the lands of the James River Valley would not be less than $40,000,000. Neither should be left out of the account the untried but probable effect of such open reservoirs of water upon the climate of adjacent regions. Such watered areas with the timber belts that would soon and inevitably spring up, would most certainly have a wonderful effect upon the rain-fall of neighboring regions while the asperities of our summer heats and our winter cold would be greatly ameliorated wherever the influences of this new condition of things should extend.

The average cost of the wells already bored—including the piping—has, according to best estimates, not varied much from $4,500. Now, if it were necessary to provide a well at this cost to properly irrigate each square mile, the added value of the one section of land would at once pay for the well with a 50 per cent. surplus to boot. But it is probable that if the boring of such wells were entered upon systematically their cost might be reduced to less than half the sum named already.

But why, it is asked, if such expenditures would so rapidly advance the value of these lands, does not the private enterprise of the owners of these lands enter at once upon this work? The answer is not far to seek. The settlers of this valley, like most of this new Northwest, are poor men, who came here within the last ten years, attracted by the offer of free lands, bringing with them little capital except their wives, young children, their clear heads, sturdy muscles, and willing hands. They are in debt, too, often, for their houses, their teams, and their farm machinery. Poor crops for the past two or three years, and a poorer one promised this year, leave them utterly unable to undertake the improvement now under discussion.

The enterprise is indeed one of such extent and one of so much promise of beneficence that national aid should step in to assist private effort. Not the building of light-houses along the shores of the Great Lakes, as security to commerce, not river levees and dredgings, not credit loaned to railroads, nor lands given to them in fee simple, not subsidies to ocean steam-ship lines, nor canals for shortening the courses of trade, promise greater and more immediate benefits to that class of people who, while bearing the burdens of Government, have not always enjoyed to the fullest the fostering national care that is now promised in these initiatory steps toward the reclaiming of the arid lands of the West. Good natural economy, good statesmanship commend this effort. The disturbing "surplus" could not be put where it would do more good nor return better interest in binding more firmly to the National Government the loyal hearts of a struggling people.

The people of this valley could well afford to return to the national Treasury a million of dollars with good interest during the next ten years if by such national expenditure at the present time such beneficent results can be effected as the best-informed believe probable. The people of the two Dakotas have not been so gently cradled in the national lap for the last five years as to estop them from pressing their claim for the expenditure of a moderate part of the generous sum yearly appropriated for rivers, harbors, and other public improvements.

It is not necessary for Government to do anything more than make preliminary and testing surveys, and to try satisfactorily whether the proposed method of irrigation is as really feasible as circumstances seem to promise. As soon as possible after the plan is definitely settled the enterprise of this Western people, which has already done so much to reclaim a wilderness to civilization, will find its own way to carry out and complete the great work.

Senator REAGAN. One gentleman testified before us that an arrangement could be made for the sinking of 8-inch wells for $2,500.

Mr. MCLOUTH. Indeed; I was not aware of that. Some estimate that a well of 1,000 feet can be sunk for $1,000.

Senator REAGAN. What you state there is the general estimate?

Mr. MCLOUTH. Yes; that is the estimate I have made from the reports in my hands.

The CHAIRMAN. How generally are these wells distributed over this country?

Mr. McLOUTH. The whole length of this valley—400 miles—from Yankton to Jamestown.

The CHAIRMAN. Down to what depth have you extended them?

Mr. McLOUTH. It is a fact, but a strange one, that they are nearly all found on the west side of the river, and have been found within a strip 40 miles in width.

The CHAIRMAN. Have experiments been made on the eastern side?

Mr. McLOUTH. Yes. In the valley of the Sioux River we have tried a number of times, but we can strike no water; we strike the primeval granite.

The CHAIRMAN. You state that the source of this water supply is entirely unknown.

Mr. McLOUTH. Some think it is due to the upper waters of the Missouri, and some think it is fed by the melting of the snows beyond. It is an unsettled question as to whether it comes from one reservoir. The chemical analysis of this water differs so much in different localities, that one is led to think that it is from separate reservoirs, and its temperature is from 48 to 80 degrees.

The CHAIRMAN. What are the strata, I mean the formations, in which there is water?

Mr. McLOUTH. It is always found in sandstone.

The CHAIRMAN. Coarse sandstone?

Mr. McLOUTH. Yes; coarse sandstone, with shale or dense limestone as a capping above the reservoir.

The CHAIRMAN. About what is the thickness of that sandstone?

Mr. McLOUTH. I am unable to say.

The CHAIRMAN. Have they examined it at many points to ascertain that?

Mr. McLOUTH. I have it in a dozen reports. The capping rock, I am informed by Mr. Smith, is about 90 feet deep.

The CHAIRMAN. You mean the strata carrying the water.

Mr. McLOUTH. The water-bearing strata. There are a great number of artesian wells in Sanborn, the adjoining county to Miner; but they seem to be due to some other reservoir. They have found wells there from 50 feet to 150 feet, one bubbling in a marsh.

The CHAIRMAN. All I have seen of the valley is sedimentary formation.

Mr. McLOUTH. The primeval rock we strike at our place east of here.

The CHAIRMAN. Is there not some doubt about that?

Mr. McLOUTH. Yes.

The CHAIRMAN. We call that quartzite.

Mr. McLOUTH. Yes, that is it.

The CHAIRMAN. The well-men bore through one stratum of it and get the strata of clay or chalk about 40 feet thick. I do not think you get the primary rock there.

Mr. McLOUTH. I am in doubt about it. But it has been generally supposed it was the primary rock. It is a strange outcropping in such a region. In North Dakota they get artesian wells from another supply—in the east side. I do not know of any on the west of the river.

The CHAIRMAN. Have there been any experiments farther west of the Missouri River?

Mr. McLOUTH. I do not know.

The CHAIRMAN. You do not appear to be in much doubt here, from the experiments you have made, as to the result.

Mr. McLouth. There seems to be no diminution in the supply of water from the increase of the number of wells. Put them close together and they do not seem to affect each other.

The Chairman. That must depend upon the extent of the water supply, where it comes from, and the thickness of the strata bearing it.

Mr. McLouth. The pressure of the water seems greater at the north, where the wells are deeper, and diminishes at the south, where the wells are shallower.

The Chairman. May not that be governed somewhat by the weight of the overlying earth?

Mr. McLouth. I have not supposed that the weight of the earth was absolutely supported by the volume of water. If that were the case it would make a difference in the pressure.

The Chairman. That is, loose rock and the water being taken out, it would become more compact, of course.

Mr. McLouth. Yes.

Senator Reagan. Wells have been successfully obtained east of the James River.

Mr. McLouth. Very close to the river only, but not at any great distance from it. They find them 40 to 50 miles west of the river. But, as a rule, if they are found on the east side, they are close to the river.

The Chairman. Is it a fact that where you bore the deepest the pressure is the strongest? Is that almost universally the case?

Mr. McLouth. Yes. The pressure at Columbia is 200 pounds to the square inch.

The Chairman. What is the depth of that well?

Mr. McLouth. From 1,200 to 1,500 feet deep—1,500 feet possibly. Some of the wells at Yankton are not more than 500 feet deep. The pressure here is 50 pounds and the depth only 900 feet.

The Chairman. I have wanted to know whether it was the depth of the well or the weight of the earth.

Mr. McLouth. The greater the depth of the well the greater the pressure. But the Jamestown well seems to be an exception to some extent.

Mr. Hinton. What is the average rain-fall or precipitation in this State—the average annually?

Mr. McLouth. I think it is 20 inches. When we get 20 inches during the summer season we are perfectly satisfied, and even 15 inches would be safe. If it is distributed 2 inches in April, 3 inches in May, 4 inches in June and July, and enough in August to ripen the corn and potatoes we do not care for rain after that. That insures a crop of the cereals and summer crops. We do not raise any winter grain.

Mr. Hinton. The reported average report is 22 inches.

Mr. McLouth. They say 22 inches in their reports. Probably they know better than I do, but I compute it at 20 inches. There have been but few meteorological stations that have carried on observations for any length of time.

Mr. Hinton. How long have you carried on yours?

Mr. McLouth. Only two years, and they have been making observations fifteen months.

Analyses of artesian waters in Dakota, furnished by Mr. McLouth.

JAMESTOWN.

[Organic matter: Free ammonia, 2.4 parts per million; albuminoid ammonia, 0.46 parts per million; nitrites, traces; nitrates, none.]

INORGANIC MATTER.

Silica	35.70	2.0833
Alumina	3.50	.2041
Carbonate of iron	2.20	.1233
Carbonate of lime	188.00	10.7643
Sulphate of lime	249.06	14,5243
Sulphate of magnesia	154.20	8.9944
Sulphate of soda	1,139.40	66.3692
Chloride of sodium	369.10	21.5296
Sulphate of potash	81.05	4.7526
Phosphates		a trace.
Hardness		21

Yankton.—Water slightly hard; pleasant to the taste; is used in boilers and gives good satisfaction.

Highmore.—Water very soft and of good quality.

Miller.—Water excellent, and good for all purposes.

Ipswich.—Water very soft; contains soda, potassium, and allied salts; tastes slightly brackish.

Columbia.—Water contains mineral properties; very soft.

Grafton.—Three per cent. of salt in water and slightly trace of sulphate of magnesia.

Ellendale.—Water not pleasant to the taste; very soft.

STATEMENT OF CHARLES S. FASSET, OF HITCHCOCK, BEADLE COUNTY.

Mr. Chairman and gentlemen, my town is situated 20 miles from here, on the county line.

The CHAIRMAN. Explain the situation in your section touching the question of moisture. Have you a well at Hitchcock?

Mr. FASSET. Yes.

The CHAIRMAN. How deep is it?

Mr. FASSET. It is 965 feet deep.

The CHAIRMAN. What is the size of the bore?

Mr. FASSET. The bottom of the bore is 3½ inches. They started with a 4½-inch pipe, and used it until they struck a strata of quicksand, which bound the pipe, and they set another pipe in that. By the breaking of the machinery they had to put in another pipe, so that when they reached the sand rock at the bottom it was 3½ inches in size.

The CHAIRMAN. Do you know the stratification through which the drill passed?

Mr. FASSET. Some clay, sand, shale, and rock over these—porous sand rock. My recollection is that it was from 6 to 9 feet deep. We went through that into what would be like a honeycomb sand rock, and we secured a nice flow from that depth.

The CHAIRMAN. What depth was that?

Mr. FASSET. Nine hundred and thirty feet; but it was concluded that we should go somewhat deeper; so we bored down into this porous sand rock from 30 to 35 feet, and it gave us more flow. I think we have the best well in the James River Valley, and we got it by going down that depth. The flow from the well the first few hours contained sand, but after that it was quite clear. After three or four days the water was clear and then it commenced to spit sand again, and that continued for nearly a week. We could hardly see the water for the sand which came through the pores of this rock; but after a week or ten days that all cleared away.

The **Chairman**. What is the pressure you obtained from that well?

Mr. **Fasset**. That has not been decided properly. The first three attempts the pressure was so great that it broke the gauge. Afterward we brought an expert there, and he stated the pressure to be 218 pounds to the inch. The last test, I think, was made by some expert in company with Augustin Davis, and they concluded that it was 186 pounds. Recently, some distance from the well, they have made it 156 pounds. They estimate that from this little well, where there is a 35 horse-power motor, as they termed it to me, running the machinery.

The **Chairman**. What number of gallons per minute is discharged? Has that been estimated?

Mr. **Fasset**. That has not been estimated.

The **Chairman**. Have you used any portion of that water for irrigating the land?

Mr. **Fasset**. Last year there was a test made on Sheffer's lot. That was an acre of land. Water from the main was thrown over that. That gentleman had sowed some timothy and clover, and had planted some trees in the lot, and by request the water was tested by throwing it over the ground from the hydrant that I think he had in his yard at that time, and the timothy came up from about 2½ to 3½ feet. Those pipes or mains that run through the streets there are 6 feet deep. There are pipes running out to the residences on each side. Sometimes these pipes would break and fill this subsoil with moisture. In the yards there to-day where the moisture has gotten into the subsoil under the trees they have made them grow from 3½ to 4 feet. That was so of box elder. In yards where it does not reach the subsoil the leaves are yellow and drop off, and some of the trees seem to be dying.

During last winter there was a water-course dug from the well east for 6 miles, to carry the waste water from the mill that was located there this spring. In running this ditch, the lowest ground was that which had a fall toward the south, to Moore Lake. There was no effort made to keep this water up, and so far as that water extends there is a beautiful strip of grain country. On one side is grain and on the other side is grass. In places where this ditch goes the water comes within a foot of the surface; in other places it is in depth from 2¼ to 3 feet. The ditch filled this spring and overflowed that tract of country. The water was afterwards drawn off and crops were put in; and to-day they are harvesting those crops, which are from 25 to 50 per cent. greater than where this water has not been.

And in that connection I would like to say this: The hot winds that swept over that spot in the spring did not affect the grain at all. The wheat is filled to the top on each side of this ditch for 2½ to 5 rods, and all who have seen the grain estimate that the yield will be from 50 per cent. to 100 per cent. greater than where there has been no moisture from this water.

The water that is in this ditch that extends to the lake, 6 miles away, is the waste water from a mill. Then we have west of the town, supplied by the well, a lake which covers an area of from 40 acres to 60 acres. This lake is from 7½ inches to 1 foot deep. In addition there is flowing from our well a constant stream running to a small pond there. They found over in that section that they could get a greater amount of water to flow east, and that it would pass over some sand and gravel. There is probably no time except for a few hours that the well is allowed to discharge more than one-half of what it is capable of doing.

The **Chairman**. Have you thought how to economize that water and run it into ditches so that it would percolate through the soil and saturate the entire ground sufficiently to moisten it for crops? Have you ever estimated how much land you could reclaim by that well?

Mr. **Fasset.** We are always estimating, but no two of us think alike. My idea is that we do not need nearly as many wells as has been generally supposed. The flowing of that well and soaking up of that subsoil showed me that if we could get this land filled with water we would not need to flood it every year; we would need to put the water on only once after our grain was put in the ground and once just before it was harvested. That is my idea. Taking that as a basis for my calculation I would say that this small well that we have there would irrigate four or five sections and furnish this flow. Certainly we could make a nice lake out of two sections, and keep it supplied with water if we turned our water in that direction. We are utilizing that water there for a feed-mill and flour-mill.

TABLE OF PRECIPITATION.

The following was received and ordered filed by the chairman:

Statement showing monthly, annual, and average precipitation in inches, as recorded at the U. S. Signal Office, Huron, Dak.

Month.	1881.	1882.	1883.	1884.	1885.	1886.	1887.	1888.	1889.	Total by months since station opened.	Averages by months.
January	....	0.14	0.17	0.00	0.15	0.48	0.33	0.78	1.26	3.40	0.425
February	....	0.25	0.47	0.58	0.22	0.16	1.11	0.52	0.98	4.24	0.530
March	....	0.80	0.42	1.53	0.12	0.62	0.64	1.22	0.19	5.54	0.692
April	....	4.18	2.14	2.70	1.06	3.52	3.72	0.88	3.41	21.61	2.700
May	....	4.50	4.45	2.90	5.20	1.58	1.39	4.98	3.04	28.04	3,505
June	....	5.86	4.33	3.18	5.43	1.90	3.98	1.10	1.04	26.82	3,352
July	*3.58	5.88	5.20	5.11	4.52	1.60	4.96	3.11	3.51	37.47	4,163
August	6.31	1.44	1.77	1.18	3.89	5.62	6.13	3.46	....	29.80	3,725
September	3.11	0.86	1.68	1.28	2.61	1.50	0.15	0.10	....	11.45	1,432
October	2.10	3.37	1.96	1.52	0.98	1.26	0.79	0.20	....	12.27	1,534
November	0.45	0.61	0.05	0.17	1.50	1.18	0.25	0.34	....	4.55	0,569
December	0.06	0.23	0.61	0.62	0.10	0.74	2.09	0.18	....	4.63	0.579
Total	15.61	28.12	23.25	20.84	25.78	20.25	25.54	17.05	13.38	....	....

*Station opened July 1, 1881.

	Inches.
Total seven complete years	160.83
Average seven complete years	22.98

A true copy.

Sam W. Glenn,
Sergeant Signal Corps, Observer.

STATEMENT OF CHARLES J. AMBROSE, OF HURON, BEADLE COUNTY.

The **Chairman.** What is your occupation?

Mr. **Ambrose.** I am clerk in the United States Government land office.

The **Chairman.** How much of a section does your district cover?

Mr. **Ambrose.** Eight counties.

The **Chairman.** How many acres are there in those eight counties?

Mr. **Ambrose.** Six million eight hundred thousand acres.

The **Chairman.** What portion of it is now public land?

Mr. **Ambrose.** I should think about one-fifth at this time.

The **Chairman.** Something over 1,000,000 acres?

Mr. **AMBROSE.** Yes, sir.

The **CHAIRMAN.** Is the land that is not yet entered suitable for entry?

Mr. **AMBROSE.** There is some of it that is, but some of it is not. Some of it is very rough land.

The **CHAIRMAN.** Is it hilly or level?

Mr. **AMBROSE.** It is principally hilly land.

STATEMENT OF PHILIP SKILLMAN, OF ABERDEEN, BROWN COUNTY.

The **CHAIRMAN.** Give us whatever information you have with regard to your locality, your artesian wells, and the effect of them, and the condition of your country about here as to the requirements for more moisture for agricultural purposes.

Mr. **SKILLMAN.** I would say in the first place that we have a county 36 miles by 48 miles, containing a little over 1,000,000 acres. All of that is available for tillage and for crops.

I indorse substantially all that was said by Professor McLouth, although in some respects I think he was in error—for instance, with reference to the artesian basin within which these wells may be had. There is a range of coteaux extending up and down the eastern part of Dakota covering perhaps 50 miles in width. Then you begin to descend the Jim Valley. The valley is about 40 to 50 miles wide. But I would also extend this area all the way over to the Missouri River. I think that would be found all the way to the river. The wells are of the same average depth. Our elevation above the sea level is a trifle over 1,300 feet. There are five or six wells in our county, and we strike water at a level of about 900 feet in depth. Then as you go east or west the surface rises, so that you have to go so much deeper in order to reach that water-bearing rock, the sand-rock. There are three wells in Aberdeen, another in Columbia, another in Groton, another at Ipswich, and one or two others in the county.

The **CHAIRMAN.** Do they all strike water about the same level?

Mr. **SKILLMAN.** About the same average depth.

The **CHAIRMAN.** Do you mean the same average vel?

Mr. **SKILLMAN.** Yes, about the same level. In going down they go through just about the same strata. I have the data here as furnished to me by those who put down those wells.

The **CHAIRMAN.** We would like to have the particulars of the strata.

Mr. **SKILLMAN.** At Aberdeen we find the strata as follows:

	Feet.		Feet.
Surface	16	Blue shale	375
Blue clay	78	Sand	10
Shale	400	Shale	15
Limestone	10		

At that point we strike what is called the water-bearing rock. On the top of this water-bearing rock there is a hard rock, almost like granite, something like 10 or 12 inches thick; then the rock begins to be a little more open and porous.

The **CHAIRMAN.** What is the color of that rock?

Mr. **SKILLMAN.** About the color of ordinary sand—a light color. After getting six or eight feet into that rock the water begins to flow. How far that formation extends throughout the country I do not know, but I know of no well where the drill has gone into that sand rock over 50 feet.

The **CHAIRMAN.** You have not gone into it in your section at all.

Mr. **SKILLMAN.** No; I do not know of any place in Dakota where they have gone through it. We have three wells at our place, and they are all of about the same pressure. The constant pressure is not far from 180 pounds to the square inch. I have seen the pressure, however, at 220 pounds. It sometimes varies without any apparent cause therefor. When there is but a small stream running the gauge will show a change of from 15 to 20 pounds to the square inch. My idea is that that is due to a pressure of gas. I think this pressure comes from the fact that the water is brought at some point into contact with natural gas. In fact, in some places, as they have gone down, gas has escaped with the water.

Senator **REAGAN.** Has that gas ever been ignited?

Mr. **SKILLMAN.** Yes; I understand it has. It sometimes comes up with the water, and then the people run a pipe into a barrel and make a place for the water to escape on the other side, so that there may not be a vacuum in the top of the barrel. Then enough gas will escape so that a little flame will burn at the top of the barrel.

The **CHAIRMAN.** You said that you thought that this artesian belt might extend to the Missouri River. Is there any reason to suppose that it stops there?

Mr. **SKILLMAN.** No; I believe it goes to the Black Hills. And I believe that the source of our water supply is in the foot-hills of the Rocky Mountains. A Professor Moore, who was in our place in 1883 or 1884, to examine our wells, told me that he had had charge of an appropriation, made, I think, by the Government for the sinking of Government wells in Colorado—I am depending on my memory now. He had made a study of the geology of the countries through the West, and had made a study of our place and other places in Dakota. I asked him whether the source might not be east of us, or whether it might not be north or west of us. His reply was—"This sand-rock which you find here undoubtedly extends out to the Black Hills. There has been a volcanic eruption which has turned this rock up edgewise." I asked him how long the water supply was likely to continue, and his reply was that as long as snow fell in the Rocky Mountains, just so long would the supply remain good.

The **CHAIRMAN.** Have you ever been up in the Rocky Mountains?

Mr. **SKILLMAN.** No, I have not been there. I will say that we were, to a certain extent, in Brown County, the pioneers in this movement of artesian wells. The first wells were put down by the railroad company, but the first for ordinary uses were put down by our city. Its wells have been there since 1882, and give no signs whatever of exhaustion. There was not sufficient fall in order to carry off our sewage, and a well was put down, and another pitch was made, so that it was sent to a draw that carried it off into the James River. That is the third well we have there.

The rock is porous and sponge-like. In some places, however, the sponge part is very frail, and will break off pretty soon. In other places the sand-rock is so that it remains together, and throws out almost pure water. The first well that the city put down, and the railroad well also, threw up great quantities of sand. I think there must have been first thrown up three or four hundred car-loads of sand. That would run clear for perhaps three, or four, or five months, and then sand would begin to come, and we would have to throw it open and exhaust the sand again. That would vary in different localities, but the same distinguishing features remain in reference to them all. It is said that the water varies in different localities, and that is so. In Brown County the water is very soft. In other places it is very hard. My idea is that it receives local coloring from the ground through which it passes.

Senator **REAGAN.** We have had the statement made here that the first water coming through one well was soft and that at a lower depth the water that came from the same well was hard; so that the same well brought up different characters of water, according to the stratum from which the several varieties of water came.

Mr. **SKILLMAN.** I am not aware that there are different strata, in reference to this matter, in the James Valley. There are two or three depths which are reached going down where water sufficient, perhaps, to get to the pipe will be found.

Senator **REAGAN.** That is in the artesian vein proper?

Mr. **SKILLMAN.** Yes.

The **CHAIRMAN.** Have you observed with care the "capping" or the rock that lies over the water-bearing rock? Might it not, in one place, contain more lime than the capping in another place?

Mr. **SKILLMAN.** I only know by what the men have told me who have been putting down the well. They told me what their drill struck.

The **CHAIRMAN.** But the character of the water on the rock would probably be governed somewhat by the character of the rock that contains the water, not perhaps so much in the rock itself, but if the water had a casing of a different material it would be affected by it. This sedimentary rock is sometimes lime and sometimes something else; occasionally it is slate.

Mr. **SKILLMAN.** Yes. But here are all these strata that are above this water-bearing rock.

The **CHAIRMAN.** I allude to the casing or stratum that is just over it. The casing of the material in that stratum might make a difference in the water.

Mr. **SKILLMAN.** Yes; I think it might.

The **CHAIRMAN.** I have found a change in such water. It was either harder or softer in some cases, and by examining the casing of the water-bearing stratum it was found, or at least believed, that that was what made the difference. Of course, the water is pressed very hard against the casing. Slate and limestone are so much alike, and formed in so much the same way, that the casing might gradually taper off from limestone into slate, or *vice versa*.

Mr. **SKILLMAN.** Yes. I will say here that this shale is somewhat like stone, but as you expose it to the air, you can crumble it up with your hand.

With reference to the capacity of the wells, and as to whether the flow of one well affects the flow from another, I will say that one of our wells is 300 or 400 feet away from the other and does not seriously affect it. When we open one well it will perhaps affect the other by a matter of 10 or 12 pounds pressure, so that there is something like communication between the two wells.

The **CHAIRMAN.** From the description of the thickness of this sandstone that carries the water—if it be a fact that the sedimentary rock extends to the Rocky Mountains, as you think it does, and that it runs north and south so that it receives the snow from that great water-shed and extends for a long distance—if that be correct, then you have a supply of water that you can not exhaust, for artesian wells depend upon supply and demand, just the same as other things.

Mr. **SKILLMAN.** I got the analysis that was made of our water, showing only a trace of organic substance, which would seem to indicate that it did not come from lakes or anything of that kind.

The **CHAIRMAN**. Did Mr. Moore state to you the experiments which led him to the conclusion that this sand-rock led from the Rocky Mountains down?

Mr. **SKILLMAN**. I can not say that he gave me any reason for his statement or conclusion in that matter; if he did I don't remember it; I do remember, however, that he held to that view.

The **CHAIRMAN**. If your theory be true, is it not a sufficient reason for the force with which the water came, without reference to gas?

Mr. **SKILLMAN**. Yes; that would be so. Because as you go west through this James Valley, the Missouri River is higher than the valley. The bed of the Missouri River is at least 150 feet higher than the bed of the James Valley. I know of the survey that was made from La Moure, which is north of here, and the engineer who made that survey told me that he took the level of the sand of the Missouri River at Pierre, and it was over 150 feet higher than the James River Valley. But still that would not give us our source. The rule is, as I understand it, that for 15 pounds of pressure there would be a rise of 33⅓ feet; with our wells, then, it would go to the top of the stand-pipe, something like 400 feet. That would be its natural feed.

The **CHAIRMAN**. That would be true but for the obstruction in the rock itself, which would take off some pressure.

Mr. **SKILLMAN**. Yes; of course the pressure would be less when you got towards the top. But if it comes from some source elsewhere the head would be higher.

The **CHAIRMAN**. But if it went a long distance, say 300 or 400 miles, would not the friction in passing through the sand retard the water so that if it did rise at all it would rise slowly?

Mr. **SKILLMAN**. Yes; unless there was a continuous body of water.

The **CHAIRMAN**. Have you ever seen experiments through a pipe of even-bodied water, and noticed what a long time it takes to get the water through, by reason of the friction? Take, for instance, a pipe 10 miles long and an inch wide; it would take a good while to get any water through that pipe.

Mr. **SKILLMAN**. Yes. I submitted to certain gentlemen connected with State institutions in Minnesota a question concerning our wells, and saying "Here is a pipe, say 1,000 feet long, and we have a certain amount of pressure given to the water," I asked the question, "What will be the daily flow or the flow per minute through that pipe?"

The **CHAIRMAN**. That is a pretty nice mathematical problem.

Mr. **SKILLMAN**. The answer I got was a difference of from six to nine million gallons per day.

The **CHAIRMAN**. That is, that you would discharge from six to nine million gallons per day through that pipe?

Mr. **SKILLMAN**. Yes. None of them put it lower than 6,000,000, and some of them put it as high as 9,000,000.

The **CHAIRMAN**. Describe the soil of this section.

Mr. **SKILLMAN**. There is first a loam of several feet, and then there is a subsoil of clay.

The **CHAIRMAN**. How is that as to holding water?

Mr. **SKILLMAN**. It is almost impervious to water. That is, the water will come until it strikes the subsoil, and then it comes very slowly. The subsoil does not let it up very quickly.

The **CHAIRMAN**. Suppose you have a ditch where there is a gentle incline, have you ever observed how it has dampened the soil on either side for a long distance?

Mr. **SKILLMAN**. Yes, I have; and when we put down our last city well, last fall, before getting the flow of it properly arranged for, it ran over a farm adjacent to the town. The result is that the owner now has a crop of not less than 30 bushels to the acre, whereas, where the water did not touch the land, the crop is hardly worth cutting.

At Groton there was some defect in putting down the pipe, and the water ran all the time. It ran over one man's land, and he sued the city, but without regard to the suit the results of the overflow were that he has had very much better crops where the land was flooded than where it was not. There is no doubt that the water is abundant, and wherever there is seen to be an abundance of water the effect of it is seen on the trees and vegetation in the neighborhood. I think it is putting it mildly to say that it will more than double the productive function of the land. We have the soil here, and we have the sunshine, and all the rest would come if we had the water.

The CHAIRMAN. Would you regard as valuable to this community an examination of the country from here to the Rocky Mountains with a view of ascertaining the extent of this belt of water, and its source?

Mr. SKILLMAN. I would regard that as of very great value.

The CHAIRMAN. If it were ascertained that this supply came from a source that was inexhaustible and might be relied upon with certainty within given limitations, would that encourage the owners of the land to sink wells?

Mr. SKILLMAN. Yes; it would then give a fixed value to the land in this neighborhood. It would give a permanent value to all investments here. We know that the water is here, and if we have a fair assurance that the water will continue, at least during our lifetime, we know what the effect will be on the land and on the products of the land. My estimate is that whereas the land is now worth from $8 to $10 per acre, if the water beneath it could be utilized it would make a difference in the intrinsic value of the land to the extent of $50 per acre, and I think that is stating it mildly.

The CHAIRMAN. The making of that investigation and ascertainment of the facts are within the functions permitted by Congress in the appropriations already made.

Mr. SKILLMAN. But it seems to me that wells might be put down experimentally for the purpose of ascertaining the localities and making certain that the water is to be continuous. I did not expect to make any statement before the committee with respect to this matter to-day, and I have therefore spoken wholly from memory. If there are any other matters upon which I can inform the committee I will be glad to do so in writing.

The CHAIRMAN. Can you state to us the cost of the wells at Aberdeen?

Mr. SKILLMAN. The cost of the first well was not far from $4,000, the people not knowing just what they would have to go through or what precise amount of boring or piping was necessary at that time; now they have contracted for wells at about $3,000 each.

The CHAIRMAN. If the business of digging wells were carried on largely, what would be about the probable cost?

Mr. SKILLMAN. From $2,000 to $2,500, and it would be done at a profit at that rate.

STATEMENT OF EDWARD STERLING, OF HURON, BEADLE COUNTY.

The **CHAIRMAN.** What is your occupation?

Mr. **STERLING.** I am farming.

The **CHAIRMAN.** Are you familiar with the farming lands of this locality?

Mr. **STERLING.** I am.

The **CHAIRMAN.** And their market value?

Mr. **STERLING.** I think I am.

The **CHAIRMAN.** What is the market value of improved lands outside of the immediate vicinity of towns?

Mr. **STERLING.** I should say $5 or $6 an acre, under the present condition of things.

The **CHAIRMAN.** What is the market value of unimproved lands in the same locality?

Mr. **STERLING.** There is but little difference between the unimproved and the improved.

The **CHAIRMAN.** What is the general character of the improvements?

Mr. **STERLING.** There are some very good improvements, but they are of all classes. When people first came here they were poor, and they have about held their own. They have not improved very extensively.

The **CHAIRMAN.** Have you seen any of the effects of irrigation on lands?

Mr. **STERLING.** I have not. Let me say to the committee that I raised, perhaps, about the first crops that were raised in this county. That was nine years ago. At that time we had a big snow-fall in the winter, and the lake beds were pretty full, so that they provided a sufficient moisture for the next two years. In those seasons our crops were magnificent. Everything that was put in the ground was a success. But from that time it has been gradually growing worse. There has been almost nothing produced, and values have decreased very much.

The **CHAIRMAN.** What would be the value of the same lands of which you have been speaking, provided you were sure of sufficient moisture each year?

Mr. **STERLING.** The change would be astonishing. I should say the difference would be from $25 to $50 an acre. Lands would sell readily here if we had sufficient moisture, and they would sell readily at that price.

The **CHAIRMAN.** Do you think it would make all that difference?

Mr. **STERLING.** I certainly do. At the opening out of this country, when we had sufficient moisture, everything grew luxuriantly, and the lands were sought for at $10 an acre in their raw state. You could get $1,500 or $2,000 for a quarter-section. To-day they go begging at $300 or $400, simply for the want of moisture.

Adjourned.

NORTH DAKOTA DIVISION.

ON THE TRAIN AT JAMESTOWN, N. DAK.,
August 4, 1889.

The committee met pursuant to call of the chairman.

Present: Messrs. Stewart (chairman) and Reagan; also Director Powell.

STATEMENT OF WARREN UPHAM, OF THE GEOLOGICAL SURVEY.

The **CHAIRMAN**. What is your occupation?

Mr. **UPHAM**. I am a geologist; at the present time an assistant of Major Powell, of the U. S. Geological Survey.

The **CHAIRMAN**. Where have you been operating?

Mr. **UPHAM**. The field especially assigned to me for observation, and which I am to make a description and draft maps, is the valley of the Red River of the North, in Minnesota and Dakota. It is a great plain. It is the famous wheat region of northwestern Minnesota.

The **CHAIRMAN**. What is the geological formation of that valley?

Mr. **UPHAM**. It has a surface of lacustrine lake deposits, and beneath that a thickness of 150 feet on an average of drift.

The **CHAIRMAN**. What do you mean by that?

Mr. **UPHAM**. Glacial drift; ordinary glacial drift. The glacial drift is chiefly a stony clay, and is found after you get beneath the lacustrine lake deposits.

The **CHAIRMAN**. What are we to understand you to mean by lacustrine lake deposits?

Mr. **UPHAM**. The valley was occupied by a lake, and in it there were brought by tributary streams considerable deposits of fine silt and sand. That is to be found over a considerable part of this Red River flat.

The **CHAIRMAN**. Would that be called clay?

Mr. **UPHAM**. Yes, it is clay, although a fine sand. It is commonly called clay. It contains clay, but it is a fine sandy-clay silt. It is suitable for making bricks.

The **CHAIRMAN**. That is what you first find?

Mr. **UPHAM**. Yes; it is.

The **CHAIRMAN**. Underneath that you find what?

Mr. **UPHAM**. There is over the entire valley a silt of over 150 feet thickness on an average, and varying from 100 to 200 feet of glacial drift. It is a stony clay, different from the other in this, that it has gravel and sand in it.

The **CHAIRMAN**. What makes you come to that conclusion?

Mr. **UPHAM**. We see the material where it has been thrown out.

The **CHAIRMAN**. What do you find beneath that?

Mr. **UPHAM**. There is water in most of the wells, and coming in such quantities from the sand beds that the wells can proceed no farther. Accordingly we could not judge from that kind of observation what there is beneath.

The CHAIRMAN. Below this formation is there a stratum that is impervious to water.

Mr. UPHAM. Yes; the glacial drift, as I denominate it, is practically impervious to water. It holds the water down. The water that gets into the lower parts of the sand beds will be held down.

The CHAIRMAN. What is beneath this stony clay? What do they find immediately under it?

Mr. UPHAM. I think that the water is found in the gravel and sand beds pertaining to the glacial drift formation.

The CHAIRMAN. After you pass this stony clay, what do you then find?

Mr. UPHAM. Of most of the Red River Valley there is no knowledge deeper than the water-bearing bed of gravel.

The CHAIRMAN. Then you meet with sand and gravel?

Mr. UPHAM. There have been veins of it in the stony clay, and we may presume that there is stone and gravel at its base. Some of the artesian wells get their flow from the base of the glacial drift.

The CHAIRMAN. What do you mean by that?

Mr. UPHAM. The bottom, where there is no more glacial drift below, and then the wells come to the water-bearing beds of sand and gravel. Some wells go deeper, but that does not pertain to any artesian flow. The artesian flows in that valley are wholly from the drift and underlying sand river.

The CHAIRMAN. First you went through a formation which is commonly called sand, very fine sand, and some clay?

Mr. UPHAM. Sand, clay, and silt.

The CHAIRMAN. Then you come to clay with gravel in it, which clay and gravel is pretty hard and impervious to water, as I understand you?

Mr. UPHAM. And a good many pieces of stone; some large enough to be called boulders.

The CHAIRMAN. And below that you find sand?

Mr. UPHAM. Ordinarily; the artesian flows come from sand and gravel. They are obviously contained within the glacial drift. They are little veins or stream courses through sand and gravel.

The CHAIRMAN. You have not traced any one water-bearing formation of sand that can be identified over the country generally?

Mr. UPHAM. It can not be stated that the water-bearing stratum is a unit over this valley. We do not suppose it to be a unit. I remember the town of Grandin, which, the best my memory serves me, is in the Red River Valley, in Dakota. That town has four wells. These wells surprised me; and I know Hillsboro is a similar case. Taking Grandin, for example, and Hillsboro give us similar facts—these four wells, one 100 feet, one 50 feet, and two 250 feet, are within a radius of a quarter of a mile.

The CHAIRMAN. They have not found any general water-bearing strata through the country?

Mr. UPHAM. It is a water-bearing stratum in that case, but not so generally. This is exceptional. They seem there to be shallow streams—courses pinched out in places, the clay above and the clay beneath pinch them—and in places the sand and gravel bed is pinched; that is to say, reduced to nothing; the drill then goes through that and strikes some stream bed.

The CHAIRMAN. How prolific are they in furnishing water?

Mr. UPHAM. Their projection is small, in diameter about an inch, The stream is rarely 3 or 4 inches.

The **Chairman.** They are not used for irrigation purposes?

Mr. **Upham.** They have never been used for that purpose. They are bored by the towns, and are used for domestic purposes. Such a well is serviceable to supply a small village, say, of 250 inhabitants, as Ada, in Minnesota. The people of that village get their drinking water from a single well. The stream is not larger than a pencil, and it flows out of the pipe and comes down in a curve very soon. Though it is very small, it supplies all the water in the town.

The **Chairman.** They do not use irrigation there?

Mr. **Upham.** No; they have sufficient rain.

The **Chairman.** That matter has not been considered there?

Mr. **Upham.** No; it is not a practical question.

The **Chairman.** You have moved forward here into a region where irrigation would be beneficial.

Mr. **Upham.** It would be beneficial for many years.

The **Chairman.** Have you ever been in a country where irrigation is practiced?

Mr. **Upham.** I have not been in a country where irrigation is practiced. I have read of it.

The **Chairman.** You have not been farther west than Dakota?

Mr. **Upham.** I have not been west of this mark. [Indicating on a map.] My work has been extensive in Minnesota.

The **Chairman.** I would like to ask if there is any practical purpose to which you could put your work?

Mr. **Upham.** Is that a relevant question?

The **Chairman.** Will you explain any practical good that will result from your investigation?

Mr. **Upham.** I feel free to do that, but I do not consider it a legitimate part of your report.

The **Chairman.** I maintain that any one who is engaged in scientific investigations should show some practical benefit that will come from them.

Mr. **Upham.** I would gladly do so for your benefit, or for the benefit of anybody else who has an interest in them. But I do not think it should be legitimately incorporated in a printed report concerning this interview.

The **Chairman.** I wish to see what relations they bear to this world—the uses of man. And it is certainly legitimate to an inquiry in relation to irrigation, so far as that is connected with geology.

Mr. **Upham.** As a valid basis for Government appropriations, it is true some economic advantages ought to be shown. I think that is the only way we can place it before the tax-payer and ask him to assist in our researches.

The **Chairman.** That is the object of my inquiry.

Mr. **Upham.** Under that preliminary statement, and considering the U. S. Geological Survey in a very different manner from what I would ordinary geological investigations, I should say that these investigations will be the means of inducing immigration. If you were to ask me the use of geological investigations generally, I should say that they were of an educational advantage—an intellectual advantage to the people at large. But as a justification for the expenditure of public money, we must show some economic advantage. They are of great advantage to immigration. In all these new States it is considered of great advantage to bring in settlers; the people want neighbors; they wish to build up towns; and my work as a surveyor in this region is of great importance to induce immigration.

The CHAIRMAN. Of what advantage are your investigations to the State and the immigrants?

Mr. UPHAM. Having made these investigations we are able to set forth a truthful, a clear, a comprehensive, a full, and complete statement of the geographical and geological condition of the country, of the material resources and agricultural advantages of this whole district. In order to do this a full and complete investigation should be made. Unless there be a plain and truthful statement of the condition of the soil and the climate the right kind of settlers will not come.

The CHAIRMAN. There are not over the country where you have been examining any excavations or borings that gave you any idea of the formation under the ground?

Mr. UPHAM. The stream-courses and natural outcroppings of the rock in continuous districts enable us to determine the structure of what is underneath without boring underneath; and that is the case for a good part of the Red River Valley. Underlying a part of the Red River Valley of the North is Cambrian.

The CHAIRMAN. What kind of rock is that?

Mr. UPHAM. All sorts of rock formation are included in the Cambrian, as in the Cretaceous. We refer to the age of the rock when we use that term.

The CHAIRMAN. What kind of rock does it contain?

Mr. UPHAM. Limestone, sandstone, and all kinds of conglomerate and slate.

The CHAIRMAN. Does it contain granite?

Mr. UPHAM. No; granite is not contained there; it is a fossiliferous formation.

The CHAIRMAN. Take granite that has been by heat or by chemical action of some kind changed from its original condition, would that be found in the Cambrian?

Mr. UPHAM. No; I think not. Of course this is hardly relative to the case. Yet some geologists maintain that the Cambrian and all other rock formations down to the latest contain granite.

The CHAIRMAN. Do you regard geology as a science?

Mr. UPHAM. Certainly.

The CHAIRMAN. Have you any further facts or statements to offer?

Mr. UPHAM. I have some brief data I prepared in relation to artesian wells in the Dakotas, and as to the evidences also of periodic variations of rain-fall as shown by the levels of the lakes east of us, which I would like to present.

The CHAIRMAN. You may proceed.

Altitudes of lakes and rivers in North Dakota, determined by railway surveys.

	Feet above the sea.
Devil's Lake, August, 1887 (probably 1½ feet higher than now)	1,431¼
Devil's Lake, lowest and highest stages during the past ten years	1,430-1,434
Stump Lake, about 5 miles southwest of Devil's Lake, August, 1887	1,417
Red River of the North:	
At Wahpeton, low and high water	943-958
At Moorhead and Fargo	866-898
At Grand Forks	784-828
At St. Vincent and Pembina	748-788
At Winnipeg, Manitoba	723-763
Lake Winnipeg	710
Sheyenne River:	
At bridge of the Jamestown and Northern Railroad, Sheyenne	1,410
At Valley City	1,200
At Lisbon	1,064
At mouth, junction with the Red River	857

James River:	
At New Rockford	1,502
At Jamestown	1,382
At La Moure	1,289
Lake Columbia, nearly 30 miles long	1,286
At Huron	1,228
At mouth, junction with the Missouri, extreme low and high water.	1,150–1,195
Missouri River:	
At mouth of the Yellowstone, near Fort Buford and west boundary of North Dakota, low and high water, about	1,860–1,885
At mouth of the Little Missouri River, about	1,740
At Bismarck, extreme low and high water	1,618–1,646
At mouth of the Cheyenne River, about	1,460
At Pierre, South Dakota, low and high water	1,426–1,445
At Yankton, low and high water	1,157–1,198

Altitudes of track at railway stations in North Dakota.

	Feet.		Feet.		Feet.
Wahpeton	965	Casselton	934	Dickinson	2,405
Fargo	905	Buffalo	1,202	Medora	2,267
Grand Forks	830	Tower City	1,172	Glendive, Mont	2,069
Grafton	827	Valley City	1,230	Milnor	1,097
Neche	831	Spiritwood	1,479	La Moure	1,307
Larimore	1,134	Jamestown	1,408	Cooperstown	1,428
Devil's Lake	1,464	Eldridge	1,541	Carrington	1,524
Towner	1,479	Windsor	1,840	Fort Totten station	1,566
Minot	1,562	Steele	1,859	Minnewaukon	1,561
Bottineau	1,639	Bismarck	1,670	Sykeston	1,628

Mr. UPHAM. Hundreds of artesian wells 50 to 300 feet deep are obtained in the drift of the flat plain of the Red River Valley. Such wells can be had nearly everywhere within 10 to 20 miles from the river, both in Minnesota and North Dakota. South of Blanchard and Hillsborough they commonly supply fresh water, but northward it is almost invariably brackish, yet good for constant use to water cattle and horses.

Grafton artesian well, 915 feet deep; being drift, 298; Cambrian strata of limestone, sandstone, and shale, 605; Archean granite, 12 feet. The water, which is taken from a depth of 438 feet, is only slightly brackish, deeper flows being shut off because they were very saline. It flows (in August, 1887) through 6-inch pipe 40,000 barrels per day, or about 1,000 gallons per minute.

Devil's Lake artesian well, 1,511 feet deep, being drift, 25; cretaceous (Fort Pierre) shale, 1,403; very hard layer of gravel cemented by pyrite, 3 feet, and fine white or light sandstone, 80 feet. The water (brackish) rises from this sandstone, flowing through 3½-inch pipe 1,800 barrels per day. This well, in height above sea, depth bored, and section passed through is closely like the Jamestown well.

Tower City artesian well, 670 feet deep, being drift, 163; the Fort Pierre shale, 502, and sandstone supplying the water, 5 feet. This may be a sand bed within the Fort Pierre formation. The water flows at rate of 9½ gallons per minute, and when piped is capable of rising to a height of 33 feet above the surface.

Jamestown artesian well, 1,476 feet deep, being mainly the Fort Pierre shale, but reaching sandstone at bottom. Pressure of water at surface, 100 pounds per square inch; temperature, 70° Fahrenheit. I find no exact record of the section passed through by this well, and should be very glad to obtain it, if any one has preserved such record.

Aberdeen artesian well, South Dakota, 904 feet deep, being drift, 94, and the Fort Pierre shale, 810 feet, to sandstone at bottom, after passing through a very hard layer about 10 inches thick. Pressure, 140 to 160 pounds per square inch; temperature, 60°. The water, though saline, is pronounced very wholesome by physicians, and is much used for domestic purposes. It is drank by stock in preference to any other water.

The Grafton well takes its supply of water about 400 feet above the sea level. The wells of Devils Lake and Jamestown go slightly below the sea level; that of Tower City stops 500 feet above the sea, and the wells at Aberdeen, which are 1,300 feet above the sea, obtain their supply 400 feet higher than those of Jamestown and Devils Lake. All these wells, excepting that at Grafton, are in the Fort Pierre shale, which stretches from north to south across a broad belt of North Dakota west of the Red River valley. Within this belt, upon a width of a hundred miles or more, the conditions for obtaining artesian water are similar to those represented by the wells of Devils Lake, Jamestown and Aberdeen.

The stumps and fallen trunks of trees of a submerged forest in Stump Lake indicate that probably one hundred or two hundred years ago, or perhaps longer ago, it held for a long time a level several feet, at least 5 to 10 feet, lower than now. But a distinct shore line 15 feet above Devil's and Stump Lakes, below which shore line trees have not yet become established, proves that within a recent time, probably not more than forty or fifty years ago, these lakes held that higher stage. Within the past six years these lakes have fallen 4 or 5 feet. These recent fluctuations of the lake levels are dependent on increase and diminution of the average rain-fall.

Further evidence of periodic variations of rain-fall, a series of dry years being succeeded by others of plentiful rains, is supplied by the fluctuations in the levels of the great lakes tributary to the St. Lawrence. These lakes attained their highest stage, within our knowledge, since the coming of white men, in 1838; and they were nearly as high in 1814-'15 and 1788. Since 1838 they have reached maximum stages in 1847, 1858, 1870, and 1882. The lowest known stage of the great lakes was in the winter of 1819-'20, when Lake Erie was 6 feet lower than in 1838. In 1796 it was 5 feet lower than in 1838. Other years of low stage of the lake levels, mostly somewhat less remarkable, were in 1841, 1853, 1865, and 1875. These maximum and minimum stages of the great lakes have thus alternated in cycles of about a dozen years, in which comparatively scanty average rain-fall for several years was followed by unusually abundant rain-fall.

STATEMENT OF T. F. BRANCH, OF JAMESTOWN.

The CHAIRMAN. You are a surveyor and engineer?

Mr. BRANCH. Yes.

The CHAIRMAN. And have been engaged in your profession in this town for how long?

Mr. BRANCH. The last eight years.

The CHAIRMAN. Are you familiar with the artesian well that has been sunk here?

Mr. BRANCH. Yes.

The CHAIRMAN. Will you describe the material through which the drill passed in boring that well, and also the size of the well?

Mr. BRANCH. There are two wells here; one in town and one on the bluff west of here.

The CHAIRMAN. What is the depth of the well out of town?

Mr. Branch. Thirteen hundred and twenty-one feet.

The Chairman. Will you give the different kinds of material through which the drill passed?

Mr. Branch. There was 1 foot of soil that is black loam; 40 feet of clay subsoil; 49 feet of pure fire clay; quicksand with limestone boulders and pieces of lignite coal, 20 feet; shale and limestone gravel, 100 feet; light-colored shale, which slacks when exposed, with seams of soapstone running through it, 150 feet; shale, very dark in color, 200 feet; shale, in layers of dark and light colors, 400 feet; sand and slate formation, 40 feet; light-colored, rocky, rotten shale, 250 feet; iron, almost pure, 1 foot; water, of bad quality, 39 feet—

The Chairman. There was some other material beside water—not just clear water.

Mr. Branch. This was taken by the man who drilled the well. I suppose he struck a basin of water there. Black, rotten shale, 30 feet. That takes it to a depth of 1,321 feet, where it was abandoned. They got into the quicksand there and had trouble with their tools, etc.

Senator Reagan. Where was that?

Mr. Branch. Out of town.

The Chairman. That well was abandoned?

Mr. Branch. Yes.

The Chairman. What is the depth of the one in town?

Mr. Branch. Fifteen hundred and seventy-six feet.

The Chairman. You have not the formations through which the drill passed there?

Mr. Branch. No.

Senator Reagan. What is the difference in the altitude of the surface of the well in town and the one out?

Mr. Branch. One hundred feet.

The Chairman. The one at the asylum is 100 feet high?

Mr. Branch. Yes.

The Chairman. Have you any account of the sandstone formation in which the water was found?

Mr. Branch. No.

The Chairman. No description of that water. Have you any description of the kind of material the drill passed through immediately before they struck the water?

Mr. Branch. Sand, I believe.

The Chairman. Was there nothing hard over it—no capping over the sand?

Mr. Branch. Yes; sand-rock. The water was found in the sand.

The Chairman. Was there not a capping to the sand-rock—hard capping?

Mr. Branch. Yes.

The Chairman. Then they came to the sand-rock which contained the water?

Mr. Branch. Yes.

The Chairman. You do not know how deep they went into the sand-rock?

Mr. Branch. No.

The Chairman. What kind of water does this well furnish?

Mr. Branch. It flows 375 gallons per minute.

The Chairman. Has the water been allowed to run out in places to show the effect it would have in fertilizing the soil, nourishing vegetation?

Mr. Branch. Yes; I do not know whether it produces vegetation. It is used for household purposes.

The Chairman. Is it good water for that purpose?

Mr. Branch. Yes. It is drunk when it is cold; it is too warm to drink at first.

The Chairman. Of what temperature is it when it comes from the well?

Mr. Branch. Seventy-five.

The Chairman. Have you ever been in a country where they irrigate?

Mr. Branch. No.

The Chairman. So that the matter of irrigating, raising crops in that way, has never attracted your attention?

Mr. Branch. No.

The Chairman. Are you familiar with the Missouri River?

Mr. Branch. I have seen it; yes.

The Chairman. You have never examined it with a view to diverting it upon the land; taking it out of its bed?

Mr. Branch. No. I was in the Yellowstone Valley when they commenced their ditch.

The Chairman. In what part of the valley?

Mr. Branch. Billings. I was there laying out the town. The main thing we use the water for here is for protection against fire. We have 3 miles of pipe.

The Chairman. Would it not be an advantage to have irrigation here?

Mr. Branch. I think so.

The Chairman. Would it not be a good thing to have full crops each year? Would not the farmers be better off?

Mr. Branch. They certainly would.

The Chairman. Are you a judge of the price of land about here?

Mr. Branch. Yes.

The Chairman. You have surveyed land here?

Mr. Branch. Yes.

The Chairman. When you get away from the immediate effect of the city, in farming land, out 2 or 3 miles from the city what is it worth an acre?

Mr. Branch. Do you mean wild land?

The Chairman. Yes.

Mr. Branch. About $2 an acre.

The Chairman. What are cultivated lands worth?

Mr. Branch. For cultivated land add $3 or $4 an acre.

The Chairman. That is, $3 or $4 more?

Mr. Branch. Yes.

The Chairman. That would make $6 or $7 an acre?

Mr. Branch. Yes.

The Chairman. What would the land be worth if it produced such crops as you had in 1881; that is to say, produced such crops every year?

Mr. Branch. It would be worth $10 an acre.

The Chairman. Do you think $6 an acre would be a fair average price for the land?

Mr. Branch. Yes.

The Chairman. The land is now worth $7 an acre; if irrigated, $10 more would be $17 an acre. I think one of these wells would irrigate a township. Say it would irrigate half the township, 18,000 acres of land

That would be $4 an acre. Eighteen thousand acres at $4 an acre would be $72,000 additional outlay. Would it not be a pretty good speculation to sink a well and divert it over the land in order to gain this $72,000?

Mr. **BRANCH.** Wells do not cost more than $5,000 or $6,000.

The **CHAIRMAN.** And your ditches would cost $5,000 or $6,000 more, probably?

Mr. **BRANCH.** Yes. That at $10,000 or $12,000, would be a good speculation.

The **CHAIRMAN.** You could irrigate a half-township. If you could do it at all with this water, you could do it certainly with $20,000. That would be making, on your basis, $50,000. But I think the land would be worth a good deal more. I think the lands would be worth $50 an acre here, pretty soon, if they produced such crops as you had in 1881.

Mr. **BRANCH.** I am taking the population as it is now. There are no buyers here now. When there are more buyers it will be worth more, of course.

The **CHAIRMAN.** Is not that what has checked emigration, the fact that you have these dry seasons here? If you could have such crops here as you had in 1881, every year, would there not be a rise in the emigration?

Mr. **BRANCH.** I think so; yes.

Senator **REAGAN.** Have there been other wells sunk in this region of country?

Mr. **BRANCH.** Not as far north as this, except at Devil's Lake.

Senator **REAGAN.** How far north is that?

Mr. **BRANCH.** About 100 miles.

Senator **REAGAN.** Do they get water there?

Mr. **BRANCH.** I do not know whether they struck water there or not.

Senator **REAGAN.** Do you know, Mr. Casey?

Mr. **CASEY.** Yes; they got water, and they had trouble by its choking up with sand.

The **CHAIRMAN.** I understand there is an abundance of water there?

Mr. **CASEY.** There is abundance of water, but not much culture. They did not get through the sand with the pipes.

Adjourned.

BISMARCK, N. DAK., *August* 5, 1889.

The committee met pursuant to call of the chairman.

Present: Messrs. Stewart (chairman) and Reagan; also Director Powell.

STATEMENT OF R. M. STEVENS, OF LISBON, RANSOM COUNTY.

The **CHAIRMAN.** What can you tell the committee with regard to irrigation and the need of it in this part of the country?

Mr. **STEVENS.** I desire to say that I did not come here to give the committee any special information on the question of irrigation, but after having heard what you said of irrigation and its benefits, I prepared a rough draught of Ransom County, and would be prepared to furnish, if desired, a perfect map of the county, bearing upon the subject of which you spoke, which you may have to look over at your leisure.

I have resided in this Territory since 1882, and as a rule we have had sufficient rain-fall to insure us good crops. But this year, the first one in our history, the crops are almost a total failure. We have had a practical failure of crops in about 80,000 acres of land that can be irrigated for less money than any other land that I know of in Dakota. Ransome County is a county composed of twenty-four civil townships, being 24 by 36 miles square. The Cheyenne River, a river rising above in the mountains and running 500 miles to where it connects with the Red River of the North, runs through Ransom County. There are 63 miles of the river in the county. The average width of that valley on either side, taking the whole course, is about 2 miles, which would make 80,648 acres of valley land, all of which can, I think, be irrigated by water taken from the Cheyenne River.

The valley is particularly level in all its parts. There is no slough, nor is there any particular elevation in the valley. The bluffs on either side seem to run very regular throughout the whole county; and there are not, as you will find in the Missouri Valley, juts of hills running out into it, and then breaking away. You will find that it is very level all the way through. By a system of water-works, in the way that has been suggested by the chairman of this committee, a large amount of land can be irrigated from the Cheyenne River alone.

There is also in Ransom County a tract of land which runs across the county, and also through the counties of Sargent, Marshall, Day, and the counties south almost to Sioux City, Iowa, which seems at some time to have been the basin of the river. That tract in my county comprises 95,000 acres of land, which, if artesian wells were dug, could be irrigated without any trouble of ascent or descent in the irrigating system. It is practically a level system, running from north to south, and at a fall of about 1½ feet to the mile.

The CHAIRMAN. Have you experimented at all with artesian wells there?

Mr. STEVENS. No; we have not any artesian wells in the county.

The CHAIRMAN. What is the nearest artesian well to your place?

Mr. STEVENS. The nearest to us is at Pierre City.

The CHAIRMAN. Are there any small streams, lagoons, or ravines running into the mountains or higher lands, from that county?

Mr. STEVENS. No; it is a perfect valley, as if it had been the bed of a river.

The CHAIRMAN. Are there not places where you could make reservoirs?

Mr. STEVENS. There are places where artificial reservoirs could be made; none others; at least not in this tract. There are on either side of this tract hills, with what in this country we call "coulées." It is simply a break between two hills, where the water finds its way. By stoppage of those, artificial reservoirs could be made down that tract of level land.

The CHAIRMAN. And in case the artesian wells should fail you might store water in the wet seasons to help you out in the summer.

Mr. STEVENS. To be candid with you, and tell the actual facts as they exist, I don't believe that enough water could be collected in that way from reservoirs that could be made in these coulées to be of any practical account. There might, however, be reservoirs made that would store artesian waters in that way. They would make good storehouses. But, so far as the natural fall of water is concerned, I don't believe these places are of sufficient size to accumulate water so as to be of practical benefit in that way.

The **Chairman**. Has there been any examination made to see what basins there were in your region?

Mr. **Stevens**. No. I am very familiar with the entire area of land in our county, so far as an individual may be familiar with it who has no particular views upon irrigation. But although I have never looked at the land with regard to the question of irrigation, I know that if I were to go back now and look at it with that subject in view, I should be able to make my statements here more to the point. There are places on either side of the Cheyenne River which could be utilized for the storage of water without any material injury to the land around it.

The **Chairman**. How much water flows into the Cheyenne River?

Mr. **Stevens**. I don't know.

The **Chairman**. How much at any one time?

Mr. **Stevens**. The river on an average is about 60 to 80 feet wide, and is on an average from 6 to 12 feet deep. At this time of year the river is very low. There are places where people can run across it dry shod without having to jump more than a few feet. But in the springtime the water coming down from the mountains, where it melts, always gives us a head of 18 to 20 feet on an average throughout our county. And I think the same will hold true through Barnes and other counties through which it passes.

The Cheyenne River also passes through Cass County and runs about 30 miles, with its angles, to the Red River Valley, entering into Red River near the railroad bridge where the train crosses coming from Fargo to Bismarck.

The **Chairman**. There would be no difficulty in making reservoirs on the branches of that river to increase its capacity, if there was not enough there?

Mr. **Stevens**. None through our county.

The **Chairman**. How would it be above that?

Mr. **Stevens**. I am not familiar enough with the topography of the country above to answer that.

The **Chairman** (to Major Powell). Do you wish, Major, to ask this gentleman about his part of the country?

Major **Powell**. No; I know very well the country he speaks of. What he calls "coulées" are very well adapted for the storage of the storm waters. But you remember you need only a little water there. It is only an occasional season that water is needed so far east as that. And it is easy to store water in the lateral valleys in that stretch of country.

Mr. **Stevens**. I think so.

Major **Powell**. Every two or three seasons there will be a dry year, when you will need two or three inches of rain more than comes from the heavens.

Mr. **Stevens**. I ought to add that the valley of the Cheyenne River comprises 80,640 acres, or approximately that. It has been the most productive soil of which we have any knowledge in this Territory while I have been in it, and is exactly the same kind of soil as that of the Red River Valley. This year, for the first time, the drought has taken every bit of the crops in our valley.

STATEMENT OF N. G. ORDWAY, OF BISMARCK.

The **Chairman**. The committee would like you to make such statement as you would desire with reference to the condition of this Territory in regard to irrigation.

Mr. **Ordway**. I came to this Territory in June, 1880, and assumed office as governor. I immediately passed up the Missouri River to Fort Sully, and crossing the Big Sioux reservation in the summer of 1880, passed up and down the streams and coulées in the Black Hills. After spending some time in examining the resources of the Black Hills, I came out across the country to this place, Bismarck. I have traversed that portion of the Territory between this point and Yankton three or four times since 1880. Also in 1880, 1881, 1882, and 1883 I visited the Red River Valley of the North. I have also passed through the Territory by wagon teams nearly all the way from Yankton to Totten, and have seen nearly all of the principal towns in the Territory grow up. I became strongly impressed in my first trip through the Territory with the idea that water could be stored, and that in most cases it could be accomplished in these soda and salt beds that we have, or lake beds, I suppose you might call them.

The **Chairman**. Are they of sufficient altitude to let the water upon the surrounding country ?

Mr. **Ordway**. Those dry lakes have held the water evidently a great many times, and they hold water now except in very dry seasons. It occurred to be that by the proper arrangement of their banks those natural lake beds could be very easily used as storage places for water, and that in addition to the water we would amalgamate and mingle the productive properties of those beds and have them for fertilizers onto the land. The alkali beds, as I understand it, are susceptible of the same productive uses as the ashes and the silt that we purchase in the East in large quantities to put on our eastern land; and it seemed to me that nature had compensated for the defects, you might say, of the soil in some places here, by leaving those beds in a condition to be utilized as fertilizers.

The **Chairman**. Do you allude to any particular locality where these beds exists ?

Mr. **Ordway**. They exist all over what might be called the arid portion or dry portion of the country. In the Red River Valley of the North, extending from Fargo north, the soil is of such depth and richness that there are very few of those beds. But all along the James River and all along the North Pacific line on both sides, after you leave Jamestown and until you strike the Montana line, you will find these beds almost all along and contiguous enough, in my judgment, to be useful for the purposes indicated.

The **Chairman**. Have they all outlets so that they would run down low before evaporation exhausted them ?

Mr. **Ordway**. This year they are not all run down. They had more rain-falls in this belt this year than they had for three years previously. This year, all along the Missouri to this point, we have had very little rain-fall; but late in the spring season we have had rains quite abundantly, and some of these beds have water in them.

The **Chairman**. When there is water in these lake beds is it very much impregnated with alkali ?

Mr. **Ordway**. Yes; very strongly.

The **Chairman**. Sufficiently strong to kill vegetation ?

Mr. Ordway. Yes; when they are very low. My idea would be that those beds would have to be raised and a sufficient volume of water accumulated so that it would be in the right condition to use and drain upon the soil. And in many places, it seems to me, even in the flood times of the Missouri in this direction, that gates might be so arranged that there could be held there much of the water which recedes. We have what we call the June rise. You know what that is. This year we had a pretty heavy rise.

Director Powell. In how much of this space do you think irrigation is necessary?

Mr. Ordway. A large portion of North Dakota and of South Dakota, bordering on the Missouri and James Rivers, until you reach Bon Homme County and the lower counties of South Dakota, ought to have water storage in order to be sure of the crops. But I do not think water storage in the Red River of the North is absolutely necessary.

Director Powell. How many crops have you raised in eight years?

Mr. Ordway. In 1880 they had a good crop here. They have cut on a stock farm here within a short distance of this town as good wheat as I ever saw; and all through here to Fargo and to Minnesota, and up the Red River, it was a splendid crop. But I do not think there has been since that more than one crop in three, on an average, in the James Valley or the Missouri Valley. I do not think the Red River Valley has ever had what you might call a real failure, except partially last year; the early frosts produced great damage in the Red River counties.

Director Powell. On the eastern portion of the Territory, in the eight years that you have been here, how many bad years have they had?

Mr. Ordway. In the eastern portion not more than two have been what you would call bad years. You can not expect big crops every year. But the yield of wheat has been from 10 to 30 bushels to the acre. In Walsh County, where I have a ranch, north of Fargo, and in Cass County, the third county north, they marketed two years ago 6,000,000 bushels of wheat, which produced a cash revenue of $4,000,000. That was the largest crop that they have ever had, and I think that Pembina and Grand Forks, to the north of Cass County, with other counties in the Red River Valley, did nearly proportionately as well in that respect.

Director Powell. How much timber have you in Dakota?

Mr. Ordway. There is quite a large amount of timber on the Red River and the rivers that start from the Turtle Mountains at the foot, and run into it.

Director Powell. That is the western portion?

Mr. Ordway. Northwestern portion. There are belts of timber on Souris or Mouse River, a half mile wide on each side, tall oaks standing, and on Park River and other rivers that find their source in the north; and we have an abundance of timber all through that portion of Dakota. Perhaps we do not appreciate that so much here, as we have coal in abundance—not right here, but across the river 40 miles. We have an abundance of coal that extends across the river into this county. In McLean County they have coal beds, and it can be put on the cars for $1.25 a ton.

Senator Reagan. What counties are those?

Mr. Ordway. The county across the river is Morton County, and the one just across here on this side of the river is McLean County. I think there is some in Burleigh County, and some in Stark County. Stark County is further north still. It is on the new line of road that parallels the North Pacific to Montana—Mr. Hill's road, the Manitoba road. There is a road extending from Grand Forks to Stark County, and in that county there are very fine deposits on that line.

I want to say one word about wells in the Red River Valley. At Grafton and other points you can get flowing wells at about 400 feet. It is the shortest distance I have seen them at any place in the Territory. In Grafton there is a very fine flowing well that they use for fire purposes, and they are about to make a park with a lake in it. That well flows in such abundance that there will be water enough to water the whole country. It even runs down the streets on each side. I have examined these wells, and I find that 400 feet is all that is necessary in that portion of the Territory. In almost every portion of North Dakota I think you will find that from 400 to 1,800 feet you will be sure of getting water. I think that all this western portion of North Dakota deserves your special attention, and that it will become a very fruitful country.

Senator REAGAN. Do you know whether the water in the well at Grafton was found in a porous sandstone?

Mr. ORDWAY. Yes; it was. It was found there, and I have specimens of it, but not with me now. It was that porous sand-rock, and it comes in great abundance from the mountains.

The CHAIRMAN. What is the depth of that well?

Mr. ORDWAY. Four hundred feet. Individuals are having them sunk for use in their houses. These are in addition to the one used for city purposes and fire purposes and the lake. They only cost $2 a foot.

The CHAIRMAN. Does the increase in the number of the wells perceptibly affect the flow?

Mr. ORDWAY. Not in the slightest respect.

The CHAIRMAN. What is the cap-rock that is immediately over the water?

Mr. ORDWAY. It is a pretty hard, blueish stone—a little blue. I do not know what you would call it.

The CHAIRMAN. Clay-slate, probably.

Mr. ORDWAY. Clay-slate I should say. I had a piece of it given to me the other day. I was out there the other day. The mayor of the city was laying out the park with a beautiful lake bed, and the water is all coming from this well which they have for fire purposes. They discard their engines and when they have a fire they just turn the water on and drown it out.

STATEMENT OF B. F. SPALDING, OF FARGO, CASS COUNTY.

The CHAIRMAN. How long have you resided in Fargo?

Mr. SPALDING. Nearly ten years.

The CHAIRMAN. What can you say as to the production of crops, whether the drought has interfered with them during the ten years that you have lived there?

Mr. SPALDING. There never has been a period of complete failure of crops from lack of rain-fall; but crops have been diminished by insufficiency of rain-fall. There has been no failure during that time. Last year we came the nearest to a failure; but that was owing to frost. But this season we will not have more than one-half or two-thirds of an average crop.

The CHAIRMAN. Have you considered all the benefits that might arise by using irrigation during the dry season?

Mr. SPALDING. I have not. Regarding the necessity of irrigation, I would extend Governor Ordway's limits a little farther east. I would say that, in my judgment, west of the western border of Cass County they can not get more than an average of one crop in two, if they can do that.

The CHAIRMAN. How far is that from the Red River?

Mr. SPALDING. Forty-three miles.

The CHAIRMAN. Outside of that strip of 43 miles along the Red River you would require irrigation to get regular crops?

Mr. SPALDING. I think so. And regarding wells, I would say that they have bored for them unsuccessfully in different parts of our county, while in other parts they find small streams. At Tower City, on the western border of our county, they have quite a large well, and also in Mayville, which is in Traill County.

The CHAIRMAN. To what depth did they go at Tower City?

Mr. SPALDING. Nine hundred and some feet.

The CHAIRMAN. What was the character of the water?

Mr. SPALDING. It was one of the first wells in the country where they found water, and I can not tell you.

The CHAIRMAN. You do not know what the substance was in which they found the water?

Mr. SPALDING. I do not. I have not thought of the matter for a long time; and in Mayville, which is in Traill County, a short distance north of Cass, they have a very powerful well.

The CHAIRMAN. What is the depth of that well?

Mr. SPALDING. My impression is that it is the same depth as the one at Tower City. At Morehead, in Minnesota, just across from Fargo, they are boring a well, and have reached 1,300 or 1,400 feet without success.

The CHAIRMAN. Do you know what material they have gone through there? Have they kept a record of it?

Mr. SPALDING. They have kept a record of it; and they have mostly gone through granite. They sent that to a geologist of Wisconsin.

The CHAIRMAN. What did he say it was?

Mr. SPALDING. That they would not strike any water.

The CHAIRMAN. What depth did they strike that formation?

Mr. SPALDING. Something like 1,200 feet.

The CHAIRMAN. Did the geologist say it was granite?

Mr. SPALDING. I do not know whether they sent a sample. They told him it was granite.

The CHAIRMAN. They might have made a mistake.

Mr. SPALDING. I have no knowledge on the subject.

STATEMENT OF W. E. PURCELL, OF WAHPETON, RICHLAND COUNTY.

The CHAIRMAN. In which direction is your county from here?

Mr. PURCELL. It is a southeast county of Dakota, on Red River, right at its source.

The CHAIRMAN. Have you ever been without sufficient rain-fall for crops?

Mr. PURCELL. Yes. We have had in our county at least two failures, what you might call failures, in ten years. Last year we did not have more than half the crop. But, as stated by Mr. Spalding, it was in consequence of frost in the early part of the season, along in the month of May, after the wheat had been sowed, after it had grown 4 inches.

This year our county will yield as large, perhaps, as any county in the Territory. But it is only in spots. In some portions of our county, which have heretofore yielded the best, this year's yield was virtually nothing. In the early spring, after the wheat had been sown three or four weeks and it looked nice, we had some terrific wind-storms, and in the portions of our county where the storm was heaviest it seemed to do the most damage. Along what we call the sand-hills in our county we have had the best crops. Most of the crops were covered by sand. A man driving along the field would see virtually nothing, yet they have the best crops there.

The **CHAIRMAN**. How do you account for that?

Mr. **PURCELL**. It is singular with us this year. Along the Red River and along the Wild Rice River, in the northern part of our county, where there has been as much rain as we have had in the south, the crops were nearly a total failure. And that is right up to the river.

The farmers in that locality say they have the same wheat and the same seed, that they have tilled equally well as in former years, and that they have had nearly as much rain-fall and yet the crop is scant. The rains this year in our county have not followed the river—we use a common expression, usually, "follow the river"—but they have left the rivers and gone into the country. For instance, 6 miles west of the Red River the Wild Rice River runs north, and they have had good crops in that region and adjacent thereto. But in what we consider the sand region this year we have the best crops. They have as much rain-fall as we have right along the river. We consider the best farms are along the river. But this year they are not as good, and they pay the same attention to the seed. I think we have only three flowing wells in our county.

The **CHAIRMAN**. Has the land back of the river been tilled as much as the other?

Mr. **PURCELL**. No. It has not been tilled more than four or five years, while the land adjacent has been tilled more.

The **CHAIRMAN**. That may have something to do with it.

Mr. **PURCELL**. That may have something to do with it. But the query with me was, in listening to the discussion of irrigation, what plan would be adopted to hold the water in a country as flat as is Richland County.

There is probably not more than an average of 3 feet fall in the bottom of the Red River for a distance of 8 miles west of the river. The land is level and flat. What plan could we adopt in that county for holding the water?

The **CHAIRMAN**. Is there any difficulty in taking the water out of the river if you need it?

Mr. **PURCELL**. No; the current is very strong.

The **CHAIRMAN**. And the banks low?

Mr. **PURCELL**. Yes.

The **CHAIRMAN**. There would be no difficulty in turning the river.

Mr. **PURCELL**. No. But how? By constructing artificial reservoirs?

The **CHAIRMAN**. By turning the stream. That is the first thing to do.

Mr. **PURCELL**. By diverting the stream?

The **CHAIRMAN**. Yes; if you have a country of that kind, a good flow in the river and very level off from it, it would be very little trouble to divert the water. When you have enough water in the river, make reservoirs; where you can not get out the stream. Where you can have artesian water, let that be the system. You will have to use your best judgment. The object to be accomplished is to get the water on the land.

STATEMENT OF ELIJAH BOLEY, OF BURLEIGH COUNTY.

The **CHAIRMAN.** How long have you resided in Burleigh County?

Mr. **BOLEY.** Twelve years.

The **CHAIRMAN.** How many years have you had good crops out of the twelve?

Mr. **BOLEY.** About six, I think, that we have considered good crops since I have been there; 1877, 1878, 1879, and 1880 were good crops; 1882, 1884, and 1885 were good crops.

The **CHAIRMAN.** How has it been since 1885?

Mr. **BOLEY.** Pretty hard since 1885.

The **CHAIRMAN.** On account of the drought?

Mr. **BOLEY.** Yes.

The **CHAIRMAN.** Have you in your section considered the question of irrigation?

Mr. **BOLEY.** We have been thinking about it considerably, but it is quite lately. We have been expecting better seasons right along since 1885; 1885 was a very good season.

The **CHAIRMAN.** What have you to say about artesian wells?

Mr. **BOLEY.** I know but little about them. I came here more for information about wells than anything else. We think we might have wells on those high lands; we think they would be of great advantage to us; we are on pretty high land.

The **CHAIRMAN.** In what part of the State is your home?

Mr. **BOLEY.** Right across the river in Burleigh County, at Mandan. The second bench across the river is quite narrow.

Director **POWELL.** What is the name of the stream near you?

Mr. **BOLEY.** Square Buttes.

Director **POWELL.** What is the one to the south?

Mr. **BOLEY.** Hart River comes in south of us; Little Hart and Big Hart and Cannon Ball.

Director **POWELL.** Your farm is right on the top of the ridge?

Mr. **BOLEY.** Yes.

Director **POWELL.** You have not cultivated the low land?

Mr. **BOLEY.** I am not on what they call the low land or second bench. Really, the first of those bottoms they call the first, and then I am on the bench above that.

Director **POWELL.** I want to get at this idea. If I remember rightly, your farming country there is all on top of the ridge, is it not?

Mr. **BOLEY.** Yes.

Director **POWELL.** And they have not attempted anywhere to cultivate the valley lands of Heart River?

Mr. **BOLEY.** I think they have what they call the valley. I think there is some of that cultivated. That is what we call the flat lands. There is nobody cultivating those that I know of.

The **CHAIRMAN.** You have not tried wells in that direction?

Mr. **BOLEY.** No. I have not dug wells over 30 feet deep. I have dug some of those 32 feet deep and 24 feet deep. We are right there close to the river, and from 20 to 30 feet we will get water. We are inclined to think it is on account of seepage from the river. We have not struck any veins of water; it seems to sink in all around.

STATEMENT OF GEORGE PEOPLES, OF MANDAN, BURLEIGH COUNTY.

The CHAIRMAN. You are a coal miner?

Mr. PEOPLES. I work at almost everything.

The CHAIRMAN. Do you know anything about the crops, whether they have been affected in your vicinity?

Mr. PEOPLES. Well, I think they are affected greatly by drought. If we had rains and the ground was dampened, we would have good crops.

The CHAIRMAN. Have you considered any mode of watering the land?

Mr. PEOPLES. I think there is a good chance of irrigating all the land west of the Red River.

The CHAIRMAN. What kind of a chance?

Mr. PEOPLES. By irrigating from the Cannon Ball and the two Heart Rivers.

The CHAIRMAN. Do they run water in the spring?

Mr. PEOPLES. Yes; there is always water in them. They are springy at the head.

The CHAIRMAN. Then you have a very easy problem before you?

Mr. PEOPLES. Yes; if we had the means to settle it.

The CHAIRMAN. Are you getting out coal at Mandan?

Mr. PEOPLES. Twenty-three miles from Mandan.

The CHAIRMAN. Have you a good vein?

Mr. PEOPLES. From three feet and a half to seven feet.

The CHAIRMAN. What kind of coal?

Mr. PEOPLES. Lignite.

The CHAIRMAN. Does it burn up?

Mr. PEOPLES. It makes a good fire.

The CHAIRMAN. What kind of ashes does it leave?

Mr. PEOPLES. White ashes; no clinkers.

STATEMENT OF T. S. UNDERHILL, OF STARK COUNTY.

The CHAIRMAN. Where is Stark County?

Mr. UNDERHILL. It is next west from here.

The CHAIRMAN. Commencing where from Bismarck?

Mr. UNDERHILL. Seventy-five to 80 miles west.

The CHAIRMAN. Will you describe that county?

Mr. UNDERHILL. It takes in the headwaters of these streams—the Heart on the south and the Knife on the north.

The CHAIRMAN. Do they furnish much water.

Mr. UNDERHILL. Constant streams of water. Stark County embraces the headwaters of the Knife. About the center of the county, along which the railroad runs, is the divide between the north and south. Two miles from the railroad is a number of streams.

The CHAIRMAN. Is there any difficuly in diverting that water and putting it upon the land?

Mr. UNDERHILL. To a limited extent I think not. These streams are moderate during the dry season and waste away before reaching the river.

The CHAIRMAN. Could not the water be stored in reservoirs in the dry season.

Mr. UNDERHILL. After talking to Major Powell I think it is practicable to make reservoirs of those basins and lakes. But the water could not be available for a large area of country, because we are in so many ranges, and ridges, and divides, and our river bottoms are limited in extent.

The **CHAIRMAN**. When you have learned the great benefit of irrigation you will find a good many places where you can store water.

Mr. **UNDERHILL**. And hold it. In this soil where springs leak away, would not a large body of water follow that and sink deep into the ground?

The **CHAIRMAN**. If you make the reservoirs to sink, yes. But if you make the reservoirs up on one side where there is no subterranean channels it would not. You would not want to build a reservoir over a channel where it would soak out.

STATEMENT OF A. O. WHIPPLE, DEVIL'S LAKE CITY.

The **CHAIRMAN**. Where is Devil's Lake City?

Mr. **WHIPPLE**. It is on the north shore of the lake.

The **CHAIRMAN**. In what part of the State is that?

Mr. **WHIPPLE**. About 90 miles east of Grand Forks, on the Manitoba road leading to Helena.

The **CHAIRMAN**. What is the condition of your country; does it require irrigation?

Mr. **WHIPPLE**. I should think it did. This year we have lost all our crops. I do not know where we are going to get water.

The **CHAIRMAN**. What are the facilities for getting water?

Mr. **WHIPPLE**. I do not know; perhaps on the west, coming out of the mountains in the spring.

The **CHAIRMAN**. Have you ever considered the feasibility of storing water in the ponds?

Mr. **WHIPPLE**. No.

The **CHAIRMAN**. You have water-sheds?

Mr. **WHIPPLE**. I suppose we have; but Devil's Lake has no inlet or outlet.

The **CHAIRMAN**. How deep is that lake?

Mr. **WHIPPLE**. Under the bluffs it is quite deep.

The **CHAIRMAN**. How much area does it cover?

Mr. **WHIPPLE**. Fifty-five miles by 15 miles.

The **CHAIRMAN**. And is it so low that you could not get an outlet?

Mr. **WHIPPLE**. No; we would not have any trouble about an outlet; several years ago there was an outlet into the Red River, where it enters into Fargo.

The **CHAIRMAN**. Why do you not secure an outlet?

Mr. **WHIPPLE**. We do not wish to do it; we want that lake there; there has been no overflow of that lake for the last fifteen or twenty years.

The **CHAIRMAN**. If an outlet were cut you could then draw the water off in dry seasons for irrigation; you could have a dam to stop up the outlet and let the lake fill again.

Mr. **WHIPPLE**. The last year that lake has receded; it is 28 feet lower on its shores than it was 22 years ago.

The **CHAIRMAN**. And it will continue on until you have rainy seasons?

Mr. **WHIPPLE**. Yes.

The **CHAIRMAN**. Then it will fill again?

Mr. **WHIPPLE**. I hope so.

The **CHAIRMAN**. That stream has too much salt in it for irrigation?

Mr. WHIPPLE. If you regard it so. It tastes like that German bitter water, if you are familiar with that.

The CHAIRMAN. You can not irrigate with salt water because it kills vegetation.

Mr. WHIPPLE. There are streams coming out of the mountains that could be made available. There are natural coulées that flow into this lake, and in 1883 those were large lakes, so that steam-boats could run up 20 or 30 miles. Now they are dry.

The CHAIRMAN. If an engineer familiar with the turning of water and storing water could make an examination and point out how to irrigate, do you think your people would undertake it? I mean, of course, if the plans were feasible.

Mr. WHIPPLE. I do not know that they would. We have had an engineer to examine the altitude of the lake out of town for the purpose of giving us some water, and he did not find the flow sufficient. That is a fresh-water lake.

The CHAIRMAN. How much of a fresh-water lake have you?

Mr. WHIPPLE. It is 6 miles long and a mile or two wide.

The CHAIRMAN. Has that an outlet?

Mr. WHIPPLE. It has an outlet when it overflows, running into the bed of a coulée and from there into Devil's Lake.

The CHAIRMAN. Do you not think there could be some plan devised for getting the water of Devil's Lake and the other lake onto the land?

Mr. WHIPPLE. We have not water enough. We have no water in the spring. It was lower in the spring than in the fall. We have had no difficulty in our section except this year.

STATEMENT OF V. B. NOBLE, OF BOTTENEAU COUNTY.

The CHAIRMAN. Is irrigation required in your county?

Mr. NOBLE. It is this year.

The CHAIRMAN. It never has been before?

Mr. NOBLE. Never before, since I have been there.

The CHAIRMAN. How long have you been there?

Mr. NOBLE. Since 1880. And settlers who have been there since 1883 say there has been no necessity for irrigation except this year.

The CHAIRMAN. Botteneau County is at about the one hundredth meridian?

Mr. NOBLE. The hundredth meridian of west longitude.

The CHAIRMAN. You have several lakes there?

Mr. NOBLE. They are in the Turtle Mountains; and those lakes might be used for irrigating purposes; they are from 400 to 800 feet higher than the main land.

The CHAIRMAN. They would make splendid reservoirs. Is there a large number of those lakes?

Mr. NOBLE. Yes; quite a number of them.

The CHAIRMAN. What extent of agricultural lands are below those lakes, and what extent could it be irrigated if they were used for reservoirs?

Mr. NOBLE. Do you mean the area they could reach?

The CHAIRMAN. Yes.

Mr. NOBLE. The area they could reach would exhaust the lake. The mountains rise up from the prairie virtually from about 50 miles long and 25 miles wide, in an oval shape and all the country around south of them. Of course, they are right on the boundary line; part of them on the Canadian side, and the land on this side is prairie land, much lower than the mountains.

The **Chairman**. Do you not think you have described a district where irrigation is quite easy, if you want it?

Mr. **Noble**. Why, certainly; I think that country could be irrigated from the mountain quite easily. Of course the mountain streams for the past five years have been drying up very rapidly. Places where there were large lakes are now quite dry.

The **Chairman**. You expect them to remain dry until the seasons have changed, and then you expect them to fill again. They have been doing that always heretofore.

Mr. **Noble**. They have been doing that always. As soon as we get a good snow-fall or rain-fall they will fill again.

STATEMENT OF E. M. PAULSON, OF MAYVILLE, TRAIL COUNTY.

The **Chairman**. How much water does the well at your place discharge?

Mr. **Paulson**. They claim that it is from four to five thousand barrels in the twenty-four hours.

The **Chairman**. How far will it spurt up?

Mr. **Paulson**. Twenty-two feet.

The **Chairman**. Of what depth is the well?

Mr. **Paulson**. Three hundred and fifty-five feet nine inches.

STATEMENT OF W. H. ROWE, OF DICKEY COUNTY.

The **Chairman**. In what part of the State is Dickey County?

Mr. **Rowe**. The southern part. It lies almost immediately south of Jamestown.

The **Chairman**. On the James River?

Mr. **Rowe**. The James River flows through the eastern portion of it.

The **Chairman**. How does the drought affect that section of the country?

Mr. **Rowe**. In the southern portion we were affected very seriously this year.

The **Chairman**. How long have you lived there?

Mr. **Rowe**. Since 1882.

The **Chairman**. How long have you been affected by the drought? How long has it been since you have had poor crops?

Mr. **Rowe**. I will state it this way: In 1882, 1885, and 1888 we had sufficient rain-fall for crops, and droughts the other years.

The **Chairman**. Have you ever considered the question of irrigation in your county?

Mr. **Rowe**. We have so much so that we have a local organization in the county to consider the subject.

The **Chairman**. Have you thought of the feasibility of artesian wells?

Mr. **Rowe**. At Ellendale they have an artesian well.

The **Chairman**. To what depth did you go for that well?

Mr. **Rowe**. Somewhere in the vicinity of 1,000 feet.

The **Chairman**. Through what material did you go immediately before you struck the water?

Mr. **Rowe**. I think a hard surface, shale, and then the water was found in sand or gravel.

The CHAIRMAN. White sandstone?

Mr. ROWE, Yes, sir; I think white sand.

The CHAIRMAN. How deep did you go into that sand?

Mr. ROWE. I could not say. The well has a pressure of 125 pounds to the square inch.

The CHAIRMAN. What is the size of the well?

Mr. ROWE. It is a 4-inch bore.

The CHAIRMAN. It furnishes considerable water?

Mr. ROWE. Yes; quite a volume.

The CHAIRMAN. Are there any streams that could be turned in your county?

Mr. ROWE. I ~~will~~ state that in the Western portion of the county, the western interior townships, in what we call the coteaux, rising from those hills are various little branches of what is called the Elm, the North and South Branches of the Elm and Maple rivers. They flow east to the center of the county and there turn off into South Dakota. The channels of those branches usually, when flowing, are quite deep, and in the other places right along from those hills the water could be stored. I do not know any other way that the water could be stored.

The CHAIRMAN. Reservoirs could be formed there?

Mr. ROWE. Yes. But this Little Maple River, after leaving the hills 5 or 6 miles, commences to form pools. It is not flowing this year.

The CHAIRMAN. You might enlarge those pools by dams and then take the water out.

Mr. ROWE. This little river could be readily dammed and made to retain the water in the spring, but it could not be raised over the bluffs onto the table-lands.

Mr. WHIPPLE, (of Ramsey County). I wish to call attention to an artesian well in our town. We got down 1,500 feet and came to sand; in fact, went into sand a long distance, perhaps 50 feet.

The CHAIRMAN. What kind of sand was it?

Mr. WHIPPLE. As white as that marble. [Indicating the top of a center table.]

The CHAIRMAN. What did your drill go through before it came to the sand?

Mr. WHIPPLE. I do not know. When we got to the sand, when the well was from 180 to 200 feet deep, we had good water; afterward the sand commenced to choke up the pipe, when it was suggested by the men sinking the well that we put down a 4-inch pipe, the other being a 3-inch pipe; we have a flow of water now that resembles milk, with a pressure of about 70 pounds to the inch; it does not amount to much, and is growing less and less because of the sand that is filling it up. They commenced the construction of that well about October or last of September, and they worked all winter to get rid of the sand; the sand is beautiful when the water is dried out of it; the result is our well is a failure after costing $12,000.

The CHAIRMAN. You say you got a stronger flow below the sand?

Mr. WHIPPLE. Yes; at 200 feet the sand came up in the pipe; it took a week to get it out. The suggestion of an inside pipe came through an expert from Chicago, but it was of no assistance and it was taken out. The cost of the pipe was as much as the boring of the well.

The CHAIRMAN. You did not try putting down a perforated pipe?

Mr. WHIPPLE. No.

The CHAIRMAN. You have not tried the experiment of putting down a pipe prepared for that purpose?

Mr. WHIPPLE. No. We took out the inside pipe.

STATEMENT OF J. J. LUCK, OF NEW SALEM, MORTON COUNTY.

The **CHAIRMAN.** What information can you give us?

Mr. **LUCK.** Our country probably could not be irrigated from streams, as it is a kind of high rolling country; but it has lots of hollows, and if artesian wells could be sunk that would afford a sufficient flow of water to fill these basins and succession of ponds we could irrigate pretty nearly the whole country.

The **CHAIRMAN.** That is to say if the artesian wells would furnish sufficient water?

Mr. **LUCK.** Yes.

The **CHAIRMAN.** Suppose they would not, could you do something in the way of saving the storm water?

Mr. **LUCK.** Yes; we could save some, and some of the little creeks could be banked up, and the water in them could be saved. In that way quite a good deal of the country could be irrigated, but not all of it.

The committee resumed session at 7 p. m.

Present, Messrs. Stewart (chairman) and Reagan; also Director Powell.

STATEMENT OF JOHN M. TURNER, OF MANDAN, BURLEIGH COUNTY.

The **CHAIRMAN.** What is your occupation?

Mr. **TURNER.** I am manager of the Mandan Roller Mill Company.

The **CHAIRMAN.** How long have you resided in Mandan?

Mr. **TURNER.** About one year, but I have lived three years in Dakota.

The **CHAIRMAN.** In what part of Dakota have you resided?

Mr. **TURNER.** I was traveling in the eastern section, along through the Red River Valley particularly and as far west as the James River. I had no knowledge of the West Missouri country until about a year ago. About the 1st of January last I became interested in the Mandan Roller Mill Company and was appointed manager of their mill.

The **CHAIRMAN.** Are you now quite familiar with this country west of the river?

Mr. **TURNER.** Yes, sir.

The **CHAIRMAN.** State whether or not it suffers from want of moisture?

Mr. **TURNER.** It suffers very materially from want of moisture. The roller mills were built three years ago, with a capacity of three hundred barrels a day, which would require 300,000 bushels of wheat. We have not, however, been able to get anything like that. We have tracts of land amply able to provide us with wheat for ten such mills if we had the necessary water. This spring—that is to say, about the last of May and first of June—we anticipated that we would have a crop of half a million bushels. Then the hot winds came, or, as some people here call them, the chinooks, and in three days' time our crops were reduced to 75,000 bushels west of the river, according to the best estimates that we have been able to make. There was no moisture whatever in the atmosphere during that time. The wheat crop was fatally injured. The flax, which was ripening about the 1st of July, escaped, and is doing better. Oats promised fairly well. The hay crop, which came after the chinooks, is doing fairly well now.

The **CHAIRMAN**. What are facilities for furnishing water for irrigation? Have you looked into that at all? Have you any streams that can be diverted or places where water can be stored?

Mr. **TURNER**. From my knowledge of the country I should say not, because our streams run through low lands, and are weak in the summer time.

The **CHAIRMAN**. You would have to store water from the small streams in order to have water during the irrigating seasons?

Mr. **TURNER**, Yes, but the character of the country is such that I doubt whether reservoirs would be feasible.

The **CHAIRMAN**. You have flat land, have you not?

Mr. **TURNER**. Between our hills only. The surface of the country is rolling. There is very little flat land, except on plateaus.

The **CHAIRMAN**. Do you not suppose that you could find on every quarter section a place for a reservoir? Suppose you wanted to make a fish pond for pleasure, could you not find a place for it?

Mr. **TURNER**. Hardly on every quarter section. But I think we could on every half section, by dividing a section into two probably diagonally. On some sections we might find a hole for that purpose.

The **CHAIRMAN**. Do you want a hole for that purpose? What you want is a water-shed, isn't it?

Mr. **TURNER**. Yes, but my mind was running in the direction of artesian wells, rather than getting water from streams.

The **CHAIRMAN**. My mind was on the catchment idea; not in the direction of artesian wells. If you had artesian wells, is there any difficulty about getting water?

Mr. **TURNER**. I don't think so. I think we could perhaps get artesian well water. We have a company organized now with a view of looking into that.

The **CHAIRMAN**. That will be very good. There is a belt running north and south along the James River that probably would give artesian water. The difficulty about that, and I must warn you to-day, is this: Many artesian wells are small, and have but a small water-shed to supply them. When you sink a good many wells you exhaust the source of supply. This is the largest belt I ever saw, and if it has its source of supply in the Rocky Mountains, as we think it has, it will be of great service. We are now making an examination of the country with the view of conducting further surveys and explorations to ascertain what can be done. In Dakota I think some good work can be done in the way of surveys and explorations, that will give the people a good deal of information.

Mr. **TURNER**. We have something on the west side of the river that we don't have on the east side, which is coal. I also find from my experience in milling that the alkali surface on lands gives us a much stronger berry of wheat. We have winds there blowing 30 or 40 miles an hour in the summer season, and I never saw any wheat in the East that would stand that. The nature of the surface-water is such that the cattle will drink it at some points, and at some they will not. We have, for instance, in one place a tube driven down into the ground and a pump attached to it, and we get water from that. Those pumps sustain us. We had a fire at our place, and we were able to hold the flames in check. That is an evidence to us that there is water everywhere around us. We have with us to-night Mr. Clark, of Mandan, who is probably the best posted man in that section of the country.

STATEMENT OF J. R. CLARK, OF MANDAN, BURLEIGH COUNTY.

The **Chairman.** Please state to the committee your views with regard to irrigation; whether it is needed in this section, and how it may be obtained?

Mr. **Clark.** I can not claim to be an expert, or even to be well posted in this matter; but my idea is, that we must depend altogether upon artesian wells for our supply, rather than our streams. Some sections can be irrigated by the reservoir system from overflow or surface water.

The **Chairman.** For the purpose of irrigation there are three sources from which water may be had: First, the streams, if they can be diverted with ease; secondly, reservoirs, and those reservoirs may be used, where there are no streams, to save the storm waters—they may be used also for the purpose of increasing the water in the streams, letting the water down at the proper time; third, artesian wells. Where you can strike a good artesian belt you can get considerable water. From what we have seen of this artesian belt a little east of here, if it proceeds from the Rocky Mountains, it is the best artesian-well belt in this country, and probably the best in the world.

Mr. **Clark.** Undoubtedly the trend of the strata is all due east, judging from the incline or dip of the country from the Rocky Mountains to this point. The Missouri River is the first material break in that slope.

The **Chairman.** Jamestown, I think, is supplied from the Rocky Mountains, though I may be mistaken in that. If it is, you have the artesian belt here, of course.

Mr. **Clark.** We think so, and we are about to test it shortly. But that is about the only hope I have of successful irrigation here.

The **Chairman.** I thought there were sources of water supply here besides that. Some gentlemen were speaking of some stream running into the river here on the west side.

Mr. **Clark.** About 15 miles away we have the Cannon Ball; then right at the town we have the Heart, and then beyond that we have the Butte. Those are none of them strong streams, however.

The **Chairman.** Do they go back a long distance?

Mr. **Clark.** About 150 miles. We can probably save at the time of overflow in the spring the surplus water.

Mr. **Lucky.** The banks east of New Salem are at least 100 feet below the plateau, so that to irrigate from the Heart you would need a dam 100 feet high.

The **Chairman.** Of course, if the stream gets down into a deep cañon, you can not get it again. But it seems to me you can go above and save a good deal on the water-sheds, by making dams and finding low places and bringing the water to the plateau. Could not that be done?

Mr. **Clark.** I think so.

The **Chairman.** If you keep the water until summer it would be just as well as if it flowed during the summer season?

Mr. **Clark.** Undoubtedly.

The **Chairman.** If you have streams of that kind you had better experiment with them.

Mr. **Clark.** I have some figures here giving the altitudes. Those waters rise at the divide. Freiburg is 136 miles west of here by rail. The altitude of that place is 2,800 feet, while the altitude of Mandan is

1,625 feet. So that we have in that 136 miles a fall of 1,175 feet. That applies to the river Heart especially.

The CHAIRMAN. What is the other stream?

Mr. CLARK. The Cannon Ball. That is the dividing line between the northern limit of the eastern reservation and our county.

The CHAIRMAN. Then there are three or four of those streams. What is the character of the land between them and the plateau?

Mr. CLARK. The land is broken. There are some tracts of level land or plateaus, and then there is some land which is very much broken.

The CHAIRMAN. By surveying you could probably find a line for a ditch. You could get a ditch on the high ground, and then the water might percolate from it?

Mr. CLARK. Perhaps so.

The CHAIRMAN. It seems to me that it would be a good idea for the people here, situated as you are, to send somebody to Utah and Montana and take a look at what has been done there. If necessary you could send for some man who has had experience and is familiar with the practical bearings of the question. You can learn more by seeing things than by talking about them.

Mr. CLARK. That is so. Everybody has theories, but that does not bring the things down to practical knowledge.

The CHAIRMAN. I think that if you had two or three practical engineers from Colorado and California who know all about irrigation, they would be worth a good deal to you. It took the people of those States a quarter of a century to find out what they now have. So far as you are concerned you don't want to wait a quarter of a century.

Mr. CLARK. No, sir; we are tired already of waiting so long.

STATEMENT OF JAMES BELLOWS, OF MANDAN, BURLEIGH COUNTY.

The CHAIRMAN. You have resided in Mandan how long?

Mr. BELLOWS. Ten years. I am one of the oldest inhabitants there now.

The CHAIRMAN. You are doubtless acquainted with the country about here?

Mr. BELLOWS. I built the railroad from the Missouri River to the Yellowstone. That gives me some knowledge of the lay of the land.

The CHAIRMAN. What do you say about the necessity of irrigating that country?

Mr. BELLOWS. During the ten years we have been here we have had two good crops. Every other year we have had very fine prospects but the long drought has deprived us of the small grains,such as wheat and oats. This year we thought we were going to have good crops. The crops that were on low ground and were put in pretty deep, seemed to withstand the dry season better than the others.

The CHAIRMAN. Are you an engineer?

Mr. BELLOWS. No, sir.

The CHAIRMAN. From what you have seen of the country, would there be any difficulty in irrigating some of this land from these streams?

Mr. BELLOWS. Not if we had money enough with which to do it.

The CHAIRMAN. It does not take money; it takes work.

Mr. BELLOWS. Well; work costs money. There is no doubt but what we could bring water from the head waters of the Heart River on to Custer Flats, and on to the rise of the land. Across the river we have

50,000 acres that lie 300 or 400 feet, I suppose, above the Heart River. That is a pretty piece of land, and very fertile. If we could get the water there on any one spot we could irrigate the whole of Custer Flats.

The **CHAIRMAN.** Could you not take the Heart River and use it and then bring it down? If it is like all other streams—the little streams that feed it find their head in hollows and little places, where you can store the waters. Perhaps there are fifty or a hundred such places.

Mr. **BELLOWS.** Oh, yes; there are places enough for storage.

The **CHAIRMAN.** That would be a feasible scheme, would it not?

Mr. **BELLOWS.** No doubt of it.

The **CHAIRMAN.** If the Government should make surveys for you, and give you estimates, etc., wouldn't they be a great assistance to the people here?

Mr. **BELLOWS.** It undoubtedly would. If this section of country could have sufficient water it would be found to be a mine of wealth.

The **CHAIRMAN.** An examination which would result in showing how these places could be irrigated would enable the people about here to do a good deal for themselves, would it not?

Mr. **BELLOWS.** Yes, sir.

The **CHAIRMAN.** Who owns these 250,000 acres of land?

Mr. **BELLOWS.** They are owned almost wholly by the railroad company.

The **CHAIRMAN.** They can not own more than one-half of it surely.

Mr. **BELLOWS.** I mean that it is unsold land, except a small portion of it, after you go back pretty well from the railroad.

The **CHAIRMAN.** I don't think I ever saw such an opportunity to make money as there is here, if a man will only get this land and irrigate it. The land will not cost him more than $1.50 to $2 per acre, and it can be made worth $30 or $40 an acre, mostly by labor. As quickly as you establish the fact that you can reclaim farms here, and as quickly as you let people see what can be done by irrigation, you will have a great rush into this country. People will come here from all parts to settle.

Mr. **BELLOWS.** From results which I have made in my garden this summer, I can see that a great deal can be done by irrigation. I have had plenty of water in my garden, and I find that I can raise everything that I want without manure or anything of that sort.

The **CHAIRMAN.** The water of the streams will keep your land perpetually rich. In that respect it is very different from rain-water. This water from the streams brings down silt. Some people spread the water over the land specially for the purpose of fertilization. They are doing that in France and in other countries where they have already rain-fall enough. They put on the land water that flowed down from the mountains, because it brings this silt with it. The Valley of the Nile has produced crops for four thousand years, and has seldom missed a crop. That land, of course, is flooded every year. You could club together here, I should think, and build a ditch of 25 miles or so. If you have not water enough to answer your purposes you could build dams and have a number of reservoirs. But if you have a ditch dug, from what I have seen of the land east of here, with this clay subsoil, I believe you can irrigate it at any season of the year and soak the land thoroughly, and it would be sufficient to give you a good crop.

Mr. **BELLOWS.** The land all through here has a clay bottom. There are a good many little streams coming into the Heart, but I suppose they could flume them.

The **CHAIRMAN.** They could either do that or dig around.

Mr. **Bellows**. To dig around them would require many miles of digging.

The **Chairman**. If you get a place where you can't flume, you could get a light iron pipe and carry it across. A very light pipe will carry water across these gullies.

Mr. **Bellows**. Yes, sir; they are using wrought-iron pipe now which is very cheap. Your suggestion is one that had not occurred to me at all, as I have looked upon it as too expensive a project for the few of us who are here. The only thing that occurred to us as practicable was the artesian well.

The **Chairman**. The artesian well may be successful, and it may be all that you want; but the experience of mankind as to artesian wells is that you can not expect too much water from a large number of them. This, however, is the most marvelous belt of artesian well-water that I have ever seen. After going through a sedimentary formation, they strike a hard capping above the water-bearing stratum, and then they strike a loose sandstone or coarse sand, about 75 feet, I believe, being the greatest depth of it. That is an immense water-bearing stratum, and this problem arises with regard to it: If all that water is supplied from a small water-shed somewhere, into which the water has come and in which it has remained, and if it is without a large continuous supply, then it will fail in time. If, on the contrary, this sedimentary formation or great bed of sandstone extends from that point to the Rocky Mountains, and is there uptilted, as long as there is a great body of snow in the mountains it will probably continue to furnish an immense volume ot water.

Mr. **Bellows**. The fact that they get water all the way from Yankton through to Jamestown is wonderful.

The **Chairman**. It is very remarkable, and also that they get it in the same body of sandstone. It comes from somewhere up here, and it probably comes from a long distance. I think if you people here would sink a well it would irrigate three or four sections of land, and you would be much better o flnext year than you are this.

Mr. **Bellows**. If an artesian well is a success here we have lots of farmers here that will sink wells just for their own farms.

The **Chairman**. If they do as well as the other artesian wells we have seen they will do more than water any one farm.

Mr. **Bellows**. Some of the farms here are pretty large. Mr. Lyon, who is now present, has a very large farm, and instead of having a few bushels of wheat he might just as well have forty to the acre. In the Gallatin Valley, through which I passed one summer, I never saw finer crops in my life than I saw there.

The **Chairman**. Then, besides the raising of wheat, you can raise everything, and you will have an all-round farm on which you can grow corn, peas, beans, tomatoes, potatoes, and everything that will grow in this latitude. Besides that you can have good trees. I should think, too, that this would be a good country for small fruits.

Mr. **Lucky**. They will do well if they are watered in the dry season. I have a number of raspberry bushes, and gooseberry bushes, and other berries of that sort. We must, however, have water.

You have been speaking about irrigating the land from Heart River. In our country it would be cheaper and better to take the water from the Missouri River, I think. That lies just as high, and with a big bend. From the other we can not get the water very far. The Missouri flows very swiftly and constantly, and that would give us irrigation better than the Heart or any other stream.

The CHAIRMAN. This question is as to how to do it. It is one that we can not determine here. It is an engineering question.

Mr. LUCKY. I think that if we could get artesian wells, the way the country lies, we could irrigate enough by sinking them on high points.

The CHAIRMAN. If I were living here I should bore artesian wells with a good deal of confidence that I should get water.

Mr. BELLOWS. I have great confidence, too. I am not a geologist, however, although I have associated a good deal with geologists, and have read considerable in geology.

STATEMENT OF LYMAN N. CARY, OF MANDAN, BURLEIGH COUNTY.

The CHAIRMAN. What is your business?

Mr. CARY. Real estate.

The CHAIRMAN. What is the topography of the country on the other side of the river?

Mr. CARY. It is rather broken.

The CHAIRMAN. Would there be any difficulty in running a line of ditch up some of those streams and getting water?

Mr. CARY. I do not think that it is practicable. I do not profess, however, to be very competent to judge on that subject. I have always been looking for a place on the streams where we could have a natural pond or lake, some hollow place into which water could be turned, but I never found any that would hold much water without going to a great deal of expense to prepare it.

The CHAIRMAN. Have you examined the Heart River?

Mr. CARY. Yes; I have been all over that country thoroughly; we have been local agents for the Northern Pacific Railroad.

The CHAIRMAN. In order to get the water on to this 50,000 acres of land, spoken of awhile ago, how far would you have to go up the river so as to get to a point in the bed of the river which would be on a level with the point at which you would want to discharge the water?

Mr. CARY. I should think probably 50 miles would carry it there. But it is difficult to get there, because there are so many ravines on the way. To run the line level for 50 miles east along the bluffs would take probably fully 25 miles of linear measure. Unless some provision was made for carrying it over the ravines I do not think it would be practicable.

The CHAIRMAN. It could be carried over the ravines by means of flumes, could it not?

Mr. CARY. Probably.

The CHAIRMAN. And by means, in some places, of pipes?

Mr. CARY. Yes. I should think that could be done, but that would be an expense greater than the farming interests at the present time would warrant.

The CHAIRMAN. I presume it would be a great deal of expense. Is there any probability of going up higher on the river and taking the source of it down?

Mr. CARY. On all the little creeks and streams that might be done, but I think our water supply is to be looked for from wells. I think we could get from the little streams some water, but they would soon be exhausted.

The CHAIRMAN. Could you not store water?

Mr. CARY. Not without flooding the very valley that you would expect to irrigate. I would not expect to take any of it from the table-lands.

The **CHAIRMAN**. You could flood the head of it and use the balance. You would not expect to get it from the table-lands at all?

Mr. **CARY**. Our streams are long, and for many miles from the source they are very weak.

The **CHAIRMAN**. They are not weak at certain seasons of the year.

Mr. **CARY**. They are strong in the spring. But the flow is not great, and in order to dam them to any great extent, you would require to get quite an area.

Mr. T. S. **UNDERHILL**. If you will allow an interruption, I would remark here that we were on these streams this afternoon. The suggestion, Mr. Cary, is whether or not up on the Green River, which is a branch of the Heart, we could not on these headwaters have immense reservoirs, sufficiently high up to bring them over the table-lands down through the whole country.

Mr. **CARY**. I think that such a thing could be done.

Mr. **LUCKY**. There would not be supply enough to water the whole country. In order to do that I should say the Missouri would be the proper thing.

Mr. J. W. **SHAW**. Would not that cost millions of dollars?

Mr. **CARY**. If we could get water by artesian wells, that would be the thing.

The **CHAIRMAN**. You could undoubtedly get a large amount of water. But when you come to discuss the question of getting water enough to water the whole country, that is hardly possible.

Mr. **CARY**. We have a broken country, and I think it could be conducted around so as to utilize all of the water that could be taken, without waste.

The **CHAIRMAN**. I don't see why you need to have any waste; if you get the water up on a knoll, it could be carried around in a circle and then brought down. This water comes up so warm that it would hardly freeze in winter, does it not?

Mr. **CARY**. It would freeze before it went very far, in cold weather.

WATER AND DITCH COMPANIES.

The Secretary of the Territory of Dakota filed with the committee the annexed list of irrigation and water-storage companies, as recorded in his office up to August, 1889:

1. The Lone Tree Ditch Company, Rapid City.
2. The Rapid Valley Ditch Company, Rapid City.
3. Black Hills Ditch Company, Rapid City.
4. Butte County Irrigating Ditch Company.
5. Lower Rapid Ditch Company, Rapid City.
6. Butte Creek Irrigating Ditch Company, Butte River.
7. Brown's Irrigating Ditch Company, Rapid City.
8. The Western Improvement Ditch Company, Rapid City.
9. The Elm Grove Ditch Company, Elm Grove.
10. The Central City Water Company, Central City.
11. The Deadwood Water Company, Deadwood.
12. The Rapid City Water Works, Rapid City.
13. Bismarck Reservoir and Water-Works Company, Bismarck.
14. Fargo Water and Steam Company, Fargo.
15. The Mutual Water Company of Dakota, Rapid City.
16. Bismarck Artesian Well and Water-Works Company, Bismarck.
17. The Bear, Butte, and Elk Creek Water Company, Deadwood.
18. Gayville Water and Mining Company, Gayville.

19. The Black Hills Canal and Water Company, Lawrence County. San Francisco, Cal., principal place of business.
20. Rockville and Teepe Ditch and Flume Company, Rockville.
21. The Rapid City Water Company, Rapid City.
22. Box Elder Water Company, Pinkerton.
23. The Bay State Water-right and Ditch Company, Lead City.
24. Bear, Buttes, Strawberry and Ruby Gulch Water Company, Deadwood.
25. The Boston and Little Rapid Milling and Water-Power Company, Rochford.
26. The Butte Irrigating Ditch Company, Butte, P. O.
27. Rapid Valley Irrigating Company, Rapid City.
28. The Wacum Ditch and Flume Company, Deadwood.
29. Rapid River Ditch and Improvement Company, Rapid City

RESOLUTION AND MEMORIAL OF THE STATE CONSTITUTIONAL CONVENTION OF NORTH DAKOTA.

Resolved, That this Convention submit to the United States Senate Committee on Irrigation and Reclamation of Arid Lands, the following memorial:

To the honorable United States Senate Committee on Irrigation and Reclamation of Arid Lands:

GENTLEMEN: The Constitutional Convention for North Dakota duly assembled at Bismarck under the enabling act passed at the last session of Congress representing the people of North Dakota, familiar with their industries and pursuits, with their resources and necessities, has learned with interest and gratification that it is the expressed purpose of your honorable committee to enquire into the needs of North Dakota in the matter of artificial water supply.

To North Dakota this is a subject of such exceeding importance, that this convention is moved to memorialize your honorable committee and through you the Senate of the United States, as follows:

First. We beg your attention to the fact that the great fertility of the soil of North Dakota has been shown by many seasons of sufficient rain-fall.

Second. The superiority of the grain grown in this soil, and especially of the wheat, is now a matter of repute throughout the civilized world, and is a contribution to the fame of our national resources. In the United States this wheat is almost a necessary ingredient of fine flours.

Third. That these facts have attracted to North Dakota a population of 250,000 earnest, sober, law-abiding people, possessed of a purpose to develop the land, and who have already made it a source of wealth and importance to the nation.

Fourth. That it is now demonstrated and understood that the peculiar excellence of the cereals of North Dakota is the result of climatic conditions as well as of qualities of the soil; that one of these conditions is the dryness of the climate, which, however, in seasons of average rain-fall in the most parts is not so excessive as to prevent yield of crops unsurpassed in other parts of the land; but that this desirable average implies seasons in some parts of North Dakota of insufficient precipitation, disastrous to agricultural prosperity and discouraging to farmers.

Fifth. Therefore we earnestly urge upon the honorable committee and upon the United States Senate these considerations:

(*a*) We recognize and approve the object before your committee—namely, the initiation of investigation and certain work at the expense of the General Government looking to the establishment of reservoirs or other systems for the irrigation of lands in need thereof, to the end that the area of public agricultural lands may be greatly increased.

(*b*) We also realize the fact that such enlargement of area means direct and formidable competition with the industries of North Dakota, (competition especially to be dreaded since irrigated farms are the most productive in the world), while already overproduction has deprived farming of nearly all profit.

(*c*) We recall to your attention and to that of the honorable body which you represent, the fact that the people of North Dakota have paid into the Treasury of the United States many millions of dollars for their lands, while proposed expenditures for mountain resovoirs are mainly intended to benefit regions from which comparatively nothing has been received from sales of agricultural lands.

(*d*) While therefore we do not question the benefits to accrue from expenditures for the mountain reservoir systems, we feel justified in claiming some similar expenditure for North Dakota, and a share in the paternal solicitude of the Government to this extent, namely, that suitable investigation, to be followed by experimental work, be made in behalf of North Dakota, to ascertain whether or not it is practicable to provide by means of artesian wells sufficient water to eliminate the dangers incident to dry seasons, and to maintain the agricultural industries of the State on a footing for competition in grain production, upon which its inhabitants absolutely depend for support.

We therefore trust that your honorable committee will give to North Dakota more than a passing glance, that you will conduct an investigation with reference to its resources and its necessities and make a report thereon which will result in the development of the former and secure if possible relief from the latter.

We beg you to notice that while there are certain ascertained artesian basins the extent of such basins has not been accurately ascertained.

Scientific experiment and survey are needed to determine this matter as well as the character of the water to be obtained and its influence on vegetation. Other essential facts to be ascertained will suggest themselves to your committee—the whole of a scope too great for North Dakota to undertake at the expense of its people now engaged in their early struggles to establish themselves.

We confidently believe that the outcome of such work by the Government in North Dakota will be to return to the Treasury many times the amount of its expenditure in the further cash entries of government lands.

We hereby certify that the within memorial was introduced and passed by the Constitutional Convention of North Dakota, and is a part of the permanent record thereof.

F. B. Fancher,
President.

Jno. G. Hamilton,
Chief Clerk.

Adjourned.

MONTANA.

GLENDIVE, *August* 6, 1889.

The committee met pursuant to call of the chairman.

Present: Messrs. Stewart (chairman) and Reagan; also Director Powell.

STATEMENT OF J. R. MEADE, OF GLENDIVE.

The Chairman. How long have you resided at this place?

Mr. Meade. Since 1880.

The Chairman. Have you made any efforts in this vicinity to fertilize the land by irrigation?

Mr. Meade. Not to any great extent. There are some two or three ranches that are irrigated.

The Chairman. Where?

Mr. Meade. Mr. Bennett has a ranch on the other side of the river, about 10 miles from town.

The Chairman. Above or below the town.

Mr. Meade. Above.

The Chairman. To what extent has he irrigated and with what success? Have you ever seen the ranch?

Mr. Meade. Yes; but I have not seen it in the dry season. His creek goes dry when he wishes to irrigate. If it does not go dry about the 1st of August, it is a success. But it generally goes dry just as he wants to use it. Down the river 75 miles Mr. Dunlap has a stream of water, and I understand it is a success. He uses his farm for raising crops: corn, potatoes, oats and all kinds of vegetables.

The Chairman. What kind of hay does he cultivate?

Mr. Meade. Timothy and wild grass.

The Chairman. How successful has he been in that direction?

Mr. Meade. I understand the timothy is 2 tons to the acre.

The Chairman. Have you ever raised alfalfa in this vicinity?

Mr. Meade. If alfalfa has been put in, it is not to my knowledge.

The Chairman. Has anybody tried to cultivate it?

Mr. Meade. That I can not answer.

The Chairman. Where does Mr. Dunlap get his water?

Mr. Meade. It is from a spring.

The Chairman. He has not tried to turn the water from the river?

Mr. Meade. No; it is water from his spring.

The Chairman. I believe you said there were three parties who were irrigating.

Mr. Meade. There are several on a small scale, but I think those two are the only ones whom we consider as having sufficient water.

The Chairman. What distance is it from the commencement of these valleys up the river to the Missouri River?

Mr. Meade. From here to the Missouri River?

The **CHAIRMAN**. No; where the valley commences west, above, to where you get to the Missouri River, below.

Mr. **MEADE**. I should say from Livingstone, the mouth of the river, three or four hundred miles.

The **CHAIRMAN**. Have you ever estimated the average width of the valley land?

Mr. **MEADE**. Four or five miles it would be, in my opinion—probably from 3 to 5 miles.

The **CHAIRMAN**. It would average 4 miles, would it?

Mr. **MEADE**. I should think it would.

The **CHAIRMAN**. Is it all level land on both sides?

Mr. **MEADE**. I should take it to be for 3 miles.

The **CHAIRMAN**. Three miles in width and 400 miles in length, would be 1,200 square miles.

Mr. **MEADE**. That is only an estimate.

The **CHAIRMAN**. How many acres would that be—768,000 acres of land, would it not?

Mr. **MEADE**. That is a large body of land.

The **CHAIRMAN**. So far as you have examined, this land is all smooth and level?

Mr. **MEADE**. Yes. I should say that the Yellowstone Valley in this vicinity was 40 miles in length; the bad lands then come in, as they do here.

The **CHAIRMAN**. But, then, there is a valley on one side or the other?

Mr. **MEADE**. In nearly every case, yes. For instance, by the Yellowstone River there would be bad lands for 30 miles and over, and then there would be good lands on the other side.

The **CHAIRMAN**. I believe there are some lands up in the valley where they do irrigate?

Mr. **MEADE**. I understand so.

The **CHAIRMAN**. Have you ever seen them?

Mr. **MEADE**. Yes.

The **CHAIRMAN**. Where is that?

Mr. **MEADE**. At Billings. They have a ditch at Billings. I have never seen it to any great extent except from the cars.

The **CHAIRMAN**. Have any steps been taken to reclaim this land by irrigation?

Mr. **MEADE**. Not to my knowledge; not to any extent. Nothing has been done in the way of water from the Yellowstone River—only from the local streams. There are three places where they irrigate largely; but I suppose there are a dozen places where they irrigate by springs.

The **CHAIRMAN**. What kind of crops do you plant here?

Mr. **MEADE**. Corn is small, on the average; not as large as the Illinois corn, but it will run 30 bushels to the acre. There are potatoes and wheat and oats. Everything except large corn requires a long season.

The **CHAIRMAN**. What is the length of your season, from the late frosts in the spring that would kill vegetation until the early frosts in the fall?

Mr. **MEADE**. That would average from the first of May to the first of September.

Senator **REAGAN**. That would be four months?

Mr. **MEADE**. Yes; we generally get the first frost the fore part of September.

The **CHAIRMAN**. Does the corn that is raised in New England mature here?

Mr. **MEADE**. Yes.

The **Chairman**. How about wheat?

Mr. **Meade**. Sometimes the wheat will do well on the table lands; but that is uncertain, as it is in Dakota. But wherever you have water it is a success.

The **Chairman**. In every instance?

Mr. **Meade**. Yes. We have land down the river, 40 or 50 miles, low buck-brush land, where they get 50 bushels to the acre.

The **Chairman**. Wherever that grows, there is good land?

Mr. **Meade**. Yes.

The **Chairman**. What kind of brush is that?

Mr. **Meade**. Low hazel-brush.

The **Chairman**. How is it where sage-brush grows? Is sage-brush an indication of good land in this country?

Mr. **Meade**. Yes. I understand it is deep soil, but it requires water to use it, because the ground is so porous.

Senator **Reagan**. Have you ascertained how far you would have to go up the valley to get water to irrigate the land at this place?

Mr. **Meade**. On the opposite side of the river it would be 30 or 35 miles. It has been looked over here by a cattleman who was an engineer, and he talked it up for a number of years very strongly. At Ferry Point it could be taken out cheaply. That is 30 or 40 miles from Glendive. Then you would strike lowlands. That place in particular, in the opinion of a practical engineer, would be a very good place for a ditch.

STATEMENT OF JAMES G. RAMSAY, OF GLENDIVE.

The **Chairman**. How long have you resided here?

Mr. **Ramsay**. Since 1882.

The **Chairman**. What is the paper or map which you have in your hand?

Mr. **Ramsay**. It is a rough sketch of the Yellowstone—what is called Lone Horse Prairie. It is not quite accurate. It was made from the best information that could be obtained without really surveying. It is made on the reports that I have had from Mr. Clark. He was a mining engineer for a long time, and he was in the cattle business here. He had a ranch near the Bad Route, and he took the trouble to run a level to see whether he could get water out of the Yellowstone. Mr. Clark says that at Ferry Point, which is 35 miles on the other side of the river and on the lowland—the second land is bench land—to get the water on the bench land you would have to go 6 or 7 miles, and that there would be some fluming to get around the bluff. It is in June that they need water in this place, and they always have water in the Yellowstone before that time. Here is a rough sketch shewing the land from Ferry Point to Glendive [producing paper].

The **Chairman**. The valley continues on the other side of the river?

Mr. **Ramsay**. Yes, for 30 miles. In some places the bluffs come close to the river and you would have to flume the water to get it out.

The **Chairman**. How much land could you irrigate?

Mr. **Ramsay**. All the way from the mouth of the river, 115 miles, and for 2½ to 3 miles wide.

The **Chairman**. To get to that body on the other side of the river would you need a flume?

Mr. **Ramsay**. Yes; below Glendive the river bottoms are wider than they are here.

The CHAIRMAN. And wider than above?

Mr. RAMSAY. Yes. I think a safe estimate would be an average of 2½ miles to Ferry Point.

The CHAIRMAN. How much land have you under that ditch? [Indicating on map.]

Mr. RAMSAY. As a rough estimate, 65,000 acres.

The CHAIRMAN. Has there been any opportunity here to enter into such an enterprise?

Mr. RAMSAY. Not yet. Some years ago some one sent a man here to see about it, and he put in a couple of ditches. But there has been nothing heard of it since. Mr. Bennett has taken a little water out of Clear Creek and irrigated 160 acres.

The CHAIRMAN. With what success?

Mr. RAMSAY. He is here himself and can tell you all about it. In 1882 and 1883 there were a good many settlers who took up a good bit of land, and now there are about seven families left.

The CHAIRMAN. Why did they quit?

Mr. RAMSAY. They could not raise sufficient crops without irrigation.

The CHAIRMAN. Did they try to irrigate?

Mr. RAMSAY. Along this strip of land here [again indicating on map] they have got in a spot where there is a little soakage or leakage, and there they raise small crops. Some years they raise a pretty good crop. There is a ranch about 5 miles from here where they have been raising crops from irrigation. I might say in regard to this point [indicating on map] that there is a rock bottom in the river, and there are rapids above.

The CHAIRMAN. That presents an invaluable place to take out water?

Mr. RAMSAY. Yes. There are rapids there, and the fall is greater right at that point [indicating] than any other place in the river. Mr. Clark says that by making the head of the ditch at that point it could be done with little expense compared with the balance of the river, because most of the banks along the other places are sandy.

The CHAIRMAN. Will we see that point as we go along on the train?

Mr. RAMSAY. You can see it from this point [indicating]; but you would not have much of an idea from this side of the river. The road on the other side of the river goes a mile and a half from the river, and the place of which I have spoken is on this side.

STATEMENT OF J. H. RAY, OF GLENDIVE.

The CHAIRMAN. How long have you resided here?

Mr. RAY. Between seven and eight years.

The CHAIRMAN. What is your profession?

Mr. RAY. That is a pretty hard question to answer at present. I am rather gathering up specimens, fooling around at the present time. I have no fixed occupation at present.

The CHAIRMAN. You are a justice of the peace?

Mr. RAY. Yes; and I am a United States commissioner, which is a little bigger office than justice of the peace—having a little more jurisdiction.

The CHAIRMAN. Are you familiar with this country?

Mr. RAY. Yes; I have traveled over this country a good deal—probably 100 miles east and west.

The CHAIRMAN. Across the river and this side, what lands do you find back from the river?

Mr. RAY. After leaving the water-course, we find sloping prairie. Wherever we strike water-courses we strike prairie land.

The CHAIRMAN. How far back from the water-courses before you strike the prairie?

Mr. RAY [indicating on the map]. Following up one of these draws, we strike it there upon the top of that butte. That is level.

The CHAIRMAN. That is about 500 feet above the level?

Mr. RAY. I think it is 360 feet from the base. I measured it with a barometer, and it is about 400 feet from the river bed.

The CHAIRMAN. Is that about the height of the plateaus on both sides?

Mr. RAY. On the other side the flat places are bad—they are precipitous.

The CHAIRMAN. When you get back on the plateaus or uplands, is that about the average height?

Mr. RAY. It rises gradually, probably until you get up to the altitude of 600 or 700 feet.

The CHAIRMAN. How is it then? Is it smooth and level land up there?

Mr. RAY. Oh, yes. After you get up on the divide it is very rich land, and vegetation grows very rapidly there.

The CHAIRMAN. What is the extent of that character of land on each side?

Mr. RAY. I have found it as far as I went.

Mr. CHAIRMAN. Then there are extensive plains on both sides of the river?

Mr. RAY. I have been out 100 miles south of the river several times, and always found a plain of that character.

The CHAIRMAN. When you get down on the base land, is it smooth, level land?

Mr. RAY. Yes; after you get away from the water-courses.

The CHAIRMAN. We want to know the situation up there. When you get up there it is a large extent of country; but do you know how much there is of level country?

Mr. RAY. With the exception of just around the bluffs it is all level.

The CHAIRMAN. After you get away from the buttes?

Mr. RAY. I am talking about the bluffs and not the buttes. After you get away from the bluffs it is all level country.

The CHAIRMAN. Is there any chance from any source to get water onto that level country?

Mr. RAY. Why, yes; I think there is the greatest kind of chance to get water.

The CHAIRMAN. From what source would you get water?

Mr. RAY. Take the altitude of Glendive, which is, say, between 2,100 and 2,200 feet from the level of the sea. From here to Livingstone it is 125 miles, and the fall of the river is, on an average, 16½ feet per mile, making some 2,200 feet. It is higher here than there, and you could take that river there and carry it anywhere, could you not?

The CHAIRMAN. You could; but it would be a very expensive job. I do not know but what there would be some other source of supply by going up higher in the mountains.

Mr. RAY. There is the Tongue River and the Powder River.

The CHAIRMAN. We cross them as we go up.

Mr. RAY. Yes; but I have no faith in being able to irrigate from tributaries, because they go dry just when you want water. There is a point [indicating on map] that they call Ferry Point, 30 miles above here, where you could take out the Yellowstone and carry it down here [still indicating], and you would have a grade of 150 feet above the river. But by the time you get to the mouth of the river you would have 600 or 700 feet, and the uplands are as fertile as the bottom lands. The rain-fall follows the divide.

The CHAIRMAN. When you get down to that point [indicating] do you have the little hills that they have in Dakota, or is it smoother land?

Mr. RAY. Were you ever through Wisconsin above Madison? Well, it is just such a piece of country as that. There are high bluffs and foot-hills. The configuration is just about the same as it is at Madison, Wis.

The CHAIRMAN. You brought in some wheat with you?

Mr. RAY. Yes.

The CHAIRMAN. Where was that wheat raised?

Mr. RAY. Right on the table-land where this house stands, without irrigation. It was sown in the spring, and there it is; it speaks for itself. It is as good quality of spring wheat as is sown anywhere. The rain-fall here last season was far above the normal.

The CHAIRMAN. When you can raise a crop here without irrigation, it is an exception?

Mr. RAY. We do not get enough rain-fall here to raise a crop, unless it is on the lowlands, when there is an overflow from the ice gorges.

Senator REAGAN. How much of that wheat did you get to the acre?

Mr. RAY. From 20 to 25 bushels to the acre. It stood thick, and the heads are good. You can see from that sample what the berry is.

Director POWELL. Do you think those uplands are better agricultural lands than the bottom-lands?

Mr. RAY. Yes; I think they are as good and sometimes better—more vegetable matter in them. These buttes wash down rapidly, and the grass and vegetation is deeper. I notice that better grass—thicker and stronger—grows on the uplands than in the valleys. It may be on account of more rain-fall, the storms following the divides.

STATEMENT OF NORRIS S. BENNETT, OF GLENDIVE

The CHAIRMAN. How long have you lived in Glendive?

Mr. BENNETT. I have been on a ranch up here for seven years.

The CHAIRMAN. Have you a ranch now?

Mr. BENNETT. Yes.

The CHAIRMAN. How far is it from here?

Mr. BENNETT. Twelve miles.

The CHAIRMAN. On which side of the river?

Mr. BENNETT. On the north side.

The CHAIRMAN. To what extent do you farm there?

Mr. BENNETT. I have a little patch fenced in, and I irrigate some. I run water over about 200 acres in the spring of the year, and have 60 acres that I raise crops on. Then I have some land that I irrigate thoroughly.

The CHAIRMAN. On that which you irrigate thoroughly what is the result?

Mr. BENNETT. Thirty-five bushels of corn to the acre. I was gone last year, however, and did not try it.

The CHAIRMAN. How much wheat did you get?

Mr. BENNETT. There is no way of getting wheat here.

The CHAIRMAN. Have you cultivated any of the grasses by irrigation?

Mr. Bennett. No; I put in some alfalfa, but the grasshoppers ate it as soon as it came up.

The Chairman. It grew, did it?

Mr. Bennett. Yes; it grew.

The Chairman. Do you have grasshoppers here often?

Mr. Bennett. No; they have not been troublesome for more than two years. I raised that corn two years ago. [Referring to the samples of corn on the table.]

The Chairman. That is a good specimen of corn.

Mr. Bennett. It is not the best selection that I could have made.

The Chairman. You can raise on irrigated land here all the crops that can be raised in this latitude, can you?

Mr. Bennett. Yes. I have raised melons. The ground is about 65 feet above the Yellowstone River.

The Chairman. How did you get the water to irrigate?

Mr. Bennett. From Clear Lake.

The Chairman. That is a stream that runs all the time, is it?

Mr. Bennett. Yes.

The Chairman. Does it run much water?

Mr. Bennett. Plenty of water in the spring time, and I run my ditch full about three months.

The Chairman. How does it affect the wild grass?

Mr. Bennett. It makes it grow.

The Chairman. How much of a cutting of wild grass can you get by irrigation?

Mr. Bennett. About a ton to the acre where it is thoroughly plowed. We have not tried the tame grasses.

The Chairman. Have you done any farming without irrigation?

Mr. Bennett. Yes.

The Chairman. What is the difference between the two?

Mr. Bennett. Some of this corn was planted outside and was not worth cutting.

The Chairman. Then you can not raise crops here without irrigation, except in exceptional years, can you?

Mr. Bennett. No.

The Chairman. It would be an accident, I suppose, more than anything else, if you should get a crop under such circumstances?

Mr. Bennett. Yes; I raised melons that weighed 40 pounds, and potatoes that weighed 3 pounds apiece. The creek runs the year round, and the place where we are obliged to take it out there are 4 feet of gravel and it is 30 yards wide. The ditch is about 4 miles long. We think it would be worth perhaps $1,000 to put in a new dam there.

The Chairman. You could build dams and reservoirs and do a good deal with this creek, could you not?

Mr. Bennett. Yes; we built a ditch in 1884 and have had it for 5 years.

The Chairman. Are you on a railroad section or a Government section?

Mr. Bennett. I am on a Government section. It is my own now.

STATEMENT OF JOSEPH W. ALLEN, OF GLENDIVE.

The Chairman. How long have you resided in Glendive?

Mr. Allen. Since 1880.

The Chairman. Have you paid any attention to the subject of irrigation?

Mr. Allen. I have.

The CHAIRMAN. Give us any information that you may have in regard to experiments that have been made.

Mr. ALLEN. In regard to the general subject of irrigation, I will say that I first saw it in the Gallatin Valley. I came to Mandan in 1866, and I saw there the general drift of things. I saw that a crop could be had without any difficulty by irrigation. I found further, after years of experience, that irrigation not only produced a crop, but fertilized the soil, from the effects of the water. It probably carried a solution or silt along with it. In 1877 I took up my permanent residence in the Yellowstone Valley at the mouth of the Big Horn, or Pease Bottom, as it was called. That lies on the opposite side of the Yellowstone from this place, and it is about 14 miles long. It was first occupied in 1876 by a party of traders. In 1877, after Custer's death, a party went down there and occupied this place called Pease Bottom, at its head, and put in some crops there. That bottom has been successfully cultivated up to this time without irrigation. There are no means of irrigating it except out of the Yellowstone River, and there are no means of getting the river there. The crops, however, have been good at a place called Baker's Battle-ground, below Billings; it used to be called Colsen. There is a change in the country and its vegetation. There can be crops raised below Baker's Battle-ground, without irrigation, in occasional years. Above that they can not raise anything without irrigation. You can see, if you pass there in daylight, the change in the topography of the country.

The CHAIRMAN. Is the low land affected by the seepage from the river?

Mr. ALLEN. Yes; the low bottom, particularly, lies very low. In regard to this very point I would call the attention of the committee that there is a rock bottom clear across the river, and rock on both sides where the head of the ditch could be taken out successfully. That is urged by some as an objection to taking the head of the river—that you can not protect it there. But there it could be done. The old bench-marks of the United States river surveys are to be seen there. All surveying instruments are corrected there. The fall of the river, the latitude of the country, and everything is corrected from the bench-marks. There are three rapids between Fairy Point and Glendive that must be at least 10 feet of a fall in 1,000 feet.

The CHAIRMAN. How can you account for the fact that men should be so enterprising as to build so many houses as are seen here, and yet leave that fertile land without use?

Mr. ALLEN. I suppose that a ditch from Fairy Point would cost at least $250,000.

The CHAIRMAN. Would it cost that much to run 5 miles?

Mr. ALLEN. If you were to run it 5 miles you could not irrigate an acre of land.

The CHAIRMAN. If you ran it 10 miles could you then irrigate an acre of land?

Mr. ALLEN. Yes.

The CHAIRMAN. Could you not extend it down as you made it and make money with it as you went along?

Mr. ALLEN. Yes.

The CHAIRMAN. How much would such land be worth if you had it irrigated—I refer to the 60,000 acres of land around here?

Mr. ALLEN. Land of the same kind in Gallatin Valley, and not so rich either, would be valuable land. There are affidavits on file in the clerk's office and the recorder's office in Gallatin County to the effect that they have raised 105 bushels of wheat to the acre on their land. What that land is worth you can tell as well as I can.

The CHAIRMAN. I suppose that land would be worth from $75 to $100 an acre.

Mr. ALLEN. Land that is thoroughly irrigated one year does not require so much water.

The CHAIRMAN. That is our experience everywhere. There is an abundance of water around here, and I have no doubt this land would be worth $75 to $100 an acre by irrigating.

Mr. ALLEN. Every acre of it.

The CHAIRMAN. I have no doubt that the land along the Yellowstone is about the paradise for irrigation. It may not be as full in productiveness. At Phœnix, Ariz., and in Kern County, Cal., where they can raise 16 tons of alfalfa to the acre, they have no better land, nor even as good land as this. But you have not been here so long a time. You have frost while they have comparatively none. Still you could produce crops beyond anything that you have ever had.

Mr. ALLEN. The earliest frost we have ever had here, that I can remember, was on the 16th of September. So that we have comparatively long seasons and could produce corn very well.

The CHAIRMAN. There is no place, I suppose, in the United States where there is a larger extent of irrigable land and an abundance of water—for I believe there is an abundance of water in this river; if not, it could be gotten by storing a little, and it would irrigate, I suppose, fully 5,000,000 acres of land. The quantity of land in the Nile Valley that is irrigated and under cultivation is, I believe, about 8,000,000 acres. You have here three-fourths as much as that, and as the water fertilizes the soil, the river bringing down so much silt, you would not need any other fertilizer. At some time this valley will be thoroughly irrigated, and will be noted for the abundance of its crops. I am surprised that the water is allowed to run practically to waste.

Mr. ALLEN. We have not the money to utilize it.

MILES CITY, MONT., *August* 7, 1889.

The committee met pursuant to call of chairman.

Present: Messrs. Stewart (chairman), and Reagan; also Director Powell.

STATEMENT OF GEORGE SCHEETZ, OF MILES CITY, CUSTER COUNTY.

The CHAIRMAN. How long have you resided in Miles City?

Mr. SCHEETZ. Since 1883.

The CHAIRMAN. Are you familiar with the country along the Yellowstone River?

Mr. SCHEETZ. Yes, the Yellowstone and its tributaries.

The CHAIRMAN. Are you an engineer by profession?

Mr. SCHEETZ. Yes.

The CHAIRMAN. Did you assist the county surveyor in making the map that you see here?

Mr. SCHEETZ. Yes.

The CHAIRMAN. You assisted also in the preparation of the report?

Mr. SCHEETZ. Yes. All the red lines on the map show the small ditches in the Territory, and every ditch of them I ran myself.

The CHAIRMAN. Can you give the committee some further information as to the facilities for irrigating the valleys that you have marked?

Mr. SCHEETZ. I can give you no further information, I think, than is contained in the report which accompanies the map. That was intended to give all the information within our command.

The CHAIRMAN. That gives a good idea of the expense, or the approximate expense, does it?

Mr. SCHEETZ. Yes.

The CHAIRMAN. Have you in this vicinity places that have been irrigated?

Mr. SCHEETZ. Yes.

The CHAIRMAN. Has the irrigation been successful?

Mr. SCHEETZ. Yes. Just as successful as in the best parts of Colorado and Utah. More successful than the best valley lands on the Gallatin. There is no soil on the earth that will produce more to the acre than the soil around here.

The CHAIRMAN. What class of crops are raised here?

Mr. SCHEETZ. Wheat, oats, rye, barley, and corn.

The CHAIRMAN. What fruits can you raise here?

Mr. SCHEETZ. Fruits are nearly untried here, except small fruits, such as gooseberries, strawberries, and so forth. There are a few apple trees that are bearing, but the country is new, and the people have not tried fruits much.

The CHAIRMAN. Do the small berries grow?

Mr. SCHEETZ. Yes, if watered.

The CHAIRMAN. You need irrigation to produce crops at all here, do you?

Mr. SCHEETZ. Yes; there has been one season since I have been here, since 1883, that an average crop would have grown if cultivated, and that was last year; one year in seven. That would not be one-third as large a crop as if they had sufficient water.

The CHAIRMAN. So that it would be improvident for one to attempt to farm here without irrigation?

Mr. SCHEETZ. Any one who will try it for a number of years will become bankrupt.

The CHAIRMAN. Has it been tried?

Mr. SCHEETZ. Yes.

The CHAIRMAN. With irrigation a sufficient crop could be raised?

Mr. SCHEETZ. Yes.

The CHAIRMAN. Are you familiar with Idaho and Colorado?

Mr. SCHEETZ. Yes; I am familiar with all the portion of the United States that is irrigated.

The CHAIRMAN. Would this land compare in productiveness with what you have seen elsewhere?

Mr. SCHEETZ. Yes.

The CHAIRMAN. What do you say of this climate?

Mr. SCHEETZ. I like it fully as well as California; I do not know that it is any better than Colorado. It gets somewhat colder than Colorado, but the cold is dry.

The CHAIRMAN. What is the average altitude?

Mr. SCHEETZ. The altitude here is higher than Colorado. The Marshall Pass and Cottonwood Pass and other passes are higher, and that accounts for our having a better climate here than they have in Colorado. We get the Japanese Current.

The CHAIRMAN. What kind of land is represented on your map?

Mr. SCHEETZ. In Custer County we estimate we have about three-quarters of a million of acres. That, however, does not include a large part of the second bench. It was a low level.

The **Chairman**. As to the second bench, will you explain how that is?

Mr. **Scheetz**. What I call the second bench is the regular valley that comes over the very low valleys that are subject to overflow. The second bench is the one that comes in between that and the hills.

The **Chairman**. Have you run levels to ascertain whether the water can be taken onto that second bench?

Mr. **Scheetz**. Yes; by going farther up the stream. It is simply a question of labor.

The **Chairman**. How is the question of water in the river?

Mr. **Scheetz**. I think the Yellowstone has enough water to irrigate 5,000,000 acres of land without any reservoir system in the average season. This year the flow of the river has not been probably one-half what it ordinarily is.

The **Chairman**. How many million acres of land can be reached by the flow of the Yellowstone that would be level enough to irrigate?

Mr. **Scheetz**. Taking it from the mountain region to the mouth of the Yellowstone, I should estimate it at 5,000,000 acres. Of course there would be more land reached, but in getting from one bench to another there would be some land that would be of no value.

The **Chairman**. You would have to go on the second bench to get 5,000,000 acres?

Mr. **Scheetz**. Yes. On the second bench, the region from Glendive to Buford, it is lower than it is here. It is simply a step from the first bench to the second.

The **Chairman**. The extent of irrigation is very limited now, is it?

Mr. **Scheetz**. Yes. There is very little irrigation in this county. On the Rosebud, which is a small stream, the whole stream is used for irrigation.

The **Chairman**. With what success?

Mr. **Scheetz**. Very good success. No better anywhere.

The **Chairman**. About how much land has been brought into cultivation by it?

Mr. **Scheetz**. About 15,000 acres, I think, on the Rosebud. The valley extends about 15 miles.

The **Chairman**. Have you experimented with alfalfa to know whether it would make a good crop?

Mr. **Scheetz**. It is very successful here. There are about 6 tons to the acre of alfalfa grown here.

The **Chairman**. What is the quality of the alfalfa grown here?

Mr. **Scheetz**. About the same as that grown in Nevada and California.

The **Chairman**. Are there any other facts that you can state which will be of service to the committee?

Mr. **Scheetz**. I think you have covered the entire ground.

Senator **Reagan**. In stating the amount of land irrigable in Custer County you confine yourself to the valley of the Yellowstone?

Mr. **Scheetz**. Largely to the valley of the Yellowstone, for the reason that on the Rosebud the valley is all used for irrigation. The ditches have already been taken out.

Senator **Reagan**. What would be the irrigable land on the tributaries?

Mr. **Scheetz**. About 2,000,000 acres, I think, taking in the Little Missouri and the Box Elder. There is a system of reservoir sites at the head that would accommodate a large body of water. You can take the Yellowstone alone, and the difference between low water and high water is very great. High water commences on the 15th of May and ends on the 15th of July, covering the irrigating season. The river rises 14 feet from extreme low water to extreme high water, so that there is a tremendous river there and an enormous amount of water that goes to waste.

The **CHAIRMAN.** You have traveled over the uplands, have you?

Mr. **SCHEETZ.** I think I have been over every foot of land in Custer county.

The **CHAIRMAN.** Are there any places in these uplands where a small area could be irrigated by storage?

Mr. **SCHEETZ.** There are large areas. The Big Horn and all such rivers head in the mountains. They have large benches, so that if storage was made there, it would cover a principality almost.

The **CHAIRMAN.** How much land would be reclaimed provided you inaugurated a reservoir system and reclaimed all the arable land in Custer County?

Mr. **SCHEETZ.** It would cover probably one-fifth of the whole area of the county. Custer County is about 100 miles wide and 200 miles long. But the larger portion of the land would be grazing land forever.

The **CHAIRMAN.** What kind of grazing land is there in Montana.

MR. SCHEETZ. The very best.

The **CHAIRMAN.** Then your estimate is that in Custer County you can reclaim one-fifth of the land by irrigation?

Mr. **SCHEETZ.** Yes. By a system of reservoirs.

The **CHAIRMAN.** Is that true of the other counties along the Yellowstone?

Mr. **SCHEETZ.** It would hold good for Dawson County to a great extent and the county above here—Yellowstone. It runs largely in the mountains. As you go to the mountains, of course there is more mountainous land. We have a series of table-lands here, one above the other.

The **CHAIRMAN.** (Addressing Major Powell.) Should you like to ask this witness some questions?

Major **POWELL.** Just one. What experience have you had with artesian wells here?

Mr. **SCHEETZ.** There are probably fourteen artesian wells sunk in and around Miles City, and they will flow from 1 miner's inch to 4 miner's inches; I think Mr. Hoffman's well will probably flow 4 inches of water.

Senator **REAGAN.** That would be the equivalent of what?

Mr. **SCHEETZ.** They vary in depth from 180 to 550 feet. Mr. Hoffman's well is 166 feet. I had one completed a month ago that is 387 feet and runs 1 miner's inch. I should think Mr. Hoffman's well would give about 48 gallons to the minute.

Senator **REAGAN.** Is there any one that runs 17,000 gallons a day?

Mr. **SCHEETZ.** It would take me some time to figure up how these miner's inches work with relation to the number of gallons a day.

Senator **REAGAN.** How far is it back to the timber-land?

Mr. **SCHEETZ.** There are some scattering pines back of us.

Senator **REAGAN.** Is the timber pretty well preserved?

Mr. **SCHEETZ.** It is scattering pine and of medium size. None of it is large and none of it good. There is no first-class timber here.

Senator **REAGAN.** Are the forests being burned out in this vicinity?

Mr. **SCHEETZ.** No; we have not been troubled here much with forest fires. Our timber is not dense enough to carry forest fires very well.

Once in a while if a prairie catches on fire and it extends into the forests that burns it considerably.

STATEMENT OF E. P. H. HARRISON, COUNTY SURVEYOR OF CUSTER COUNTY.

The CHAIRMAN. You are county surveyor of this county, are you?

Mr. HARRISON. Yes. I have been county surveyor for the last six or eight months.

The CHAIRMAN. You made the report and map which we have here.

Mr. HARRISON. Yes.

The CHAIRMAN. Have you any information to give to the committee in addition to that which you have placed in your report?

Mr. HARRISON. I think not. I think my report covers all the ground.

The CHAIRMAN. Are you familiar with the county? Have you been over it yourself?

Mr. HARRISON. Not so thoroughly as Mr. Scheetz. I have been over quite a large part of it, however.

The CHAIRMAN. What do you say as to the practicability of storing water and irrigating a larger quantity of land than is indicated in this report?

Mr. HARRISON. I think it is thoroughly practicable. It is, certainly, for the second bench; that could not be reached much from the river.

The CHAIRMAN. What is the character of the land back of these benches, compared with the river land?

Mr. HARRISON. I think it is better.

The CHAIRMAN. What is the character of the soil?

Mr. HARRISON. It has more body, it is not so sandy; and I think it holds moisture better than the lands down in the valley.

The CHAIRMAN. Do you concur with Mr. Scheetz that 20 per cent. of this whole county can be reclaimed by irrigation?

Mr. HARRISON. Yes. I do not think that estimate too large at all. I think it will fully reach that.

The CHAIRMAN. You have not been troubled with forest fires?

Mr. HARRISON. No. The only fires we have been troubled with here are prairie fires. When the prairie fire gets into the timber it troubles us.

The CHAIRMAN. Have you timber for commercial purposes here?

Mr. HARRISON. No. Just enough for ranch purposes; and in some cases we have to go a great distance even for that.

The following is the report submitted by Mr. Harrison:

REPORT OF THE COUNTY SURVEYOR, CUSTER COUNTY, MONTANA.

OFFICE OF COUNTY SURVEYOR,
Miles City, Custer County, Mont., July 8, 1889.

To the honorable The Board of County Commissioners of Custer County:

GENTLEMEN: In accordance with your instruction of July 1, 1889, to prepare a map of Custer County, showing the amount of valley lands at present under irrigation, and also all lands that can be brought under irrigation in this county, and also a report showing the available amount of water in the various streams and all other data pertaining to this subject, said map and report to be used by the Senatorial Committee and asked for by them in their letter of June 18, 1889, from Mr. Hinton, the engineer of the committee, I submit herewith the map and following report:

Custer County is watered by the Yellowstone River and its various tributaries, and also by the tributaries of the Missouri and Little Missouri Rivers and Beaver Creek.

As the Yellowstone is the largest stream, covering the greatest amount of valley land, I will name it as being the most desirable for Government aid in the construction of a system of irrigating canals. The valleys of the Yellowstone are ordinarily from 20 to 50 miles long and from 1 to 4 miles wide, lying alternately on each side of the river. The soil is generally a sandy loam, and wherever irrigation has been tried crops of wheat, oats, barley, corn, potatoes, alfalfa, and all other sorts of garden truck have been raised that are not excelled by the production of the famous and fertile valleys of the Gallatin, Madison, and Jefferson.

The valleys of the Yellowstone in this county comprise about 384,000 acres, all of which could be irrigated, still leaving half its water in the stream, besides what would get back to its stream from seepage and the waste-ditches.

These valleys have now a population of 1,000 people, and would, if brought under irrigation, soon support 30,000.

The Yellowstone passes through Custer County for a distance of 200 miles and carries about 906,000 cubic or miner's inches of water at its ordinary stages, and during the months of May, June, and July, the time when water for irrigating is most necessary, its volume is increased fully one-fourth.

A ditch or canal has been taken from the river on the north side, opposite the mouth of the Big Horn River, to cover what is known as the Pease Bottom. This ditch is only partially completed, but the results obtained have been most satisfactory. This ditch could be so enlarged and constructed that after covering the Pease Bottom it could be carried around the face of the bluffs in flumes, and be used for watering the valleys below and on the same side of the river. These valleys embrace about 100,000 acres.

On the south side of the river, at a point below Guy's Bluff, a canal could be constructed covering the large valley on which are the stations of Myers, Sanders, Howard, and Forsyth, on the Northern Pacific Railway, its length being about 30 miles. No heavy fluming would be necessary, as the streams coming into the Yellowstone from the south side between these points are all small. This canal would cover about 57,600 acres of land. A small tract of land is now under irrigation on this valley, its water being gotten from Reservation Creek.

The largest valley in any one body lies from the foot of the Buffalo Rapids (which have a good fall) down the river on the south side for 50 miles, and varies in width from 1 to 4 miles. A large ditch could be constructed covering this entire area, amounting to 80,000 acres. It would of necessity be expensive, as the work at the rapids would have to be done in solid masonry, and the canal carried over Powder River either by an aqueduct or a tunnel under the bed of the stream. In other respects its work would be ordinary earth-work. This would reclaim a large area of the finest land in Montana, at present used only for grazing purposes.

Powder River, the next longest in the county, flows from the Montana-Wyoming boundary line, a distance of about 170 miles, to its mouth, where it empties into the Yellowstone River. The valleys covered by it will average 1¼ miles in width, and embrace about 163,200 acres, which is good soil and very productive where water has been gotten on the lands.

Tongue River crosses the Montana-Wyoming boundary about 150 miles from its junction with the Yellowstone at Miles City, and flows through valleys averaging 1 mile in width, embracing about 96,000 acres. This valley is capable of producing crops equal to any that can be raised in the Territory where water can be put on them, as has been demonstrated on the river near the Wyoming line.

The Miles City Irrigating Ditch Company have in course of construction and nearly completed a canal that will cover about 9,000 acres of Tongue River Valley, and be then carried to the Yellowstone Valley lying east of Miles City, where it will be used on about 21,000 acres.

In connection with the construction of this canal, Tongue River has been dammed at a cost of $50,000. The heavy cost of ditch-construction on the streams is at the point of departure from the bed of its stream, the earth-work being comparatively light.

Rosebud Creek has its source in Custer County, and flows northeast, to its confluence with the Yellowstone River, for a distance of about 100 miles. This valley averages about one-half mile in width on each side of the stream, and embraces about 64,000 acres of land. The supply of water in this stream is limited, but for which fact the fertile valley would be all under cultivation, as the water can be taken out from the bed of the stream at a comparatively small cost.

Little Missouri is in the southeastern portion of the county, and flows through it for a distance of 65 miles, where it crosses into Dakota. This valley embraces about 112,000 acres of land.

Little Powder River, a tributary of Powder River, flows through the county for a distance of about 30 miles. Its valley averages about a half mile in width on each side of the river, and embraces about 19,200 acres of land.

In addition to the above-named streams there are numerous smaller ones, which in most cases have had all the available water taken out into ditches. A noticeable fact about these small streams is, that the water is often in pools, sometimes flowing for a quarter of a mile, when it will sink and not rise for frequently 3 and 4 miles; a fact which makes it unavailable for irrigation.

The season of the year when the largest volume of water would be consumed is during the months of May, June, and July, this being the time when the crops would be growing, but for fall and winter pasture it can be used advantageously as late as October.

Regarding the amount of water necessary for the land, close observation and the experience of all who have given attention to the matter is, that 1 cubic or miner's inch of water is sufficient for the irrigation of 1 acre.

The valley lands of Custer County contain to-day fully 125,000 acres of land that have been virtually abandoned after spending years of toil and thousands of dollars in a vain attempt to successfully farm without irrigation.

The following table gives the estimated amount of water in the streams, the number of acres of valley land, and the number of inches of water used at the present time:

Name of River.	Water in stream.	Water used for irrigation.	Valley land.	Land under irrigation.
Yellowstone	*Inches.*	*Inches.*	*Acres.*	*Acres.*
Tongue	906,000	6,000	384,000	6,000
Powder	77,200	10,200	96,000	10,200
Little Powder	46,920	1,920	163,200	1,920
Rosebud	4,320	320	19,200	320
Otter	4,770	3,020	64,000	3,020
Pumpkin	2,900	2,400	9,600	2,400
Muddy	410	160	38,000	160
Lame Deer	720	320	4,800	320
Beaver	500	....	5,000	....
Terry	400	160	40,000	160
Little Beaver	400	400	....	400
Emmells	380	380	5,000	380
Reservation	500	240	10,000	240
Hanging Woman	320	320	4,800	320
Little Missouri	240	240	10,000	240
	5,000	....	112,000	....
Total	1,050,980	26,080	965,600	26,080

Respectfully submitted.

E. P. H. HARRISON,
County Surveyor.

Approved by the Board of County Commissioners, July 8, 1889.

GEO. W. ALLERTON,
Chairman of the Board.

STATEMENT OF GEORGE R. MILBURN, OF MILES CITY, CUSTER COUNTY.

The CHAIRMAN. How long have you resided in Miles City?

Mr. MILBURN. Most of the time since March, 1883.

The CHAIRMAN. Have you made yourself familiar with this county?

Mr. MILBURN. I have traveled over much of it; partly in the Crow Reservation and the country south of here on Tongue River and on the Rosebud and Powder Rivers. I have been north as far as Wolf Point, and west as far as the western limit nearly on the railroad.

The CHAIRMAN. In your travels have you paid attention to the subject of reclaiming the land by irrigation?

Mr. MILBURN. I have given that attention to it that any other citizen would who was interested in the welfare of the country. I have no scientific knowledge in connection with it.

The CHAIRMAN. Have you observed the section of country where irrigation is practiced?

Mr. MILBURN. Yes.

The **Chairman**. What is the result of irrigation as far as you have observed?

Mr. **Milburn**. The result is extraordinary. The crops resulting are astonishing to a person who has been accustomed to farming in the East in the ordinary way.

The **Chairman**. What portion of the East did you belong to?

Mr. **Milburn**. I was born in Washington City. I can compare the results here with those I have seen in Maryland and Virginia, particularly.

The **Chairman**. How will an acre of land irrigated here compare in productiveness with the best acre of land you have ever seen in Virginia or Maryland?

Mr. **Milburn**. I should say it would produce five times as much, year in and year out, for a term of ten years.

The **Chairman**. That one acre of land here would, if cultivated for a continuous period of ten years, produce five times as much as an acre of the best land in Maryland or Virginia with which you are acquainted?

Mr. **Milburn**. I believe it would.

The **Chairman**. Has there ever been a failure of the crops here where they have been irrigated?

Mr. **Milburn**. Never to my knowledge. Almost always, when there is not irrigation, the crop will fail. The crops obtained here in a year of phenomenal rains will not compare in quality or quantity with those which would be produced by irrigation.

The **Chairman**. Suppose we had proper surveys, which would designate the land that could be irrigated and the means whereby it could be irrigated, and suppose we had land laws that would enable people to obtain the land and at the same time not lead to monopoly, is the country so situated that private enterprise would develop it rapidly?

Mr. **Milburn**. There is no doubt whatever of that. Inquirers are coming into the country all the time, sent in here by people who desire to find good agricultural lands.

The **Chairman**. Have you reflected on the changes necessary in the land laws to facilitate irrigation?

Mr. **Milburn**. I have not.

The **Chairman**. You have no suggestions to make in regard to that?

Mr. **Milburn**. I have not considered that matter at all.

The **Chairman**. Have you considered the matter of protecting what growing timber you have here?

Mr. **Milburn**. Yes.

The **Chairman**. What is your idea as to how the timber should be protected?

Mr. **Milburn**. I think the only measure necessary is to send to the penitentiary the men who set fire to the forests by carelessness. In other words, enforce the laws already on the statute-books.

The **Chairman**. For that purpose would you not want some responsible citizen to look after it?

Mr. **Milburn**. That is exactly what is wanted.

The **Chairman**. There is no necessity for having any secret agents for that purpose, is there?

Mr. **Milburn**. None whatever.

STATEMENT OF ABRAM HALL, RECEIVER OF LAND OFFICE, MILES CITY, CUSTER COUNTY.

The **CHAIRMAN.** What is the extent of your land district?

Mr. **HALL.** It takes in all of Custer County and Dawson County, the eastern part of Yellowstone County and Meagher County.

The **CHAIRMAN.** About how long would it be from north to south and east to west?

Mr. **HALL.** It is all the eastern part of Montana, as far west as the twenty-eighth township. There are about thirty-two townships in it.

The **CHAIRMAN.** Thirty-two, from east to west?

Mr. **HALL.** Yes. They are numbered from west to east.

The **CHAIRMAN.** How much land has been disposed of in that area?

Mr. **HALL.** There have been 565 homestead entries made in this office since the establishment of the office in 1880 or 1881, and there have been 420 pre-emption filings made.

The **CHAIRMAN.** Then the railroad lands are to be deducted?

Mr. **HALL.** Yes sir.

The **CHAIRMAN.** Have you ever figured up how much remains of the public land now undisposed of, either by railroad or otherwise?

Mr. **HALL.** I have not figured it up, but there is a very small per cent. of the land yet taken.

The **CHAIRMAN.** Either by the railroad or by public entries?

Mr. **HALL.** By either.

The **CHAIRMAN.** The great majority of it then is public land?

Mr. **HALL.** Yes; but there is very little of it in comparison with that which has been taken or disposed of by the Northern Pacific Railroad.

The **CHAIRMAN.** Have you traveled over it much to see the character of the soil?

Mr. **HALL.** I have, considerably.

The **CHAIRMAN.** Of course we take it for granted that it is not fit for cultivation, as a rule, without irrigation.

Mr. **HALL.** That is correct.

The **CHAIRMAN.** In passing over it have you had in mind the question of irrigating it?

Mr. **HALL.** Yes.

The **CHAIRMAN.** Did you see the facilities for irrigating it?

Mr. **HALL.** It appears to me the facilities are good. The Montana streams all afford an abundance of water at the very time of the year when it is most needed; that is in June and July.

The **CHAIRMAN.** Does not a large amount of water run down the streams at times when it is not needed?

Mr. **HALL.** Yes.

The **CHAIRMAN.** Have you observed the contour of the country and the source of the streams with a view of seeing where water could be stored and held back?

Mr. **HALL.** No; I cannot say that I have.

The **CHAIRMAN.** So that from your experience you would not be able to make any estimate of what may be done in that respect?

Mr. **HALL.** No.

Senator **REAGAN.** What portion of the land in your district would you consider available for cultivation under irrigation?

Mr. **HALL.** I could not state really. I should think that what has been stated is a fair estimate, namely, twenty per cent., if not more.

The **CHAIRMAN**. You think that perhaps more than twenty per cent. can be?

Mr. **HALL**. There is at least that much that can be irrigated. I should think that would be a fair percentage.

Senator **REAGAN**. That is, in your district.

Mr. **HALL**. Yes. The valleys below here have been mostly taken up under the homestead and pre-emption filings. But a great many of them—in fact most of them—have been abandoned for the present. They were taken in the first place by, perhaps, adventurers or speculators. I think there have been about two crops of settlers in this country, and there is a third coming in. The valleys below here are only sparsely settled. I know that if there could be a system of irrigation projected the valleys would be very rapidly settled up. Every legal subdivision would be immediately available.

The **CHAIRMAN**. Are the homestead and pre-emption laws applicable to this section of the country?

Mr. **HALL**. Yes.

The **CHAIRMAN**. That is, can a homesteader come here and make a home without having some combination or arrangement whereby the water can be brought in? Of course he can take the land, but can he stand it here as a rule?

Mr. **HALL**. I shouldn't think a man could make a living at farming independent of any stock interest.

The **CHAIRMAN**. Agricultural pursuits, then, without irrigation, are impracticable here?

Mr. **HALL**. To a great extent, yes. We have a few farmers that have made a living, but very few. Usually they have combined farming with stock-raising.

The **CHAIRMAN**. What modification in the homestead law would enable people to make homes here? Have you given thought to that subject?

Mr. **HALL**. I don't know that I have. I should think the present homestead system would be successful to a great extent, though perhaps a modification of it might be made.

The **CHAIRMAN**. What will people do on this desert land while they are getting their homes made and their ditches? Can they do much until they get their ditches in?

Mr. **HALL**. No; they can not.

The **CHAIRMAN**. Can a single homesteader as a rule enter land, except where he can find small fertile places?

Mr. **HALL**. No; I think not, without a system of irrigation.

STATEMENT OF WILLIAM COURTNEY, OF MILES CITY, CUSTER COUNTY.

The **CHAIRMAN**. What is your occupation?

Mr. **COURTNEY**. I am a live-stock broker.

The **CHAIRMAN**. How long have you resided in Miles City?

Mr. **COURTNEY**. Eight years.

The **CHAIRMAN**. Are you familiar with the surrounding country?

Mr. **COURTNEY**. To some extent.

The **CHAIRMAN**. Have you traveled over it?

Mr. **COURTNEY**. Yes; in the early days I traveled over it. I have been for twenty-three years a resident of Montana. I was over the country a good deal before there were any settlements here.

The **CHAIRMAN**. Have you observed the effects of irrigation and the facilities therefor in this part of the country?

Mr. **COURTNEY**. Not to any great extent, but I have partially.

The **CHAIRMAN**. You have seen the results of irrigation?

Mr. **COURTNEY**. Yes.

The **CHAIRMAN**. What are those results in this country?

Mr. **COURTNEY**. They are simply astonishing.

The **CHAIRMAN**. What part of the country do you come from?

Mr. **COURTNEY**. From the State of New York. I was born in England, but have been thirty-five years in America.

The **CHAIRMAN**. Do you know something about farming in England?

Mr. **COURTNEY**. Yes.

The **CHAIRMAN**. And in New York?

Mr. **COURTNEY**. Yes. I was nine years at an Indian Agency in the West, Fort Berthold. I saw a good deal of farming at that point, but they had no irrigation there. They found the soil much more fertile on the bench lands than on the bottom lands, and they raised better crops on the bench land.

The **CHAIRMAN**. Have you observed the crops of this county, that have been produced by irrigation?

Mr. **COURTNEY**. Yes.

The **CHAIRMAN**. Supposing you should take a term of ten years, how would you compare the land here that is irrigated with land in New York with which you are familiar?

Mr. **COURTNEY**. I think that irrigation would produce more than five times the ordinary crop.

The **CHAIRMAN**. Irrigation here would produce more than five times the ordinary crop, on good land? Is that your idea?

Mr. **COURTNEY**. Yes.

The **CHAIRMAN**. I ventured in a recent article to say that irrigation would more than double a crop and I was much criticised by a number of newspapers for my "exaggeration."

Mr. **COURTNEY**. That is by no means an exaggeration. I have an artesian well in operation at my home here in Miles City.

The **CHAIRMAN**. How deep is that well?

Mr. **COURTNEY**. Five hundred and thirty-five feet.

The **CHAIRMAN**. Through what material did you go to reach it?

Mr. **COURTNEY**. I think through sandstone.

The **CHAIRMAN**. What did you strike immediately above the water?

Mr. **COURTNEY**. Sandstone, I think.

The **CHAIRMAN**. Was it hard?

Mr. **COURTNEY**. Yes; it took some time to bore through it.

The **CHAIRMAN**. What did you find the water in?

Mr. **COURTNEY**. In gravel, I think. We got a very good flow, I think 100 barrels in twenty-four hours.

The **CHAIRMAN**. What is the size of the well?

Mr. **COURTNEY**. It is a 4-inch well.

The **CHAIRMAN**. Have there been many wells sunk in this town?

Mr. **COURTNEY**. About fourteen altogether.

The **CHAIRMAN**. Has the increase in quantity in the wells affected the flow of the water?

Mr. **COURTNEY**. No.

The **CHAIRMAN**. The other wells flow about the same quantity as yours?

Mr. **COURTNEY**. Yes.

Senator **REAGAN**. Are the wells of about the same depth?

Mr. **COURTNEY** They vary in depth very much.

The **Chairman**. Then you have not struck any uniform stratum from which the water comes?

Mr. **Courtney**. No. On the other side of the Yellowstone River, at about an elevation of 600 feet above the Yellowstone, there is a man farming who dug down 50 feet and got good water. His crops were then looking well.

Senator **Reagan**. Does he irrigate from his well?

Mr. **Courtney**. No. He has had no means of irrigating, but at 55 feet from the surface he got good water.

Senator **Reagan**. How is the water here in this city?

Mr. **Courtney**. The character of the water is very good. I went down 18 feet for a well for drinking purposes, and got a good flow, winter and summer. We use it at my home.

Senator **Reagan**. Is the artesian water good for drinking purposes?

Mr. **Courtney**. I do not like to use it for drinking purposes, but it is good water for irrigating and for washing. I use it on my lawn and in my laundry and for cooking.

The **Chairman**. What kind of a grazing country is this?

Mr. **Courtney**. We have the best grazing land in the Northwest, without exception. I have been all over Montana, and I consider we have got decidedly the best grazing lands in the Northwest.

Senator **Reagan**. If all the land that was susceptible of irrigation here was devoted to agriculture and the raising of grasses and so on, and the balance was used for pasturage, what kind of a country would you have up here?

Mr. **Courtney**. A splendid country. Our valley would be full of industrious farmers if irrigation were made extensive. As it is, our county supports, in round numbers, about 200,000 head of cattle, and gives pasturage for that number. There are 36,000 square miles in Custer County. In ordinary seasons we find an abundance of pasturage, and cattle, I think, are fatter, in better order, and mature earlier in this county than in any other place I know of in the Northwest. I will simply give you an illustration of that. In 1886 I sold about 900 head of three-year-old steers that were raised in northern Wyoming, and were driven up here to Montana. We had a hard winter in 1886-'87. In 1888 those two-year-olds were four-year-olds, and the new owners gathered about 600 head of them and took them to Chicago and sold them for $52.50 a head. In the same year that these cattle were sold a lot of Wyoming cattle were marketed, and the Wyoming men who marketed the same class of steers, exactly, could get for them only $39 a head. That shows the difference between the cattle raised here and the cattle raised in Wyoming.

The **Chairman**. Wyoming is a pretty good stock country?

Mr. **Courtney**. Yes. We have also here, I may say, inexhaustible coal-fields. The whole country is spread over with vast coal-fields. In some places the veins crop out 7 feet in thickness. That is a very important point for settlers coming here. They can get fuel cheap. We can deliver good lignite coal at our homes here at an average of $2 a ton, and there are very extensive fields of it.

The **Chairman**. That is a great consideration for settlers.

Mr. **Courtney**. Yes; a most important consideration.

The **Chairman**. Does that coal extend all over the county?

Mr. **Courtney**. Yes,

The **Chairman**. Is it near the surface and easily obtainable?

Mr. **Courtney**. Yes. There are numbers of men here that hardly mine at all, but scratch the ground and get their supply of coal.

STATEMENT OF L. A. HUFFMAN, OF MILES CITY, CUSTER COUNTY.

The CHAIRMAN. How long have you resided in Miles City?

Mr. HUFFMAN. About ten years; in the neighborhood a little longer.

The CHAIRMAN. Have you traveled over this section of country?

Mr. HUFFMAN. I have.

The CHAIRMAN. Are you familiar with its topography?

Mr. HUFFMAN. Yes.

The CHAIRMAN. Have you looked the country over with a view to irrigation—storing water, diverting water from the rivers, etc.?

Mr. HUFFMAN. Yes, I have.

The CHAIRMAN. Can you describe the general topography of the country and what its advantages are for obtaining water?

Mr. HUFFMAN. Not being an engineer, I have not examined the country scientifically.

The CHAIRMAN. You have examined it as a practical man?

Mr. HUFFMAN. Yes; I have. It seems to me there is no country better adapted, naturally, for that purpose, taking into consideration the fall of the streams and the amount of water they carry in the springtime from the melting of the ice and snow. In June the streams have a large volume of water in them, and there are basins where a large number of reservoirs could be built for storing water. Since I read of your sayings in Congress and of the prospective work of this committee, it has seemed to me that here in the Yellowstone Valley more than in any other place I know of, considering the amount of land that could be reclaimed, the water could be more easily stored. If you will look out of the window you will see low hills, in which there are streams, and back of these streams you will find basins with a gulch leading out of them 2 miles long that might be made into reservoirs; and this little Tongue River goes over this bank.

The CHAIRMAN. You have no means of estimating what proportion of the country might be brought under irrigation by storage? You have not figured on that?

Mr. HUFFMAN. No, I have not figured on it; but I have it in my mind as to the great quantity of water that might be stored. The water that goes down these rivers would affect an enormous amount of land.

The CHAIRMAN. Then you agree with others who have testified in regard to irrigation?

Mr. HUFFMAN. Yes.

The CHAIRMAN. In what State did you live originally?

Mr. HUFFMAN. Iowa.

The CHAIRMAN. What do you say in regard to the productive capacity of irrigated land here as compared with that of Iowa? During a period of ten years, what would be the results?

Mr. HUFFMAN. There can be no comparison. We can raise more of the stuff I have seen planted here, beginning with garden vegetables. I do not know but that I will except corn. But of all that I have seen experimented with here, we can raise double what they can in Iowa.

The CHAIRMAN. You can have a sure crop here every year under irrigation?

Mr. HUFFMAN. Yes. We would escape one difficulty that they have there—our crops would not be destroyed at the time of harvest. We can rely on a dry harvest for the grain, and that they can not do in Iowa.

The CHAIRMAN. And you would have your own time to plant?

Mr. HUFFMAN. Yes.

The **CHAIRMAN**. Take a term of years in both countries; how would you compare an acre of land here with an acre in Iowa?

Mr. **HUFFMAN**. It would be a good deal better in all respects here, and would produce at least double. I consider double the crop a conservative estimate—especially hay—all forage.

The **CHAIRMAN**. Have you seen irrigation practiced long enough to observe anything about the effect of fertilizing land by that means? You have not looked into that.

Mr. **HUFFMAN**. We all know that a piece of prairie that is utterly worthless produces hay when irrigated, good blue stump hay, very nutritious. That we do not find anywhere else.

The **CHAIRMAN**. I think Major Powell can tell you something about the fertilizing effects of water.

Mr. **HUFFMAN**. Yes, I have read his writings with interest.

Director **POWELL**. To what extent back in the hills 3, 6, 8, and 10 miles can the storm waters be stored? What are the facilities up on the second, third, and fourth benches for storing storm waters?

Mr. **HUFFMAN**. They are vast. But as to the expense, it takes an engineer to estimate that. And, as I stated before, this country, from its topography, its contour, is better adapted to that sort of irrigation than any other country I have been in. I can not conceive of a better, when you take into consideration the nearness of water to the land to be supplied. You can go into the mountain ranges and find larger places for reservoirs for storing water, but that would be too far away from where you would want to use the water.

STATEMENT OF S. GORDON, OF MILES CITY, CUSTER COUNTY.

The **CHAIRMAN**. What is your occupation?

Mr. **GORDON**. Editor of the Daily Yellowstone Journal.

The **CHAIRMAN**. How long have you resided here?

Mr. **GORDON**. Nine years.

The **CHAIRMAN**. Have you traveled over this country?

Mr. **GORDON**. To some extent, yes.

The **CHAIRMAN**. Has your attention been called to the subject of irrigation and its effect?

Mr. **GORDON**. Yes.

The **CHAIRMAN**. What do you say in regard to its effect upon the land?

Mr. **GORDON**. Its effect is miraculous.

The **CHAIRMAN**. From what State were you originally?

Mr. **GORDON**. New York city, originally.

The **CHAIRMAN**. Were you familiar with the farms outside of the city?

Mr. **GORDON**. No; I lived in the city all the time; I have lived in Minnesota, too.

The **CHAIRMAN**. Do you know anything about farming land there?

Mr. **GORDON**. Yes.

The **CHAIRMAN**. What do you say in regard to the land there—its productive capacity for ten years as compared with land here?

Mr. **GORDON**. This land here has an advantage over the land in Minnesota.

The **CHAIRMAN**. What would be the relative capacity for production for a period of ten years?

Mr. **GORDON**. I think the wheat crop there is 10 or 12 bushels to the acre. I think here on irrigated land it would be 50 bushels to the acre.

I have at my office a sheaf of wheat that I ought to have brought here with me. It was produced on irrigated land.

The Chairman. Then, with your land, you have the other advantages of producing all sorts of crops.

Mr. Gordon. Everything that has been planted here grows spontaneously if it has water.

The Chairman. You have not had a chance to try whether fruits will grow here?

Mr. Gordon. Berries have been tried here; I do not think the larger fruits have been. There are some places where they have crab-apple trees.

The Chairman. Have you looked over the topography of the country with a view to seeing whether irrigation might be practiced here?

Mr. Gordon. I have, but I do not think my opinion would be worth much on that subject. I have no practical ideas on the subject.

The Chairman. Except what you have gained from others?

Mr. Gordon. Just what I have heard from others. What you have heard here to-day from other gentlemen would be what I would say.

The Chairman. What we have heard stated to-day is about the general judgment of the people familiar with the subject?

Mr. Gordon. That is the way we talk all the time.

The Chairman. What do you say as to the climate in this country?

Mr. Gordon. It is the finest that I have ever experienced. I do not know whether any other gentleman has touched upon the subject or not, but for the purposes of agriculture we have from six weeks to eight weeks longer season for crops than in any other place, comparing it particularly with Minnesota, where I have had most experience. The spring here commences earlier and the fall later. Our growing season commences about the 15th of March and ends in October.

STATEMENT OF J. W. STRIVELL, OF MILES CITY.

The Chairman. How long have you resided in Miles City, Custer County?

Mr. Strivell. Ten years.

The Chairman. Are you familiar with this section of Montana?

Mr. Strivell. Yes.

The Chairman. Have you traveled over it considerably?

Mr. Strivell. Yes; extensively.

The Chairman. What is your occupation?

Mr. Strivell. I am a practicing lawyer and interested in stock.

The Chairman. And those occupations have called you over the country?

Mr. Strivell. Yes.

The Chairman. Has your attention been called to the subject of irrigation?

Mr. Strivell. Yes, often. My attention has been called to it as the only remedy for this country—its salvation, if it is to have any.

The Chairman. Agricultural pursuits without irrigation would be impracticable?

Mr. Strivell. Wholly so.

The Chairman. What are the facilities for agriculture with irrigation?

Mr. Strivell. Very extensive. The effort to cultivate land without irrigation is a failure. I agree with one of the gentlemen who was on the stand in the early part of this examination, that it is only a question of time when it would break any man; but with irrigation, the reverse is true. I think this would be as successful a country with irrigation as there is on the globe. I have seen irrigation extensively practiced in Arizona. I have been over the lands in the Salt River and the Gila River Valleys.

The CHAIRMAN. Those valleys are fine illustrations of the effects of irrigation?

Mr. STRIVELL. Yes. I know they would be worth nothing without irrigation, and I think this country would be equally successful.

The CHAIRMAN. As the Salt River Valley?

Mr. STRIVELL. Yes. I think it would produce as well as the Salt River Valley. I have raised alfalfa, and I see no difference between it and the alfalfa in the Salt River Valley in Arizona. I have seen alfalfa in Colorado, and where we irrigate I think our alfalfa is equal to that in either of those places.

The CHAIRMAN. How many tons can you cut in a season, where it is properly cultivated—on irrigated land?

Mr. STRIVELL. Of course they tell fabulous tales in the Salt River Valley about cutting 10 tons to the acre in a season. I have alfalfa not irrigated, except as it gets moisture from a lake. This alfalfa is 10 feet from that lake, and it has all the effects that could be derived from irrigation, and I have cut it three times up to this date. I use it for horse feed. But I would not put the amount so high as they do in Arizona. I am convinced that with irrigation we could produce 6 tons to the acre.

The CHAIRMAN. How is your land with regard to variety of crops?

Mr. STRIVELL. All that you could produce in Illinois or the Mississippi Valley. I agree with Mr. Huffman that the corn would not be the kind of corn that is raised in the Mississippi Valley—so extensively raised there—though it might be. But all other crops that could be raised anywhere else in this northern latitude could be raised here.

The CHAIRMAN. From what State were you originally?

Mr. STRIVELL. New York, originally. I lived twenty-four years in Illinois.

The CHAIRMAN. Then you are more familiar with Illinois?

Mr. STRIVELL. I am perfectly familiar with that State.

The CHAIRMAN. What would you say as to all-around crops for a period of years? What would be the comparison between the land here and the average best land in Illinois?

Mr. STRIVELL. The estimate for Illinois is one successful crop in three years; the others a diminished crop. We could raise with irrigation a successful crop every year. Of course I do not mean that we might not in localities be subject to a storm or something of that kind—hail, perhaps, in a limited way. Though we are not in the hail belt we do sometimes have it. But you could safely count on a successful crop every year.

The CHAIRMAN. Do you know to what extent the water that is put upon the land fertilizes it?

Mr. STRIVELL. I think that depends on the water. If the water has a large amount of sediment in it, as it has in the Salt River Valley, it would. The Nile is an example of that. But I have no knowledge except of the water from the wells. I do not know that that has any fertilizing quality.

The CHAIRMAN. I do not suppose that it has any more than rainwater.

Mr. STRIVELL. No; but the water that comes down filled with sediment has a fertilizing quality to a large extent.

The CHAIRMAN. Suppose you were to catch the storm waters in reservoirs, how would that be?

Mr. STRIVELL. My opinion of the fertilizing quality of water is that it comes from the sediment carried in the water, and that would, if retained in a reservoir a long time, settle on the bottom.

The CHAIRMAN. I think Major Powell can give you some information on that head.

Director POWELL. Water stored in a pond from year to year becomes filled with microscopic plants, microscopic animals and organisms, and for that reason is valuable as a fertilizer.

Mr. STRIVELL. I have no doubt that is true.

The CHAIRMAN. Have you looked over the country with the view of ascertaining the extent to which you might practice irrigation here?

Mr. STRIVELL. Yes; I understand the formation of the country very well.

The CHAIRMAN. What are the opportunities for storing the water in ponds?

Mr. STRIVELL. Almost limitless. The country is made up of hills and gorges. A valley that you would at the mouth as you pass it scarcely suspect amounted to anything, yet when you get into it you would find it to be sometimes 25 to 35 miles long. I do not think I exaggerate. At the head of such a valley as that you could find a place where water could be stored for that whole lateral valley.

The CHAIRMAN. Would a system of surveys showing how that could be done and marking out the places be useful here?

Mr. STRIVELL. It would be almost invaluable. I think the great possibilities of this country are to be developed in the Rocky Mountains and arid regions.

The CHAIRMAN. You are practicing law here. Have you considered what changes should be made in our land laws to adapt them to our arid region?

Mr. STRIVELL. I have not, except this: It would require a combination of capital to make irrigation successful—to make ditches of sufficient length and capacity to irrigate the farms. You will find an illustration of that in a fine valley above here, known as the Pease Bottom. They have a ditch there which is an eminent success. But it takes a combination of capital. You can find land so low that you can utilize a basin. A basin might irrigate the whole valley, the people there being joint tenants.

The CHAIRMAN. At the last session Congress reserved these reservoir sites, and when the surveys are made they will be used in common by the people who irrigate from them.

Mr. STRIVELL. That is all that is necessary.

The CHAIRMAN. Do the people need any modification of the laws to enable them to combine and construct the works when they enter the lands?

Mr. STRIVELL. The matter of water is now receiving a large amount of attention from our constitutional convention which is now in session at Helena. I think that proprietary rights by an individual should be done away with, and I think they will be in our constitution. That is to say, our constitution will prohibit one individual from monopolizing the water.

The CHAIRMAN. You do not want the land divorced from the water?

Mr. STRIVELL. No, it should be with it.

The **CHAIRMAN**. Where the water is the principal and the land an incident, you do not want them separated?

Mr. **STRIVELL**. No.

The **CHAIRMAN**. Probably your convention has adopted the Colorado provision. The matter of arranging that is not difficult; it can be accomplished.

Mr. **STRIVELL**. I think so.

Senator **REAGAN**. What is the character of the soil in these valleys?

Mr. **STRIVELL**. The Yellowstone and Tongue River Valleys?

Senator **REAGAN**. Yes; where reservoirs could be made. What is the character of the soil there?

Mr. **STRIVELL**. If you will allow me, I will give you the opinion of another. The first time I came to this country I was with a Mr. Ames, of Illinois, a nephew of Bishop Ames. He said that the soil was better than the soil of Illinois.

Senator **REAGAN**. My question related to the character of the soil for holding water.

Mr. **STRIVELL**. As to whether it is impervious to water?

Senator **REAGAN**. Yes.

Mr. **STRIVELL**. It is largely impervious to water.

Senator **REAGAN**. How would that be in the valleys?

Mr. **STRIVELL**. You can make a ridge by damming, etc., elevate your water range and make your trough for a long distance out of the soil, and that will carry your water thoroughly almost any distance and take it off in lateral lines. It is perfect in regard to that.

Adjourned.

ON TRAIN AT BILLINGS, MONTANA, *August* 7, 1889.

The committee met on call of the chairman.

Present: Messrs. Stewart (chairman) and Reagan; also Director Powell.

STATEMENT OF H. W. ROWLEY, OF BILLINGS.

The **CHAIRMAN**. How long have you resided at Billings?

Mr. **ROWLEY**. Since 1882.

The **CHAIRMAN**. What is your occupation?

Mr. **ROWLEY**. I am a civil engineer.

The **CHAIRMAN**. Did you make the map which is before us, marked R. S. B., No. 3?

Mr. **ROWLEY**. Yes.

The **CHAIRMAN**. What does it represent?

Mr. **ROWLEY**. The valley of the Yellowstone, from Billings west, 35 miles.

The **CHAIRMAN**. And what else?

Mr. **ROWLEY**. And the country immediately tributary thereto. It is all the valley of the Yellowstone.

The **CHAIRMAN**. Does it represent anything else?

Mr. **ROWLEY**. It is a map of the valley. The red lines [indicating] show the ditches that have been constructed. The upper line [indicating] is the larger ditch, the one first constructed.

The **Chairman**. Does that include the larger portion of the land?

Mr. **Rowley**. Yes; that takes in the whole country. The others are parallel ditches, taking in that land down to the river.

The **Chairman**. What length is that?

Mr. **Rowley**. Thirty-five miles.

The **Chairman**. What size in width?

Mr. **Rowley**. Twenty-four feet at the bottom and 30 at the top.

The **Chairman**. How much land does it cover?

Mr. **Rowley**. It covers about 65,000 acres. It is not of sufficient size to irrigate that much.

The **Chairman**. Is there ample water in that river at that point to irrigate the land?

Mr. **Rowley**. Yes.

The **Chairman**. How much land is irrigated by that ditch?

Mr. **Rowley**. Five thousand acres at the present time.

The **Chairman**. Are the other ditches completed—those that we see marked here?

Mr. **Rowley**. They are nearly completed. Most of them are completed. I do not know but all of them are now completed. Some of them were constructed this year.

The **Chairman**. Have any of them been used to irrigate land?

Mr. **Rowley**. Yes; the ditch marked "Cañon Ditch" has been in operation two years.

The **Chairman**. What crop do you raise on the lands that are irrigated by these ditches.

Mr. **Rowley**. Wheat, oats, and some corn, alfalfa and millet and small fruits. I do not know all the crops; there is a great variety in a small way.

The **Chairman**. With what success have you produced crops with irrigation?

Mr. **Rowley**. We have very good success. The land here that is watered seems to be very productive.

The **Chairman**. From what State were you originally?

Mr. **Rowley**. I was born in New York; I have lived in Minnesota most of my life.

The **Chairman**. Are you familiar with the productions of Minnesota?

Mr. **Rowley**. Yes.

The **Chairman**. How will the land here compare with the land of Minnesota?

Mr. **Rowley**. I think it is equal to it and better for some things. It is much better for grass and alfalfa and things of that character. Grain has not been raised here to any great extent. But I do not see why it is not as good a grain country as Minnesota is.

The **Chairman**. Have you cultivated alfalfa to any considerable extent?

Mr. **Rowley**. To a sufficient extent to prove that it is a successful crop here.

The **Chairman**. How much hay do you produce to the acre?

Mr. **Rowley**. The hay that is produced is native grass.

The **Chairman**. I mean alfalfa—how many crops?

Mr. **Rowley**. Two or three crops a year—from 6 to 9 tons.

The **Chairman**. How with regard to the small fruits? Do berries flourish well?

Mr. **Rowley**. Yes.

The **Chairman**. You have not tried the larger fruits?

Mr. **Rowley**. This country has not been settled very long, but there are some few places in the valley where they have made a start and say that they can raise them.

The **Chairman**. How much farther west does the valley extend?

Mr. **Rowley**. This immediate valley extends up here 30 miles.

The **Chairman**. And there are other valleys on the Yellowstone beyond that?

Mr. **Rowley**. Yes.

The **Chairman**. For how long a distance?

Mr. **Rowley**. It opens out into valleys all the way along.

The **Chairman**. How far up?

Mr. **Rowley**. To the National Park.

The **Chairman**. What distance would that be from here?

Mr. **Rowley**. One hundred and fifty miles.

Senator **Reagan**. From Billings?

Mr. **Rowley**. Yes.

The **Chairman**. Have you ever made any estimate of the entire extent of the valley land of the Yellowstone River from the Park down to the Missouri?

Mr. **Rowley**. No; I never have.

The **Chairman**. What county are we in?

Mr. **Rowley**. Yellowstone County.

The **Chairman**. It joins on to the county in which Miles City is situated?

Mr. **Rowley**. Yes; Miles City is in Custer County.

The **Chairman**. And this joins on to Custer County?

Mr. **Rowley**. Yes.

The **Chairman**. How much valley is on this river?

Mr. **Rowley**. I can not say; I never had any occasion to estimate it. But take the two sides of the river, and what is now the Crow Reservation, and there is a large amount of valley land.

The **Chairman**. What would be the average width of it?

Mr. **Rowley**. Probably 2 miles wide. This valley broadens out to 8 miles in some places. Two or three miles, probably, would be the average.

The **Chairman**. What is the character of the land back from the river?

Mr. **Rowley**. To the north there is a large extent of table land—what is known as the lake basin country—a strip of country running from 20 to 30 miles in width, and perhaps 70 miles in length. It would be a fine agricultural country if it were watered.

The **Chairman**. Is there any opportunity to water it?

Mr. **Rowley**. Some think that there is.

The **Chairman**. What means of watering it have been suggested?

Mr. **Rowley**. Only by storage reservoirs.

The **Chairman**. What opportunities have you for storage reservoirs?

Mr. **Rowley**. That is a matter that has not been investigated. In the country, at the upper end of this basin, which runs up to the mountains, there is a large amount of water during certain seasons of the year—during June and July.

The **Chairman**. Is there a stream running through it?

Mr. **Rowley**. No; but probably there is plenty of water up there which could be gotten.

Senator **Reagan**. Is it too high at any point for the water from the river to be carried on to it?

Mr. **Rowley**. I think it might be. There is between all the streams rolling country and bench lands.

The **Chairman.** What is your first large stream that comes in as a tributary?

Mr. **Rowley.** Below here the Big Horn is the first river.

The **Chairman.** That is as large as the Yellowstone?

Mr. **Rowley.** Yes.

The **Chairman.** That has streams running into it?

Mr. **Rowley.** Yes.

The **Chairman.** Is it toward the south that these streams go?

Mr. **Rowley.** Yes.

The **Chairman.** Is it table land there, or how is it?

Mr. **Rowley.** Rolling country. Most of the streams head in the mountains, and then they run down into a rolling country, where nearly all of it can be irrigated.

The **Chairman.** What is the character of the land when irrigated?

Mr. **Rowley.** The land is good—nearly all of it.

Director **Powell.** You built one of these canals?

Mr. **Rowley.** Yes.

Director **Powell.** Can you give us an idea of the cost of constructing a canal?

Mr. **Rowley.** That was built at a time when everything was very high, and all the lumber was bought at a high price.

Director **Powell.** Put it in this shape, if you have thought of it in that direction: What does it cost, the original plant, of getting water on to the land—the cost per acre?

Mr. **Rowley.** It would be hard to get at it in that shape. The character of the country in some places is different from what it is in others, and it would cost more in some places than in others.

Director **Powell.** How much would it cost where you have seen it? Approximate it.

Mr. **Rowley.** That ditch, about 35 miles long, cost $100,000.

Director **Powell.** How much land will it irrigate?

Mr. **Rowley.** It probably irrigates at its present capacity about 15,000 or 20,000 acres.

Senator **Reagan.** Have lateral ditches been constructed to carry off the water?

Mr. **Rowley.** Yes; that is the way it all has to be done. These farms lie quite a distance from the main ditch. Some three or four farmers get together and take out a ditch, and then they will branch out.

Senator **Reagan.** How much wheat to an acre will they make on this irrigated land?

Mr. **Rowley.** From 20 to 25 bushels, and perhaps more than that. Wheat has not been raised to such an extent as oats. There has been no market for wheat. There is no mill in this country, and it does not pay to ship wheat east, and therefore it has not been experimented with.

The **Chairman.** How many bushels of oats to the acre do they raise?

Mr. **Rowley.** Forty to 60 bushels of oats.

The **Chairman.** Is corn raised in this part to any extent?

Mr. **Rowley.** No. But I do not know any reason why they can not raise good corn here.

Senator **Reagan.** Will corn have a good time to mature?

Mr. **Rowley.** This country seems to be as good as Minnesota for raising corn.

Senator **Reagan.** Have you estimated how much corn to the acre there is raised on irrigated land?

Mr. **Rowley.** No, I have not.

STATEMENT OF H. H. MUND, OF BILLINGS.

The **CHAIRMAN**. How long have you resided in Billings?

Mr. **MUND**. Since 1882.

The **CHAIRMAN**. Have you traveled over the country pretty generally?

Mr. **MUND**. I have been down this valley frequently, but never back to any place south.

The **CHAIRMAN**. Have you observed the effect of irrigation here?

Mr. **MUND**. Yes, frequently.

The **CHAIRMAN**. How is the land when there is no irrigation?

Mr. **MUND**. There is nothing raised. That is about it. It is just as you see the country coming up here—all barren.

The **CHAIRMAN**. You can not produce ordinary crops without irrigation?

Mr. **MUND**. In a damp season we can raise a small hay crop, but nothing else.

The **CHAIRMAN**. With irrigation, how is it?

Mr. **MUND**. Everything increases in productiveness. As Mr. Rowley has stated, from six to nine tons of alfalfa; two tons to the acre of native grass. I have seen the third season two tons to the acre cut on land that was absolutely barren without irrigation.

The **CHAIRMAN**. How is it with all-around crops?

Mr. **MUND**. Everything seems to do very well here so far as I can see.

The **CHAIRMAN**. Have you been farming?

Mr. **MUND**. No; I do not know millet from barley. I think Mr. Rowley stated those yields too low. I understood that when they raised oats it was forty bushels to the acre. Under irrigation, vegetables are simply wonderful. The potatoes we do not think can be beaten anywhere. I think that holds good in all irrigated countries. I have seen it in Colorado and the Black Hills.

The **CHAIRMAN**. How does this land compare in productiveness with the land in Colorado?

Mr. **MUND**. I should think that it is fully as good. It is a different character of soil, so far as I have been able to judge—more gravel there. But no fault can be found with the soil here when it is under irrigation. I have some grass which I would like you to examine. That was brought in from some little distance north of here. That was raised under irrigation. It is about four feet long and it is timothy hay.

[The sample of hay which was introduced by Mr. Mund, by actual measurement was found to be fifty-seven inches in length.]

STATEMENT OF ALEXANDER FRAZIER, OF BILLINGS.

The **CHAIRMAN**. How long have you resided here?

Mr. **FRAZIER**. Since 1881.

The **CHAIRMAN**. What is your business?

Mr. **FRAZIER**. I am in the grain and fuel business at the present time.

The **CHAIRMAN**. Have you ever been a farmer?

Mr. **FRAZIER**. Not much of a farmer.

The **CHAIRMAN**. Are you familiar with the growing of crops in this country?

Mr. Frazier. Yes; I have observed the growth of crops in this country since coming here.

The Chairman. Have you noticed it anywhere else?

Mr. Frazier. Yes, in Nova Scotia.

The Chairman. Can you raise crops here without irrigation?

Mr. Frazier. We can not raise crops here without irrigation. Some seasons, such as last, we have had considerable rain, and some crops could have been raised then without irrigation. But, as a rule, they can not be raised.

The Chairman. What have you to say of the growth of the crops here with irrigation?

Mr. Frazier. It will exceed anything, by natural growth, anywhere else.

The Chairman. You mean crops produced by rain-fall?

Mr. Frazier. Yes. I think our farms can produce one-fourth more than they can anywhere else by rain-fall.

The Chairman. By irrigation do you get a good crop each year?

Mr. Frazier. All the time. There has never been a failure here so far.

The Chairman. How was it in Nova Scotia? Could you get a good crop every year?

Mr. Frazier. If we had plenty of rain. If it were dry we could not.

The Chairman. Take an irrigated farm here of a given number of acres and one in Nova Scotia of the same number and allow for a period of ten years, what would be the difference between the two farms?

Mr. Frazier. The irrigated farm would exceed the other one-quarter, take it year in and year out.

The Chairman. Not more than that?

Mr. Frazier. I do not like to say more; but it might.

The Chairman. How many tons of alfalfa hay can you produce to the acre here?

Mr. Frazier. You can produce three crops during the season, averaging, perhaps, 2 or 3 tons to the crop.

The Chairman. How much can you produce in Nova Scotia?

Mr. Frazier. One crop.

The Chairman. How much would that be?

Mr. Frazier. A ton and a half would be a big crop.

The Chairman. Have you traveled out over the country outside of this valley?

Mr. Frazier. Yes.

The Chairman. What is the character of the country on the north?

Mr. Frazier. Arid, north and south; very dry.

The Chairman. Is there any chance to irrigate it?

Mr. Frazier. There might be from the Yellowstone if it were drawn out high enough.

The Chairman. Is there any chance for storing water?

Mr. Frazier. There is on the lake basin region. North of us, perhaps 30 miles, there are several lakes that might be suitable for storage purposes.

Senator Reagan. How long has this valley been under irrigation, do you know?

Mr. Frazier. Since 1882 or 1883. This large ditch, of which you have heard, was constructed in 1883.

Senator Reagan. Has the ground been under irrigation that long?

Mr. Frazier. Part of it has and part not. There are several sections of this land unsold and unoccupied, and consequently unirrigated. But farmers have bought the land here, and for miles they are irrigating. Two smaller ditches belong to the farmers themselves.

Senator **REAGAN.** Does the productiveness of the land increase after the first year's irrigation?

Mr. **FRAZIER.** I do not know that it increases; it keeps up. There has been no decrease in its capacity so far.

STATEMENT OF L. WHITNEY, OF BILLINGS.

The **CHAIRMAN.** How long have you resided in Billings?

Mr. **WHITNEY.** Since 1882.

The **CHAIRMAN.** What is your occupation?

Mr. **WHITNEY.** Just now I am county treasurer.

The **CHAIRMAN.** Are you familiar with the country about Billings?

Mr. **WHITNEY.** Yes.

The **CHAIRMAN.** Have you traveled over it considerably?

Mr. **WHITNEY.** Yes.

The **CHAIRMAN.** Have you ever been a farmer?

Mr. **WHITNEY.** Yes; raised on a farm.

The **CHAIRMAN.** Where?

Mr. **WHITNEY.** In Illinois. I have also farmed a little in Kansas.

The **CHAIRMAN.** Have you farmed any here?

Mr. **WHITNEY.** No.

The **CHAIRMAN.** Have you observed farming here?

Mr. **WHITNEY.** Yes.

The **CHAIRMAN.** What can you say of the farming here by means of irrigation?

Mr. **WHITNEY.** It is very good.

The **CHAIRMAN.** In what part of Kansas were you?

Mr. **WHITNEY.** Lane County, about 300 miles west of Kansas City.

The **CHAIRMAN.** How does the land here, where you have irrigation, compare with the land in Lane County, Kansas.

Mr. **WHITNEY.** I think it exceeds the land in Kansas—better land, better soil.

The **CHAIRMAN.** How is it as to the certainty of crops?

Mr. **WHITNEY.** With irrigation it is very much better. There they have some very dry seasons, when there is an entire failure of crops. With irrigation here it is certain every year.

The **CHAIRMAN.** A full crop every year?

Mr. **WHITNEY.** Yes.

The **CHAIRMAN.** How does the crop, when produced here, compare with the crop in Illinois—taking the crops all around?

Mr. **WHITNEY.** The small grains are produced here at the present time better than in Illinois. When Illinois was new it produced very good crops of wheat and oats; but now they do not get such crops there.

The **CHAIRMAN.** How is it here with potatoes?

Mr. **WHITNEY.** We have very good potatoes here.

The **CHAIRMAN.** How is it with vegetables of all kinds?

Mr. **WHITNEY.** Vegetables grow better here than in Illinois.

The **CHAIRMAN.** Of course, you have not tried any but the small fruits?

Mr. **WHITNEY.** Small fruits grow very well here. I was out on a little fruit farm this evening and it was appearing very well. We were in hopes of taking you out there to look at it.

The **CHAIRMAN**. Does alfalfa grow well here?

Mr. **WHITNEY**. Yes.

The **CHAIRMAN**. Have you examined to see how much alfalfa they produce here when it is properly cultivated?

Mr. **WHITNEY**. The man who has the largest field of alfalfa here told me that he gets 2 tons to the acre, and that he cuts three crops. He was telling me that he expects to get four crops this year. I was out at his place, and the alfalfa was 2 feet in height and as thick on the ground as it could stand.

The **CHAIRMAN**. What use do you make of alfalfa?

Mr. **WHITNEY**. It is an excellent food for all kinds of stock.

The **CHAIRMAN**. How does it compare with native grass?

Mr. **WHITNEY**. In regard to its quality as a food, do you mean?

The **CHAIRMAN**. Yes.

Mr. **WHITNEY**. Our native grass is a very fine grass. It makes a fine hay. It is very rich. We have not tried the alfalfa long enough to see which would be the better grass.

The **CHAIRMAN**. Have you used alfalfa in feeding hogs?

Mr. **WHITNEY**. Yes; it has been fed to hogs. They seem to do very well on it.

The **CHAIRMAN**. Have you ever estimated the extent of country along the river in this county that could be irrigated?

Mr. **WHITNEY**. We claim that there are nearly 100,000 acres in this valley, and we are situated at the lower end of it.

Senator **REAGAN**. Do you mean in this county?

Mr. **WHITNEY**. Yes; it is all in this county. There are nearly 100,000 acres. Something like 60,000 under the big ditch.

The **CHAIRMAN**. There are other valleys in this county?

Mr. **WHITNEY**. Yes; there are 40,000 acres in this valley above that ditch.

The **CHAIRMAN**. How much below?

Mr. **WHITNEY**. About 60,000 under the ditch, and 40,000 above. This valley ends right here across the bridge.

The **CHAIRMAN**. On the river valley in this county, how is it?

Mr. **WHITNEY**. Below, there is a table-land—I hardly know the extent of it—which lies next the river, and which, if it could be irrigated, would amount to 100,000 acres more.

The **CHAIRMAN**. That is this side of the Crow Reservation?

Mr. **WHITNEY**. Yes; below us here. We are in the center of the county. That extends some 60 miles below us.

The **CHAIRMAN**. How is it as to the Crow Reservation? That is in your county, is it not?

Mr. **WHITNEY**. For judicial purposes. It does not belong to this county.

The **CHAIRMAN**. How is it there?

Mr. **WHITNEY**. That is a pretty large tract of country—two, or two and one-half million acres of land; I do not know the exact amount.

The **CHAIRMAN**. Can it all be irrigated?

Mr. **WHITNEY**. It can be all irrigated. The lands south are different from the lands north. The land south is cut up by streams, and each of those streams has a valley, and the bench-land could be irrigated because it has a good down grade.

The **CHAIRMAN**. All that land across the river, then, can be irrigated?

Mr. **WHITNEY**. Yes, in the reservation. For instance, there is a little stream over which they have built a railroad to go to the coal mines. I was with the surveyor, and he told me that the fall in the stream there was 210 feet by actual survey.

The CHAIRMAN. Then there is a large quantity of land in this county that can be irrigated?

Mr. WHITNEY. Yes. Besides that there is a tract which has been mentioned as the lake basin country. That is between this and the Mussel Shell River. The soil in that country is different from the soil here—it is the best soil in this country; but there are no streams whatever running through it.

The CHAIRMAN. How do you propose to irrigate that?

Mr. WHITNEY. If we were going to experiment I should try the storage system. I should go up those mountains and try and get those little streams into a reservoir. It has never been examined very thoroughly, but parties who have traveled over the country say that they think an irrigating ditch can be built. By a little stream of water called the Sweet Grass, 20 miles in length, the water could be brought to the basin. I think it possible for that to be done. Then irrigation by means of artesian wells has been suggested.

The CHAIRMAN. Have any artesian wells been sunk in this vicinity?

Mr. WHITNEY. Only here in town, but that well was not very deep.

The CHAIRMAN. How deep is it?

Mr. WHITNEY. A little over a thousand feet.

The CHAIRMAN. Through what formations did the drill pass?

Mr. WHITNEY. Slate, all the way.

The CHAIRMAN. Did you not go through the slate?

Mr. WHITNEY. They did not go through it. It is like the formations of those bluffs across the river.

The CHAIRMAN. Was the slate flat or did it tilt?

Mr. WHITNEY. Flat. It is a sort of shale instead of slate. I was wrong in saying it was slate; it was shale.

The CHAIRMAN. You did not find any other strata?

Mr. WHITNEY. No, nothing but that. The man who had charge of the work told me that just as they quit they were getting into a lighter substance, whatever it was, and apparently more sandy. But the money gave out and they stopped right there, and it has never been taken up since. It does seem to me that a well system ought to be tested, especially in this lake basin country.

The CHAIRMAN. You have no necessity for it here?

Mr. WHITNEY. Not in the valley. The town is supplied with water, and we can get water easily enough in the valley. But here are bluffs 250 feet high which would have to be irrigated, and those bluffs are of the same height anywhere along the stream. I have estimated carefully about 450,000 acres of land, and probably every acre of it could be brought under irrigation.

The CHAIRMAN. Is it rich land?

Mr. WHITNEY. Richer than that in the valley. It is the wash from the hills. Go up there and look at the sage brush and the stuff that grows there and you will see it is rich.

The CHAIRMAN. Is there a large growth of sage brush up there?

Mr. WHITNEY. Yes.

The CHAIRMAN. Do you in this country regard that as an indication of good land?

Mr. WHITNEY. Yes. I have no doubt from what they tell me they have raised there that that land would yield 40 bushels of wheat to the acre.

Senator **Reagan**. How long has this country about Billings been settled?

Mr. **Whitney**. There were a few settlers here before the town was started, but they were scattered along the river. The most of the settlement has been made within the last seven years.

Senator **Reagan**. Has some effort been made here to raise apples, pears, plums, and cherries?

Mr. **Whitney**. Plums and cherries, I think, would grow, and some have been raised here. As to apples and pears, I do not think anything has been done in that line. There have been a few trees put out.

Senator **Reagan**. Do they seem to grow well?

Mr. **Whitney**. The trouble with fruit trees seems to be the dryness. Unless they are well irrigated they are apt to be killed in the winter. They will have to be very carefully managed and the ground irrigated to make a success of them. But small fruits—plums and cherries—would grow well. We have wild plums growing on the reservation.

The **Chairman**. Has anybody undertaken in this country to write a description of it; its resources? Have you any documents on that subject?

Mr. **Whitney**. Mr. Smalley has written something of that kind.

STATEMENT OF J. H. CONRAD, OF BILLINGS.

The **Chairman**. What is your occupation?

Mr. **Conrad**. I am a ranchman.

The **Chairman**. You raise stock?

Mr. **Conrad**. Yes.

The **Chairman**. In what part of the county?

Mr. **Conrad**. I am raising stock, not especially in this county but in this Territory, and also in Wyoming.

The **Chairman**. Then you have traveled all over the country about here?

Mr. **Conrad**. Yes. I have spent about twenty years traveling over these prairies.

The **Chairman**. Are you familiar with the valley of the Yellowstone generally?

Mr. **Conrad**. Yes. From the head to the mouth.

The **Chairman**. And with the country on either side?

Mr. **Conrad**. Yes.

The **Chairman**. Have you ever made an estimate of the amount of valley land there is in the Yellowstone?

Mr. **Conrad**. There are 400 miles of valley land in length.

The **Chairman**. What would be the average width?

Mr. **Conrad**. It is safe to say 5 or 6 miles.

The **Chairman**. Do you think it would average 5 miles?

Mr. **Conrad**. Yes.

The **Chairman**. Taking out the space of the river, do you think the real valley land would average 5 miles?

Mr. **Conrad**. Yes. There are a number of bottoms, like this we have here, of from 50,000 to 100,000 acres, of what would be called bottom land. That can be irrigated at a very small cost. But my experience of this country is that fully 85 per cent. of it could be irrigated by the Yellowstone, Missouri, Big Horn, and their tributaries.

The **Chairman**. You would have to resort to storage then?

Mr. **Conrad**. Not necessarily. The Yellowstone River has sufficient fall to irrigate all the prairie lands from the mountains to the Missouri River, where it empties.

The CHAIRMAN. You have some bad lands that you would exclude from the prairie land?

Mr. CONRAD. Yes. I think it is a safe estimate to say that 85 per cent. of the land is susceptible of cultivation, and that would be productive in raising crops.

The CHAIRMAN. That is, if all the water were made available?

Mr. CONRAD. Yes.

The CHAIRMAN. How wide a space would you make? You say it is 400 miles from the head of the valley to the mouth of the river?

Mr. CONRAD. Yes; from the mouth of the river to where it comes out of the mountains it would be that length.

The CHAIRMAN. Then how much north and south?

Mr. CONRAD. I think it could be irrigated for 50 miles on each side of the river. When you get back on the table-lands the soil is very much richer as a rule than on the bottoms. Take it in the basin of the country and on the Crow Reservation, and on both sides of the river, it seems to me to be a rich black loam soil; the greater portion of it, except where you get into these bad lands.

The CHAIRMAN. What has been the result of irrigation where it has been practiced?

Mr. CONRAD. I have watched it while I have been in the Territory, for twenty years, and I have never known a failure of crops where they had water to irrigate the crops. As compared with my observation of crops in the East, they are very much greater. It is safe to say 50 per cent. better here. East of here, about 125 or 150 miles—in Wyoming—the mountain streams run out of the mountains, where it is very easy to irrigate, and the farmers there raise from 40 to 50 bushels of wheat to the acre.

The CHAIRMAN. As a regular thing?

Mr. CONRAD. As a regular thing; year in and year out. They also raise from 40 to 60 bushels of oats; and as to potatoes I would not undertake to say exactly, but I am safe in saying that it is double the yield of anything I have seen in the United States elsewhere.

The CHAIRMAN. And you have no failure of crops?

Mr. CONRAD. None whatever, of any kinds of crops.

The CHAIRMAN. How is it with your experience in the East? Would you not have rain some time in the spring and then drought and then rain in the harvest, and so on?

Mr. CONRAD. I began farming in Virginia, and we got three crops out of five; that is to say, three years in five, on an average, we had a good crop.

The CHAIRMAN. If you were to take the best land in Virginia and land irrigated here and compare the production for, say, ten years, what would be the difference between the two places?

Mr. CONRAD. It would be more than double. In the first place, you raise 50 per cent., year after year, more than you can possibly raise without irrigation.

The CHAIRMAN. More than their best crops in the most favorable seasons; and you would get a sure crop every year?

Mr. CONRAD. You would get ten crops in ten years; whereas you are in big luck if you get five full crops in ten years in the States.

The CHAIRMAN. Have you observed the production of alfalfa?

Mr. CONRAD. Yes. They get three crops a year of it. And here it is proven that they get in this valley from 6 to 10 tons an acre. I know of land in Montana that when watered for four or five years has produced more than that, but how much I would not like to say.

The CHAIRMAN. Does it improve after a little while?

Mr. CONRAD. It improves year after year.

The CHAIRMAN. You do not know how long it would continue to do so?

Mr. CONRAD. They have been raising alfalfa about here for seven or eight years, and they seem to get an improvement in it each year. The roots of the alfalfa seem different from those of other crops. They run down to a very great depth. In Nevada they are better posted on alfalfa than they are here.

The CHAIRMAN. It has been a great success in Nevada?

Mr. CONRAD. Yes. I have not seen a failure where they have watered for twenty years in this country.

The CHAIRMAN. If all the lands susceptible of irrigation were brought under cultivation there would be a good deal of land remaining for pasturage, would there not?

Mr. CONRAD. Yes; the remaining land would be very useful for pasturage. In fact there is none of the land that is not susceptible of irrigation except these bad lands that you came through this morning before you came to Glendive. We have not a great deal of bad land in Montana. The bad lands do not extend very far back into the Territory.

The CHAIRMAN. The worst view of it is had in coming up the railroad?

Mr. CONRAD. Yes. You look out of your car window and see the bluffs on each side, and you think perhaps the prairie country is the same way. But when you get up to the benches you find it to be the finest land in the country; better land than the State of Illinois. The great majority of it is table-land, and for hundreds of miles it is as level almost as a floor. And all of that can be watered by bringing canals from those rivers. I do not think storage would be necessary at all.

The CHAIRMAN. If there is not water enough in the rivers, you can increase the water by storage, can you not?

Mr. CONRAD. Yes; by simply building the dam in the natural place.

The CHAIRMAN. Is it your experience in travelling over the mountains that almost all streams and all feeders head in flats or lakes, as a rule?

Mr. CONRAD. No. There are no streams that I know of in Montana that do not head in these mountains here, or near some mountains.

The CHAIRMAN. Is there a convenient place, as a rule, for making reservoirs?

Mr. CONRAD. Yes. You can find those wherever you want them.

The CHAIRMAN. Are there plenty of such places in this Territory?

Mr. CONRAD. Yes. The land runs into these coulées.

The CHAIRMAN. What do you mean by coulées?

Mr. CONRAD. Little places that dams can be made in and would hold an unlimited amount of water.

The CHAIRMAN. Are they found numerously throughout the country here?

Mr. CONRAD. Yes.

The CHAIRMAN. Along the little streams?

Mr. CONRAD. Yes.

The CHAIRMAN. Would it be of any advantage to the people here to have a survey of this land to show how much land could be irrigated, and how much water could be stored, and estimates of the cost of construction, etc.?

Mr. **Conrad**. I should think it would be of decided advantage.

The **Chairman**. The Government has undertaken to make these investigations and surveys, and is going to give considerable attention to the subject. You are aware that the law already reserves all places on the public lands that are adapted for the purposes of making reservoirs or ditches, and all rights of way of that character?

Mr. **Conrad**. Yes; we have embodied that in our constitution here now. We have set aside all rights of that kind that may be wanted in the future, without cost.

The **Chairman**. Have you any other facts that you would like to state to the committee?

Mr. **Conrad**. I simply wish to say that when you get through with this work I hope you will not forget the Yellowstone Valley. Here is where we have the most farming land of any place in Montana.

Senator **Reagan**. Is it your opinion that the continued irrigation and cultivation of this valley has increased its production?

Mr. **Conrad**. Yes, decidedly. Where the farms are continuously cultivated the farmers seem to get better crops each year.

Senator **Reagan**. Have you ever reflected that that might be the result of the fertilizing matter in the water?

Mr. **Conrad**. Well, I do not know but that is it. It is probably because it washes out the alkali and makes the land susceptible of cultivation.

The **Chairman**. Pond water is a great fertilizer.

Mr. E. V. **Smalley**. I should like the committee to ask Mr. Conrad something about this great Judith Basin above here.

Mr. **Conrad**. That is one of the most fertile valleys in this country.

The **Chairman**. Is it being cultivated?

Mr. **Conrad**. Yes.

The **Chairman**. Where is it?

Mr. **Conrad**. Between here and Fort Benton, on the Missouri River. It runs into the Missouri River. The farmers are irrigating it in a small way, but they have not sufficient water to irrigate the whole of it. As to raising fruit, particularly plums, it used to be known years ago that plums of unusual size were produced there.

Senator **Reagan**. Have they tried to raise apples and pears successfully?

Mr. **Conrad**. They have done so in the western part of the Territory, but here they have not tried it yet. The farmers have had all that they could do to raise potatoes and things that were indispensable. They raise a good deal of grain there, because it is easily irrigated, and the farmers have been able to irrigate it with their plows at small cost. But that basin is not more productive than these bench lands up here would be if you got water on them.

Senator **Reagan**. What are the results of farming in that basin?

Mr. **Conrad**. They have made a good deal of success of it, because each farmer has been able to go out and build his little ditch and get water on it. Here is a farming country over here that they raised a good deal of oats on, and the supply is greater than the demand because there is no railroad in there yet. But the streams run out of the mountains and the farmers can irrigate their land easily, and so they can raise everything easily. The best evidence of this irrigation you will see to-morrow along the Gallatin when you get to Bozeman. It is no more productive than this valley, but it is easily irrigated, and the farmers have irrigated that whole valley.

Senator **Reagan**. How much land is under cultivation by irrigation in that valley?

Mr. **Conrad**. I would not undertake to say, but, I should judge, about 100,000 acres. They have two large flour-mills there. They raise fruits and vegetables in unlimited quantities.

Senator **Reagan**. Do they raise such fruits as apples and peaches?

Mr. **Conrad**. I will not say as to peaches, but I know they raise apples. I would not like to say about pears. Good strawberries, however, and fruits of that kind are raised there, and are shipped all over the Territory. They have not raised many apples. With a frontier farm it is all the farmer can do the first five or six years to get the water on to his farm and to raise the substantial things of life with which to support his family. After that is done he goes to work and raises some of the luxuries. I have seen as fine corn raised here near Billings as I have ever seen in Virginia.

Senator **Reagan**. How are the land laws suited to the occupancy of this country with regard to land that can be irrigated?

Mr. **Conrad**. The land laws are good with the exception of the delay that has occurred in Washington in getting titles to land.

Senator **Reagan**. Where there is considerable capacity for irrigation can homesteaders take the land and make it successful?

Mr. **Conrad**. Yes. But they can not do so where there is a large expense connected with irrigation, because they can not get the water out. To take the land under the desert land act costs more to get the water out than the land is worth after you get the water on it.

Senator **Reagan**. How so?

Mr. **Conrad**. Well, one man can only take up 640 acres under that act, and to dig a ditch ten miles long would cost a good deal of money.

Senator **Reagan**. What kind of land laws would you suggest that would be better?

Mr. **Conrad**. I could not answer that question intelligently. I do not know what suggestion to make. I should think, though, that if this system of irrigation was carried out by the Government all this land that lies out here now an idle waste, would be taken up by actual settlers and farmers.

Senator **Reagan**. It would be necessary to have the laws so modified that they could combine together, would it not, and operate it as a company?

Mr. **Conrad**. No. If they could get water there they could take it up under the homestead and pre-emption act, as they do now.

Senator **Reagan**. They could do that out on the prairies where they could get at it by individual effort?

Mr. **Conrad**. Yes.

Senator **Reagan**. But where they could not do it by individual effort then there must be some arrangement whereby they can combine, must there not?

Mr. **Conrad**. Yes. In that event, in case the Government does not go to work and irrigate the land the only way I should think that the land could be irrigated would be to sell it in large lots to companies that would go to work and irrigate it.

Senator **Reagan**. Would not that create a monopoly in land?

Mr. **Conrad**. Of course it would. Instead of the farmer getting the land for $2.25 or $2.50 an acre, he would have to pay $10 or $15 or $25 or whatever they would sell it for. The only true system for putting it in the hands of the actual settlers would be for the Government to dig these canals and sell the land at a price, if necessary, that would pay the expense of digging and maintaining the canals, or let them have a rental for the water. We pay $2 an inch for the water in this valley now.

Senator **REAGAN**. Do you think it is desirable to have the title of the land and water separate, or ought they to be together?

Mr. **CONRAD**. They ought to be together. The land would be worth nothing without the water.

Senator **REAGAN**. That would be a pretty bad monopoly, then, if they could monopolize the water.

Mr. **CONRAD**. Yes. But you could irrigate these bench lands and give the land and water to the actual settler at say double what the Government charges for it now; and it would be settled very quickly, and it would be very much cheaper to the farmer than trying to irrigate it himself.

Senator **REAGAN**. Do you think that if the State had these lands they could irrigate and sell them and not let them fall into the hands of monopolies that would take advantage of the situation?

Mr. **CONRAD**. Well, the State of Texas did not do it.

Senator **REAGAN**. There is some danger in letting the State do it, you think?

Mr. **CONRAD**. Well, I would not say that. But I think that the National Government has managed the land so far and has managed to keep it out of the hands of monopolies, and I do not see why they could not continue to do so.

The **CHAIRMAN**. Is there any other gentleman here that can give us any other information?

Mr. **CONRAD**. Captain Merritt can tell you a good deal.

Captain **MERRITT**. I am not sufficiently familiar with the topography of the country to give the committee any information that would be of value. I have been here only since December, and my time has been taken up in constructing a little railroad up here to Red Lodge. I know but very little of the country around here from actual observation.

FURTHER STATEMENT OF H. H. MUND, OF BILLINGS.

The **CHAIRMAN**. Is there something you wish to add to what you have already stated?

Mr. **MUND**. I wish to call the attention of the committee to two or three things that have been omitted from the testimony given here.

The question was asked whether alfalfa was ever used for fattening hogs. It is not, I think, used for that, but it has been used for fattening sheep. Last fall a man had 500 yearling wethers, as they were called, and paid for them $1.75 apiece. At shearing-time they sheared 14 pounds 2 ounces to the fleece. He sold the balance on the basis of $3.50 apiece. That is, he got a ewe and a lamb in exchange for that alfalfa. That is on Mr. Steward's ranch, a little way out of here.

As to artesian wells, it was attempted to get water from artesian wells here at an early day, and I am very strongly of opinion that water was reached and passed. I am satisfied that water was reached long before the 1,000-foot depth was reached, though we did not get a flowing well.

With reference to the question of irrigation, it must be remembered that while there is better irrigation at Bozeman than here, yet they have been irrigating there for twenty-five years, while at this point irrigation has been tried only for five or six years.

With regard to the desert land law, the Government has allowed a man who has an actual interest in one of those ditches to prove up. That is, if he had one-fourth or one-tenth interest in a regularly-constructed irrigating ditch that brought water to the land, it was considered that he had done the work of reclaiming the land.

STATEMENT OF F. COUSINS, OF BILLINGS.

The CHAIRMAN. How long have you resided in Billings?

Mr. COUSINS. Since 1883.

The CHAIRMAN. Are you familiar with this region.

Mr. COUSINS. I am.

The CHAIRMAN. What have you to say with regard to irrigation?

Mr. COUSINS. I would like to call the attention of the committee to a fine tract of land north of this basin country and north of the Musselshell. It is a tract of country that can be irrigated with stored water. There is not enough water in the streams that flow from the mountains, but there are excellent facilities for storing the water by means of dams at the heads of those streams where they issue from the mountains. The tract is about 30 miles long by an average of 10 miles wide.

The CHAIRMAN. What is the character of the land?

Mr. COUSINS. It is of the same general character that prevails through this country, except that there is more black loam near the mountains. At a distance of a few miles from the mountains it assumes this gumbo sage-brush character.

The CHAIRMAN. Has there been much farming done in the valley?

Mr. COUSINS. There has been some done near the streams, There are really no valleys; they are mostly benches.

The CHAIRMAN. They have done some irrigation there.

Mr. COUSINS. Yes; a good deal of irrigation. That specimen of timothy grass that you have had before you came from that country. There are several fine streams, but there are a great many small streams from which water can be stored and carried out to the plains with good effect.

The CHAIRMAN. Is there a considerable field of that kind of grass?

Mr. COUSINS. Yes; there are extensive fields of that kind of grass.

The CHAIRMAN. Have they raised any alfalfa in that region?

Mr. COUSINS. Very little. They have perhaps done so for a year or so, but not much yet. They have raised the natural hay, however.

The CHAIRMAN. Are they raising a variety of crops there?

Mr. COUSINS. Oats and hay make the principal crops. They don't raise any vegetables but what they want for their own use.

The following papers were filed with the committee at Billings:

THE LANDS OF YELLOWSTONE COUNTY.

Within the limits of Yellowstone County, Mont., there are about twenty townships, or 460,000 acres of land, which are marked upon the Congressional surveys as "Agricultural lands."

This tract lies along the divide between the Musselshell and Yellowstone Rivers, and although it is drained on each side by *coulées* running to the above rivers, there are no living streams throughout its whole extent, and but few springs, except in the rainy season. The surface is very generally level, or so nearly so that it could very readily be irrigated, provided a source could be found from which to obtain the water. The soil is very rich, being washed from the hills and uplands; undoubtedly it is the richest soil in this region. In several places there are small ponds, evidently formed by the surface-water collecting in them, which become nearly or quite dry in very dry seasons, though they are usually great resorts for ducks and geese in the fall. Wells have been dug at several points along the stage-line which crosses this section from Billings to Lavina, and water is usually found at 15 to 20 feet.

This section should be thoroughly investigated, with a view to the practicability of its irrigation, either by going to the mountains west and collecting the water from the small streams rising there—bring it by an irrigating ditch to the proper points for distribution over this area—or artesian wells should be dug upon various portions of the tract, in order to thoroughly settle the point as to whether they would be successful or practicable. This scheme would be impracticable for private enterprise from the difficulty of insuring a reasonable return for capital invested, but if undertaken by the Government and if successful, a return would be made at once by the sale of the land, which at present is unsalable and only fit for grazing.

LIST OF IRRIGATION WORKS IN THE YELLOWSTONE VALLEY.

1. *M. and M. Land Irrigation Company's Ditch.*—Bailey & Billings, agents, Billings, Mont. Built in 1882 and 1883; 35 miles in length; 24 feet wide at bottom; will carry 3 feet of water; capacity about 7,000 inches. It will irrigate 15,000 acres or more. Covers about 60,000 acres. Water is sold at $2 per inch per annum. Built at an expense of about $90,000.

2. *Crayon Creek Ditch.*—Address, Billings, Mont. Built in 1885, by S. H. Erwin, Jos. Danford, J. Dennison, *et al.* It is 15 miles in length; capacity about 2,000 inches; built by labor of the stockholders. The company has 1,000 shares, valued at $10 each; stock paid by labor on the ditch, and each stockholder has a right to a miner's inch at least of water; but they actually receive nearly 2 inches on each share of stock owned.

3. *Italian Company's Ditch.*—Address, Park City, Mont. It is about 10 miles in length. Supplies about 10 ranches of 160 acres each; was built in 1887.

Mill Company's Ditch.—Address, Perry Whitsett, Park City, Mont. It is about same size and capacity as the Italian Ditch; has 10 share-holders, and cost about $300 to each in labor; was built in 1889.

5. *Clark's Fork Company's Ditch* was built in 1882; is about 4 miles in length; owned by and supplies water to six ranchmen, each owning about 160 acres.

All the above ditches supplied by the Yellowstone River.

The McAdow Ditch, built by Mr. P. W. McAdow, is some 2¼ miles in length, but can only be used in high water, and is a complete failure this year from that reason.

There is estimated to be at least 40,000 acres in the Clark's Fork Valley of the Yellowstone, in which the foregoing ditches are located, which would be available for cultivation provided water could be used, but it would be at considerable expense on account of the distance the water would have to be conveyed. It could be reached from the Yellowstone, and the supply would be ample. This land lies above all the present ditches.

Crops have been raised in this valley of wheat, from 25 to 40 bushels; of oats, from 50 to 70 bushels; of hay, from 1 to 1¼ tons; and of alfalfa, usually 2 tons each cutting per acre and three cuttings each season.

All root crops are very fine and large. Potatoes are mealy, large size, and always sound to the core. The crop is 300 to 400 bushels per acre.

Water should be supplied about eight months in the year, as it is necessary to use it upon some portion of the growing crops or in preparation for planting them, or upon the grass and hay lands, from the time frost is out of the ground until the ground is again frozen in the fall (which is sometimes nearly Christmas). The elevation of Billings above the sea is 3,115 feet. Our soil is excellent—a loam, somewhat sandy. It is usually estimated that an inch of water will irrigate an acre, and if carefully used will probably do a little more, but this, of course, varies with the nature of the soil. Without irrigation this valley would be practically useless for purposes of agriculture.

Adjourned.

ON TRAIN NEAR BILLINGS, *August* 8, 1889.

The committee met pursuant to call of the chairman.

Present: Messrs. Stewart (chairman) and Reagan; also Director Powell.

STATEMENT OF JAMES D. WHELPLEY, OF LIVINGSTONE.

The CHAIRMAN. How long have you resided in Montana?

Mr. WHELPLEY. Nine years.

The CHAIRMAN. How long in Livingstone?

Mr. WHELPLEY. About a year.

The CHAIRMAN. What county is this?

Mr. WHELPLEY. Park County.

The CHAIRMAN. Are you familiar with the topography of the country?

Mr. WHELPLEY. I am fairly well familiar with Park County.

The CHAIRMAN. Have you considered the matter of irrigation?

Mr. WHELPLEY. Not so much in Park County as I have in Fergus County.

The CHAIRMAN. Where is that?

Mr. WHELPLEY. North of Billings.

The CHAIRMAN. Have you resided in that county?

Mr. WHELPLEY. Yes, I resided there for four years.

The CHAIRMAN. And you considered the matter of irrigation relative to that county?

Mr. WHELPLEY. Yes, practically.

The CHAIRMAN. Will you give us a description of the land that can be reached by the flow of the streams, and what success has been met with where irrigation has been practiced?

Mr. WHELPLEY. Fergus County is included in what is known as the Judith Basin, which is the subway drainage of the Judith River, which runs into the Missouri. The Judith is fed by a large number of spring creeks that rise in the mountains and form the basis of the river; whereas the river itself has comparatively little water in it. There is a large amount of water distributed over the basin.

The CHAIRMAN. Does much water go down the river in flood times?

Mr. WHELPLEY. A great deal. But the country is peculiar, owing to the sinkage of water. It is like it is in other parts of the Territory—the upper part is coarse gravel, and the real bed of the stream is 40 or 50 feet below the surface of the ground. The flow ceases in the spring, the water sinks into the earth, and for months the streams are dry.

The CHAIRMAN. How would you prevent the water sinking?

Mr. WHELPLEY. The only way I have seen it done is by puddling the river bed. The sawdust and dirt fill up the cracks between the bowlders.

The CHAIRMAN. Could it not be done by ditches from the original bed?

Mr. WHELPLEY. You will find that every inch of water in the basin is covered by water rights.

The CHAIRMAN. Is there any opportunity there to store water?

Mr. WHELPLEY. There is at the head of the Judith, but you would interfere with water rights.

Senator REAGAN. What do you mean by "water-rights?"

Mr. WHELPLEY. We have no good law on that subject in this country; we use the California law, and it is defective for this Territory. That is one of the first things to settle in this country.

The **CHAIRMAN.** Do you allow a person to hold a water-right without using it?

Mr. **WHELPLEY.** By the common law he can acquire a right by filing his papers within one year, or else he acquires the right by the first use of the water.

Senator **REAGAN.** Under what law is that done?

Mr. **WHELPLEY.** They use the California law here.

Senator **REAGAN.** Did your legislature adopt the California law as the law of this Territory?

Mr. **WHELPLEY.** No; I do not think it has done so.

Senator **REAGAN.** It is a custom of the country?

Mr. **WHELPLEY.** Yes.

The **CHAIRMAN.** Is your convention which is in session at Helena likely to incorporate in the State constitution the provision which is in the constitution of Colorado?

Mr. **WHELPLEY.** It has not been adopted, and it is a question whether it will be or not.

The **CHAIRMAN.** Leave all questions of law out of the subject and give us the physical conditions of that valley. Could water be stored there so as to increase the volume?

Mr. **WHELPLEY.** Yes; I think it could be.

The **CHAIRMAN.** In addition to the Judith River, are there any other creeks and streams coming into the valley?

Mr. **WHELPLEY.** They are all tributaries of the Judith River.

The **CHAIRMAN.** They come in from both sides?

Mr. **WHELPLEY.** Yes. It is a pretty well watered plain. There is one stream there which is remarkable—Big Spring Creek.

The **CHAIRMAN.** I noticed coming along this morning that some of the farmers had allowed the water to stand on their land. Have you taken into consideration the question of drainage as well as that of irrigation?

Mr. **WHELPLEY.** The question of drainage is not agitated with us very much; the question with us is enough water.

The **CHAIRMAN.** Do you not know you can have too much water?

Mr. **WHELPLEY.** Yes; but I think in alkali valleys like this of Billings, where the soil is clay, most of the land drains itself very rapidly.

The **CHAIRMAN.** They will have to be very careful of that kind of land or lack of drainage will spoil it.

Mr. **HINTON.** Have you any statistics in regard to this district?

Mr. **WHELPLEY.** No; there is no map in existence to-day, topographical or any other character. I have myself most of the maps of Montana. There are little patches of land that have been surveyed for ranches, but they are so disjointed as not to permit of a connected map of the whole country. Most of this surveying was done by the War Department, as I understand, and the original map is made from these surveys. They did a good deal of it by guess work. I know the map is wrong, being thoroughly acquainted with the country.

The **CHAIRMAN.** Are you acquainted with the country further east of the Yellowstone?

Mr. **WHELPLEY.** The Judith River becomes a very large stream before it reaches the Missouri River. But there is land that will not be used for a great many years—it is bad land.

The **CHAIRMAN.** Have you been on the table lands that are on both sides of the Yellowstone River?

Mr. **WHELPLEY.** On the north side, yes.

The **CHAIRMAN.** What kind of territory is that?

Mr. **Whelpley.** It comprises long stretches of table lands broken by coulées.

The **Chairman.** What do you mean by "coulées?"

Mr. **Whelpley.** Ravines. Coulée is the Montana name for ravine; a coulée is a ravine; they gradually lead into larger coulées or ravines between the divides. The divides consist of long stretches of table land as a general rule.

The **Chairman.** Is it good land?

Mr. **Whelpley.** Yes.

The **Chairman.** Are you an engineer?

Mr. **Whelpley.** Yes; I came out here for that purpose, to practice my profession.

The **Chairman.** What are the chances of getting out the waters of the Yellowstone onto these table lands?

Mr. **Whelpley.** I do not think it is practicable.

The **Chairman.** Many engineers tell us it is practicable.

Mr. **Whelpley.** It may be on the plateau for a limited number of miles back of Billings. But I should not consider it practicable for a number of years to come.

The **Chairman.** I am not talking of the number of years it will take, but whether it can be done?

Mr. **Whelpley.** Yes, it can be done.

The **Chairman.** From your observation what is the result of irrigation, so far as producing crops is concerned?

Mr. **Whelpley.** Better crops are produced here than in rainy sections.

The **Chairman.** From what country did you come originally?

Mr. **Whelpley.** New York State.

The **Chairman.** From the interior.

Mr. **Whelpley.** Part of the time. New York State is my home.

The **Chairman.** You have seen land cultivated in the East?

Mr. **Whelpley.** Yes; I have seen the finest in New York State.

The **Chairman.** Take the land in New York State for a number of years and compare it with irrigated land in Montana, and what is the result?

Mr. **Whelpley.** I think in small grains the productiveness per acre is larger here. There is no fertilizing done here—it is virgin land.

The **Chairman.** And how is it as to regularity of crops?

Mr. **Whelpley.** We have an absolute regularity of crops.

The **Chairman.** Is that the case in New York?

Mr. **Whelpley.** No, the crops vary there.

The **Chairman.** If you were to compare land in the two places for a period of ten years which would have the advantage—the land in New York or in Montana?

Mr. **Whelpley.** The land here.

The **Chairman.** How much advantage, taking all around crops?

Mr. **Whelpley.** There are a great many things that grow in New York that can not be produced here.

The **Chairman.** Take such crops as can be produced here.

Mr. **Whelpley.** I think this country would have the advantage.

The **Chairman.** Have you given any attention to alfalfa?

Mr. **Whelpley.** I have seen three crops obtained in one season.

The **Chairman.** How much of a crop?

Mr. **Whelpley.** Four tons to the acre.

The **Chairman.** In the three crops.

Mr. **Whelpley.** No, 12 tons to the acre in the three crops.

The **Chairman**. Have you seen 12 tons produced to the acre here?

Mr. **Whelpley**. Yes.

The **Chairman**. How would that compare with Livingston, where they raise garden truck?

Mr. **Whelpley**. It will compare favorably.

The **Chairman**. Does your land improve or retrograde by irrigating?

Mr. **Whelpley**. The alkali becomes removed from the soil, and the soil becomes better by irrigating.

The **Chairman**. It is a fact that running streams and stored water furnish a good deal of fertilization.

Mr. **Whelpley**. I went into the Judith Basin in 1881, and there was practically no farming done there. When I left there in 1885 they were raising winter wheat without irrigation close to the mountains. But it was only where the snow had been excessively deep in winter that it could be raised.

The **Chairman**. That would occur only where there was plenty of snow?

Mr. **Whelpley**. Yes; but there were certain localities where it did not fail.

The **Chairman**. But, as a rule, you require irrigation?

Mr. **Whelpley**. Yes.

The **Chairman**. How are the hill-sides as to furnishing food for stock in summer?

Mr. **Whelpley**. They are very fine.

The **Chairman**. They are claimed to be unsurpassed, I believe?

Mr. **Whelpley**. Yes; they are unsurpassed.

The **Chairman**. What kind of country would you have here if the land was susceptible of irrigation, if irrigated and cultivated, and the plains used for stock-raising?

Mr. **Whelpley**. We have not a market even if we had it all irrigated and cultivated.

The **Chairman**. Could you not raise stock?

Mr. **Whelpley**. There is a certain limit to stock-raising.

The **Chairman**. Do you not think there is a market for all the meat you can produce?

Mr. **Whelpley**. If you are going to flood the country with stock you will have to raise very much more hay.

The **Chairman**. If you can provide winter feed, there is no limit to the stock you can raise here?

Mr. **Whelpley**. None in the world.

The **Chairman**. Then if you had it irrigated and cultivated to such extent as to furnish food for cattle in the winter, you would make this country very productive?

Mr. **Whelpley**. Certainly.

The **Chairman**. Have you ever been in any region that would be better for that purpose than this?

Mr. **Whelpley**. Never.

The **Chairman**. Are there many new enterprises for irrigation being set on foot now?

Mr. **Whelpley**. Not for irrigation, that I know of, in this neighborhood. I believe there is a company formed for taking a ditch out of the 'Spring Creek,' which I spoke of. It takes a week to make that big 'Spring Creek' rise, and it never falls very low. It is never dry in summer, but the settlers along it are mostly half-breeds. The white people have been chary about going in there.

The **Chairman**. Would a survey which would show where reservoirs, ditches, and other hydraulic works could be constructed to advantage, and which would also show what land could be irrigated and the cost of irrigating it, be a benefit to this country?

Mr. **WHELPLEY.** A very great benefit.

The **CHAIRMAN.** Would there be many places where irrigation is not now practiced that would be developed, in your opinion, and where a few people could do it?

Mr. **WHELPLEY.** I think very few places. There are few places in this part of the country where a few people could do much of anything of that character.

The **CHAIRMAN.** It requires large capital?

Mr. **WHELPLEY.** It requires large capital.

The **CHAIRMAN.** Has much attention been paid to the storing of water in small places in this neighborhood?

Mr. **WHELPLEY.** None to speak of.

The **CHAIRMAN.** What effect would the cutting of timber have on these streams?

Mr. **WHELPLEY.** The cutting of the timber helps to dry up the streams, and decreases the opportunity for the storage of water.

The **CHAIRMAN.** Has the timber been cut off much in this vicinity?

Mr. **WHELPLEY.** It is being rapidly taken from the mountains of the Judith Basin.

The **CHAIRMAN.** For what purposes?

Mr. **WHELPLEY.** For domestic purposes.

The **CHAIRMAN.** Have you been troubled with forest fires?

Mr. **WHELPLEY.** Large patches have been burned not far from here. The fire goes along the ground, and it affects the trees, and even though they do not fall down, they are injured very materially. They sometimes stand for years, however, and help to hold water.

The **CHAIRMAN.** What precautions might be taken by the Government to preserve this timber and at the same time allow a reasonable quantity to be taken off for domestic purposes and mining?

Mr. **WHELPLEY.** Of course, I have not given thought to those questions. I am only answering on the spur of the moment. The only way, I think, is to have a timber inspector, and allow only a certain growth of timber to be taken.

The **CHAIRMAN.** Is the present system of secret agents satisfactory to the people?

Mr. **WHELPLEY.** The people fight against the secret agent on the principle that they are free American citizens, and do not like that sort of thing. So far as I am concerned, I do not see that your secret service has saved any of our timber. The timber goes just the same.

The **CHAIRMAN.** What effect does it have on the people to have secret agents here arresting them?

Mr. **WHELPLEY.** It creates a combination among the ranchers, as you may say, to defeat the secret service. It is a sort of agreement that they should protect each other and have what they want.

The **CHAIRMAN.** If you had a local agent who was a citizen here, whom everybody knew, and if he made reasonable arrangements, would the people comply with those arrangements?

Mr. **WHELPLEY.** Certainly they would. If a proper man had ample authority, and was appointed with some regard to his qualifications for the office, of course the people would recognize the reasonableness of the situation. Much would depend on the man; but I think if the right man were appointed his word would be regarded.

The CHAIRMAN. The people who live here desire the timber to be preserved, I suppose?

Mr. WHELPLEY. They all see the necessity of it.

The CHAIRMAN. The secret agents do not do any good towards stopping its destruction, do they?

Mr. WHELPLEY. In my opinion they do not.

The CHAIRMAN. Would you then recommend a division of the country into timber districts, and the appointment of reasonable men to see that the arrangements were carried?

Mr. WHELPLEY. Yes; a timber inspector who would say what age or growth of timber should be cut and what should not would be a very desirable officer. There is certain timber that would be better taken out. I think the secret agents are probably doing some good in checking the wholesale destruction by saw-mills, and so on, of the timber we have left. That would not come under my observation, but they may be doing good in that way. The ranchers have to have timber.

The CHAIRMAN. And with proper regulations they could have it without denuding the hills?

Mr. WHELPLEY. Certainly they could.

The CHAIRMAN. Do you not think that denuding the hills of timber would be a great detriment to agriculture?

Mr. WHELPLEY. I think it would be the ruination of agriculture. I wish to say, before getting through, that the Little Belt Mountains will make a great water storage place. There is a fine forest there, but it is gradually becoming worked into by the ranchers.

We got information last week that the Judith River was lower than it had ever been in the history of the country. There are two big ditches running out in the basin above Utica. The Yellowstone is about the only river where the water is not fully occupied. Park County is not so much interested as other counties in irrigation. We have not the same extent of arable land, and we have a good deal of mountain. We have large masses of low grade ore about the Yellowstone that we can not get into.

Adjourned.

BOZEMAN, MONT., *August* 8, 1889.

The committee met pursuant to call of the chairman.

Present, Messrs. Stewart (chairman) and Reagan; also Director Powell.

STATEMENT OF JOHN WILLIAMS.

The CHAIRMAN. Where do you reside?

Mr. WILLIAMS. On the West Gallatin.

The CHAIRMAN. How long have you resided there?

Mr. WILLIAMS. Since 1869.

The CHAIRMAN. What is your occupation?

Mr. WILLIAMS. Farming and stock raising.

The CHAIRMAN. Have you given attention to the subject of irrigation?

Mr. WILLIAMS. Yes.

The CHAIRMAN. What can you say of its results; what effect has it produced in crops?

Mr. WILLIAMS. The fact is, I do not think we could raise a crop here without irrigation.

The CHAIRMAN. Irrigation is a necessity here, then?

Mr. WILLIAMS. Yes.

The CHAIRMAN. With irrigation what kind of crops can you raise?

Mr. WILLIAMS. We can raise good crops, I call them; better than we raise in the East.

The CHAIRMAN. Have you farmed in other countries?

Mr. WILLIAMS. Yes; in Missouri.

The CHAIRMAN. How do the products of a farm here, taking a period of ten years, compare with the products of the best farms in Missouri?

Mr. WILLIAMS. The small grain—that is what I raise here—is about double what I have raised in Missouri.

The CHAIRMAN. Do you have any failures of crops where you irrigate?

Mr. WILLIAMS. Very seldom. In some locations the frosts hurt crops; but that is very seldom.

The CHAIRMAN. How is it with other crops besides small grain? How do they succeed?

Mr. WILLIAMS. What kind do you mean—corn?

The CHAIRMAN. Corn, potatoes, and so on.

Mr. WILLIAMS. We raise large crops of potatoes here.

The CHAIRMAN. How many bushels of potatoes do you raise to the acre? What is a fair crop?

Mr. WILLIAMS. I have raised at the rate of 400 bushels to the acre; may be more.

The CHAIRMAN. What do you say as to the expense of farming by means of irrigation as compared with other kinds of farming?

Mr. WILLIAMS. The expense is somewhat more, of course. I suppose that it costs about 50 cents per acre a year to irrigate the ground once; but sometimes we have to irrigate twice. We have had to do that this year.

The CHAIRMAN. Then it has cost you $1 a year?

Mr. WILLIAMS. Yes.

The CHAIRMAN. Have you raised alfalfa here?

Mr. WILLIAMS. No; I have not.

The CHAIRMAN. Have you seen it raised?

Mr. WILLIAMS. Yes.

The CHAIRMAN. How does it succeed?

Mr. WILLIAMS. That which I noticed did not succeed very well on account of the ground being too wet. The alfalfa was sown on a damp heavy soil, what we call meadow lands here.

The CHAIRMAN. How well are you acquainted with the general country around the eastern part of Montana?

Mr. WILLIAMS. I am better acquainted with the Lewis and Clarke, Madison, and Gallatin Valleys.

The CHAIRMAN. Which one of those counties has the most land that can be irrigated?

Mr. WILLIAMS. Gallatin County, I think.

The CHAIRMAN. What extent of land is there in this county on which you could get water?

Mr. WILLIAMS. That is hard to state.

The CHAIRMAN. Of course you can not tell accurately. But it is very large, is it not?

Mr. WILLIAMS. Yes, it is. There is a large amount of land which could be watered here where no water has been put as yet.

STATEMENT OF DAVID DAVIS.

The **Chairman**. Where do you reside?

Mr. **Davis**. Twelve miles down the East Gallatin.

The **Chairman**. What is your occupation?

Mr. **Davis**. Farming.

The **Chairman**. Do you irrigate your land?

Mr. **Davis**. Yes; that is, part of it, and on part of it I have no water.

The **Chairman**. On that part which you have watered, what success have you met with in raising crops?

Mr. **Davis**. We raise about double the other crop.

The **Chairman**. Have you ever farmed in any other country?

Mr. **Davis**. No; I was a boy when I came here.

The **Chairman**. On irrigated land, what do you call a fair crop of oats?

Mr. **Davis**. Fifty or 60 bushels to the acre, although I have raised 75. But I will call 50 or 60 bushels a fair crop.

The **Chairman**. Have you raised any wheat?

Mr. **Davis**. Yes.

The **Chairman**. How much wheat have you raised to the acre?

Mr. **Davis**. On irrigated land 40 bushels to the acre. This season, if my crop goes 15 bushels to the acre on unirrigated land, I will be satisfied.

The **Chairman**. You have irrigated some, have you not?

Mr. **Davis**. Not the wheat, only oats.

The **Chairman**. Have you raised any barley?

Mr. **Davis**. We had 50 acres in barley, but none of it was saved.

The **Chairman**. Why? Because you had no water?

Mr. **Davis**. Yes.

The **Chairman**. Have you tried raising other crops besides small grain?

Mr. **Davis**. No.

The **Chairman**. Not garden truck—potatoes and so on?

Mr. **Davis**. Yes, potatoes, turnips, and such truck as that.

The **Chairman**. How do they prosper?

Mr. **Davis**. This country is good for potatoes.

The **Chairman**. What kind of hay do you raise?

Mr. **Davis**. Timothy hay.

The **Chairman**. That is the hay generally raised in the valley, is it not?

Mr. **Davis**. Yes; there is some clover raised, but I have not raised any myself.

The **Chairman**. You have not tried alfalfa?

Mr. **Davis**. No.

The **Chairman**. What do you regard as a good crop of timothy hay on irrigated land?

Mr. **Davis**. They have raised as high as three tons to the acre.

The **Chairman**. One cutting?

Mr. **Davis**. Yes.

The **Chairman**. What would be an average crop?

Mr. **Davis**. My crop this season would not go over a ton to the acre. It was not irrigated.

The **Chairman**. You can do something without irrigation here.

Mr. **Davis**. Yes.

Senator **Reagan**. It was mentioned that you might have to irrigate land once or twice. Which is the more common?

Mr. **Davis**. The amount differs.

Mr. **Reagan**. Then it depends on the character of the land?

Mr. **Davis**. Take the upland, and in a season like this it would need irrigation twice.

Senator **Reagan**. At what season of the year do you usually irrigate?

Mr. **Davis**. I always commence about the 4th of July; but this season I ought to have commenced the 4th of June. I commenced the 10th or 12th, but I should have commenced eight days sooner.

Senator **Reagan**. When do you plant your oats?

Mr. **Davis**. In April or May.

Senator **Reagan**. This year you thought it best to commence in June?

Mr. **Davis**. Yes. Of course, we usually calculate on June rains; but this year we did not have them.

Senator **Reagan**. At what stage of the crop do you put water on the land?

Mr. **Davis**. It is best when the grain gets up to shade the land, high enough to have little roots to hold the soil. When the grain is too short the water washes the soil from the roots.

The **Chairman**. How do you irrigate—by flooding the land?

Mr. **Davis**. Yes.

The **Chairman**. How long do you allow the water to stay on the land?

Mr. **Davis**. Well, there again there is a difference in regard to the land. Take the upland, there is a good deal of fall, and it is running from one ditch to another. You make your ditches 10 to 12 feet apart, and you keep the water running well.

STATEMENT OF T. L. LUCE, OF NORTH.

The **Chairman**. Where do you reside?

Mr. **Luce**. About 4 miles from town here at North.

The **Chairman**. What is your occupation?

Mr. **Luce**. Farming.

The **Chairman**. Have you practiced irrigation?

Mr. **Luce**. I do where I can.

The **Chairman**. So far as your experience has gone, what is the result of irrigation in producing crops in this valley?

Mr. **Luce**. My experience is that it is one-half more where there is irrigation than where there is no irrigation.

The **Chairman**. What State were you from originally?

Mr. **Luce**. Vermont.

The **Chairman**. How would an irrigated farm here compare in productiveness with a farm of the best land in Vermont?

Mr. **Luce**. The land here would be far ahead of the land in Vermont.

The **Chairman**. One acre of land here would be equal to how many acres in Vermont?

Mr. **Luce**. Well, I do not know, as far as that is concerned—perhaps three acres.

The **Chairman**. That is to say, if a farm in Vermont would have good crops, a farm of irrigated land here would have an average of three times the crop of the farm in Vermont?

Mr. **Luce**. Just about three times.

The **Chairman**. What is a fair crop of oats in this valley?

Mr. **Luce**. I do not know that I can answer that question.

The **CHAIRMAN**. How many bushels of oats have been raised to the acre in this valley?

Mr. **LUCE**. I have raised 80 bushels to the acre.

The **CHAIRMAN**. Did you ever raise any wheat?

Mr. **LUCE**. Very little.

The **CHAIRMAN**. There has been some wheat raised in the valley, has there not?

Mr. **LUCE**. Oh, yes.

The **CHAIRMAN**. How many bushels, where it is well cultivated?

Mr. **LUCE**. From 40 to 70 bushels to the acre.

The **CHAIRMAN**. How long have you been farming here?

Mr. **LUCE**. Eleven years on the place where I am now.

The **CHAIRMAN**. Does the land deteriorate or produce about the same crops from year to year?

Mr. **LUCE**. It remains the same.

The **CHAIRMAN**. And cropped every year?

Mr. **LUCE**. Yes.

The **CHAIRMAN**. After 11 years of cropping all over, does the land produce as heavy a crop as it did when you commenced?

Mr. **LUCE**. Yes, a little more.

The **CHAIRMAN**. Do you know of any farm in the valley where, by cropping, it produces less?

Mr. **LUCE**. Yes, there are farms.

The **CHAIRMAN**. Where they are irrigated?

Mr. **LUCE**. I think where they are irrigated.

The **CHAIRMAN**. How do you account for that?

Mr. **LUCE**. Well, it is from the lightness of the soil.

The **CHAIRMAN**. I suppose you can raise small fruits in the valley?

Mr. **LUCE**. Yes; berries can be raised.

The **CHAIRMAN**. Have you ever tried any of the larger fruits, such as apples?

Mr. **LUCE**. No; I have not.

The **CHAIRMAN**. Have not some of your neighbors tried them?

Mr. **LUCE**. No.

STATEMENT OF W. W. ALDERSON, OF BOZEMAN.

The **CHAIRMAN**. What is your occupation?

Mr. **ALDERSON**. I am a newspaper man at present.

The **CHAIRMAN**. You are the editor of what paper?

Mr. **ALDERSON** The Avant Courier.

The **CHAIRMAN** How long has that paper been established?

Mr. **ALDERSON**. Between seventeen and eighteen years.

The **CHAIRMAN**. How long have you resided in this valley?

Mr. **ALDERSON**. I have been in the valley twenty-five years; I came here in 1864.

The **CHAIRMAN**. Have you taken an interest in irrigation?

Mr. **ALDERSON**. Yes. I was a practical farmer, and I am a dairyman, and have been for twelve years.

The **CHAIRMAN**. What can you say as to the effect of farming by means of irrigation?

Mr. **ALDERSON**. As to crops it is an absolute necessity in most of the locations in Montana. There are locations close to the streams, and in the lowest ground where indifferent crops can be raised without irrigation. But I think the most favorable ground can be improved by irrigation. That has been my experience. I have a farm within a mile of this place. I have some crops there, though not favorable. There was some difference in the depth of the soil.

The **CHAIRMAN**. Then irrigation here may be regarded as a necessity?

Mr. **ALDERSON**. It is a necessity.

The **CHAIRMAN**. What can you say of the crops produced by irrigation? What is the average crop of oats where the land is well cultivated?

Mr. **ALDERSON**. The crops of this country are superior to any I have seen in any locality, and I have resided in Illinois, Wisconsin, and Minnesota. Of course, I have traveled in other States. I know the yield generally produced in most of the States; and I think, with irrigation in the Gallatin Valley—of course I am better acquainted here than anywhere else—the crops exceed anything that I have ever seen.

The **CHAIRMAN**. And you generally raise crops; that is to say, you have no failures?

Mr. **ALDERSON**. We have no failures. We have had crops injured some by early frosts in fall; but it was generally where crops were planted late in spring, and, perhaps, irrigated too late. In early years, on account of our want of experience in irrigation, we sometimes suffered some loss of crops; but it was on account of the late sowing or too late irrigating.

The **CHAIRMAN**. Then with proper management of a farm you can by irrigation produce a crop every year?

Mr. **ALDERSON**. Yes. We have had no failures here—nothing like a general failure.

The **CHAIRMAN**. What do you say of the effect of continuous cropping here?

Mr. **ALDERSON**. There seems to be no diminution of the crops. This year has been unusually dry, and the water has been scarce; but the crops last year were just as heavy on the same land that has been cultivated for twenty years as they were in the early years.

The **CHAIRMAN**. Do you produce generally as good crops as we saw to-day?

Mr. **ALDERSON**. Yes. Those crops are on pretty moist land. They do not generally resort to irrigation here until rather late in the season, and a great many of them did not prepare for the unusual drought that we had. They generally commence irrigating about the latter part of June or the first of July, and the crops needed irrigation sooner this year.

The **CHAIRMAN**. What is an average crop of oats where the ground is well prepared and well cultivated and irrigated?

Mr. **ALDERSON**. The oats run from 50 to 100 bushels to the acre. I should think that an average crop, where the ground is properly cultivated and irrigated, would be 75 bushels to the acre.

The **CHAIRMAN**. How much of wheat?

Mr. **ALDERSON**. Wheat would be about 40 bushels to the acre.

The **CHAIRMAN**. Would it average that?

Mr. **ALDERSON**. Perhaps 40 bushels is a pretty high average. But it seems to me that it can not run short of that. A great many crops run from 50 to 60 bushels to the acre. The wheat that we raise here is soft wheat; the white hard wheat would run lower than that—25 bushels to the acre. They tell me that by continual cultivation and irrigation the hard wheat will become soft. I presume that is the case. That is what I have been informed by farmers and mill men.

The **CHAIRMAN**. You are generally somewhat familiar with Montana?

Mr. **ALDERSON**. Yes, I have been over part of the Territory.

The **CHAIRMAN**. What do you say as to the Territory generally? Is it well supplied with water?

Mr. **ALDERSON**. Yes; it is a well-watered country. This valley is better supplied, perhaps, than the balance.

The **CHAIRMAN**. Are you using the full supply of water which you have in the river here?

Mr. **ALDERSON**. This stream here is taken out at a place on Mill Creek between here and West Gallatin, during the irrigating season. But there is some water in West Gallatin that is not appropriated. There is only a small portion of the arable land in the valley that is under cultivation.

The **CHAIRMAN**. Is there any opportunity for increasing the supply of water by storing it?

Mr. **ALDERSON**. Yes; there is a splendid opportunity at the head of this stream, at what is called Mystic Lake. There is a lake up there, and an excellent opportunity to construct a dam, at a reasonable cost, to store almost any amount of water. There is a good deal of water, from the melting of the snows in the spring, which runs to waste, and it is at a time when they are not irrigating that the water runs away.

The **CHAIRMAN**. What proportion of the valley is under cultivation compared with the whole; that is, good arable land if it had water?

Mr. **ALDERSON**. Not to exceed one-fourth.

The **CHAIRMAN**. What is the value of the land that is improved and under irrigation?

Mr. **ALDERSON**. Farms have been sold here for from $12 to $25 an acre; in some instances perhaps a little higher. It depends on their location as to the town and the water range.

The **CHAIRMAN**. What has been the expense per acre of procuring water? Can you estimate that?

Mr. **ALDERSON**. No, I have never figured on that. Nearly all the water has been brought out by private parties, by two or three farmers operating together until this last enterprise, the West Gallatin ditch, which was completed last summer. That was undertaken by two or three farmers in the first place, but they failed to carry it through.

The **CHAIRMAN**. What is the size of that ditch?

Mr. **ALDERSON**. That is 24 feet, I think.

The **CHAIRMAN**. Twenty-four feet on the bottom?

Mr. **ALDERSON**. I am not certain of that—whether it is 24 feet on the bottom or on the top. I have just been informed that it is 24 feet on the top and 16 feet on the bottom.

The **CHAIRMAN**. What is the length of the ditch?

Mr. **ALDERSON**. About 20 miles.

The **CHAIRMAN**. What did it cost to construct such a ditch as that?

Mr. **ALDERSON**. They variously estimate it at from $35,000 to $80,000.

The **CHAIRMAN**. About how much land will it irrigate?

Mr. **ALDERSON**. They claim to have sufficient water for 50 farms of 160 acres each. They have a way of estimating the number of inches required for each acre.

The **CHAIRMAN**. How much more expensive is it to farm by irrigation after you have the water than it is where you have rain-fall?

Mr. **ALDERSON**. It used to cost me for irrigating about $1 a year per acre.

The **CHAIRMAN**. You irrigated twice?

Mr. **ALDERSON**. Yes, twice. I used to estimate the cost at 75 cents for irrigating once. But that, of course, included the ditches. When the ditches are all fixed and prepared it is comparatively a small job.

The CHAIRMAN. How many inhabitants have you in this county?

Mr. ALDERSON. We have no way of telling except by the vote that is cast at the general elections. We cast about 1,600 votes, and we estimate four persons to each voter. That would give the population I should think. Of course, we are a community of homes and families here in this county—emphatically so, because in a farming community we have no other interests.

The CHAIRMAN. Where do you have a market for your products?

Mr. ALDERSON. We find a market for our products in the mining camps at Helena, Butte, Anaconda, Phillipsburgh, and New Chicago. We ship some grain down the Yellowstone. We now ship barley to Milwaukee and St. Paul. By the way, we raise a superior quality of barley.

The CHAIRMAN. What do you say of this country as a stock country?

Mr. ALDERSON. This is a splendid stock country. We have pretty deep snows in the winter, and the stock is kept in bands. Each farmer has little bands. They run out on the hills in summer and in winter are fed in the valley. The lands in the foot-hills make splendid pasturage lands.

The CHAIRMAN. There are lands in this valley that are yet unoccupied?

Mr. ALDERSON. Yes; some land owned by the railroad company. But there is still considerable unoccupied Government land without any water facilities.

The CHAIRMAN. Would surveys by the Government, indicating what land could be irrigated, giving the lines and ditches, setting apart places for reservoirs, and estimating the cost of the construction of the works, be useful to the people here?

Mr. ALDERSON. I should think so. I think the benefit would be incalculable, because there is no expenditure of money that can exceed the results of irrigation in the way of crops. That has been the result of my observation and experience.

The CHAIRMAN. You are aware of the acts that have been passed by Congress. The first, in the first session of the last Congress, appropriated $100,000 to survey the places that the Government might select as reservoir sites. A provision was made for reserving from settlement, sale, and occupation all lands so reserved. At the second session there was appropriated $250,000 more for surveys, and the work has already been begun. Now, would the prosecution of that work facilitate the settlement of the country? If the people knew the lands that could be irrigated and the expense that would attach, would they combine to construct the ditches in many cases or get capital to do it?

Mr. ALDERSON. There has been the difficulty, and it is the difficulty now. You see for six or eight years the farmers here attempted to construct this canal but failed. Finally it was taken up by a few capitalists in Illinois, and they had all they wanted to do. If the old settlers can not construct those expensive ditches, of course new settlers can not. Those that are here now are pretty well fixed—in good circumstances. But they have secured their water rights.

The CHAIRMAN. And additional water could be stored in a good many instances, I presume?

Mr. ALDERSON. Even then it would require a good deal of expense to take out the ditches from the body of those streams.

The CHAIRMAN. There are a good many places where they would have the opportunity.

Mr. ALDERSON. Yes; a good many places. If the idea is to redeem he country and bring it under cultivation, take the bench land on the West Gallatin River. There is a strip of country 30 miles long and it s fertile. But it would be expensive taking out water, and there are no two or half dozen farmers, under ordinary circumstances, who could accomplish that. It will perhaps be done by a corporation, a stock company, just as this ditch here was constructed

The CHAIRMAN. Have you ever tried the plan of forming a corporation and issuing stock to the parties owning the land and allowing them to control the corporation; has that been tried?

Mr. ALDERSON. That has been tried in certain instances. That is the case with this West Gallatin ditch.

The CHAIRMAN. Do you generally have the land and water owned by the same person, or do they buy the water?

Mr. ALDERSON. They do not go together. This is the first instance where the farmers have the opportunity of purchasing the water—that is, in this valley.

The CHAIRMAN. Have they any contract whereby they can get the water, or is it under the control of the corporation so that it can take the water away from the farmers?

Mr. ALDERSON. No; I think the farmer has a contract with the company that extends for a number of years. The water belongs to the farmer. I know that when I sold my farm here, the water right went with it.

The CHAIRMAN. Have you observed the effect of cutting the trees off the water-courses?

Mr. ALDERSON. We have not observed it here. There has been so little timber cutting here that I do not think it has perceptibly affected anything. There has been no timber cut except down toward the foothills.

The CHAIRMAN. Have there been any forest fires?

Mr. ALDERSON. There are some forest fires, but they have not been serious around this county.

The CHAIRMAN. You are familiar with the whole Territory, are you not?

Mr. ALDERSON. Yes. They have had some pretty severe fires on the west range of the Rocky Mountains, between here and Missoula, and they have had some pretty heavy forest fires up in the National Park.

The CHAIRMAN. Has there been any observation here of the best mode of letting the people have what timber they require and then preserving the forest as much as possible?

Mr. ALDERSON. It has been talked of, but there has been no action taken by the community in regard to it. There should be some arrangement.

The CHAIRMAN How does this system of secret agents representing the Government operate?

Mr. ALDERSON. So far as I know it has never resulted in any particular benefit either one way or the other.

The CHAIRMAN. What would you think of substituting for these secret agents, timber agents or inspectors appointed from the different communities—agents whom the citizens in the different localities all knew?

Mr. ALDERSON. I think that would be an excellent plan. Everybody would know the man who was placed in that vicinity, and his authority and advice and instructions would be respected.

The CHAIRMAN. The people, you think, would be in favor of that system if they were fairly dealt with and consulted about it?

Mr. ALDERSON. Yes; that is my idea.

The CHAIRMAN. What do you think of selling the public land—land that is not fit for agricultural purposes? Would it not be as well for the Government to keep it and let the people cut the timber by paying a suitable price?

Mr. ALDERSON. I think it would be best for the Government to retain control.

The CHAIRMAN. And permit the people to cut the timber and take away the dead stuff?

Mr. ALDERSON. Yes; but to preserve sufficient timber to hold the snow and moisture.

The CHAIRMAN. Have you not in sections observed how the timber has affected the streams?

Mr. ALDERSON. No, I have not.

The CHAIRMAN. You know as a fact that the timber does preserve the snow?

Mr. ALDERSON. It must, as a necessity. Of course I have observed that. If there were any danger of the timber being taken off the mountains here, it would be a serious question with us.

The CHAIRMAN. Is there not danger from forest fires?

Mr. ALDERSON. Yes, that is a great danger to us. The timber in this vicinity will grow as fast as it is used.

The CHAIRMAN. Do you, in the measurement of grain, estimate by the weight or by bushels?

Mr. ALDERSON. We measure all the grain. But when we sell, the custom has prevailed of selling oats and barley by the hundredweight. Heretofore wheat has been sold by the bushel—60 pounds to the bushel.

The CHAIRMAN. How does the wheat that is grown here compare with that of other countries?

Mr. ALDERSON. It is heavier than it is in Illinois, Wisconsin, and Minnesota.

The CHAIRMAN. How much heavier is it here?

Mr. ALDERSON. It is from one fifth to one-quarter heavier. I think it will average one-fourth heavier than in what used to be called the Northwestern States.

Director POWELL. Have you taken out the water so that the question of water-rights has become to be of interest?

Mr. ALDERSON. Yes. It has come to be a pretty fixed question in regard to the small streams, East Gallatin, Bozeman, and Meadow Creeks. Of course the water is claimed, but there is quite a number that can not be supplied. The old claims have come to be disregarded by parties settling up the streams at the base of the mountains and they get the first chance at the water. It occurs every season that the older settlers are deprived entirely of their rights, and of course it has led to a great deal of quarreling, and in some cases very serious quarreling—shooting and killing.

STATEMENT OF T. C. BURNS, OF MILK RIVER

The CHAIRMAN. Have you ever farmed in this valley?

Mr. BURNS. No. But I lived in the vicinity, 60 miles east of here. I lived on one farm for ten years, 30 miles east of Livingstone.

The CHAIRMAN. On the Yellowstone?

Mr. BURNS. Yes.

The CHAIRMAN. Did you farm by irrigation there?

Mr. BURNS. Yes.

The CHAIRMAN. With what success?

Mr. BURNS. Very good success usually.

The CHAIRMAN. What kind of crops did you farm there?

Mr. BURNS. Wheat, oats, vegetables, and hay.

The CHAIRMAN. What was an average crop of wheat there?

Mr. BURNS. Not a great deal of wheat had ever been sowed there. At least we never sowed enough except for our own use. It was not handy to the mills. Oats were preferable on that account. I suppose the yield would be something like the yield here.

The CHAIRMAN. The condition would be about the same?

Mr. BURNS. Yes.

The CHAIRMAN. Is the land about the same?

Mr. BURNS. No. I think the land about here is a little better. The soil is not so deep there as a rule as it is in this valley.

The CHAIRMAN. What is a fair average crop of oats where you were?

Mr. BURNS. I should say 40 or 50 bushels.

The CHAIRMAN. Describe the place north, at which you now reside?

Mr. BURNS. It is known as the New Reserve, that was opened a year ago.

The CHAIRMAN. How far north is it?

Mr. BURNS. About 200 miles north perhaps. It is 340 miles by railroad from there to Helena.

The CHAIRMAN. How near to the Canadian line is it?

Mr. BURNS. Within about 40 miles—the settlement I speak of.

The CHAIRMAN. What irrigation have they had there?

Mr. BURNS. Nothing until the present season, except what the Government has done at the Indian agency and at Fort Sanborne. I believe there has been something in the way of a garden irrigated at Fort Sanborne, but nothing to speak of.

The CHAIRMAN. Do they irrigate there this season?

Mr. BURNS. Many of them do. Many settlers have been induced to come in there from the East by the railroad companies, which would ust as lief the people would not irrigate. The result is that they have all been fooled.

The CHAIRMAN. It is a pretty hard thing to bring them in here and teach them that, is it not?

Mr. BURNS. I think the settlers have come to that conclusion. The railroad company has even gone further than that.

The CHAIRMAN. What railroad company?

Mr. BURNS. The St. Paul, Minneapolis and Manitoba road. They induced settlers to come in there by issuing certain pamphlets saying it was a mild climate and that they would not have to irrigate. Seeing that they did require to irrigate the farmers went to work and constructed ditches, and about the time the farmers were ready to use the water the railroad company procured papers from the court enjoining them from using the water, because they would cause their tanks along the road to go dry.

The CHAIRMAN. Is there an opportunity to irrigate in that region?

Mr. BURNS. There is, to a certain extent, although water is not so plentiful there as in other portions of the country. I do not doubt, however, that we could get water by storage and making lakes, and so forth.

The CHAIRMAN. Have you traveled over the country with a view to seeing whether water could be stored or saved?

Mr. BURNS. No; I have not. I understand though that there are a number of lakes on the bench lands and on the high lands.

The CHAIRMAN. Is the soil very good there?

Mr. BURNS. Yes.

STATEMENT OF P. W. KOCH, OF BOZEMAN.

The CHAIRMAN. How long have you resided in Bozeman?

Mr. KOCH. Nearly twenty years.

The CHAIRMAN. What is your occupation?

Mr. KOCH. I am a bank cashier.

The CHAIRMAN. Are you familiar with this country, and have you traveled over it?

Mr. KOCH. Yes.

The CHAIRMAN. Have you ever been engaged in any other business except as cashier of the bank here?

Mr. KOCH. Yes. I have been engaged in land surveying, in Indian trading, and in mercantile pursuits of different kinds.

The CHAIRMAN. Then I understand you are a civil engineer also?

Mr. KOCH. Yes.

The CHAIRMAN. Have you surveyed a good deal of land in this section?

Mr. KOCH. Yes. Some on this side, but more on the west side; on the Pacific Slope; in the western part of the Territory.

The CHAIRMAN. Have you observed the effect of irrigation on different parts of the Territory?

Mr. KOCH. Yes.

The CHAIRMAN. Is it regarded as a necessity in this Territory?

Mr. KOCH. It is in most cases, with the exception of some bench lands in the immediate vicinity of the mountains, where winter-wheat can be raised without irrigation. It is an absolute necessity everywhere else. The bench lands where the snow lies thick in the winter seems to hold enough moisture, but in the main valleys irrigation is absolutely necessary, in most years.

The CHAIRMAN. What do you think of the effect of irrigation in producing crops?

Mr. KOCH. I never saw such crops in any other country as are raised here by irrigation. Our average of crop here is at least double that in any other State in the United States where they have not irrigated.

The CHAIRMAN. You get a good crop?

Mr. KOCH. Excellent.

The CHAIRMAN. This has been an unusually dry year, has it not?

Mr. KOCH. The dryest I have seen since I have been in Montana. I have kept a record ever since I have been here.

The CHAIRMAN. What proportion of the land could be irrigated if all the appliances for saving water were used?

Mr. KOCH. The question is simply whether the bench lands along the lower course of the Yellowstone and Missouri are of sufficiently low elevation to utilize the water in those streams.

The CHAIRMAN. What, in your opinion as an engineer, is the proportion that could be irrigated? You have passed over it, though you may not have used instruments upon it.

Mr. KOCH. I think the amount of cultivated land in Montana will be ultimately limited by the question of water. Of course, that is not counting the west side of Montana—the Pacific slope—because there a comparatively slight part of the country is adapted to irrigation.

The CHAIRMAN. You are limited to the water running in the streams. Does not the largest proportion of the water go to waste?

Mr. KOCH. Yes. The time for irrigation comes after the highest stage of water in the river has passed away. The highest stage of water in the river here is in June and early in July, and the irrigation season does not begin until July.

The CHAIRMAN. Could not a large portion of that water be saved above by reservoirs?

Mr. KOCH. Yes. I do not believe that any country is better adapted for reservoirs than this. As you go along you find a number of lake-beds, and where the lake-beds are you very generally find a gentle current. Below the outlet of those lake-beds there are always narrow cañons, so that it would be comparatively an easy matter to construct dams.

The CHAIRMAN. Then, a good deal of water might be kept back with no very great expense?

Mr. KOCH. Yes. I believe that in many of these streams the amount of water might be doubled at comparatively little expense.

The CHAIRMAN. I have traveled over the mountains a good deal myself, and I find what you say to be true all through the mountain regions. That would be cheaper than litigation, would it not?

Mr. KOCH. A good deal cheaper.

The CHAIRMAN. The law now reserves all places that may be designated by the Geological Survey for the storage of waters. Do you think that is wise?

Mr. KOCH. Yes.

The CHAIRMAN. What would you say, then, of the advantage of a survey which would designate those places where water could be stored, and which would indicate the cost and the other items of information necessary to enable the people to judge of the feasibility of the work?

Mr. KOCH. It would be a very great advantage. The maps of the Geological Survey are of great assistance in regard to our Territory here. I thought I knew everything about this country, but from studying those maps I learned more than I ever did before. I succeeded after great difficulty in securing those maps—and, by the way, it seems to me a great misfortune that those maps are not obtainable by the general public.

The CHAIRMAN. Would it not be practicable for settlers themselves to unite and construct many works of irrigation throughout a large portion of the country without these very expensive investments?

Mr. KOCH. Certainly it would.

The CHAIRMAN. You think that the surveys and estimates of costs would do much good and enable people to avail themselves of the most desirable places?

Mr. KOCH. Yes.

The CHAIRMAN. It is very difficult for a settler, is it not, to come here and ascertain the cost, and then get others to help him to build ditches, especially if the others do not believe in the efficacy of irrigation?

Mr. **Koch**. It is impossible for a settler to do it. It is impossible for a person to be convinced of the benefits of irrigation unless he sees them. Unless one makes a study of it he will never realize the amount of land that may be reclaimed by a canal drawn from the mountains. You can take an instance of it right over here. There is a stream called Middle Creek in this valley, which, next to the Gallatin, is most relied upon for irrigating purposes. There have been a dozen suits in which several hundred people are interested, that have been instituted this year. I believe that $5,000 judiciously expended up there will double the water available for irrigating purposes. There will be a good deal of money spent in those suits, and between the lawyers' fees and the costs they will involve considerable expense to the parties concerned.

The **Chairman**. A suit to determine water rights settles nothing. If A sues B, when he gets through, he recovers nothing. The only good done is that they are called in. Their claims are brought up and recorded.

Mr. **Koch**. Yes. In every one of those cases there are from twenty to thirty defendants.

The **Chairman**. Then if you can irrigate the bench lands, as you think you can, by saving the water, the amount of arable land is very large?

Mr. **Koch**. Yes. You take the northern and eastern part of Montana and it is nearly all a rolling prairie country. It would be all available for agriculture, or at least the greater part of it, if it could be irrigated.

The **Chairman**. What proportion?

Mr. **Koch**. It is difficult to say. I believe that over one-half of the area of Montana is certainly capable of successful agriculture if it had water. I think that any one familiar with the eastern and northern part of the Territory will support me in that. Of course here in the mountains that is not so.

The **Chairman**. Would not the remainder of the land that could not be irrigated furnish good summer feed for stock?

Mr. **Koch**. Yes.

The **Chairman**. All over the State?

Mr. **Koch**. Yes, except the very high mountainous portions.

STATEMENT OF ENOCH HODSON, OF BOZEMAN.

The **Chairman**. Are you engaged in the timber business?

Mr. **Hodson**. I have been running a saw-mill for eight years, and making more or less ties for railroads.

The **Chairman**. Are you cutting the timber on the Government land?

Mr. **Hodson**. I suppose so. However, I do not know where the railroad land begins or the Government land ends.

The **Chairman**. Are they destroying timber pretty badly through here?

Mr. **Hodson**. Not in this vicinity.

The **Chairman**. Are they in any place in Montana?

Mr. **Hodson**. I have seen places where they did such things.

The **Chairman**. Is there any arrangement to preserve the undergrowth and preserve the timber from fire?

Mr. **Hodson**. No.

The **CHAIRMAN**. What is the Government regulation here, and how is it carried out?

Mr. **HODSON**. They make examples of a few individuals against whom somebody happens to have a spite, and they fight them to make themselves "solid" with the powers that be, so that they can hold their own positions. That is all that has ever been known of it in Montana. There has not been anything done for the benefit of the general public.

The **CHAIRMAN**. Suppose there was a responsible timber agent here who would make regulations to preserve the undergrowth and prevent the forest fires, and, generally, to aid in the preservation of the timber, would the people readily comply with all reasonable regulations on his part?

Mr. **HODSON**. I think they would. They are all interested in the preservation of the timber, and they would assist him, I think.

The **CHAIRMAN**. By the present system there is a good deal of timber being destroyed by fire and otherwise?

Mr. **HODSON**. Yes, by fire more than by any other cause; but it is not on account of any lack of interest on the part of the timber men.

The **CHAIRMAN**. But you would all rather be put under regulations and watched by somebody whom you knew in the neighborhood, and who was responsible, than to have secret agents coming among you?

Mr. **HODSON**. I certainly would most readily and cheerfully accede to any regulations of such an officer. I have no use for secret agents.

The **CHAIRMAN**. You will all have to unite in preserving this timber; if not you will have barren hills, small streams, and heavy floods.

Adjourned.

HELENA, MONT., *August* 9, 1889.

The committee met pursuant to call of the chairman.

Present: Messrs. Stewart (chairman), Plumb, and Reagan; also Director Powell.

STATEMENT OF BENJAMIN H. GREENE, SURVEYOR-GENERAL OF MONTANA.

Mr. Chairman and gentlemen, I will read this report which I have in my hand. It is a report on irrigation made by the civil engineers of Montana. After I shall have read the report, Colonel De Lacey, who has a personal acquaintance with all the mountains and rivers of this Territory, will answer any questions you may wish to propound. The report is as follows:

HELENA, MONT., *August* 9, 1889.

DEAR SIR: By request of the Hon. T. H. Carter, Delegate-elect to Congress from this Territory, the Montana Society of Civil Engineers have prepared the following report on the present condition of irrigation in Montana, and a rough statement of what can be accomplished in that direction by the construction of suitable canals and storage reservoirs.

The Society have endeavored to obtain reliable data from the different sections of the Territory by distributing a large number of printed circulars with blank township plats, and from some sections have received replies which have proved of material assistance in compiling this report; other sections have failed to respond, and in these we have relied on a personal knowledge of the country furnished us by Colonel

W. W. De Lacy, one of the oldest and most experienced surveyors in this Territory, at present chief clerk of the surveyor-general's office at Helena.

Trusting that the data herewith furnished may be of material assistance to your committee in determining what is required in this Territory, the report is respectfully submitted.

Very respectfully,

B. H. GREENE,
President Montana Society of Civil Engineers.

Hon. WM. M. STEWART,
Chairman of United States Senate Committee on Irrigation and Arid Lands.

REPORT ON IRRIGATION IN MONTANA.

Montana is traversed by the main range of the Rocky Mountains, which crosses its northern boundary about 90 miles east of its northwest corner, and extends in a southeasterly direction to a point near the city of Butte; thence taking a westerly turn, it joins the Bitter Root Range and forms the soutwesterly boundary between Montana and Idaho as far east as the National Park.

The western portion is consequently very mountainous, as there are many subsidiary ranges or spurs from the main range.

About two-thirds of the total area lying east of these mountain ranges consists of high table-lands, cut by large rivers which have their source in the mountains.

The principal rivers on this slope are the Missouri and Yellowstone.

The Missouri is formed by the Jefferson, Madison, and Gallatin Rivers, and flows northerly to the Great Falls, and thence easterly across the Territory.

Its principal branches are the Dearborn, Sun, Teton, and Milk Rivers, from the west and north, and the Smith, Judith, and Musselshell Rivers, from the south. The Yellowstone rises in Northwestern Wyoming, flowing northerly through the National Park to Livingston, and thence easterly and northeasterly, emptying into the Missouri near the eastern boundary of the Territory, at Fort Buford.

Its principal tributaries are from the south, and consist of Clark's Fork, Big Horn, Rosebud, Tongue, and Powder Rivers.

On the west slope of the mountains are the Deer Lodge, Blackfoot, and Bitter Root Rivers, flowing westward to the Columbia River.

The lands to be irrigated throughout the Territory may be divided into three classes, viz, valley, bench, and high table-lands.

The valley or bottom lands lie along the rivers, and have been mostly occupied by settlers, but are imperfectly irrigated and without any system, in dry seasons farmers having to fight for water.

The bench lands are occupied in a few cases, and have been found very productive when irrigated.

The high table-lands are used entirely for grazing, and in many cases possess a rich soil.

The irrigation of these high lands is the most difficult problem to be encountered.

The large rivers in eastern Montana run in deep valleys from 200 to 500 feet below these high lands, which can only be reached by long and expensive canals.

It is not considered practicable to conduct the waters of the Missouri River to these table lands, but those of the Yellowstone River and its branches can undoubtedly be so utilized.

In western Montana there many available sites for reservoirs, the most notable of which are Red Rock Lake in Madison County, and a large lake-bed, nearly dry, lying north of Great Falls, in Cascade County.

The present season has been an unusually dry one, and fully two-thirds of the crops in the valleys of western Montana will be lost from the drought. Many large streams are entirely dry, there not being half enough water in them to supply the numerous small ditches.

On nearly all of these streams are suitable reservoir sites, and were dams now constructed these valleys would be abundantly supplied with water for the dry season.

Even in springs following mild winters a large amount of water is wasted by flowing to the lower rivers early in the spring before it is needed for irrigation, which, if held back in reservoirs, could be utilized for irrigating in the summer.

It is universally admitted that irrigation is required in all sections of Montana except in a limited area north of Flathead Lake, in Missoula County.

The irrigating season begins in May or June and ends in August, although hay lands are sometimes irrigated in the fall; that is to say, in October and November.

The snow-fall in the mountain ranges varies from 4 to 10 feet in ordinary winters, but last winter it did not exceed 2 or 3 feet, except perhaps in the Bitter Root Range.

In eastern Montana the usual fall is from 6 inches to 2 feet.

The canals and ditches at present constructed in the valleys are, with a few exceptions, small local affairs built by each farmer for his own private use. A few stock companies have built canals, the largest of which is in Gallatin County.

By the construction of larger canals and short distributing ditches, a considerable saving in the use of water might be effected.

It will be seen from the foregoing remarks that the works requiring the aid of the State or General Government in their construction consist of storage reservoirs in the mountainous portions, and large canals in northern and eastern Montana. With these works in operation it is probable individual effort would be sufficient to carry out the work of distribution.

Appended will be found a compiled statement of each county in the Territory, giving the principal ditches constructed so far as known, a rough estimate of the lands occupied by settlers and in part under cultivation, and an approximate estimate of the number of acres that could be brought under cultivation with suitable works for irrigation.

Summarized for the whole Territory these are as follows:

	Acres.
Total area of territory, 146,000 square miles, or	93,440,000
Amount of land now occupied and partially irrigated and cultivated	1,000,000
Estimated arid area that could be reclaimed	20,000,000

Of this amount it is not probable 3,000,000 acres will ever be reclaimed without the aid of the State or the General Government.

If these improvements were carried out, the lands would be raised from a valuation of $1 per acre to $10, or a total increase of over $180,000,000.

The increase in live stock and personal property would amount to $100,000,000 more. The agricultural population would be augmented by 500,000 people, and with the increased population of the cities, towns, and villages, engaged in commercial and manufacturing pursuits, the total population of Montana would be at least 1,500,000. All this can be brought about by an expenditure which, compared with the magnificent results to be accomplished, would be but a mere bagatelle.

The increased value of the lands now belonging to the United States would fully compensate them for the money expended in the works, and would furnish homes for over 1,000,000 of people, making the State of Montana one of the richest in the Union.

We have indicated on the map which accompanies this report the lands which can be irrigated wholly or in part, also the constructed ditches so far as known, and several proposed ones, which we believe to be practicable, but they require investigation by competent engineers; also several reservoir sites.

Beaverhead County.—Three thousand seven hundred and forty square miles; 48 townships surveyed; 34 townships sectionized; 680,000 acres.

It is not known how much ground is cultivated or inclosed for meadow land—estimated at from [illegible]0,000 to 80,000 acres.

It is supposed that with irrigation this might be increased to 250,000 acres.

This county is a very mountainous one, and the lands are generally high. It is watered by the Big Hole and Beaverhead Rivers, with their branches, the Grasshopper, Rattlesnake, Red Rock, etc.

There are narrow bottom and also bench lands on these streams. If the surplus water of the Beaverhead alone could be stored it would amount to a body of water 20 miles long, 12 miles wide, and 15 feet deep; one hundred billion cubic feet. The soil is alkaline on bottoms and sandy loam on table-lands. Irrigation is necessary during the growing season every two weeks, commencing in May and ending in August. Nothing can be produced without irrigation.

There are three canals on the Beaverhead, near Dillon, which will aggregate 62 feet in width and 4 feet in depth. These belong to organized canal companies.

There are a very large number of private irrigating ditches. The river has been dry for a number of miles this season. There are many excellent table-lands, which would produce largely if irrigated, and there are many natural sites for reservoirs. At Red Rock Lake a dam can be constructed which would back the water for 15 miles, and raise the lake 15 feet high. There would then be enough water stored for nine months that would reclaim thousands of acres.

Cascade County.—Two thousand five hundred and seventy square miles, 60 townships surveyed and 57 sectionized, or about 1,140,000 acres; of this there is supposed to be irrigated or under cultivation or fence about 50,000 acres. This could be increased probably, by reservoirs and canal, to 600,000 acres.

This county is watered by the Missouri River and its branches.

Sun River, Birdtail, St. Peters, and Dearborn in the west, and Arrow Creek on the east. On the east and south are the Highwood and Little Belt Mountains.

On the west the county is chiefly a table-land, from which arise isolated buttes, such as Birdtail Rock and Square Butte, near Fort Shaw.

There is a large town at the Great Falls, on the Missouri, with unrivaled manufacturing power in the water of these falls and the Big Springs.

There are several canals already partly built, in this county, of which there are the Sun River ditch, 9-foot base, 3 feet deep, 10 miles long, on Sun River.

Teton River canal, commencing at the mouth of Deep Creek, on the Teton, and extends to a point about 1 mile from the mouth of Muddy Creek, a confluent of Sun River.

This canal, with various reservoirs and canals, when completed, will irrigate the vast area of bench lands between Teton and Sun River. A branch canal is now in progress to connect the large lakes lying about 20 miles north of the Great Falls with the main canal, which will not only be a feeder, but will also render the lakes available for storage purposes.

There is also a ditch on the east side of the Missouri River, near the town of Chestnut. It is 8 feet wide, 3 feet deep, and about 10 miles long—and is intended to be continued for 10 miles more.

A reservoir can be established on Smith River, which runs for many miles through a cañon, and a canal taken out to water the bench lands between Smith River and the Missouri.

On the waters of Belt and Arrow Creeks also there are doubtless sites of reservoirs.

Choteau County.—Twenty-four thousand eight hundred and thirty square miles; 145 townships surveyed; 140 townships sectionized, or 3,080,000 acres. It is supposed that about 50,000 acres are now cultivated, and that about 5,000,000 acres can be reclaimed by the use of canals and reservoirs. This county is very well watered by the main Missouri, which passes through it from south to east, having numerous branches, amongst which are, on the left bank, Sun River, Teton, Marias, and Milk Rivers, all with innumerable affluents. On the right bank are Sand Coulée, Box Elder, Belt Mountain, Highwood, Shonkin, and Flat Creeks, Arrow and Judith Rivers, and the Musselshell. The Blackfoot and the Fort Belknap Indian Reservation, and Fort Assinniboine Military Reservations are situated north of the Missouri and on Milk River. That part of this county between the Rocky Mountains, the Missouri River on the east and west and Sun River on the south and Marias River on the north, except the reservations, is a table-land of moderate elevation, susceptible of cultivation to an indefinite extent.

Several canals have been projected and are now being built. Of these, are the North Fork of Sun River Canal, 15 feet wide at base, 21 feet at top. The water is diverted from the North Fork of Sun River, and about 4 miles completed. It is intended to take it for many miles on the bench above Sun River. The North Fork offers an admirable site for an extensive reservoir.

Teton River Canal commences at the mouth of Deep Creek, a confluent of the Teton River, and extends across the table-land to Muddy Creek, a branch of Sun River, where it will be dammed, making a reservoir 1¼ miles long by three-fourths wide, whence there will be two canals taken out, one on each side of the stream. Other branches will be constructed to join the large lakes 20 miles north of Great Falls, from which canals will be made to irrigate the bench lands as far as possible.

There are other canals, such as the Rocky Gap Creek, or "Brown's ditch" Eldorado, 8 feet wide, 2½ feet deep, 10 miles long, near the town of Choteau. Black Leaf ditch, 6 feet wide, 2 feet deep; Kipp ditch, and Lepley ditch, the precise situation of which is not exactly known. In the mountains, and on the banks of streams, there are everywhere excellent chances for making reservoirs and canals in this region of country.

On the right bank of the Missouri, in the region watered by the Belt Mountain, Highwood and Shonkin Creeks, there is no doubt, from the formation of the country, that the bench-lands can be reclaimed, and that reservoirs can be made in the Highwood Mountains in which these streams head.

There are small lakes to the east of Shonkin Creek, which no doubt could be used as storage reservoirs. Beyond this there are "bad lands," but to what extent is not known. North of the Missouri is a large scope of country extending to forty-ninth parallel, formerly comprised in the reservation of the Blackfeet and other tribes, but now thrown open to settlement, and watered by the Marias, Missouri, and Milk Rivers and their numerous affluents. This region contains an immense body of agricultural land, of which the larger and best part is on Milk River and its branches. The valley of this river is from 3 to 5 miles wide, with a deep rich soil. The river itself, in the spring, is full to its banks, but in the summer and fall it becomes very small. Most of the streams which flow into it on either side have water near their sources, but become dry or run in pools in the lower part of their course. On the bench-lands, just above the bottom lands of the river, the settlers have found a stratum of gravel containing water, and by sinking wells from 7 to 12 feet deep they can always obtain it. The table-lands have excellent soil generally, and if means can be found to get water on them will become very productive. Timber is scarce, but lignite coal is found in many places. But little is known of this country in an engineering point of view, and it is therefore impossible to state where reservoirs or canals can be built. The elevation of the country is supposed to be about 3,300 feet.

Crow Indian Reservation.—Seven thousand eight hundred and thirty square miles; 37 township exteriors surveyed; 18 townships sectionized. About 1,500,000 acres can be irrigated. Amount settled on is unknown. The Crow Reservation is watered by the Yellowstone River and its branches, the Stillwater, Rosebud, Rocky Fork, Clark's Fork, Pryor Creek, Big Horn, and Little Big Horn, with their affluents. Many of these streams have extensive bottoms.

The Big Horn River, below old Fort C. F. Smith, has one about 75 miles long and from 1 to 5 miles wide. The reservation is very well watered, and there would be no difficulty in making reservoirs and taking out canals anywhere.

The bench-lands between the creeks could be easily irrigated and would produce largely. There are many fine bottoms on the Yellowstone River.

Custer County.—Number of square miles 22,300, of which 550 are on Cheyenne Reservation; amount of surveyed land, about 131 townships, exteriors surveyed; 77 sectionized, amounting to 1,694,000 acres. Chief streams are the Yellowstone, and on its south side are Tongue and Powder Rivers, with their branches; Armell, Rosebud, O'Fallon, Cabin, Mizpah Creeks, with their branches, and the Little Missouri in the southwestern part. North of the Yellowstone are Pease, Alkali, Big and Little Porcupine, and Sunday Creeks. The majority of these run dry or in pools after the high water in the spring has ceased. Between these and the Musselshell is a table-land, which could probably be irrigated by a large canal or canals from the Yellowstone. The soil is good, and would produce largely if irrigated. On this table-land are many depressions which could be used as storage reservoirs; the fall of the Yellowstone is sufficient for this to be done. On the south all the large streams contain water. There are already many small ditches for irrigating purposes, and two large ones are on the north side of the Yellowstone, at Pease Bottom, and another near Miles City. It is supposed that about 30,000 acres are under irrigation. By means of large lateral ditches and storage reservoirs in basins on the table-land this amount can be very largely increased, say to about 3,000,000 acres.

Dawson County contains 25,650 square miles, of which 3,080 square miles are contained in the Fort Peck Agency Reservation, and 375 in the Fort Buford Military Reservation.

There are 73 townships, the exteriors of which have been surveyed, of which 47 have been subdivided.

The county is thinly inhabited along the Yellowstone and its branches in the southeast and the Musselshell Valley on the west, and Milk River and the Missouri on the north.

That part lying between the Yellowstone, Missouri, and Musselshell is a table-land, generally destitute of water. There is a large water-course, called Big Dry Creek, but it has very little water in it, except pools, in the summer time.

A canal, however, from the Yellowstone or Musselshell might reach it, and the soil could be readily made very productive. A canal taken from the Yellowstone and running back of it some 20 miles would also open a large scope of good country, and there is also good land on the Missouri which could be opened in the same way.

Whilst there are 15,000,000 acres in the county, there would be probably not more than 4,000,000 which could be reclaimed as above mentioned. There have been a few ditches made in the Yellowstone country on the north side, such as the Clear Creek ditch, 6 feet wide, 2¼ feet deep, 4 miles long—has a reservoir containing 45 acres. Creek is 40 miles long, with drainage 10 miles in width. Water can be increased by digging down to bed-rock and putting in dam.

About 12 miles from Yellowstone, on Fox Creek, is natural reservoir or lake, about 4 miles long, 1 mile wide. About one-eighth is covered with water in dry season. If a dam were constructed across the lower end of the lake, where it is a quarter of a mile wide, the water could be taken from the bed of Fox Creek by ditches. This project would make a reservoir about 3,000 acres in extent, and would redeem many thousand acres.

There are also ditches taken out of Spring Creek, Crane Creek, and Fox Creek, and most of the farmers have ditches.

Water can be taken out of the Yellowstone about 35 miles above Glendive and ditch probably could be continued to the mouth of the river, 120 miles, which would reclaim all the valley lands on the Yellowstone in Dawson County. A number of streams could be turned into the ditch.

Deer Lodge County.—Four thousand seven hundred and sixty square miles; 31 townships surveyed and sectionized, or 620,000 acres.

It is supposed that about 100,000 acres are under cultivation or inclosed, and that 350,000 acres can be reclaimed by irrigation by means of reservoirs and canals.

This county is a very mountainous one, and is situated on the headwaters of the Columbia River. These mountains have a large amount of pine timber on them. It is remarkably well watered by the Deer Lodge, Little Blackfoot, and Big Blackfoot Rivers, and Nevada, Flint, and Stony Creeks and their branches.

The principal valley is on the Deer Lodge River, which has a course from south to north, where the county seat, Deer Lodge City, is situated, and also the large mining town of Anaconda. This valley is about 30 miles long and 12 miles broad, and has an elevation of about 4,500 feet. There are a number of branches to this stream on both sides, of which Warm Springs Creek is the longest. The branches on the west side are more numerous and contain more water than those on the east side of the river. There are also small lakes which could be used as storage reservoirs. If this were done and the water distributed by canals, many thousands of acres now idle could be utilized. The Hellgate River, below the junction of the Deer Lodge and Little Blackfoot Rivers, runs through a narrow gorge or cañon, but there are small valleys and settlements here and there along it. There are also valleys and settlements on the Little Blackfoot, Big Blackfoot, Nevada Creek, Flint Creek, and many other places.

Owing to the mountainous and timbered character of the county, and the abundance of water, there should be no difficulty in making large irrigating canals or finding sites for reservoirs. There are many private ditches but no large canals in this county.

From information received, on the Upper Flint Creek about 3,000 acres could be reclaimed by reservoirs. There are very fine locations for such on Flint Creek just below the falls, and also on Trout Creek, one of its tributaries. The sites would be sufficiently elevated to cover a large section of land on the dividing bench between them.

At the mouth of Flint Creek, near the town of New Chicago, on Willow Creek, one of the affluents to the left bank, a reservoir there established would reclaim between 10,000 and 12,000 acres.

The snow in the mountains falls very deep, ranging from 6 to 10 feet, and consequently in the spring the streams rise very high.

There is no doubt that irrigating canals can be established, and large quantities of land reclaimed, but the cost is too great for local efforts. Nearly all the grains and most of the vegetables are grown in this county that can be raised in other parts of Montana.

Fergus County.—This county contains 7,415 square miles, or nearly five million acres. It is bounded on the west and southwest by the Little Belt Mountains. In the south and center are the Big Snowy Mountains, separated from the Little Belt Mountains by the Judith Gap, a very remarkable pass, 3 miles wide.

The Big Snowy Mountains turn north and are succeeded by the Little Judith Mountains, which again join on to the Judith Mountains north of them. These different ranges form a semicircular "belt" (whence the name) inclosing the Judith Basin, watered by the Judith River and Arrow Creek and their affluents.

This basin contains a great deal of excellent land, both table and bottom, along the creeks. It is also well cultivated, and contains many sheep ranches and bands of cattle. The elevation of the valley is about 4,000 feet.

South and east of the Big Snowy Mountains are the tributaries of the Musselshell River, of which the Swimming Woman, Flatwillow, and Box Elder are the largest and most permanent. There are extensive bottoms and also table-lands of moderate height on the Musselshell, which can be irrigated by canals and would produce well. There are also many opportunities of forming reservoirs in these table-lands, as in many places there are small lakes which could be enlarged and transformed into reservoirs.

The Judith River, heading as it does in the mountains, affords excellent opportunities for making reservoirs and taking out canals for irrigating the numerous table-lands and bottoms with good effect.

On the east side of the Judith River, near the town of Lewiston, is a remarkable spring, called the Big Spring, once undoubtedly a hot spring, as its waters are still of such a temperature that neither it nor the stream flowing from it ever freezes in winter. This would yield a large body of water for irrigating the surrounding benches. There are no large canals in this county, but a very large number of small ditches.

Many of these mountain streams totally disappear for miles after reaching the plains, and afterwards reappear. There is no doubt that careful examination would develop many sites for canals and reservoirs. There are at present more than 150,000 acres under cultivation, and with canals and reservoirs probably 1,500,000 could be reclaimed.

One hundred and sixty-four townships, with exteriors, surveyed; 117 townships sectionized, amounting to 2,696,000 acres.

There are fine sites for reservoirs on the heads of Wolf Creek, which is also one of the finest parts of the county for agriculture.

Gallatin County.—Two thousand nine hundred square miles; 28 townships exteriors run; 19 townships sectionized, or about 360,000 acres.

There are probably 100,000 under cultivation. And 400,000 could be reclaimed by irrigating works, such as reservoirs and canals.

This county is watered by the East and West Gallatin Rivers, Middle Creek, and their branches. Also in the western corner are part of the Madison and Jefferson Rivers. The Gallatin Valley is very valuable and highly cultivated agricultural ground. There is also some arable land on the Jefferson and Madison.

There are a great number of small ditches taken out of the different streams for private irrigation. One large canal has been built extending along the base of the mountains from the West Gallatin to the East Gallatin River. This canal is 25 miles long, is 24 feet wide on bottom, and 4 feet deep. It narrows on approaching the East Gallatin to 14 feet wide and 3 feet deep, will carry 8,000 inches of water, and has cost $100,000.

There is also the Middle Creek ditch, carrying 2,000 inches of water.

Other canals could no doubt be taken from the West Gallatin and Madison, and reservoirs established, as the country surrounding the Gallatin Valley is hilly and mountainous. As the valley is high, considerable snow falls in the winter, and the streams can consequently rise very high in the spring, the surplus water of which could be stored.

Jefferson County.—Two thousand and sixty square miles; 40 townships exteriors surveyed; 33 townships sectionized, supposed equal to 660,000 acres.

Estimated that 250,000 can be irrigated. There may be 25,000 acres cultivated or inclosed.

This county is bounded on the east by the Missouri and on the South by the Jefferson Rivers, and is watered by their affluents, the Prickly Pear, McClellan, Beaver, Crow, and Hot Spring Creeks, on the north and east, and Bowlder River, White Tail Deer, and Pipestone on the south. The valleys are generally narrow. A canal could probably be taken out of the Jefferson River, on left bank, which would irrigate a large amount of land adjoining it and the Missouri.

There are reservoir sites in the mountains in several places, particularly in the Crow Creek Cañon and head of Beaver Creek. There are two ditches on Crow Creek of a capacity of 1,870 and 1,000 miners' inches, respectively.

The irrigating season begins in May and ends in August. In the Crow Creek Valley alone it is estimated that two or three times the amount of ground could be cultivated beyond what is now in use, if irrigated by means of reservoirs.

The snow falls from 5 to 6 feet deep in the mountains in usual winters. No crops can be raised without irrigation. The crops on 4,000 acres have been lost this year in consequence of want of water.

Lewis and Clarke.—One thousand seven hundred and sixty-nine square miles, of which 1,142 square miles is mountainous land, valuable for timber and grazing. There are about 400,000 acres which, if irrigated, would be susceptible of cultivation.

Thirty-six townships surveyed, of which 33 have been sectionized, or 660,000 acres. It is supposed that there are about 50,000 acres inclosed or under cultivation.

The county is bounded on the east by the Missouri and Cascade County, on the north by Sun River, on the west by the Rocky Mountains, and on the South by a spur of the Rocky Mountains and a line extending east to the Missouri River. The principal streams are the Big Prickly Pear and its branches, Ten and Seven Mile Creeks; Silver Creek, Little Prickly Pear, the Dearborn and its branches, and Sun River and its branches, all of these streams being affluents of the Missouri.

The Big Prickly Pear Creek with its affluents, Ten Mile, Seven Mile, etc., waters a large valley, well cultivated, containing the city of Helena, and surrounded by mines and mining districts. There are probably about 6,000 acres irrigated and under cultivation.

The entire basin could be irrigated by a good reservoir system and by new ditches.

There are available sites for reservoirs at the junction of Prickly Pear and McClellan Creeks, where two reservoirs can be constructed; aggregate capacity, 38,000,000 cubic feet. A series of reservoirs can be built in McClellan Gulch.

Ten Mile Creek at its headwaters affords fine facilities for reservoir sites, as do also the headwaters of Seven Mile and Silver Creeks.

The water-flow in high water of different streams is estimated as follows:

	Miners inches.
Junction Prickly Pear and McClellan Creeks	30,000
Ten Mile Creek	20,000
Seven Mile Creek	8,000
Silver Creek	8,000
Total	66,000

or about 102,960 cubic feet per minute, which is sufficient to fill a reservoir 1 mile square 5.32 feet in 24 hours.

There are a number of private ditches taken out of Ten Mile and Prickly Pear, sufficient to use all the water contained in them in the irrigating season.

The principal ditches are the Helena ditch, capacity 1,000 miners' inches; and another, capacity 2,000 inches. These are mining ditches taken out of Ten Mile.

There are also ditches from Seven Mile and Silver Creeks which now take up all the natural flow of these creeks.

From these sources of supply only 6 per cent. of the Prickly Pear Basin can be irrigated.

The greater part of the remaining 300,000 acres is in the valley of Sun River and on the Dearborn and Flat Creeks. Only about 4 or 5 per cent. is now under cultivation.

There are now canals being constructed in these parts of the county.

One of these, the Dearborn and Flat Creek canal, is 4½ miles long, 20 feet wide on bottom, 4 feet deep, and has a dam in Dearborn River 12 feet high, 21 feet wide, 200 feet long.

The other, the Florence canal, is taken out of the South Fork of Sun River, near the town of Augusta. It is 12 feet wide at base, 18 feet on top. It is to be 23 miles long, of which 8 are already built.

There is a fine basin on the headwaters of the Little Prickly Pear. Owing to its formation heading in a cañon, a reservoir can be easily established, which will irrigate the whole of this valley. There are facilities also for this purpose on the headwaters of the Dearborn and of Sun River, and thence by canals the bench-lands can be easily irrigated.

Madison County.—Four thousand five hundred and forty-six square miles; 80 townships surveyed; 46 subdivided, or 920,000 acres, of which about 500,000 acres could be irrigated by reservoirs and canals.

It is estimated that there are about 100,000 acres now under cultivation.

This county is well watered by the Madison, Jefferson, and Ruby Rivers and their branches; also in the west, for a short distance, by the Big Hole or Wisdom River, and head of the Black Tail Deer Creek. All these streams have arable land, both bottom and table lands. There are a number of streams flowing from the mountains, many of which head in small lakes, which offer excellent opportunities for the making of reservoirs and canals. This is especially the case on the Ruby and the Madison Rivers. There are no large canals built, but a very large number of private ditches.

The snow falls very heavily in the mountains, sometimes as deep as 8 feet.

The irrigating season lasts from about 15th June to 1st August. Meadows can be irrigated at any time.

Nothing can be done without water.

Several very fine sites can be found for reservoirs at the head of Ruby River, and also at Red Rock Lake at the head of a branch of Red Rock Creek, and on the Madison River.

Meagher County.—Seven thousand one hundred and sixty square miles in county; 94 townships surveyed; 90 townships sectionized.

It is supposed about 500,000 acres can be irrigated.

About 35,000 acres is supposed to be cultivated.

The county is very mountainous.

It is watered by the Missouri River and by its branches, flowing into it on the east side; also by Smith River and the Musselshell.

There is excellent bottom and bench land on the Missouri River. These are now irrigated by small, private ditches. There could be reservoirs established on some of the streams, and canals taken out, notably on Sixteen Mile Creek, which would enable a large amount of land to be farmed, now useless. The valley of Smith River is about 5,000 feet high, and is better fitted for grass than for agriculture, although both wheat and oats will grow there. There are good sites for reservoirs at various points.

On the Musselshell, also below the forks, there is plenty of bench, land to be reclaimed, and sites for canals and reservoirs on Big Elk, Lebo, American Fork, and Fish Creek, and along the Musselshell River.

Missoula County.—Nineteen thousand five hundred and eighty square miles; 22 townships surveyed and sectionized, or about 440,000 acres; there are, perhaps, about 150,000 acres inclosed or under cultivation.

This county is watered by different branches of the Columbia River, being the Hellgate and Bitter Root Rivers, which unite and form the Missoula River, which again unites with the Flathead River to form the Clark's Fork of the Columbia. Part of the Kootenai River, coming south from the British possessions, waters the northwest corner of the county.

The Flathead Indian Reservation, containing about 2,100 square miles, is in this county, extending from Clark's Fork of Columbia to the middle of Flathead Lake.

The west and longest valley is that of the Bitter Root, on the river of that name. It is about 55 miles long and about 12 miles wide, with an average height of 3,300 feet. The valley is on both sides of the river, which has numerous affluents. Its general course is due north. This valley is very fertile, and has a mild climate in winter. It is remarkable as being the earliest settlement in Montana.

The Jesuits had a mission amongst the Flatheads, where Fort Owen now is, in 1842, and made a farm and raised wheat and vegetables about that time, or shortly after. They sold out to Major Owen in 1852, who erected a trading post, still in existence, and it became a rendezvous in the winter for the men who traded with the emigrants on the California routes. Here they brought their bands of horses and cattle. These men gradually settled down and went to farming, and when Captain Mullan came through here in 1859 there was quite a little settlement.

The west side of this valley is remarkably well supplied with water from numerous streams, and there are a number of private ditches, and the greater part of the available ground is reported as being irrigated and reclaimed. Much of the ground is timbered. There are orchards on this side, planted by Bass Brothers, N. B. Harlan, and perhaps by others.

Up to the 1st of August the creeks furnish all the water needed. This year, being the driest ever known, there has not been enough.

The east side of the Bitter Root Valley is not so well watered, there being only three large creeks—Burnt Forks, Skalkaho, Weeping Child—and a few small ones.

There is a large amount of good farming land, and several ditches are taken out of the main river, of which one, the McCarthy ditch, commencing 8 inches about town of Stevensville, 10 feet wide, supplies several farms.

Shepherd ditch, size not known.

Harlan ditch, 12 feet wide, 5 miles long, carries 2,000 inches water; supplies water to 1,000 acres of land; cost $6,000.

Humble ditch, near Corvallis, size unknown.

Surprise ditch commences 6 miles above Corvallis; 12 feet wide, 6 miles long, 2,000 inches water; cost $10,000. Incorporated company.

Republican ditch taps river near mouth of Weeping Child Creek; 12 feet wide, 11 miles long.

W. B. Harlan takes water from Rock Creek on west side, and brings it across the river to his ranch in a flume suspended by a wire cable. He has a large orchard of 1,500 trees, apple, plum, cherry, and pear, several hundred of which are in bearing. It is estimated that on the east side of the Bitter Root at least 50,000 acres additional could be reclaimed by canals and reservoirs. The head of the river and many of the streams on both sides run through cañons, where reservoirs could be easily constructed.

The irrigating season commences in June and ends about 1st of August. When snow fall is light, it is necessary to irrigate in April before plowing. Meadows are irrigated early in the season and late also. Fruit trees should be irrigated on the approach of winter. Nothing can be done without irrigation, except in the river bottoms, which get either the overflow or seepage from the river.

There has been produced in this valley by irrigation, wheat, 20 to 60 bushels; oats, 30 to 110; peas, 20 to over 80; corn, as high as 50; potatoes, from 130 to 600 bushels, of these, some weigh from 4 to 4½ pounds. Tomatoes, melons, and squashes are all grown here. Apple and plum trees grow more fruit than they can hold up.

All northern small fruits grow in great profusion. This valley may be said to be the garden spot of the mountains.

There are other valleys on the Hellgate and Missoula Rivers, called Hellgate Ronde, Grass Valley, and Frenchtown Valley, extending along these rivers at intervals for 24 miles.

In this section are reported 3 ditches taken from Grant Creek in the Hellgate Ronde, carrying, respectively, 200, 600, and 1,000 inches. These take all the water of the creek.

These valleys, with irrigation, produce all the different varieties of grain, trees, and vegetables. Mr. Flynn reports that he raised 5,600 bushels of oats on 100 acres last year. Nothing can be done without irrigation. All of these valleys could probably be irrigated from the Big Blackfoot or Missoula River, which contain plenty of water, sufficient for large canals, and there are quite a number of creeks which could be employed as feeders.

There are small valleys, also, in Clark's Fork, of which the largest are those called the Horse Plains and Thompson's Prairie, which are now settled upon along the Northern Pacific Railroad. There is not a large amount of agricultural land along this stream, most of which is heavily timbered. There would be no difficulty in irrigating what there is from the river, which is very large and has a heavy fall.

There is also a very fine agricultural district on the Flathead River, above the large lake of that name. The altitude is about 2,500 feet, and it is reported that every kind of grain and vegetable can be grown there without irrigation. This is accounted for by there being more moisture during the spring and summer than in other sections of the country, which may be accounted for probably by the vicinity of the lake and the heavy timber.

On the Indian reservation, which contains a large amount of fine land, agriculture has been practiced for more than 30 years by the Jesuit fathers and the Indians under their direction. Very fine crops have been raised. There are also large bands of horses and cattle.

Irrigation, when practiced in the Bitter Root Valley and elsewhere, requires about 1 inch per acre. The water is allowed to run 2 or 3 days at a time, and generally 2 or 3 times in the season.

The snow falls from 10 to 4 feet deep in the mountains, and all the streams rise very high in the spring. With storage reservoirs an immense amount of water could be saved for irrigation.

Park County.—Four thousand seven hundred and forty square miles; 55.5 township exteriors surveyed; 40 townships sectionized. About 500,000 acres could be irrigated by canals and reservoirs. Supposed about 15,000 acres now under cultivation. This county is very mountainous. The Crazy Mountains are situated in the north, on east side of Shields River. On the west it is bounded by the Gallatin Range and the Bridger Mountains, and in the south are the Snow Mountains and the Bear Tooth Range, with their numerous spurs.

There is a valley on both sides of the Upper Yellowstone which can be irrigated by the Yellowstone or its branches; also on Shields River, which is quite a long stream with many affluents, giving an excellent opportunity for canals and reservoirs. East of the Crazy Mountains and north of the Yellowstone there are many streams, such as Duck, Gage, Little Timber, Big Timber, Medicine Bow, Sweet Grass, and White Beaver Creeks.

These generally cut through a table-land, which has good soil and is nearly level. A canal from the Yellowstone, taken out near Livingston, would soon reach this bench and bring into cultivation a very large area. There are opportunities, also, of making reservoirs on it as noticed in report of Yellowstone County.

The southern part of this county, adjoining the Crow Reservation, is generally very mountainous and broken, but there are many settlers at Rocky Fork and Red Lodge, where the coal mines are situated. There is plenty of water, but the agricultural land is circumscribed.

Silver Bow County.—Seven hundred and sixty square miles; 8 townships surveyed; 7 townships sectionized. It is supposed that about 40,000 acres could be irrigated and rendered productive. The amount under cultivation is unknown—certainly not 5 per cent. This county is essentially a mining county, containing, as it does, the great mining town of Butte. The average height must be about 5,000 feet, and the agricultural portions are situated along the Big Hole or Wisdom River, in small bottoms; on Divide Creek, one of its branches, and in the Silver Bow Basin, at the head of Silver Bow Creek, around the town of Butte.

There are many mining ditches in the Silver Bow Basin and along that stream, which is a branch of the Deer Lodge River. One or two of these ditches cross the divide at the Deer Lodge Pass, which is 3 miles wide, and thus unite the waters of the Missouri and Columbia Rivers. A canal could be taken out of Wisdom River which could irrigate most of the agricultural land on the south side of the Rocky Mountains in this county, and reservoirs in the mountains, sites for which can be readily found, with canals, could irrigate the lands on the north side.

Yellowstone County.—Three thousand three hundred and ninety square miles, or 2,272,000 acres; 62 township exteriors surveyed, of which 49 are sectionized. About 500,000 acres can be irrigated, mostly by canals from Yellowstone and Musselshell.

Between these two rivers there is a bench-land; this is about 170 and 200 feet above the Yellowstone, but can be reached by a canal from either the Musselshell or Yellowstone. Midway between the two rivers is a depression, which has been the bed of a lake, and can be readily turned into a reservoir. The streams flowing into both the Musselshell and the Yellowstone are generally small.

There are two ditches or canals on the Yellowstone, north side—one 20 feet wide and about 27 miles long, and the other 10 feet wide and about 15 miles long, inside or south of the other one.

There are probably about 50,000 acres irrigated.

RECAPITULATION.

No.	County.	Area.	Supposed under cultivation.	Supposed can be cultivated by irrigation.
		Sq. miles.	*Acres.*	*Acres.*
1	Beaverhead	3,740	80,000	250,000
2	Cascade	2,570	50,000	600,000
3	Choteau	24,830	50,000	5,000,000
4	Crow Reservation	7,830	....	1,500,000
5	Custer	22,300	30,000	3,000,000
6	Dawson	25,650	50,000	4,000,000
7	Deer Lodge	4,760	100,000	350,000
8	Fergus	7,415	100,000	1,500,000
9	Gallatin	2,900	100,000	400,000
10	Jefferson	2,060	25,000	250,000
11	Lewis and Clarke	1,769	50,000	400,000
12	Madison	4,546	100,000	400,000
13	Meagher	7,160	35,000	500,000
14	Missoula	19,580	150,000	600,000
15	Park	4,740	15,000	500,000
16	Silver Bow	760	1,000	40,000
17	Yellowstone	3,390	50,000	500,000
	Total	146,000	986,000	19,790,000

The CHAIRMAN. How long have you resided in Montana?

Mr. GREENE. Nearly four years.

The CHAIRMAN. Have you traveled considerably over the Territory?

Mr. GREENE. Not a great deal.

The CHAIRMAN. Suppose the United States Government should make the necessary surveys so as to determine the cost of construction of reservoirs, etc., would not that, in your opinion, be of service to the people of Montana, and could not a large area of country be easily irrigated that is not now in use.

Mr. GREENE. I am prepared to answer "yes" to that. I have seen enough for that.

The CHAIRMAN. Would you not before the surveys could be completed have a large increase in your population, taking up all the convenient places first? Do you not think it a little premature to say how vast sums of money shall be expended before you have the lands taken up?

Mr. GREENE. Yes.

The CHAIRMAN. Mr. Plumb, the chairman of the Committee on Public Lands of the Senate, is here, and I would like you to state, if you have reflected on the subject, what changes would be necessary, if any, in the present land laws to enable people to occupy these lands and at the same time prevent the water falling into the hands of the few, and thus have the water and land divorced.

Mr. GREENE. The great difficulty we now labor under and have since my residence here, is that the land surveys are inadequate. We can not locate a great deal of this property by land lines. There is not a survey for all the eastern portion of Montana, and my office is filled with applications from settlers.

The CHAIRMAN. Are the homestead laws inadequate to enable settlers to acquire title where irrigation is necessary? Do they need modification?

Mr. GREENE. I fancy they would meet the case. I think they would meet the exigency.

The CHAIRMAN. As surveyor-general for this Territory I would ask you whether you have observed or not the denuding of timber from the land, burning it off, as it has been for two or three years. What effect has that had upon the streams and the moisture? Have you observed?

Mr. **GREENE.** No; you see I am so closely confined to my office that I do not have the opportunity of observing. I presume it is the same as in other countries—the moisture evaporates much more rapidly.

The **CHAIRMAN.** Suppose instead of secret agents, such as we now have, we had timber agents appointed to let the people have the timber at reasonable rates, on condition that they would take care of the underbrush and dead timber and assist in preventing fires, do you think you would have the co-operation of the community in carrying it out?

Mr. **GREENE.** I feel very sure we would. It is preferable to the present system, if you can call it a system.

Senator **PLUMB.** What Senator Stewart is aiming at is this: Is a system which is not designed to proceed upon a theory that every one who takes public timber may be prosecuted for it, and so on, but a system which shall permit every one who wishes to have such timber as he needs, sparing the small growth, or to take the timber under terms which are consistent with his integrity and self-respect, and at the same time not burdensome in a financial way—a system which simply permits the taking of the larger timber as it is needed and which will protect the remainder from fires, leaving the underbrush on the ranges to catch the snow. He wishes your view as to the merits of two systems. And I would like to have your views myself, because it is a question to which I have given attention here and elsewhere. We want a system that will meet the views of the Government and the people of this country.

Mr. **GREENE.** It would be suitable to the people.

Senator **PLUMB.** As it is now, any one who cuts timber is liable to be brought before a magistrate, there to show whether he cut the timber for certain specific purposes or not.

Mr. **GREENE.** Yes.

Senator **PLUMB.** That is to say, a man who cuts timber for a mining company or a mill is liable to be arrested for the purpose of ascertaining whether he is cutting within the purview of the act of Congress. The system which Senator Stewart suggests would enable the people to have all the timber they might want for use in the Territory, upon a legitimate basis of minor compensation, at the same time keeping all that is valuable to the Government in the shape of underbrush, which will replace what is taken away and hold the snows and prevent their evaporation after they fall. That is the question between these two plans. Which would be the better?

Mr. **GREENE.** I can only say that I fancy such a system would be acceptable. There are others here who could speak very positively on that subject. Colonel Sanders could give you an expression of public opinion on that subject.

The **CHAIRMAN.** I would like to hear from mining men, or their representatives, as to what system the community here would assist in carrying out, so that the mountains would not be denuded, and thus permit the water in flood times to rush down and injure the country. No system can be carried out unless the people help to do it.

Senator **PLUMB.** Do you know about the Yellowstone Valley? Have you ever been there?

Mr. **GREENE.** I never have.

Senator **PLUMB.** You do not know anything about whether the boundaries of that Park are what they should be with a view to preserving the natural curiosities, the water supply, game, fish, etc.?

Mr. **GREENE.** No; I have never been at the Park.

STATEMENT OF W. F. SANDERS, OF HELENA.

The **CHAIRMAN**. How long have you resided in Montana?

Mr. **SANDERS**. Twenty-six years, lacking a few days.

The **CHAIRMAN**. What has been your occupation?

Mr. **SANDERS**. I have been mining, farming, practicing law, and perhaps some other occupations that have escaped my memory.

The **CHAIRMAN**. Are you acquainted with the whole Territory?

Mr. **SANDERS**. Yes; except that portion which is occupied by Indians, and that I have been over as much as most other persons.

The **CHAIRMAN**. Has your attention been called to the question of preserving the timber that is used for holding the snows and saving the moisture, and at the same time allowing people to cut timber?

Mr. **SANDERS**. Yes; I have looked over the difficulties of the situation considerably.

The **CHAIRMAN**. What system would you suggest as best calculated to preserve the timber and enable the people to have what they need, and at the same time secure their co-operation in carrying out the wishes of the Government?

Mr. **SANDERS**. First, as to the co-operation of the people. That is assured. They have an interest in it personally, while the Government's interest is public. We have laws upon the statute-books denouncing very severe penalties upon anybody who puts this timber in peril by leaving fires out—setting out fires in any shape to burn up the timber, which is the great cause of its destruction in the Territory. There has been more timber burned in Montana in the last month than has been used by the people for twenty-five years, I think. And what has occurred in the last month occurs almost every year. It takes the entire summer season to destroy as much timber as was destroyed during the month of July.

Fires result very frequently from lightning. That has occurred under my observation. More, however, are from the Indians leaving out fires and setting out fires; some white persons do that too. To punish these persons, many years ago a law was passed, I do not remember the penalty, and we have printed that law upon cloth and posted it upon the trees along the highways of Montana. I mention this fact to show that the people of Montana have a profounder interest in this question than anybody else has.

The **CHAIRMAN**. Does the timber in this Territory usually grow upon agricultural land?

Mr. **SANDERS**. There is practically no timber upon the agricultural lands of Montana. A few poplars of one kind and another, and willows along the banks of the streams, are all the trees that are on agricultural land, and cottonwood, which is a kind of poplar. So that, speaking practically, there is not a stick of timber that can be obtained by a citizen of Montana, except under the law allowing the cutting of timber on mineral land. Whether the destruction of timber by the people for their own use over this area is greater than the reproduction of it by nature I can not answer. I think that is in doubt. There are, however, three kinds of trees growing here to which we might direct your attention. There is what we call the lodge-pole pine; the scientific name I do not know. It grows densely and like wheat in a field, from 30 to 70 feet high, and is from 6 to 10 inches in diameter. There is pine proper, and there is also a kind of fir. These three practically furnish all the timber that is in Montana. The Rocky Mountains are an upheaved rock, covered with a very thin layer of drift, on which these trees grow. They demand moisture and fertility to supply them, and when they get so dense, so large, that the supply is not adequate, they die, fall down, become dry and feed the flames that destroy the timber that is healthy. Those fires do more to destroy the timber than the people do.

From this point west, traveling through the forests of pine and fir and cedar, an observing person will find that a great many trees have fallen and are lying upon the ground. If that person will examine them, he will find that they are decayed inside. And then you go and chop down trees for saw-logs or any purpose for which they are needed, and you will frequently find them in the same condition—decayed inside.

The **Chairman**. Would cutting out the other trees and cleaning off the dead ones make the fires less liable to occur?

Mr. **Sanders**. Unquestionably. Nature has not revealed any more to me than she has to anybody else; but it is perfectly apparent that those trees decay because they lack some nutrition. That you will find in trees of various sizes.

The **Chairman**. Do the trees grow very closely together?

Mr. **Sanders**. Yes, they grow closely together. I am speaking of the larger trees. It is a dense forest.

The **Chairman**. Then they drop down and become dry wood? Do they rot rapidly?

Mr. **Sanders**. They remain there a long time. The country is very dry, and the trees full of resinous substance, and they feed the flames easily.

The **Chairman**. Suppose the Government, instead of having secret agents, should have timber agents with convenient districts under their control to regulate the cutting of timber, to carry out instructions and allow the people to have what timber they want at a nominal price, reserving the land—to have no land for sale—and imposing upon the people the condition that they should remove the dead trees and preserve the underbrush—these timber agents to be men who live in the different communities and known to the people, could there be more done than is now done to preserve the forests?

Mr. **Sanders**. I have reflected upon this question in all its aspects. In the first place, I believe that everybody who goes upon the public domain and cuts a tree should be held responsible under penalties to take care of the limbs and see that they are destroyed, so that they may not feed the fires.

The **Chairman**. What would you think about a condition, where they are cutting timber for mining purposes, to compel them to remove the dead timber?

Mr. **Sanders**. I am opposed to the Government turning itself into a huckster-shop by selling the timber. I think the people should be free to go there, provided they obeyed certain regulations which should be made. I think the people of Montana would exercise sufficient espionage over citizens who went there, and that it would not be unjust to them if the Government had individuals there to see that the regulations were enforced.

The **Chairman**. Would you have a certain officer there to look after the district or an agent sent out? What would be the best scheme?

Mr. **Sanders**. It might be that you could not get anybody here to take the place; so that you would do better to import them.

The **Chairman**. Would such a place be unpopular out here?

Mr. **Sanders**. Not at all.

Senator **Plumb**. The question the Senator desires to put is this: You have a system which permits you to take timber for certain purposes, and if the question arise whether or not it is taken for this purpose the man who takes the timber is liable to prosecution by some agent who may take the view that he should be prosecuted, and, therefore, whoever cuts timber is running a certain risk; because the Government maintains agents here who are bound to do something to earn their salaries, and frequently they recommend prosecutions that can not be maintained. Suppose we substitute for that system one that will permit everybody to have the timber, who may want it for his own use, at a price which will repay the cost of administering the system, and limit the cutting of timber to the amount that the person may need—make the whole thing legitimate—do you think that would be preferable to the system which is now in operation? Do you think the latter would be more acceptable to the people than to have the present one with the risk they are running?

Mr. **Sanders**. A thousand fold.

The **Chairman**. You are in favor of a system whereby the Government shall regulate the cutting of timber, so that a sufficient amount of undergrowth can be preserved to keep up the forests, and you would not recommend the selling of any timber land where agriculture can be pursued, but would keep it as it is?

Mr. **Sanders**. No; I do not wish to legislate against rich men; but I do not know any way of preventing rich men cutting any more timber than the poor man. There is another regulation that has been enforced with strictness and almost cruelty. I do not see why the timber in Idaho should not be brought into Montana.

The **Chairman**. You would allow a free cutting of the timber under such regulations as would allow the forest to grow up again and to take it anywhere in the United States?

Mr. **Sanders**. Yes; that is what prosecutions have rested upon, and it has done more to demoralize and wreck public justice than anything else. It is not good to enforce a law that is against the sense of justice. While in these prosecutions they have been able to prove that this timber was cut, they have been unable to prove that it was on mineral land, and the juries will find according to the proof. They do not believe in the system, and it seems to us petty for a Governmen with 60,000,000 of people to go around huckstering its wood.

The **Chairman**. In regard to irrigation—you have traveled over this Territory and are familiar with its topography.

Mr. **Sanders**. Yes.

The **Chairman**. Would the settlement of the country be materially advanced if we had surveys showing where reservoirs could be made and where the ditch lines would be, with estimates of the cost of constructing them, so that the people could understand the situation?

Mr. **Sanders**. Very much.

The **Chairman**. Could the population be largely increased before the inauguration of the great enterprise of utilizing the waters of such rivers as the Yellowstone and Missouri? Could much be done by the people themselves?

Mr. **Sanders**. Yes; considerable could be done by the people.

The **Chairman**. Then we may postpone the discussion of who shall do the great work until we can see what we have to utilize—until we shall have ascertained what the people themselves can utilize.

Mr. **Sanders**. In the light of economy I think these reservoirs should be one above another in lateral streams. It is easy to take the water around to a lateral stream where there is a good place for a reservoir.

The **CHAIRMAN.** And in lateral valleys?

Mr. **SANDERS.** Yes.

The **CHAIRMAN.** That is a question for an engineer. But when these places are established the people will have good places to settle in.

Mr. **SANDERS.** I have just reported from the Tongue River, where the water is brought from the Big Horn Mountains, and where the finest crops of corn, timothy hay, wheat, barley, and oats grow, such as I have not seen anywhere in Montana. That is in northern Wyoming. I was surprised that they got the water up there, and at the wonderful fertility that the hill-tops manifested after they got it there. I do not know a given lesson in irrigation that is of more interest than the Tongue River.

Senator **PLUMB.** Have you ever been in the Park?

Mr. **SANDERS.** Yes.

Senator **PLUMB.** Suppose we determine to maintain it as a park, as a place of resort for the purpose of the preservation of the natural objects of curiosity, would you suggest its extension? When I speak of natural objects of curiosity, I include the headwaters of the streams, game, and fish.

Mr. **SANDERS.** I am quite reconciled to the extinction of the rattlesnake, buffalo, and such animals as that.

Senator **PLUMB.** I am speaking of keeping it up. Suppose we determine to keep the Park up as a place of resort for the purpose of keeping these natural curiosities and preserving the headwaters of these streams for the fish, game, and so on, would it be desirable to enlarge it?

Mr. **SANDERS.** I do not know of any portion of the public domain surrounding the National Park the occupancy of which would imperil the usefulness of the Park in the particulars to which you refer. Certainly the boundaries of the National Park contain nearly all the objects of natural curiosity that there are in the country except the mountains.

Senator **PLUMB.** Would there be any greater water supply by the extension of the Park, so as to cover more fully the sources of that water supply and prevent their being diverted, and thereby made more accessible and useful to the people of the valley?

Mr. **SANDERS.** The occupancy of the public domain tends somewhat to destroy trees, and therefore limits the water supply. The headwaters of the Snake River drains very considerable forests, and the extension of the National Park or any other form of reservation over them to preserve the timber would be of some use. But I think that country contains fine valleys and is to some extent largely occupied.

The **CHAIRMAN.** Would it be injured by erecting small dams, so as to raise the lakes somewhat to increase the storage of water? Could it be done there without injury to the Park?

Mr. **SANDERS.** I think it would help the Park to enlarge the lakes.

The **CHAIRMAN.** You would have to draw them off during the irrigating seasons somewhat?

Mr. **SANDERS.** I do not see how that would injure anything.

The **CHAIRMAN.** Have you made any estimate, in passing over this country, of the comparative amount of land that might be irrigated and of the area that could not be?

Mr. **SANDERS.** I have not done so in exactly that form. I took occasion about fifteen years ago, in response to some inquiries, being pretty familiar with the topography of the country, to divide the country up into fractions of six, saying that one-sixth was agricultural practically; two-sixths more agricultural with sufficient expenditure of money.

The **CHAIRMAN.** That is, was susceptible of irrigation?

Mr. **SANDERS.** Yes. And a sixth of it mineral, and a sixth of it timber, and a sixth of it useless, if I remember right. That is the way I took it then. I think I should revise those figures now; but I made them then as the result of my best judgment.

The **CHAIRMAN.** From my observation I hardly think they would need very much revision. I have been over the Territory.

Mr. **SANDERS.** I made those figures with some care.

Senator **PLUMB.** Mineral land is also timber land to some extent, is it not?

Mr. **SANDERS.** There is really mineral land wherever there is timber as a rule. Of course there is some mineral everywhere in the Territory. It is very hard to break off a rock within 200 miles of this Territory without on close examination finding some gold in it.

STATEMENT OF WALTER W. DE LACY, OF HELENA.

The **CHAIRMAN.** How long have you resided in Montana?

Mr. **DE LACY.** Thirty years.

The **CHAIRMAN.** Have you traveled over it pretty extensively?

Mr. **DE LACY.** Yes; I have been over it considerably.

The **CHAIRMAN.** What has been your occupation?

Mr. **DE LACY.** Surveyor and civil engineer.

The **CHAIRMAN.** You have made estimates of the amount of land that could be irrigated and that that could not, have you?

Mr. **DE LACY.** Yes. I do not so much know about what could not, as about what could be irrigated.

The **CHAIRMAN.** You do not know but what there might be more irrigated than you anticipated?

Mr. **DE LACY.** Yes. There might be more.

The **CHAIRMAN.** But what could be irrigated you estimate at about how much?

Mr. **DE LACY.** About 20,000,000 acres.

The **CHAIRMAN.** You do not pretend to say but what that might be largely increased by going on the other side of the mountain?

Mr. **DE LACY.** Yes. It might be.

The **CHAIRMAN.** Did you include in that area of 20,000,000 acres any land except that that would lie comparatively smooth and level?

Mr. **DE LACY.** Only the table-land.

The **CHAIRMAN.** You did not include in that the slopes of hills and rolling lands?

Mr. **DE LACY.** No.

The **CHAIRMAN.** Those might be irrigated, might they not, by terracing, when the population became dense?

Mr. **DE LACY.** Yes, but I did not include those.

The **CHAIRMAN.** If a policy of terracing the hills were pursued, that area would be much increased, would it not?

Mr. **DE LACY.** Yes. I will say this much in relation to that subject: that in a great many places the ground at the foot of the hills is very valuable ground for one reason, that it is apt to be very good soil, and it is not so liable to frost as that which is in the bottoms. I know that in the Bitterroot Valley—which was the earliest settled, it being settled in 1842—when people first came here they planted wheat in abundance and they lost their crops very shortly by frosts. Afterward they planted their crops on the bench lands on the foot-hills, and there they found the lands infinitely better, and saved their crops. That has been the experience in that valley ever since.

The **CHAIRMAN.** What would you say for the general water supply of this Territory; is it extensive or not?

Mr. **DE LACY.** I would say that it is very good in some parts. In the western part it is generally very good, and that is a very dry country; but the water supply is generally good; better than some countries that I have seen.

The **CHAIRMAN.** You have quite a district of high mountains that catches the snow?

Mr. **DE LACY.** Yes. And there are a great many small streams as well as large ones.

The **CHAIRMAN.** What is your observation as to the result of irrigation in producing crops?

Mr. **DE LACY.** The result of my observation has been that you can not produce anything here that is worth talking about without irrigation.

The **CHAIRMAN.** With it, what succcess is there? Where it is properly conducted and the water is put on, not too much or too little?

Mr. **DE LACY.** The irrigation in such cases is very successful. That is to say, it makes a sure and certain crop.

The **CHAIRMAN.** And how is it as to the quantity or amount of the crop?

Mr. **DE LACY.** It makes a very large crop.

The **CHAIRMAN.** How are the hills as to furnishing pasture for stock?

Mr. **DE LACY.** They are very good indeed. I would remark that the hills are almost indispensable for sheep-raising, because they are a winter supply. The wind blows the snow away from the hills, and the consequence is that the sheep can go up there and feed; so can horses. Cattle usually do not do that.

The **CHAIRMAN.** There is more food for cattle, sheep, and stock in summer than in winter, of course?

Mr. **DE LACY.** Yes.

The **CHAIRMAN.** Suppose you had the valleys cultivated and the arable land under cultivation so that you had ample feed for your stock for market and ample feed for the winter, would not the amount of stock that could be raised be largely increased?

Mr. **DE LACY.** Yes.

The **CHAIRMAN.** Using these hills for the summer?

Mr. **DE LACY.** Yes; using the hills for the summer. And it would be very much increased by irrigation, because there would be so much more meadow-land. I have never been engaged in agriculture, but I have been engaged in sheep farming. You can take almost any bench-land—I do not care what it is—and irrigate it, and it will produce in this Territory Kentucky blue-grass.

The **CHAIRMAN.** Without sowing?

Mr. **DE LACY.** Without sowing.

The **CHAIRMAN.** Would it come up naturally

Mr. **DE LACY.** Yes. It comes up naturally.

The **CHAIRMAN.** Then you say that by irrigating this land in this Territory it will produce spontaneously Kentucky blue-grass?

Mr. **DE LACY.** Yes. It has done it, I know. It did it where I was. I know that we could get very large crops. If it was not Kentucky blue-grass, it was a grass exactly like it.

The **CHAIRMAN.** It is equally nutritious?

Mr. De Lacy. Yes. It is equally nutritious. Timothy grass would also grow.

The **Chairman.** But that has to be sowed, I suppose?

Mr. De Lacy. Yes. That would have to be sown.

The **Chairman.** It does now grow spontaneously?

Mr. De Lacy. No.

The **Chairman.** That is a very important statement, that these benches when irrigated will produce Kentucky blue-grass without the seed being sown, or a grass equally nutritious.

Mr. W. C. Childs. I can confirm that statement. You can see it if you take a pleasant ride 6 miles east of here.

Senator **Plumb.** It comes up spontaneously, does it?

Mr. Childs. Yes; it is hardly blue-grass, but "blue-joint," as it is called.

Mr. De Lacy. They told me it was blue-grass, and I thought it was.

Senator **Plumb.** What is the difference between that and Kentucky blue-grass?

Mr. Childs. This is much better than the Kentucky blue-grass.

Senator **Plumb.** What is the difference in its features; what peculiarities distinguish it from Kentucky blue-grass?

Mr. Childs. In the early growth of blue-joint, when it first comes up in the spring, or at any time in the year when it receives moisture, it has a very close resemblance and appearance to Kentucky blue-grass, but as it advances in growth it gets to be perhaps 20 inches long, and has more the appearance of a field of growing grain. There is a seed which it produces. Stock prefer it to oats; it looks very much like grain. I think you will find the testimony universal that stock grazing upon blue-joint or bunch-grass, which in the opinion of most people is but a larger or more rank growth of blue joint, will fatten almost as readily as they will when stall-fed.

Of course this season has been very dry. I spoke of this grass as being seen within 6 miles of here, and I did so because in that place I own the right of way, and it has not been grazed on for three years, so that you can see the grass growing in its normal state. You will see there the condition that Mr. De Lacy has mentioned. And while I do not call it blue-grass and do not understand him to call it Kentucky blue-grass, it certainly is very similar.

Mr. De Lacy. This that I speak of was very similar indeed in appearance to the Kentucky blue-grass, and the man I had with me called it that.

Senator **Plumb.** Does the irrigation require to be kept up—that is, is it necessary to keep the water on the land?

Mr. Childs. This grass does not grow unless supplied with moisture. It is true that quite a growth obtains when there is a rainy season, but Mr. De Lacy and myself are personally acquainted with a section of the country in the eastern part of the Territory, where I can construct a ditch and supply that grass with water amply, and cut a ton and a half of it to the acre on a tract embracing perhaps 60 or 100 acres.

The grass can be seen there in its normal state, although not so profuse now as it sometimes is, because this has been a very dry season and there has been a lack of moisture.

Senator **Plumb.** Is it entirely different as a species from the ordinary bunch-grass of the prairie?

Mr. Childs. I will not say entirely different. I have just remarked that in the opinion of many the bunch-grass and the blue-joint are identical, except that the bunch-grass is of a more rank growth. It grows stronger and grows in bunches here and there, whereas the blue-joint covers the ground very much thicker than the bunch-grass.

Senator **Plumb**. It does not make a sward?

Mr. **Childs**. No, sir, and I think that observation will confirm the statement that cultivated fields of timothy will in the course of five or six years tend to produce a grass very similar to this blue-grass. The first year's cutting or the second year's cutting is a coarse rank growth, and the third year and each succeeding year the timothy assumes a finer and thicker growth. It may be only a fancy of mine, but it seems to me as if it were tending toward blue-joint.

Senator **Plumb**. How many years in succession have you known this land to yield crops by means of irrigation?

Mr. **Childs**. To my personal knowledge eighteen years.

Senator **Plumb**. Each year?

Mr. **Childs**. Yes.

Senator **Plumb**. Has it seemed to lose any of its fertility in that time?

Mr. **Childs**. No.

Senator **Plumb**. Has the land been manured or anything given back to it besides what is taken away?

Mr. **Childs**. In some instances. It has been said that Montana land does not need any manure. But my opinion is that it will astonish people when it is manured. If you take a field of 30 or 40 acres and let one portion of it be deprived of manure and another portion be manured, you can distinguish the results readily. Another thing, manuring of the land very largely takes the place of moisture. In other words, land which has been manured will do very much better without moisture than that which has been manured.

The **Chairman**. Manure preserves the moisture, does it not?

Mr. **Childs**. Yes.

The **Chairman**. And it prevents evaporation?

Mr. **Childs**. Yes.

Senator **Plumb**. What quantity of water do you deem proper for irrigation?

Mr. **Childs**. In making any statement concerning the amount of water required for the purpose of irrigating an acre of land I always like to make a qualification, and I do so now. That is to say, what is termed a half of a miner's inch, if it is at your command whenever the land demands irrigation and you use it with good judgment, is ample; provided the land immediately to be irrigated is furnished with that amount of water whenever the demand for irrigation exists. But in practice it would be necessary to have as a rule 2 inches to the acre, because most land that is supplied with water for irrigation is supplied by ditches that are from 1 to 5 and 6 miles in length, and the water in traveling from its source, while being taken from the river to the lands to be irrigated, is subject to a great deal of evaporation as well as to seepage or soaking into the land. So that I think that for every 2 inches that start from a stream to travel through an irrigating ditch of, say, 3 miles length, before it reaches the land to be irrigated, an inch and a half of it is lost on account of bad management, by not providing the proper means to prevent loss from evaporation and from seepage.

Then, again, a very large amount of loss is sustained by the fact that the conditions are such that a man has to allow the water to run through these ditches whether he needs it or not; and when it is not being used it runs to waste, which in my opinion constitutes two-thirds, if not a larger portion, of the time that the water is running through the ditch.

Senator PLUMB. How would you protect against evaporation?

Mr. CHILDS. Where the water is taken from a stream or reservoir, and has to be conducted a great distance to reach lands sought to be irrigated, let it be conducted in boxes or pipes or other means that will accomplish the same purpose. Box flumes would help the purpose very materially. It is well known to every one here that last month, I think it was, there was a shortage of water, and in fact there is now, in the supply to this city.

The owner of one system of water supply here (Mr. Hill) had as his private property a lake called Park Lake, some 20 miles distant from here. That lake contained, estimating the contents by its known area and depth, about 3,000,000 cubic feet of water, or nearly so. In his effort to bring it here to his reservoir which supplies the system in the city, he told me that he made an opening so as to allow the flow of 500 miner's inches, in an effort to have it travel down the ditch 26 miles long, to reach the reservoir. That water did not get to more than 3 miles from town before it had disappeared by evaporation and soaking into the ditch, as the ditch had not been used for several years.

That would show, of course, a very great loss from evaporation and seepage into the ground.

Senator PLUMB. Does not a ditch generally improve by reason of the silt in the bottom of it becoming water-proof?

Mr. CHILDS. In some cases it does, but still the water soaks through. In most cases these ditches travel through sand and gravel.

The CHAIRMAN. What is the proportionate loss between a large ditch and a small one? Of course you can not give the exact proportion.

Mr. CHILDS. A large ditch, of course, would have a larger evaporating surface, and therefore would involve a greater loss.

The CHAIRMAN. You think a large one would lose more, proportionately, than a small one would?

Mr. CHILDS. From evaporation—yes.

The CHAIRMAN. From evaporation and seepage taken together; how is it?

Mr. CHILDS. I would hardly be prepared to answer that.

The CHAIRMAN. In the experience of California, where ditches have been in use from 10 to 70 miles long, it was ascertained that the loss was much less, proportionately, where there was a large flume than a little flume. That was ascertained in practice, universally, in California, and I suppose the same thing would apply here.

Mr. CHILDS. I am not positive as to how that would be.

The CHAIRMAN. I want to finish the examination of Mr. De Lacy now. You have surveyed much of the Territory, I understand, Mr. De Lacy?

Mr. DE LACY (resuming). Yes; much of it.

The CHAIRMAN. And that brought you to travel over the mountains?

Mr. DE LACY. Yes.

The CHAIRMAN. What have you to say of the facilities of making reservoirs to store water high up in the mountains and in the mountains generally, whether high or low?

Mr. DE LACY. The opportunities are very great. I think there are hardly any regions of the country in this western section where the finest reservoirs could not be had.

The CHAIRMAN. Could they be made cheaply?

Mr. DE LACY. Yes.

The **Chairman**. And without the erection of costly dams?

Mr. **De Lacy**. Yes; without the erection of costly dams. There is a peculiarity among the mountains here; they are smooth on the summit. When you come down from one place to another they are smooth. I know that from the fact that I have taken pack trains on the summit of the mountains, and following the summit all the way down for as far as 200 miles at one time without a trail, camping over night at one of those depressions where I would find a meadow, and on either side there would be water. I had the best kind of a camp. Going down on the sides of the mountain you may perhaps immediately come to a cañon.

The **Chairman**. Is that true of all mountain ranges, that they have a considerable area of flat land and lakes and places where the water would be kept back?

Mr. **De Lacy**. Yes.

The **Chairman**. And that would be so in the snowy region where you could keep it longer?

Mr. **De Lacy**. Yes. It is very common in these ranges to have small lakes below the summit, or just immediately below. The water is of a very intense blue. They have a natural dam right at the mouth. In some instances you find the same thing but with the water gone. In that case the dam is broken.

The **Chairman**. By cutting down so that you can get all the water out, and by having regulating gates in the mountains, many of those streams could be increased, I suppose?

Mr. **De Lacy**. Yes; very much increased, indeed.

The **Chairman**. Suppose the Government, having reserved all those places, as it has done, and reserving the right of way for those ditches, should survey and locate them and map them, so that the people would know where they were, with a view of aiding irrigation, is there not a vast amount of land that could be cheaply reclaimed?

Mr. **De Lacy**. Yes, a large proportion of it.

The **Chairman**. Before you would deal with the great rivers?

Mr. **De Lacy**. Yes; before you would need to deal with the great rivers.

The **Chairman**. What do you say as to the value of these surveys in aiding settlers?

Mr. **De Lacy**. I think the surveys would be of every use in the world in showing settlers just what they could do and what can be done. It is just like anything else. A man will go and settle in a place where he sees that there is a chance to make money. It may not be such immediately, but it will be in time. People will take chances if the chances are not too remote.

The **Chairman**. Isn't it a fact that the people generally who live in the mountain regions are ignorant of the topography of the mountains around them?

Mr. **De Lacy**. Yes.

The **Chairman**. You have seen people contending about water and water rights when with a very little trouble and the expenditure of a very little money they could have plenty of water?

Mr. **De Lacy**. Yes.

The **Chairman**. That is very common, is it not?

Mr. **De Lacy**. Yes, very common.

The **Chairman**. I have settled many neighbors' disputes about water by directing my clients to go up a little higher and get water.

Mr. **De Lacy.** That could be done in very many cases where it is not done, where they are disputing about the water.

The **Chairman.** It is going to cost considerable money to make these surveys, and the object of this committee is to ascertain whether the work is going to be sufficiently useful to the people to warrant the expense—whether we can say to Congress that this will be so advantageous that it will enable the people to get homes.

Mr. **De Lacy.** There is no doubt that the surveys will be of the very greatest possible utility, and would increase immigration. They will point out to a great many men what they do not know now.

The **Chairman.** It is difficult for an individual farmer to find out facts as to places 30, 40, or 60 miles away from him, or as to places on the tops of mountains, and it is difficult for an investigation to be made in regard to it.

Mr. **De Lacy.** Very difficult.

The **Chairman.** It is beyond the reach of people in general and beyond their experience, is it not?

Mr. **De Lacy.** Altogether beyond their reach and experience. In fact people do not always understand about it when they are told about it. The farmer especially is not so apt to become acquainted with the mountains of the country as the miner is, because miners are all the time prospecting. They are going around all the time looking for minerals, and they have developed the faculty of observation keenly. When a miner is looking for minerals he is looking for everything. He will see the chance of getting water, and will mentally calculate the amount of water that will suit his purposes. I have always found that miners make the closest calculations of any class of people that I know of in regard to such matters.

The **Chairman.** Is it not the fact that the miner's attention was called to this question of water supply at great altitudes by reason of his finding mines in the mountains for which he required water, whether his mine was a quartz or a placer? For if a quartz mine he wanted water for his mill.

Mr. **De Lacy.** That is true.

The **Chairman.** The difference between the farmer and the miner is that the miner is more interested in looking for water than is the average farmer?

Mr. **De Lacy.** Yes.

Senator **Plumb.** Do you know whether in the valleys along these streams there is a flow of water underground?

Mr. **De Lacy.** I think in many instances there is where there is gravel. I think there are a great many streams along which that would be true. A great many of our streams are running dry alternately; that is to say, there will be a stream of water for a mile or two, then the water will sink, and then it will reappear. When that is the case they are generally on a loose gravel bed. I think the reason of that is that the water percolates through the gravel and disappears, and then for some reason comes up again. That is very common.

Senator **Plumb.** A rock or something of that kind may force it up again?

Mr. **De Lacy.** Yes.

Senator **Plumb.** How deep is the water in these valleys?

Mr. **De Lacy.** It is generally found at bed rock, and its depth differs with the depth of the bed rock. In a great many of the streams that I am acquainted with, that are apparently dry, I think that reservoirs could be built by sinking a dam down to bed rock. Frequently you will see a stream that is in a little cañon of perhaps 100 yards or so, and the stream may be dried up at either end of that though having water above. I think if a well were put down to bed rock the water would be forced up and there would be a reservoir, and a very convenient reservoir. Those places would be especially adapted for irrigation, because the stream comes there and has not very high banks.

STATEMENT OF HIRAM KNOWLES, OF HELENA.

The CHAIRMAN. How long have you resided in this Territory?

Mr. KNOWLES. Continuously from 1868.

The CHAIRMAN. You have been over the Territory pretty generally, have you?

Mr. KNOWLES. Yes.

The CHAIRMAN. Have you observed the effect of irrigation in this Territory?

Mr. KNOWLES. I have.

The CHAIRMAN. What do you say as to the results of irrigation?

Mr. KNOWLES. Wherever we can get water on our soil it will produce good crops.

The CHAIRMAN. What State were you from originally?

Mr. KNOWLES. I came from Iowa to Montana. I lived in Nevada a number of years, and came here in 1868 permanently. I was here in 1866.

The CHAIRMAN. What would be the comparative production, say during a period of 10 years, between irrigated land in Montana and the best land in Iowa?

Mr. KNOWLES. I will state this in relation to that: In all crops where you look to seed, like wheat, oats, or barley, this soil, if irrigated, will produce a better crop than in Iowa or Illinois.

The CHAIRMAN. A better crop than their best crops?

Mr. KNOWLES. A better crop than they average in Iowa or Illinois.

The CHAIRMAN. Do you have frequent failures when you are irrigating?

Mr. KNOWLES. We have once in a while something that is hard to account for. That is to say, we have some seasons a better crop than we have in others. But it is supposed that is owing to a lack of knowledge of how to irrigate.

The CHAIRMAN. There is danger of irrigating too much?

Mr. KNOWLES. Yes; and irrigating at the wrong time.

The CHAIRMAN. The people must find that out by experience?

Mr. KNOWLES. Yes; they find that out by experience. They have not found out that it is not proper to irrigate at certain seasons—when the grain is in a condition of formation.

The CHAIRMAN. With a view to a chance for settlers to make farms, suppose we had the country surveyed with reference to irrigation? Suppose we knew what lands could be irrigated and what could not, and that we had estimates of the cost of constructing reservoirs, etc., do you think such information would be valuable?

Mr. KNOWLES. Yes.

The CHAIRMAN. Do you think or not there could be a large amount of land in this Territory reclaimed at comparatively little expense?

Mr. KNOWLES. Oh, yes; there are large areas of land that could be reclaimed. In passing through on the line of the railroad you see only a very small portion of the land that could be reclaimed by irrigation.

The **CHAIRMAN**. Have you been in the habit of traversing the mountains?

Mr. **KNOWLES**. Yes; in early days.

The **CHAIRMAN**. Have you noticed that most of the mountain streams head in flats, lakes, and such places, and discharge in narrow gorges, where water could be kept back cheaply?

Mr. **KNOWLES**. Yes. The gorge depends upon the hardness of the rock, the strata of the mountains. You are speaking about these lakes high up in the mountains. At a point immediately west of Deer Lodge, 40 miles from here, is Mount Powell. From the summit of Mount Powell you can see 18 lakes from the mountains, and yet there are no lakes in the valleys. From the summit of Mount Powell can be seen 18 lakes, some of them a mile and a half long, and some of them a quarter of a mile. They all can be utilized in the way you speak of.

The **CHAIRMAN**. And some of them at trifling expense.

Mr. **KNOWLES**. Yes. Well, take for instance Rock Creek Lake, which is used as a reservoir for mining purposes. They have built a dam there where they raise the water for about 20 feet. There they can mine the whole season until frost comes.

The **CHAIRMAN**. Then with surveys might not your population be largely increased without considering the most expensive schemes of turning the great rivers along canals?

Mr. **KNOWLES**. Oh, certainly. Take for instance around Mount Powell. That water comes down and is appropriated, most of it for irrigating purposes, and some for mining purposes. That water comes down in a rush in the spring, and in the fall of the year or in summer, in July, there is not water enough to irrigate the land that is under cultivation. It is so with Warm Spring Creek and Race Track Creek. If that water were retained at the head in these lakes by means of a dam or gate that could be opened, we could probably irrigate twice as much land as is now irrigated along those streams.

The **CHAIRMAN**. Then is not the first thing to be done, not only by the people of this Territory but by the other States and Territories where arid lands are, to ascertain where water can be obtained cheaply and use that first upon the land before undertaking great enterprises?

Mr. **KNOWLES**. Oh, yes.

Senator **PLUMB**. Would it facilitate the erection of reservoirs through private enterprise or the aid of the local governments, county or State, if these surveys were not only made, but if the Government of the United States would provide the land necessary for the reservoirs and have the water accessible to the people who made the reservoirs?

Mr. **KNOWLES**. Certainly there could be legislation on that subject. There ought to have been long ago. Eighteen years ago I wrote to the Land Department that there ought to be reserved in every patent that is granted to a settler upon the public domain all of the water that flows over his land, except sufficient to irrigate it. It ought to be that that would be subject to appropriation. You see, under the decisions of the court up to this time, where the Government has sold land, if the water had been appropriated that flows over that land, the doctrine of riparian rights applies.

The **CHAIRMAN**. Does that doctrine apply here?

Mr. **KNOWLES**. Yes; the same as in California.

The **CHAIRMAN**. California went on applying the doctrine of appropriation for 36 or 37 years. Then a case arose, and they went back and imported all their facts from Scotland. The doctrine of riparian rights could not be enforced in California. The courts grant injunctions, but the community is against it, and it cannot be enforced. It is a misapprehension of the common law. The common law is a system of principles applicable to all conditions of men, and the water to be used under these principles is for the common good. The trouble is this: the courts have forgotten that, and have gone to Europe for the facts. You must recognize this one thing—this country can produce facts, and you must apply the law and facts to the use of water. The State must do this thing. I do not know that the Government of the United States can interfere here, because there are vested rights; but the State must recognize the right of appropriation.

MR. **KNOWLES**. We have here a proposition pending before the convention, which is the same as the Colorado provision. It is proposed to adopt this in our constitution:

> The water of every natural stream not heretofore appropriated within the State of Montana——

The **CHAIRMAN**. What do you mean by "appropriated"? We fought for twenty years over the question of what was meant by "appropriation," and we finally got it down to this decision—to mean for an economical use, for beneficial purposes.

Mr. **KNOWLES**. We decided that too. But we say that—

> The water of every natural stream not heretofore appropriated within the State of Montana is hereby declared to be the property of the public; and the same is dedicated to the use of the people of the State, subject to appropriation as hereinafter provided.

But here is the trouble. Right there we are prohibited from interfering with the property of the United States, and the Government of the United States holds this land. When the Government sells a piece of land, if the water has not been appropriated, the purchaser gets the water as a part of the vested rights. That is the old decision. But by legislation of Congress you can do otherwise. You can make it so that the purchaser will not get more of the water than is sufficient to irrigate his land. And that is what Congress ought to do on that subject, and relieve us from that trouble.

Senator **PLUMB**. In a Colorado case recently decided the question of riparian rights is known; but what we call the common law entirely disappears. There they not only take their water, so an engineer told me, out of the heads of the streams to the exclusion of the man who owns the land below, but they take it out of one valley into another.

Mr. **KNOWLES**. Congress recognizes as long as this land is public land the right of appropriation, and recognizes the right of way over the public domain. But the Government may sell this land before this water is appropriated and the right obtained over it for irrigating ditches. In that case the party who buys the land comes in there with a doctrine that is generally attached to a purchase of land from the Government of the United States in all the older States, that the water is incident to the land. I say all do that except Colorado and California.

Senator **PLUMB**. What occurs in a humid valley is no authority here.

Mr. **KNOWLES**. I rendered a decision in a case that was taken to the Supreme Court of the United States. It was denied that we could appropriate water for irrigation, but that we could for mining purposes, and that put it upon the ground of use for any beneficial purpose; and the Supreme Court of the United States sustained it.

The **CHAIRMAN**. You need not be afraid of the Supreme Court of the United States, because in certain decisions they have recognized this half of the continent. That court will honor the recent decisions in

Nevada and Colorado, and former decisions in California. The doctrine of appropriation will be the doctrine for arid regions.

Senator **Plumb**. Let the people of this Territory memorialize Congress to give a grant for school purposes, and ask for a donation of the running water across the public lands through the Territory of Montana, provided, of course, it does not interfere with previous acts of Congress.

Mr. **Knowles**. Passing from this question of appropriation of the water: We have put in our constitution a provision that the right of way for irrigating ditches shall be considered for public use. That is the right of one man to go over the land of another.

The **Chairman**. That is a necessity.

Mr. **Knowles**. No; it is against all decisions. You cannot by legislation take one man's property and give it to another, for any purpose.

The **Chairman**. There is no decision that the taking of water in such a way is not a public use, where the community can not live without it.

Mr. **Knowles**. The use of water might be, but is the right of way?

The **Chairman**. If the use of water is a public use the taking of land necessary to use it is a public use. The taking of private property for a railroad is a public use, and so with water.

Senator **Plumb**. There is one question which might be overlooked, which the judge evidently has in his mind. It may be necessary to use the public land which can not be obtained.

Mr. **Knowles**. The right to go over public land is already given, as long as it is public land. Now a railroad is a public agent, and it has been so decided by the Supreme Court of the United States.

The **Chairman**. I know it is. Why? Because the public is interested in it.

Mr. **Knowles**. No; the Government provides highways for the commerce of its people, and the railroad is a public agent.

The **Chairman**. But the use of water where the public could not exist without it is certainly the highest kind of public use.

Mr. **Knowles**. By that we have all the principles of common law overthrown.

The **Chairman**. No; you must learn to apply the principles of common law to existing facts. What is the use of applying the common law to facts that existed a hundred years ago?

Mr. **Knowles**. We have sought here to provide that where water is sold the price that shall be paid for water shall be regulated by the county commissioners.

The **Chairman**. Have you taken the trouble to ascertain about what proportion of the land in this Territory is within reach of water? Have you ever figured upon it?

Mr. **Knowles**. There has been a large amount; more than now. The area of the country is 140,000 square miles, and we have 90,000,000 acres.

STATEMENT OF J. C. ROBINSON, OF HELENA.

Mr. Chairman and gentlemen, I have had a good deal of experience myself with timber, by having had flumes, and I have watched that matter carefully.

Where the bulk of the wood has been cut for use in the mining countries, and it is said that is where men cut large bodies of this wood, and leave upon the ground these resinous pine boughs, and the fire gets into them and spreads and makes an immense fire, they have a deep interest in the subject, and all the men are trained to watch and use the utmost precaution to keep fires from breaking out. And my experience with these flumes has been that the fires break out, not where men are cutting timber, but in other places. These big fires break out where timber is not used. At my flume there is a vast amount of these pine boughs scattered over the ground, and if they should make an attempt at any time to secure the timber from fire by burning up these boughs, that very act would endanger all the timber around there, because the fire would escape from the burning boughs.

The CHAIRMAN. Are fires occasioned by lightning?

Mr. ROBINSON. I do not believe they are to any great extent, although a gentleman told me two days ago that down on Elk Creek, in Deer Lodge County, a fire broke out and spread over an immense area of ground. That was by lightning. However, I think the instances are rare. But that was told to me by a reliable man, whose name I forget.

The CHAIRMAN. What would you say about a system which would have agents who reside here to control the cutting of timber, which would be permitted at a nominal cost sufficient to administer the system, as compared with the present system, where men are arrested all over the country charged with having cut timber contrary to law. For instance, there were some four or five hundred prosecutions of that kind in Arizona last year; but they failed before the jury. Would you change the system, or would you leave it as it is?

Mr. ROBINSON. I do not believe any system could be devised that would prevent careless persons setting fire to the timber. If I were hunting out in the mountains and should light a match to light my pipe or cigar and carelessly throw the match away, it would be almost impossible to have me watched to prevent me setting fire to the timber in that way.

The CHAIRMAN. Which of the systems would be the best, the one that is now in existence or the one I have suggested?

Mr. ROBINSON. I believe the system they have for prosecuting for setting out of fires is as good as you could devise, unless you make it possible to offer a larger reward to detect the people.

The CHAIRMAN. Are you in favor of arresting and prosecuting people because they cut timber on the public land?

Mr. ROBINSON. No; the prosecutions for cutting timber on the public land should be stopped.

The CHAIRMAN. What would you substitute for that system?

Mr. ROBINSON. I would let it stay as it is.

The CHAIRMAN. You would have no supervision of it at all?

Mr. ROBINSON. No; for this reason: Men will not go upon the public domain and cut timber when they have no use for it, because they have plenty of other things to do. Take the flumes where they cut annually as high as 50,000 cords of wood. Of course a man can not use all that wood himself, and he has to sell to his neighbors. Here my neighbors can not cut for themselves and they have to buy. If I want a load of wood for domestic purposes I have to hire a man to go out in the mountains and cut it for me.

There are prosecutions in Montana. I do not know how it is elsewhere, but these flume companies are cutting wood on the public land and taking it into the mining districts and selling it. They do that every day The way we construe the law is—and I think it is the proper construc. tion to be put upon it—wherever the timber is sold within the limits of the Territory it is for domestic purposes.

The CHAIRMAN. The courts have so held, but it has been held to the contrary.

STATEMENT OF TIMOTHY E. COLLINS, OF GREAT FALLS.

The CHAIRMAN. How long have you resided in the Territory?

Mr. COLLINS. About twenty-five years.

The CHAIRMAN. What is your occupation?

Mr. COLLINS. I am at present in the banking business, but I have been mining.

The CHAIRMAN. Your business of mining has called you pretty well over the Territory.

Mr. COLLINS. Yes.

The CHAIRMAN. Have you taken into consideration the subject of irrigation in your travels?

Mr. COLLINS. I have thought over the matter of irrigation considerably within the last few years.

The CHAIRMAN. Have you observed the results of irrigation?

Mr. COLLINS. Yes.

The CHAIRMAN. Do you pronounce it a success here?

Mr. COLLINS. Yes, an undoubted success.

The CHAIRMAN. Do you regard it a necessity to the farmers in this part of the country?

Mr. COLLINS. As a rule, yes.

The CHAIRMAN. Have you traversed the high mountains to observe their topography?

Mr. COLLINS. Yes.

The CHAIRMAN. What do you say as to the possibility of increasing the water supply by reservoirs or dams?

Mr. COLLINS. I think the water supply can be increased very much in that way.

The CHAIRMAN. Will you state your reasons for thinking so.

Mr. COLLINS. First, because the principal rain-fall is in the mountains; and secondly, because in its course from the mountains down to the agricultural lands a great quantity of it sinks into the ground, and by the time it reaches the agricultural valleys only a small portion of the natural waters of the country drained are on the surface.

The CHAIRMAN. Does not a large portion of it flow down at seasons when you are not irrigating?

Mr. COLLINS. Yes; the irrigating season in Montana is about ten weeks. That would be a maximum.

The CHAIRMAN. How as to the balance of the year?

Mr. COLLINS. The balance of the year the water goes to waste.

The CHAIRMAN. What are the facilities for retaining water in reservoirs?

Mr. COLLINS. In every section of Montana that I have been in, the facilities are excellent, both in cañons in the mountains, and in lakes in the foot-hills.

The CHAIRMAN. Are there not many ravines and small streams that run dry when they come to the valley in summer, in which by proper storing of the water they might be made useful to bring under cultivation considerable tracts of land?

Mr. COLLINS. Yes.

The CHAIRMAN. In the aggregate a good deal of land?

Mr. COLLINS. In the aggregate a good deal of land.

The CHAIRMAN. Has the attention of the people been called to that so that they have been practicing it at all?

Mr. COLLINS. No; it has not got to that extent. The people have not practiced the storage of water at all.

The CHAIRMAN. They have taken just what ran, and if there was not enough they would have a lawsuit over it?

Mr. COLLINS. That is it, exactly.

The CHAIRMAN. Where the water did not flow in the summer time, or the irrigating season, but did flow in the flood time, there has been no effort to utilize the surplusage of water for the purpose of extending the farms?

Mr. COLLINS. No.

The CHAIRMAN. What do you say of the effect of a system of surveys, where the Government would reserve the sites of reservoirs and rights of way for ditches, estimating the cost, and pointing out the best manner of working? Would such surveys and estimates be useful in encouraging settlement here?

Mr. COLLINS. It would make land now owned by the Government and which is practically worthless now, worth from $10 to $50 an acre.

The CHAIRMAN. It would enable the Government to dispose of large quantities of its land?

Mr. COLLINS. Yes.

The CHAIRMAN. And enable the people to make homes?

Mr. COLLINS. Yes.

The CHAIRMAN. Are you an engineer by profession?

Mr. COLLINS. No.

The CHAIRMAN. Then you can not give us any information as to the facilities for turning the great rivers and irrigating the table-lands below?

Mr. COLLINS. No.

The CHAIRMAN. Have you been over that country pretty much?

Mr. COLLINS. Yes.

The CHAIRMAN. Are those table-lands fertile?

Mr. COLLINS. Very fertile. The soil is rather "quicker" even than that in the valleys.

The CHAIRMAN. I believe that is the fact.

Mr. COLLINS. The land is somewhat warmer at a little altitude than in the low places.

The CHAIRMAN. Have you observed the growth of alfalfa here?

Mr. COLLINS. Yes.

The CHAIRMAN. Does that flourish?

Mr. COLLINS. It flourishes very much where it is seen. I have only seen it in the valleys. I have observed particularly this year, which has been an extraordinarily dry year, that four weeks ago it was cut and amounted to about 4 tons to the acre. The gentleman that cut it said that he had cut it twice and he thought he would cut it twice again before the season closed. The two cuttings together had amounted to 4 tons to the acre.

The CHAIRMAN. He would then get 6 or 8 tons altogether from it in one season?

Mr. COLLINS. Yes.

The CHAIRMAN. How many tons have you known to be produced?

Mr. COLLINS. That is the only field that I can bring to my recollection.

The CHAIRMAN. What do you say as to alfalfa as food for stock in this country?

Mr. COLLINS. It is very good food indeed for sheep, horses, and cattle, according to what I have heard from stockmen.

The CHAIRMAN. It makes good hay?

Mr. COLLINS. Very good hay.

The CHAIRMAN. They grow wheat where they can irrigate here, do they not?

Mr. COLLINS. Yes.

The CHAIRMAN. Is wheat a success here?

Mr. COLLINS. A great success. I think No. 1 hard wheat raised in Dakota and Minnesota can be raised here with great success.

The CHAIRMAN. Of wheat cultivated here, how much can be got in the ordinary season by irrigation?

Mr. COLLINS. About 35 bushels to the acre.

The CHAIRMAN. How is the ground affected by continuous cropping, under irrigation, as far as your experience goes?

Mr. COLLINS. I have never given any study to that particular branch.

The CHAIRMAN. You do not know whether the land improves or not?

Mr. COLLINS. I do not.

The CHAIRMAN. You do not know whether water has a tendency to fertilize the ground or not?

Mr. COLLINS. The farmers all tell me that it has a tendency to fertilize the land.

The CHAIRMAN. The land does not require so much manure?

Mr. COLLINS. No.

FURTHER STATEMENT OF W. C. CHILDS, OF HELENA.

The CHAIRMAN. You have already explained to us the quality of this grass called blue-joint. Have you traveled over the Montana country pretty generally?

Mr. CHILDS. I have.

The CHAIRMAN. Is there a comparatively large amount of land that can be irrigated in this Territory?

Mr. CHILDS. A very large area is susceptible of irrigation if supplied with water by the utilization of the reservoir system. The water is accessible for the purpose, too.

The CHAIRMAN. Independently of turning the great rivers?

Mr. CHILDS. Yes.

The CHAIRMAN. You stated that you had farmed in the eastern portion of the Territory. Have you ever taken into consideration the practicability of turning the Yellowstone and Big Horn and other streams upon those lands?

Mr. CHILDS. Only in a very general way. My experience in the eastern part of the Territory was of short duration, but I am engaged now quite extensively in farming in this valley.

The CHAIRMAN. From what you know of the fall of the streams and of these valleys, do you think it would be practicable?

Mr. CHILDS. From the fall of the Yellowstone and the Musselshell, the Flat Willow, and a number of others, they could be diverted from their natural course and put into canals, and would irrigate a large area, in which all classes of crops may be grown.

The CHAIRMAN. If there should not be water enough, could you increase it from the lakes above?

Mr. CHILDS. Yes. In taking out these large streams and canals and attempting to serve a double purpose of utilizing them as canals and for water reservoirs, that in my opinion could be done, sometimes at a very small cost, where you can take advantage of the natural topography of the country; in other places by excavating and building artificial reservoirs; in some places by simply damming the gulches and depressions, and at almost any place by building entire reservoirs.

The CHAIRMAN. And thus store the flood waters?

Mr. CHILDS. Thus store the flood waters.

The CHAIRMAN. That has been done in large areas in India and other countries?

Mr. CHILDS. Yes; and it can be done here.

The CHAIRMAN. By doing that you would have water sufficient to irrigate most of the land that can be reached by these streams?

Mr. CHILDS. Yes. You can get more than double the advantage; first, by holding the water in storage, and next by stopping their annual flow at seasons when they are not used, at which times now they go to waste.

The CHAIRMAN. Your idea is that that treatment of the river would mitigate the floods below?

Mr. CHILDS. Yes; it undoubtedly would.

The CHAIRMAN. How does irrigated land compare in productiveness when well cultivated with land that has natural rain-fall in the east?

Mr. CHILDS. From my observation and information from other sources I do not hesitate to say that our crop will yield double, as an average.

The CHAIRMAN. I stated in an article in the *Forum* last April that I thought it would average that, and I was very severely criticised. I am glad to see my statement supported.

Mr. CHILDS. It can be very easily verified.

The CHAIRMAN. Can it be verified here?

Mr. CHILDS. Oh, yes, very generally.

The CHAIRMAN. You can get a crop nearly every year, can you not, with irrigation?

Mr. CHILDS. You get a crop here every year when you irrigate. The vegetation that is supplied with sunshine and moisture at the same time has, of course, the best possible chance.

The CHAIRMAN. How is it when gathering your crops

Mr. CHILDS. Very fortunately the rainy season terminates here before harvest.

The CHAIRMAN. In planting your crops you are not troubled with rains to interfere with your planting?

Mr. CHILDS. Not to any great extent; hardly often enough to mention.

The CHAIRMAN. Could you be aided by Government surveys?

Mr. CHILDS. Certainly. A survey of the country which is so situated as to make it possible to construct reservoirs to serve the purpose of irrigating the valleys or the land below would designate the natural features so that they would come to the knowledge of all who were interested. It would astonish a great many people who have lived here for fifteen or twenty years to find out how easy it is to get water that they have been crying so loudly for. They will be astonished to find that they have not heretofore known of the existence of the water.

The CHAIRMAN. Would the Government be able to dispose of any considerable amount of its public land in consequence of such surveys?

Mr. CHILDS. I should say yes. There is a very large area of Government land which, deprived of the use of water, is practically valueless; but when supplied with water it would produce crops of a gross value of some $50 to $60 an acre each year. That statement can be very readily verified.

The **Chairman**. If such surveys can induce settlement, then you would regard them as valuable?

Mr. **Childs**. Certainly.

The **Chairman**. What is your opinion as to their effect in that respect?

Mr. **Childs**. I should certainly say that they would tend greatly to induce settlement.

The **Chairman**. That is to say, before entering on the work of handling those great rivers?

Mr. **Childs**. I should think that settlement would obtain in anticipation of the work of making reservoirs. After a surveyor had pointed out where reservoirs would be located settlers anticipating a supply of water would settle there, even if they had to suffer some privations in the mean time.

The **Chairman**. Would it not have the effect to induce combinations of settlers, knowing what they could do?

Mr. **Childs**. I should think so.

Senator **Plumb**. What is your opinion as to the extent of the visible water supply—the amount of water precipitated and the amount that flows down the streams, and to what extent would that water irrigate the level areas?

Mr. **Childs**. I think there is ample water flowing from the source of the streams to irrigate all the land in the Territory, if properly handled and used with judgment, and at the times when the land demands it.

Referring to a particular stream which furnishes the water for this valley, the Prickly Pear stream, I am living at the head of it, and have made myself acquainted pretty thoroughly with the amount of water flowing at different seasons, and I should say that the amount of land now being irrigated from the water of that stream is about 12,000 acres. I think that in ordinary flood seasons, say from the 25th of May through to the 25th of June, which is one month, there are 50,000 miner's inches flowing; and that is a quantity of water that if reservoired, as it can be at a very small cost and held in storage, is sufficient to irrigate twice the acreage during the entire season. But what does happen for the want of this storage is that during the flood season, when not used, it rushes down and goes on to the ocean and is lost.

The **Chairman**. The question that Senator Plumb asked you, and the point he wanted to get at, and which I am anxious to hear you upon also, is the extent of land that can be irrigated by ordinary irrigation works in the small streams and ravines and the catchment basins that can be made without very great outlay; that is, without an outlay that is beyond the reach of settlers, providing the surveys were made and the thing pointed out. What would be the extent of land that would be reached in that way without dealing with the large rivers? Would it be large or small? In other words, what would be the amount of land that would be brought under cultivation by the utilization of the easy places of irrigation before going to any large expense?

Mr. **Childs**. There is a large amount of land that gets its irrigation from the sources you mention; that is the small mountain streams. That amount of land could be very largely increased if the local waters were held in storage.

The **Chairman**. Are there ravines that are not used at all where storage would enable men to make farms?

Mr. **Childs**. Yes; very many.

The **Chairman**. Would that be extensive in the Territory?

Mr. CHILDS. Very extensive in this Territory, if the water were held in storage at the heads of those streams.

The CHAIRMAN. So that there is a great deal of irrigation within the reach of a combination of settlers, without great outlay?

Mr. CHILDS. Yes.

Senator PLUMB. What is the average yield per acre in Montana of the different staples?

Mr. CHILDS. My judgment is that the average yield of wheat is 35 bushels to the acre on land that is well supplied with water.

Senator PLUMB. Is that spring wheat?

Mr. CHILDS. Yes; then the oats on land similarly supplied with water will yield 45 bushels to the acre. There are some sections in which the yield is as high as 75 bushels. Of course in some instances of particular cases the yield has been very much larger. But I should say the average would be 45 bushels to the acre of oats.

The CHAIRMAN. Does this country produce corn?

Mr. CHILDS. Yes; although I would not call it a country where corn would mature with certainty every year. I have corn growing on my place, and there is corn there now—stalks at least 6 feet high—table corn.

Senator PLUMB. How is it as to the crop of barley, potatoes, etc.?

Mr. CHILDS. I should say that barley would yield 40 bushels, as a good average. I would place the average yield of potatoes at about 150 bushels to the acre.

Mr. MAGINNIS. That is too small.

Mr. CHILDS. Well, I was speaking of the average. I have harvested myself as high as 400 bushels of potatoes to the acre.

Mr. MAGINNIS. A friend of mine told me that he raised 60,000 pounds of potatoes last year on 3 acres.

Mr. CHILDS. Well, my statement now is that I have harvested 24,000 pounds on one acre. But, in speaking of 150 bushels to the acre, I was giving not the largest cultivation, but an average result.

Senator PLUMB. What would be the highest yield of these different products and the lowest yield, out of which you make up this "average?"

Mr. CHILDS. In making that average, as I have already remarked, there are even instances known where as high as 100 bushels to the acre of wheat have been harvested, but only of small areas, and I have known wheat fields to yield as low as 25 bushels.

Senator PLUMB. That is the entire field?

Mr. CHILDS. Yes; the entire field; that field being very much larger than the one yielding 100. You can therefore hardly make an average without making a pro rata average.

Senator PLUMB. Take oats, rye, barley, etc.; what is the maximum and what is the minimum?

Mr. CHILDS. Putting it in that way, I should say that the maximum yield of oats would be 75 bushels to the acre; of wheat 60 bushels to the acre; of barley 60 bushels, and potatoes 300 bushels. The minimum yield I would put as follows: Oats, 35 bushels; wheat, 25 bushels; barley, 25 bushels; and potatoes, 100 bushels. It would be rare to find any place where the yields stated as minimum yields would be smaller.

Senator PLUMB. With the exception of potatoes, none of those are hoed crops. What makes the difference between maximum and minimum yield? It can not be cultivation?

Mr. CHILDS. It is the nature of the soil and the locality.

Senator **Plumb**. What makes the difference in locality, with reference to the crops?

Mr. **Childs**. I think a very large difference is the result of getting bad farms, and a very large difference is due to the locality.

Senator **Plumb**. What is the favorable locality and what the unfavorable in that respect?

Mr. **Childs**. That locality is most favorable, or seems so to me, which has the greatest depth of soil.

Senator **Plumb**. That is a question of soil rather than location.

Mr. **Childs**. Yes; but still it is soil in a certain locality. What makes the locality more favorable is the having greater depth of soil.

Senator **Plumb**. I thought by "locality" you meant the altitude or the land having some certain slope, or something of that sort.

Mr. **Childs**. I think that perhaps there is also some influence exerted by the fact of greater or less altitude. Then, with reference to the proximity to the foot-hills, I think that as a rule those lands which are called bench lands, near the foot-hills, seem to yield more largely of crops of grain; that is, those immediately in the foot-hills. Of course all of us might assign different reasons for the different quantities of yields. We seem to think that there is a greater depth of soil at the immediate foothill than farther down, and we think that the crop gets a better supply of natural moisture, and perhaps is protected some from the hot winds. There are various reasons that can be assigned for the difference in productiveness of different localities. The manner of seeding and taking care of the crop has great influence. The manner of irrigating has great influence. Some crops are watered to death—they are absolutely drowned—while some die for want of water. And again others suffer because they are supplied with water at improper times. There are a great many things that influence the productiveness of crops in localities.

Senator **Plumb**. How often during a growing season when water has to be applied at all is it proper to apply it?

Mr. **Childs**. That depends on the nature of the soil also; in some localities where there is a subsoil of clay it will hold the water with one irrigation. Of course much depends on rain-fall and the humidity of the atmosphere. Other places having a sandy soil would require more water, because much escapes by going through the sand below the roots of the vegetation.

Senator **Plumb**. Then irrigation is something of an art—it needs to be learned?

Mr. **Childs**. Indeed, that is so. You would find that to be a fact by interviewing the farmers. You would find that they would value the services of an expert irrigator at double or treble the services of an inexperienced one.

Senator **Plumb**. What is the average price of these crops, reduced to bushels? You sell everything by the pound here, I believe?

Mr. **Childs**. Yes, we sell everything by the pound.

Senator **Plumb**. If you cannot state it by the bushel, state it by the pound and we will reduce it to the bushels ourselves.

Mr. **Childs**. The price would vary with the market, and the question of supply and demand would also come in. The average value of oats is $1.25 for 100 pounds.

Senator **Plumb**. At the farm?

Mr. **Childs**. At the farm it would be $1. I was thinking of the price at the market.

Senator **Plumb**. I was speaking of the farm price, which I think is the best to go by.

Mr. CHILDS. The price of wheat and barley would be the same—$1.25 per 100 pounds. I think that would be a fair average price. Of course, this year, on account of the drought, I would add 50 per cent. because of the very small amount produced.

Senator PLUMB. How is it as to potatoes?

Mr. CHILDS. Potatoes are worth here on the farm about a cent a pound. This year they will be higher. All farm products will be higher this year.

Senator PLUMB. What is the value of farm labor here?

Mr. CHILDS. I think, as a rule, farm laborers are paid $35 a month and their board. Their board I think people generally estimate at $15 a month, making board and wages $50 per month.

Senator PLUMB. The man who employs a farm laborer employs him by the month and not by the year?

Mr. CHILDS. By the month.

Senator PLUMB. Some portion of the time, of course, those laborers are not employed?

Mr. CHILDS. That is so.

Senator PLUMB. As to these grains, are they drier; that is, do they contain less moisture than similar grains grown in countries where there is rain-fall? Do they make a drier flour, for instance?

Mr. CHILDS. That is a matter I could not pass judgment upon.

Senator PLUMB. Do you know whether they are a heavier grain, according to the bushel measure?

Mr. CHILDS. Yes; they are heavier. In that connection I can say this: Right in this valley were harvested crops of wheat, barley, and oats that were awarded a premium at the Centennial Exposition for quality and weight per bushel. The same grain was sent across to the World's Fair, in London, and took the premium there for quality and weight.

Senator PLUMB. Are the spring-wheat flours of Minnesota bought and sold here?

Mr. CHILDS. That I do not know.

Senator PLUMB. I want to say that in Colorado they consider the wheat raised in that country as drier and better, for crackers especially, than the wheat raised in Kansas; but the bakers nearly all buy the Kansas flour because it is more moist. While Colorado raises its own flour, still it buys a considerable quantity of Kansas and Nebraska flour.

Mr. CHILDS. I sent East considerable samples of wheat, barley, and oats, at the request of the Messrs. Lilienthal, of New York City. They handle a very large portion of California product of barley. It was really amusing to me to read their letters giving their expressions of wonder at the barley raised here. The statement has been made to me that the Milwaukee brewers offered one-eighth of a cent a pound more than for that of their own production.

Senator PLUMB. Do you raise any rye here?

Mr. CHILDS. I do not think that rye is raised to any great extent; but we can do it.

Senator PLUMB. What do you do for winter pasture?

Mr. CHILDS. We resort generally to the foot-hills.

Senator PLUMB. They have natural grasses?

Mr. CHILDS. Yes.

Senator PLUMB. You do not raise anything for winter pasture?

Mr. CHILDS. No; nothing but the natural grasses.

Senator PLUMB. Rye is very often raised in the valleys for winter pasture.

Mr. **Childs**. The question of pasture is a very peculiar one in Montana. It is simply a question of the ability of the cattle to get to the grass, which they can do if it is not covered with snow. If they can reach the grass it is sure that they will get a good living, because the grass is very nutritious. It is dry hay—"standing" hay, as we call it.

Senator **Plumb**. Is there any difficulty about getting to it in the winter?

Mr. **Childs**. Yes; it is sometimes so far below the top of the snow that they can not get it.

Senator **Plumb**. Then the question of winter pasture is an important one here?

Mr. **Childs**. Yes, indeed.

Senator **Plumb**. Is there any fixed relation or proportion between a man's holding of land in this neighborhood and the amount of it that he can water; that is to say, can a man water all he has usually?

Mr. **Childs**. No, I think he can not, as a rule; that is, not if he makes no effort to improve on what nature has done. About 25 per cent. of the holding is the amount that can be covered by water, unless some special effort is made.

Senator **Plumb**. Then the balance is used for pasture?

Mr. **Childs**. Yes; the other 75 per cent. in many instances can be covered with water out of the same stream, if the farmer would go to a slight expense and build a dam to elevate it.

Senator **Plumb**. What is the value of lands in this Territory subject to ditch, where, say, one-fourth of the area can be supplied with water? Suppose, for instance, a man to have 160 acres and has water for 40 acres. What would be the value of such a farm for agricultural purposes, supposing it to have a good fence?

Mr. **Childs**. If the farm was situated where it would command a market for its products, I should say that the 40 acres covered by water would be worth ten times as much as those not covered by water, and perhaps more than ten times as much.

Senator **Plumb**. What would a farm of that kind be worth generally in the Territory; that is, 160 acres of a general average value? I will get at the individual phases of it later.

Mr. **Childs**. Fifty dollars per acre, if situated where it had the command of water.

Senator **Plumb**. But I mean taking the entire value throughout the entire Territory?

Mr. **Childs**. Then say $30 per acre.

Senator **Plumb**. What would be the maximum value of land of that kind for farming purposes; that is, the highest kind of land for farming, and having no other prospective value?

The **Chairman**. Do you mean where it is irrigated?

Senator **Plumb**. No; I do not speak with reference now to irrigation particularly.

Mr. **Childs**. Do you mean the value of the whole farm?

Senator **Plumb**. The whole farm of 160 acres.

Mr. **Childs**. One hundred dollars per acre, including the necessary improvements of fencing to make it a farm—with water.

Senator **Plumb**. And what would be the smallest value of a farm of that kind in this Territory?

Mr. **Childs**. Ten dollars per acre.

Senator **Plumb**. Then what is the difference, in value of farm products, between a farm located, say, within 3 miles of Helena and a farm located within, say, 3 miles of Virginia City, Mont.? I am speaking now of the staple products, not vegetables.

Mr. Childs. I should value a farm located within 3 miles of Helena, that would produce hay, which is a staple product, at three times the value of a farm near Virginia City.

Senator Plumb. What is the value of the product of such a farm within 3 miles of this city and one within 3 miles of Virginia City?

Mr. Childs. I should say double.

Senator Plumb. That is to say, the wheat, corn, and rye and so forth would be worth here twice what it would be there?

Mr. Childs. No; not the grain.

Senator Plumb. That is just what I want to get at. I want to get at the value of the product.

Mr. Childs. I should say there would be but a small percentage of difference in the value of the product.

Senator Plumb. Then the market is local?

Mr. Childs. Yes.

Senator Plumb. What you get here is not distributed much on the railroad, but goes directly from the producer to the place where it is consumed?

Mr. Childs. Yes.

Senator Plumb. Then what is it that makes the difference between the value of a farm at Virginia City and a farm at Helena—not the difference in value of the product, since the value of the product there is nearly what it is here?

Mr. Childs. I would like to be understood as correcting my statement, that it would be double the value; for I understood the question to refer to the hay product.

Senator Plumb. No. Your hay land, I understand, is a kind of bottom land which produces a hay that your arable lands do not produce. What I am trying to get at now is agricultural land. I wish to get at the value of a quarter-section of this ordinary bottom land—not hay land—of which say 40 acres are under plow and under good water, and the whole of it under cultivation and ordinarily improved. I want to get at that for the purpose of fixing the effect of the market on the different localities and comparing the value of it generally—lands in non-irrigable regions.

Mr. Childs. The difference in the value of lands is a result of the difference in the size of the market. That is to say, at Virginia City the supply exceeds the local demand, hence they have to send it away at a cost of transportation, which reduces the net profit to them, whereas in Helena there is nearer an equality between supply and demand.

Senator Plumb. But I understand you to say that there is a very trifling difference between the value of wheat, etc., at Virginia City and at Helena?

Mr. Childs. Yes; there is not very much difference.

Senator Plumb. Is that difference represented by a greater difference in the value of the lands; that is, are lands worth at Helena a greater percentage over the lands at Virginia City than the products of the Helena lands are worth over those of other land?

Mr. Childs. I think not, as agricultural lands. And I ask to be corrected about stating that they were worth twice as much.

Senator Plumb. But you still say that lands within 3 miles of Helena, valuable only for agriculture, having no anticipation of being subdivided, were worth $50 an acre?

Mr. **Childs**. Yes.

Senator **Plumb**. Then what would it be worth within 6 or 7 miles?

Mr. **Childs**. Two or three miles would not make much difference.

Senator **Plumb**. That would be the difference of cost of bringing things in, and the lack of association?

Mr. **Childs**. Yes.

Senator **Plumb**. Then where would the lands be that are worth $10 an acre?

Mr. **Childs**. It seems to be settled that the school lands would not be sold for less than that, and that makes the price for cheap lands. They would be situated off the line of railroad where the people could not get their products to market.

Senator **Plumb**. They would be in isolated places?

Mr. **Childs**. Yes.

Senator **Plumb**. Then, taking out the $10 an acre lands in isolated places and coming to the lands around Bozeman, Billings, and Missoula, and the smaller places on the railroad, what would be the value of lands there within easy reach, say within 3 or 4 or 5 miles?

Mr. **Childs**. It would not be very much different from that of land here, because the freight rates are pretty small. Again, at a distance from Helena it might be found true that the land might produce larger crops to the acre, making up somewhat for the difference on account of distance.

Senator **Plumb**. Are there any crop failures in this country?

Mr. **Childs**. There are no crop failures except for lack of water, except once in a while. I should say, perhaps, once in five years the grain crops which are planted late suffer from frost.

Senator **Plumb**. Are there any things that might be called a total failure?

Mr. **Childs**. No; except where there is a total failure of moisture. I know that in my own case as to 100 acres of land that last year produced 45 bushels of oats to the acre, which were harvested, that very same land I purposely put in a crop late this year expecting to have water, but was disappointed; I did not get any. So that three weeks ago the growth was so stunted that I concluded it would not pay to cut it even for hay, so I turned 100 head of stock into it to eat it up, thinking that was the only way to utilize any portion of it. That was wholly because there was no water.

Senator **Plumb**. Is there any total failure here except for lack of water?

Mr. **Childs**. None that I ever heard of.

Senator **Plumb**. What is the effect of the hot winds that you spoke of, and where are they generated?

Mr. **Childs**. The hot winds generally come from the southwest, and are supposed to be the trade winds. But until this year they never have been severe enough to attract our attention, in the way of doing much damage. This year, however, there has been a very bad condition of hot winds. They have blown most continuously. The atmosphere has been very hot and very dry, and the fires that have been burning around us have intensified that condition. In the opinion of most people all that had the effect of taking the moisture away from vegetation rather than supplying it, if there was any in the atmosphere.

The **Chairman**. Even where they had plenty of water?

Mr. **Childs**. Yes.

Senator **Plumb**. When are lands plowed in this climate for the purpose of agriculture?

Mr. **CHILDS**. Ordinarily the lands are plowed in April. Of course it depends on the early opening of spring.

Senator **PLUMB**. Do you ever plow in the fall before?

Mr. **CHILDS**. Some people plow in the fall.

Senator **PLUMB**. Do the lands have to be watered before they are plowed?

Mr. **CHILDS**. Ground that has been cultivated, generally speaking, does not have to be watered. When they are breaking in new ground they generally take occasion to break it after getting a good rain-fall. If they do not get rain-fall and insist on breaking it then they irrigate it.

Senator **PLUMB**. That is for the purpose of breaking the sod?

Mr. **CHILDS**. Yes; in the case of hard ground.

Senator **PLUMB**. Is it expensive to cultivate here? For example, do the hoed crops, such as potatoes, etc., need as much cultivation here as in the section of the country where there is plenty of rain-fall?

Mr. **CHILDS**. I am not much acquainted with the operations in the Eastern States. Farming is only a recent addition to my experience. But my observation is that there is very little labor necessary in the production of crops of potatoes on clean ground—new ground, which is apt to be clean and not foul with weeds. Potatoes need but very little labor. Irrigate them once or twice after they are hilled up and they will yield very largely—that is to say, in ground that is in good condition.

Senator **PLUMB**. What other kind of root crops do you raise in this country besides potatoes?

Mr. **CHILDS**. They raise a large beet crop. The beet crop is very large Mangel-wurzel in this Territory has produced, I think, 60 tons to the acre, where grown on good soil with good moisture.

Senator **PLUMB**. Does that require as much moisture as other crops?

Mr. **CHILDS**. I think it does, and more. We grow turnips also here; almost every kind of vegetable is grown here. It is difficult to believe one's own eyes, almost.

Senator **PLUMB**. Is there any food crop which could be raised in this country in fair quantity, according to the acreage, without irrigation? I do not mean to say in particular localities, but generally.

Mr. **CHILDS**. No.

Senator **PLUMB**. Have no experiments been made in that direction?

Mr. **CHILDS**. I do not know of anything that can grow here, generally speaking, without the aid of water. Of course, it is claimed in the north country that cultivation flourishes there without irrigation, but I venture the assertion that if the people will dig down a foot or two they will find water. It might not have been supplied from the surface, but they will find it underneath. In my belief, if you dig 7 feet anywhere you will find standing water.

Senator **PLUMB**. Do you mean on the bottom-lands?

Mr. **CHILDS**. No; on the bench lands.

Senator **PLUMB**. Is that a sheet of water underlying the whole bench, as you understand it?

Mr. **CHILDS**. I should judge so from its putting in an appearance wherever you attain that depth.

Senator **PLUMB**. It does not rise?

Mr. **CHILDS**. No.

Senator **PLUMB**. Does it remain at the same level, do you think?

Mr. **CHILDS**. Yes; although I have an artesian well there that has been flowing for about two years. That, however, is dug up in the mountains.

Senator **Plumb.** At what depth did you get that water?

Mr. **Childs.** Well, to call it an artesian well needs a little explanation. I had a natural spring in a ravine at a breaking out of the mountain. I got a boring apparatus and sank a hole immediately back of the spring. The natural flow from the spring was, I should say, 5 inches of water. I sank the hole to the depth of 160 feet. At 20 feet from the surface the flow was increased quite perceptibly. At 40 feet there was perceptibly an additional flow. At 80 feet there was an additional flow, and that continued 80 feet deeper. I do not think that I added to the flow at the last 80 feet; and, having all the water that I wanted, I stopped there and put in a 3-inch pipe, and the water came up above the surface and it flows continuously out of an opening in the 3-inch pipe 13 inches above the ground. That is a 3-inch "T." And, of course, there is another 3-inch opening, to which I attached a pipe, and have taken that down the gulch for a distance of three-quarters of a mile, where it is discharged about 90 feet below its source. I have not measured the flow of that accurately, but it flows sufficiently to yield 200 gallons per minute, and has been flowing continuously for two years. It is a very good, clear quality of water.

There is one other point in that connection that I would like to mention here. That is as to the proposition of there being flowing water under the surface of the beds of streams. I know that to be true. I know that as to the McClellan stream here, which empties into the Prickly Pear above my ditch 2,000 feet, there is now water running to the extent of 25 or 30 miner's inches, while back where the water first appears in the stream it is dry up to a point where a ditch takes out all the water that would flow on the surface; demonstrating fully that the water sinks, goes under ground, and rises again to the extent of 25 miner's inches. I am now digging a bed-rock drain there and am fully persuaded from the examination and the surveys that I have made that I will get a flow of 150 inches of bed-rock water, whereas the normal flow at the surface at this season of the year, especially at this dry season, would not have been any greater than that.

I believe that it is true generally of mountain streams. That there is a very large amount of water that sinks when it is flowing through the valleys, disappears through the gravel and sand to bed-rock, and running a bed-rock drain will secure it again.

Senator **Plumb.** As to your experiment with this artesian well at the foot-hills, you think there is generally an underground supply of water near those foot-hills?

Mr. **Childs.** No, I do not. I do not think that there is an underground stream of water unless you get near the bed of natural streams, near the gravel.

Senator **Plumb.** There are no underground springs, then, you think, as a rule?

Mr. **Childs.** I think these springs are the results of openings which happen to occur below the level of some underground reservoir, which has resulted from the water percolating through the rocks and striking a cavity, and, being above the natural outlet, it percolates down through the seams of the rocks and makes these natural springs. I am satisfied that, as my well gave an increasing flow at 20, 40, and 80 feet, I came across streams running there at that section or depth.

Senator **Plumb.** What do you say as to the relative value of agriculture here, in this part of the country, and, say, in the Missouri Valley, or the country where water is obtained by natural precipitation? How much better off is a farmer there with 160 acres of land than a farmer here?

Mr. **CHILDS.** Do you mean in the productiveness of his soil?

Senator **PLUMB.** In the productiveness of the soil and his proximity to market, everything taken together?

Mr. **CHILDS.** I should say that a farmer here with 160 acres of land, with water for irrigating the same, is 400 per cent. better off than the other farmer. That is, he is four times better off.

Senator **PLUMB.** That is to say, taking his market, and the certainty of his crops, and the larger amount to be raised, and so on, you think he is four times better off here?

Mr. **CHILDS.** I should judge so as an average.

W. A. **BURLEIGH.** Ask Mr. Childs, Senator, as to the size of the potatoes that he has seen growing here.

Mr. **CHILDS.** My reputation for veracity is very well established, but I will venture one other assertion. I have seen potatoes dug and put on the scales that weighed 5½ pounds each.

Senator **PLUMB.** That, of course, is not the average weight.

Mr. **CHILDS.** There is a very large percentage of a certain variety of potato that will go to a pound and a half. I think there have been harvested patches of potatoes to the extent of one or two or perhaps five acres of certain varieties that will average 1½ pounds apiece.

Senator **PLUMB.** Do you produce onions here?

Mr. **CHILDS.** Yes, from the seed; onions that excel the Bermuda onion.

Senator **PLUMB.** They are flavorless, are they? More like the Spanish onion?

Mr. **CHILDS.** There are different varieties, having different flavors. The kind I had reference to is nearly flavorless.

STATEMENT OF W. A. BURLEIGH, OF HELENA.

The **CHAIRMAN.** How long have you resided in Montana?

Mr. **BURLEIGH.** About eleven years.

The **CHAIRMAN.** You have lived in Dakota a long time, too, I believe?

Mr. **BURLEIGH.** I went to Dakota in 1861 and resided there till I came here, about eleven years ago.

The **CHAIRMAN.** You represented Dakota as a Delegate to Congress?

Mr. **BURLEIGH.** Yes, for four years.

The **CHAIRMAN.** Has your attention been called to this subject of farming by irrigation?

Mr. **BURLEIGH.** I have devoted a great deal of thought to the subject. I was one of the gentlemen who, some time ago, suggested the matter to the people here.

The **CHAIRMAN.** Have you traveled over the Territory considerably?

Mr. **BURLEIGH.** The eastern portion of it I have, but not the mountains. The Yellowstone Valley and its tributaries I have been over a good deal.

The **CHAIRMAN.** What is your observation on irrigation and its success?

Mr. **BURLEIGH.** So far as I have witnessed it it is a present and perfect success. In fact the country is perfectly worthless for agricultural purposes without irrigation.

The **CHAIRMAN.** With irrigation how does it compare with land you have been in the habit of seeing cultivated in Dakota and other places further east?

Mr. BURLEIGH. With irrigation the soil of the Yellowstone Valley, in eastern Montana, will in my judgment produce larger crops than any country that I ever knew anything about.

The CHAIRMAN. To what extent is irrigation practicable in the eastern portion or eastern half of this Territory?

Mr. BURLEIGH. With proper reservoirs to save the water that runs down in the spring, I believe that more than one-half of eastern Montana is susceptible of irrigation.

The CHAIRMAN. What is the character of the soil as to fertility?

Mr. BURLEIGH. The soil is very fertile indeed, provided it has water. Without water it is not. I should like to make an observation at this point, if I should be allowed to do so.

The CHAIRMAN. Make any statement you wish without waiting for questions.

Mr. BURLEIGH. I know of three of the best farmers in eastern Montana who live in the Yellowstone Valley, and all of them on the other side of the railroad. They went there with from $12,000 to $20,000 apiece. They undertook to cultivate the soil without irrigation, and two of the three told me that had it not been for their stock they would have been bankrupted. Then they got together and took out a ditch just below Custer Station on the opposite side of the river, by their own efforts, and are now making the ditch larger to irrigate thousands of acres out of the Yellowstone River.

I have seen blue-grass with irrigation grow 30 inches high, and in my judgment if it had been cut it would have produced 3 tons to the acre. I know it is Kentucky blue-grass because I sent to Kentucky and got the seed. I have seen larger timothy grow with irrigation on the bottoms, larger clover and larger alfalfa than I ever saw grow in any other country.

The CHAIRMAN. Can the Government facilitate irrigation by making surveys?

Mr. BURLEIGH. Yes; if the Government surveys are made under scientific direction. People will then have confidence in the country, and if arrangements are made by which even private enterprise can engage in irrigation under the direction of a competent Government engineer, I think it will very largely benefit the country.

The CHAIRMAN. To what extent can land be brought under cultivation by private enterprise, probably, if parties had all the facts with regard to the particular localities?

Mr. BURLEIGH. All the land susceptible of cultivation lying below the head of the water.

In regard to the storage of water, there are hundreds of little streams in this Territory that are full of water from melted snows and rains of the spring. There are natural reservoirs where that water in very many instances can be saved to be used during the dry season and when these springs are dry. If that system could be adopted there, it seems to me it would add immeasurably to the wealth of the country and the people. I do not "think" anything about it; I know it.

The policy of the Government has been one of the most peculiar kind. Long since steam-boat navigation has ceased here the Government has continued to make appropriations to improve the navigation of these upper rivers. Navigation of these upper rivers is a thing of the past. They drain the water out as rapidly as possible, so that it shall not stay very long if they can help it. And when the waters are going down to the lower country the policy of the Government tends to make it worse. Then they start to build jetties below to let it out of the Mississippi. Whereas if the money were expended up here—some such measure as you suggest—it would be of immeasurable benefit to this whole country.

The CHAIRMAN. Do you believe it would mitigate the floods if the waters were stored up here, as you think they might be?

Mr. BURLEIGH. Certainly it would. The water being turned upon the soil here would promote evaporation and increase the rain-fall. Take the Missouri River; when it starts out of the boom in June it causes the greatest consternation. If you turn the water from those water-sheds on to the country below, inundations are inevitable. The clearing out of the channels here has a tendency to send the water down as quickly as possible. I have been thinking this thing over seriously in the light of common sense, and I have wondered whether we are really advancing in intelligence as a people or whether we are not degenerating ever since the days of the old Egyptian monarchs, who first conceived the idea of converting the great Egyptian desert into the granary of the world.

The CHAIRMAN. Undoubtedly the world has largely lost a knowledge of the art of irrigation; but it is recovering it.

Mr. BURLEIGH. Our people should endeavor to regain some knowledge of it. I would like to say a word or two now to the committee with regard to the timber land.

The CHAIRMAN. Condense what you have to say into as small a space as possible, as our time is limited.

Mr. BURLEIGH. My idea is that the system of employing secret agents, which has been pursued by the Government here, has been very detrimental to the people of this country and should not be continued. I think there should be a Government agent here to supervise the timber.

The CHAIRMAN. Would you allow every person, under proper regulations, to cut what timber he required?

Mr. BURLEIGH. Yes; and the thinning out of the timber will be an advantage. It would be better for the forests and for this people if about nineteen trees out of every twenty were cut down; but care should be taken to cut down the right trees and to leave the right trees standing. The growth is now so dense here that the wood takes the moisture from the ground, and the forests actually perish. There would be moisture enough to sustain about one tree in twenty and bring it up to a large size; so that really the forests ought to be somewhat denuded.

In regard to forest fires, I have some peculiar views, and I think they are founded in fact. As you came up from Miles City you found that there had been fires between the railroad and the river.

The CHAIRMAN. Yes.

Mr. BURLEIGH. That is all occasioned by the miserably incompetent appliances used by the railroads on their locomotives. I venture to say that forty-five fires out of every fifty that have occurred in the West, and that have devastated and that are now devastating the country, have come from incompetent devices which the railroad companies have employed upon their locomotives, so that cinders and sparks have been thrown off without limit. There has been more timber destroyed by fire in the Territory of Montana, as Colonel Sanders has said, since the first day of last July than has ever been consumed by settlers in this Territory. The same applies to the grass. We are annoyed to death by the burning of the grass. Many railroads will not even keep the combustible material off their right of way. I make that suggestion in no unfriendly spirit against the railroads, but I state the fact.

The CHAIRMAN. Anything that the Government can do will, I think, be done, so that the people can have the timber, and at the same time not interfere with the growth of the forests. But the matter of keeping the land from fires is a most important one.

Mr. BURLEIGH. From Lake Superior to Puget Sound the Government has donated to the railroads a great belt of country 40 miles wide, and it is nothing more than right that the railroads should be required under the strictest laws to protect the settlers and the country against devastation by fire.

The CHAIRMAN. I think the States separately might pass laws on that subject also.

Mr. BURLEIGH. I think our people will do so when they have a State government. We have a provision in our new constitution sufficient to cover the subject. Of course there should be some modification of our land laws here, but that can be suggested as we go along. This thing of sending Pinkerton's detectives here to hound down our people is villainous and should not be continued.

STATEMENT OF G. C. SWALLOW, INSPECTOR OF MINES FOR MONTANA.

The CHAIRMAN. How long have you resided in Montana?

Mr. SWALLOW. I have been practically here since 1867, though I have been away sometimes.

The CHAIRMAN. Has your attention been called to the subject of irrigation?

Mr. SWALLOW. Somewhat.

The CHAIRMAN. Have you traveled over the country here to observe the topographical features and conditions bearing on that subject?

Mr. SWALLOW. I have seen the whole country. I am inspector of mines for the Territory, and I have traveled a good deal through the Territory.

The CHAIRMAN. What do you say as to the opportunities for irrigation in this Territory?

Mr. SWALLOW. I think there is water enough in the Territory now to irrigate all the arable land we have.

The CHAIRMAN. About what proportion of the land would be arable land?

Mr. SWALLOW. One-half.

The CHAIRMAN. And there is water enough to irrigate that?

Mr. SWALLOW. I think there is water enough, if it is properly managed, to irrigate half of this Territory.

The CHAIRMAN. What do you say about the storage of water in reservoirs to save it for the time of irrigation—whether that could do very much?

Mr. SWALLOW. That will have to be done. We can not irrigate one sixth of it now.

The CHAIRMAN. What are the facilities for storing the water in connection with the topography and the streams?

Mr. SWALLOW. I never knew any country that had so many facilities as this for that purpose. All the mountains are full of ravines and places for reservoirs.

The **Chairman.** Steep ravines are not good. Are there marshes and flat places adapted for reservoirs?

Mr. **Swallow.** Yes; all our mountains are full of them.

The **Chairman.** Are there many places where sufficient water does not now come down the ravine or steep, but where by storage enough water could be had?

Mr. **Swallow.** Yes; I have been over Judith Mountain, and I am surprised to see that all the mountain streams are flowing. The streams where they open out into the valley are dry. I will mention one which they call "Dry Wolf," because it does not flow. I traveled up that valley several miles, and for 3 miles there were 500 inches and for several miles 800 inches of water. There was really plenty of water to irrigate the farms, if the farms could get it, but it sinks.

The **Chairman.** Can it not be taken out by ditches, high up, or by flumes or pipes, or other means that might be resorted to?

Mr. **Swallow.** Of course; there is no trouble about it whatever.

The **Chairman.** What is your opinion as to the value of surveys for the purpose of irrigation and locating reservoirs and ditches and estimating the cost thereof, and how much would that benefit the country?

Mr. **Swallow.** It would fill this country up. People do not know now what it is going to cost them, and until they do know they will not get water. If you give them the information and make it certain that they can get water, they will settle here.

The **Chairman.** And in many cases they will get the water themselves?

Mr. **Swallow.** Yes; if they know how and where.

The **Chairman.** Is it expensive for individuals to find out where and how?

Mr. **Swallow.** They do not know enough now. They have to come here and hire an engineer and pay him $10 a day and his expenses, and they do not know where to send him when they find him.

The **Chairman.** Consequently they do not know where the irrigation can be had that is easy to be had?

Mr. **Swallow.** No. At one time I met a colony of Swedes up in the Judith Mountains. The country was very dry, and they thought they would go out prospecting. They went along for 8 miles in the valley, and there they have built, and have now water enough. The grass in that valley in some places is as high as my knees. There are hundreds of square miles in those mountain valleys that are full of grass.

I have been listening here, and I see your attention has been given to this question of mountain reservoirs, but apparently altogether for agricultural purposes. I want to make a suggestion if you will allow me.

The **Chairman.** Certainly.

Mr. **Swallow.** Does the province of your committee include the supply of water for mining purposes?

The **Chairman.** That will come in incidentally; but the miners are a pretty shrewd class of people and are very apt to regulate their matters pretty successfully themselves.

Mr. **Swallow.** I know that; but if you go up into these mountains to regulate all these matters and take away the water from the miners and give it all to the farmers that might not be just the proper thing to do. Can you not regulate it so that the miner can be protected the same as the farmer?

The **Chairman.** Certainly; the miners will be protected.

Mr. **Swallow.** They have themselves built a great many reservoirs to save the water.

STATEMENT OF ALFRED MYERS, OF BILLINGS, PARK COUNTY.

The CHAIRMAN. What is your business?

Mr. MYERS. I have been stock-raising and farming in Park County.

The CHAIRMAN. Have you looked into the subject of irrigation and the matter of fertilizing the land by putting water on it?

Mr. MYERS. Yes; I have given considerable thought to that, and have had considerable experience of it in farming.

The CHAIRMAN. With what success?

Mr. MYERS. Very satisfactory success, as far as I have been able to conduct the water to the land.

The CHAIRMAN. Have you had large crops?

Mr. MYERS. Yes; I have had a large yield and a certain yield on the land which I have been cultivating.

The CHAIRMAN. To what extent can irrigation be practiced in this part of the country, do you think?

Mr. MYERS. I think all along the base of the mountains and on the plateaus on the eastern part of the Rocky Mountains it could be practiced very extensively by a system of reservoirs for storing the water and conducting it on to the table-lands. It would be very successful and profitable.

The CHAIRMAN. How would Government surveys be regarded in that connection.

Mr. MYERS. They would be very material in pointing out to the people the manner in which a system of reservoirs could be used for the storing of water, and the probable cost of their construction and so forth. That would very greatly help the reclaiming of the arid lands.

The CHAIRMAN. And you think one-half of the country east of here could be irrigated?

Mr. MYERS. Yes; I think so.

The CHAIRMAN. What variety of crops can you raise here?

Mr. MYERS. Oats, wheat, barley, rye, potatoes, and all kinds of vegetables. They raise a very fair quality of Indian corn. Hay is a success here, and the grasses, alfalfa, timothy, clover, blue grass, and so forth, also.

The CHAIRMAN. Suppose that the land that could be made subject to irrigation were generally under cultivation here, would that be valuable?

Mr. MYERS. Yes.

The CHAIRMAN. How does the summer range compare with the winter range in this country? Is there more summer range than winter range?

Mr. MYERS. Yes; a great deal more.

The CHAIRMAN. Suppose you had forage for your stock in winter, and feed to fatten them, so that you could send fat sheep, fat hogs, and fat beeves to market, would the balance of the land be valuable for your summer range?

Mr. MYERS. I think it would; it would enhance the value and make a demand for this land that was not adapted to winter grazing.

The CHAIRMAN. Would it not furnish additional advantages, over almost any other country, to those who had irrigable land, by enabling them to have pasture land for the summer?

Mr. MYERS. I think it would. It would place this country in a very favorable condition compared with others.

The CHAIRMAN. Is there any section of the country east of here with which you are familiar that would have equal advantages?

Mr. **Myers**. No, sir; not after you get out of the Rocky Mountains—after you get off these table-lands.

The **Chairman**. I mean as to the rich lands of the Mississippi Valley—would farming be conducted there with the same profit that it could be here?

Mr. **Myers**. I think not. I think farming here, where an abundance of water can be procured, would be more successful than it would be there.

The **Chairman**. How do the crops compare here with the crops East; for instance, in Illinois, or whatever State you are familiar with?

Mr. **Myers**. I am familiar with all the States. I have lived in Illinois, in Missouri, in Iowa, and other States. In small grains, I think we can produce more to the acre here than in any other of the central Middle States.

The **Chairman**. And are more sure of a crop?

Mr. **Myers**. Yes.

The **Chairman**. Taking it for ten years, how do you think it would be?

Mr. **Myers**. It would be more certain here, with a supply of water. In these lands there are very few seasons in which we can procure a good crop without irrigation. The rain-fall does not come exactly at the right season and does not continue long enough. In the case of these arable lands we scarcely ever have rain enough during the season to produce a crop. A gentleman spoke of the northeastern part of the Territory. That, perhaps, has some land that in some seasons would produce crops without so much rain as the land here, but there is no certainty of the supply of crops here without artificial irrigation.

The **Chairman**. Are there any other particular facts that you would wish to state?

Mr. **Myers**. Nothing further than to say that I think it is entirely practicable to reservoir and store the water along the base of the mountains. Of course there may be places west that would be equally practicable, but the large extent of country that is adapted to the storing of water is on the eastern base of the Rocky Mountains.

You suggested the idea about reclaiming the National Park. You are going to make all this timber region a national park virtually. You might enlarge westward the National Park a little without any injury to any other interest, perhaps, but in any other direction you will be apt to get into a valuable mining country.

STATEMENT OF SIMEON S. HOBSON, OF HELENA.

The **Chairman**. How long have you resided in Helena?

Mr. **Hobson**. I have resided here for ten years.

The **Chairman**. Have you given the subject of irrigation some attention?

Mr. **Hobson**. Yes.

The **Chairman**. Are you a farmer?

Mr. **Hobson**. Yes; and a stock-raiser.

The **Chairman**. Where?

Mr. **Hobson**. In the Judith Basin.

The **Chairman**. What are the facilities in this Territory for irrigation?

Mr. **Hobson**. They are very good in the valley in which I live.

The **Chairman**. Have you examined the Territory generally?

Mr. HOBSON. To a considerable extent I have. It is a large Territory, however.

The CHAIRMAN. From your observation, about what proportion of it might be irrigated if the water were stored and saved?

Mr. HOBSON. I should not think that over 25 or 33 per cent. of the Territory. The mountain ranges are very large in this Territory.

The CHAIRMAN. If you take the eastern part, how much would it be?

Mr. HOBSON. Perhaps one-half of that might possibly be irrigated in that way. The valley in which I live is a large valley, and one-half of that certainly could be irrigated.

The CHAIRMAN. How much is under cultivation in your valley; what proportion of the land?

Mr. HOBSON. Not over 5 per cent., I think. It is difficult to estimate correctly. The people use all the land they can find along the bottoms of the streams, about as wide as they can conveniently get the water to, but there is a good deal of water taken out with small ditches.

The CHAIRMAN. Have you taken any means to increase the water supply at all except taking what flows down at the time you want to use it?

Mr. HOBSON. No other.

The CHAIRMAN. Have you examined the places above to see whether there are opportunities for storage?

Mr. HOBSON. Yes; and there are very fine opportunities. We are entirely surrounded by mountains that are not very high nor very steep.

The CHAIRMAN. Are there any lakes or flat places above?

Mr. HOBSON. Yes.

The CHAIRMAN. Has there been any system adopted in your valley of taking out the water above by a large ditch and bringing it down and distributing it?

Mr. HOBSON. No. There is a great deal of fine bench land in that basin that could be irrigated with a proper system of reservoirs. I do not think there is a body of land in the Territory that is as well adapted for that.

The CHAIRMAN. What kind of crops do you produce there?

Mr. HOBSON. Principally oats.

The CHAIRMAN. Can you produce all the small grains?

Mr. HOBSON. Yes; but we have no market for it.

The CHAIRMAN. But the valley can produce it?

Mr. HOBSON. Oh, yes.

The CHAIRMAN. Can you produce all of the vegetables?

Mr. HOBSON. All of them.

The CHAIRMAN. Can you grow alfalfa?

Mr. HOBSON. Yes. I have 20 acres of alfalfa.

The CHAIRMAN. How does it do?

Mr. HOBSON. It grows very finely.

The CHAIRMAN. About how much a year can you get from an acre?

Mr. HOBSON. About six tons to the acre each year.

The CHAIRMAN. You find it valuable food for cattle, do you not?

Mr. HOBSON. The best we have ever had. I do not think the subject of alfalfa raising is generally understood in this country. My experience and that of my neighborhood is that it only does well on ground that requires irrigation. Ground that is so low that it requires no irrigation does not do well for alfalfa. I am really the only man in my county that has been successful with alfalfa, and that accounts for it. The others put it on low ground.

The CHAIRMAN. Have you tried fruits?

Mr. **Hobson**. Nothing but small fruits. We raise plenty of strawberries, currants, and such things.

The **Chairman**. Are there any other suggestions that you desire to make?

Mr. **Hobson**. Nothing further, but that I think if a system of Government surveys were made a great many farmers would club together and take advantage of the information, if they knew just where to apply it.

The **Chairman**. It involves considerable risk, you think, for private individuals to hire surveyors to make preliminary surveys?

Mr. **Hobson**. The business of raising crops in this country would not pay for the employment of that class of skilled labor. The great drawbacks to agriculture in this country are the high prices of labor and the scarcity of water. I do not think any agricultural country was ever developed thoroughly with labor at $40 a month.

The **Chairman**. Labor can earn, and you can afford to pay, $40 a month, provided you could raise first-class crops.

STATEMENT OF CONRAD KOHRS, OF HELENA.

The **Chairman**. How long have you resided in this Territory?

Mr. **Kohrs**. Twenty-seven years.

The **Chairman**. What is your occupation?

Mr. **Kohrs**. I am farming and stock-raising, and have been engaged in placer mining for many years.

The **Chairman**. You are quite familiar with this Territory?

Mr. **Kohrs**. Yes.

The **Chairman**. Have you given attention to irrigation?

Mr. **Kohrs**. Yes.

The **Chairman**. Of what advantage to the people here would a system of Government surveys be that would indicate the places for reservoirs and the rights of way for ditches, and that would estimate the cost of such?

Mr. **Kohrs**. It would be a great benefit for our country, because the people would learn of the facilities they have for storing water, which they do not know anything about now.

The **Chairman**. If that was done, is there a large amount of public land that would be brought under cultivation?

Mr. **Kohrs**. A very large amount.

The **Chairman**. What proportion of the land in the Territory do you think could be irrigated if the water were used properly?

Mr. **Kohrs**. I think that you could increase the agriculture of this Territory by twenty times as much as its present output if you had the water properly distributed. I do not think that more than 5 per cent. of the arable land is under cultivation now.

The **Chairman**. Have you ever been over the plains east of here on the table-lands?

Mr. **Kohrs**. Yes; I am well acquainted with the entire Territory.

The **Chairman**. What is the character of those table-lands, taking the whole range east of here?

Mr. **Kohrs**. I am not so very well acquainted with the Yellowstone country as Mr. Myers is; but, taking it north and northeast, it lies well for irrigation. The most of the country there has a clay subsoil. There is no country in Montana that lies so favorably for storing water as the northeastern part, because all over the country there are natural lakes in which water can be stored without great expense. That is less true of the southern part of the country.

The **CHAIRMAN**. If the land that can be irrigated were irrigated and cultivated, what would you do with the remainder of the land?

Mr. **KOHRS**. There would always be a great deal left for grazing. I think the extent of grazing is larger than most people have any idea of.

The **CHAIRMAN**. If you had forage for the winter, so that you were not under the necessity of keeping cattle during that season unless the winter was an open one and unless it was convenient to do so, you could fatten them, and there would be a vast amount of land, would there not, that you could use for grazing?

Mr. **KOHRS**. Yes; there would be a great deal left for good summer grazing; that is, if the water-courses were not shut off from our cattle.

The **CHAIRMAN**. On the contrary, would not the water-courses, if the waters were taken out, afford better facility for getting at the water?

Mr. **KOHRS**. No, I do not think so; because you would find that the larger portion of the land would be under fence and the creeks would be dry and the cattle naturally would have to go farther for water.

The **CHAIRMAN**. Would it not be easy to take lateral ditches out and let the cattle have water that way?

Mr. **KOHRS**. Yes.

The **CHAIRMAN**. Would it not make a good base of supply, properly managed, so that they could go farther back and occupy a larger area of country?

Mr. **KOHRS**. Yes; it could be done in that way.

The **CHAIRMAN**. So that you could employ the arable land and the pasture land both?

Mr. **KOHRS**. Yes; we would have a very fine country, provided the farmers could go and get a market for their products. At present we are pretty far from transportation in some parts of the Territory.

The **CHAIRMAN**. Suppose that Montana were a meat-producing country, transportation of dressed beef ought not to be very heavy?

Mr. **KOHRS**. No; it is not in comparison very heavy, as in the case of grains.

The **CHAIRMAN**. It seems to me that this should be a great meat-producing country, and then your distance from the market would not be a great drawback.

Mr. **KOHRS**. It would not, if we could break up that ring in Chicago.

IRRIGATION INCORPORATIONS IN MONTANA.

The following list was furnished the committee by the secretary of the Territory:

Boulder Valley Ditch, Mining, and Milling Company; principal place of business is in Boulder Valley, Jefferson County, Mont.; filed in the office of secretary of Montana, January 22, 1876.

Big Spring Water-Ditch Company; principal place of business is Helena, Lewis and Clarke County, Mont.; filed in the office, of secretary of Montana, January 15, 1883.

Cañon Ditch Company; principal place of business is Dillon, Beaverhead County, Mont.; filed in the office of secretary of Montana, May 8, 1888.

Eldorado Ditch Company; principal place of business is Chotean, Choteau County, Mont.; filed in the office of secretary of Montana, September 10, 1883.

Moreland Ditch Company; principal place of business is Hamilton, Gallatin County, Mont.; filed in the office of secretary of Montana, September 5, 1882.

Miles City Irrigating and Ditch Company; principal place of business is Miles City, Custer County, Mont.; filed in the office of secretary of Montana, December 26, 1885.

Surprise Ditch Company; principal place of business is Corvallis, Missoula County, Mont.; filed in the office of secretary of Montana, March 30, 1885.

Republican Ditch Company; principal place of business is Corvallis, Missoula County, Mont.; filed in the office of secretary of Montana, May 3, 1886.

Ryan Ditch Company; principal place of business is in the counties of Yellowstone, Custer, and Dawson, Montana; filed in the office of secretary of Montana, September 24, 1885.

The Belt Creek Land and Ditch Company; principal place of business is Choteau County, Montana; filed in the office of secretary of Montana, December 15, 1883.

Tongue River Irrigating and Ditch Company; principal place of business is Miles City, Custer County, Mont.; filed in the office of secretary of Montana, August 22, 1882.

The Italian Ditch Company; principal place of business is Park City, Yellowstone County, Mont.; filed in the office of secretary of Montana, September 15, 1886.

The Deseret Ditch Company; principal place of business is Powdersville, Custer County, Mont.; filed in the office of secretary of Montana, May 3, 1886.

The Miller Creek Ditch Company; principal place of business is Missoula, Missoula County, Mont.

The Beaver Creek Ditch Company; principal place of business is Warm Springs, Jefferson County, Mont.

Union Ditch Company; principal place of business is Dillon, Beaverhead County, Mont.; filed in the office of secretary of Montana. June 6, 1887.

Ward Ditch Company; principal place of business is Corvallis, Missoula County, Mont.; filed in the office of secretary of Montana, June 4, 1888.

STATEMENT OF WILLIAM F. WHEELER, C. E., OF HELENA.

In 1883 I wrote for the Interior Department an article on the forestry of Montana at the request of Mr. Furnuss, a commissioner on forestry, etc., which paper was published, I think, in the Agricultural Report. I had been United States marshal nearly ten years and had traveled over the country, and gave the result of my observations on our forests. This spring I have also written a report on the same subject for the Bureau of Statistics of the Treasury Department at Washington, which will most probably be published in one of its quarterly reports. I here make a synopsis of my observations and conclusions for your committee.

The area of the timber-lands of Montana is estimated at about 35,000 square miles. The distribution of timber is confined mostly to the great mountain ranges, their spurs, and detached clumps of mountains.

The densest, most extensive, and valuable bodies of timber lie in the part of the Territory west of the Rocky Mountains. In size and appearance the trees here partake of the Washington Territory and Oregon type, while the trees east of the mountains resemble in appearance and growth their congeners of the Atlantic coast. This difference is accounted for by the fact that the clouds that are driven eastwardly from the Pacific Ocean discharge the greatest part of their moisture against the sides of the mountain ranges facing towards the ocean.

The eastern slope of the main range, the several spurs branching from it and running parallel with it frequently for one or two hundred miles, and the several detached ranges and clumps of mountains which often stand alone far out on the plains, are covered with a fair growth of valuable forests and supply a large area of country adjacent to them.

There is practically no hard timber in Montana, as oak, ash, hickory, etc. Trees do not grow in the valleys or on the great rolling prairies east of the mountains. The plains are treeless. However, along the margins of all the streams there usually grows a narrow fringe of poplar, cottonwood, quaking asp, alder, and willow. It makes very inferior lumber, and it is mostly used for fuel and fencing. Railroads now traverse every principal valley of the Territory, and the supply of lumber for building purposes is ample, and is sold at moderate prices. Coal is found in every county, and of however inferior a quality in some districts (its quality is generally excellent) it forms a cheap and an abundant fuel, especially in the plains or prairie portions of the country.

The extensive and almost exclusive use of barbed wire for fencing saves annually millions of feet of lumber and small trees. So, with these substitutes for timber (coal and barbed wire), the present growth of timber will not be exhausted for ages to come, unless destroyed by forest fires.

The smelting-furnaces and quartz-mills use a large amount of wood annually for fuel and in the form of charcoal. A great deal is also used in timbering up mines. For sawing into lumber and shingles and for making railroad ties, piles, and for trestles much is consumed. In this manner I estimate the consumption of last year at 150,000,000 feet, board measure.

The greatest destruction of timber is by the extensive forest fires that occur occasionally. These were notably destructive in 1869, 1873, and 1886. But that raging at the present time covers a greater area of mountains, and I believe will be the most destructive Montana has ever experienced.

Our local laws for the prevention of forest fires are excellent, but there are no special officers to enforce them, and witnesses to an overt act are seldom found.

In my opinion the best way to preserve our forests would be to survey them into small lots and sell them out to our people. The law should regulate the cutting of the timber, so as to prevent all being cut off of any tract, at any time, so that there may be continually a new growth.

One fact in my observation is very gratifying, that is, that a new growth of timber springs up almost immediately after the timber has been cut or burned off, and, if not molested, will produce a growth as large as the old one in the same time. I know of mountain sides now which were burned over twenty years ago where the new growth is from 15 to 25 feet in height.

The first water ditches constructed in Montana were for the purpose of washing the sands and gravel bearing gold along the various bars and gulches where it was found. A great number of these ditches were built from 1862 to 1869. According to the only record preserved, viz, The Statistical Almanac of Montana for 1869 (the only one ever published), there had been up to the end of that year 287½ miles of mining ditches constructed at a cost of $806,500.

Their total capacity was 35,370 miner's inches, at a steady flow under 6 inches of pressure. The longest ditch mentioned was 50 miles in length, cost $15,000, and had a capacity of 1,500 inches, and the shortest 1¼ miles long, with a capacity of 4,000 inches. It cost $2,500. The difference in cost of water ditches depends entirely on the nature of the country through which they are built. Where it is rocky or precipitous the expense is greater. In a prairie or valley the cost is at the minimum.

The purposes for which these ditches were built have been answered. The ground which they covered is generally exhaustively mined out. A few places are still mined with fair results, but the poorer diggings are leased to Chinamen, who are satisfied with small profits. As a matter of course, the ditches have decreased greatly below their cost in value, and are now used for a purpose entirely different from the original one. They have been converted into irrigating ditches, and the water they carry is used by farmers in cultivating their crops; and for this purpose they are becoming more valuable every year, and this increase in value will continue to grow, unless the storage system of reservoirs shall solve the question of a greater supply of water.

Nearly every farmer in Montana, except in a few locations along the margins of streams, has his own little ditch, generally constructed by himself, to carry the water to irrigate his crops. Sometimes, where a long or expensive ditch has to be built, the people along the line of it unite in the work and cost of construction and share the benefits equitably.

The ditches where the water is not sold, but used by the proprietors, either for mining or for irrigation, are not taxed separately, but are assessed as improvements on the land, like houses, barns, fences, etc.

Within the last few years, especially since the completion of railroads into and across Montana, the population has increased rapidly. The majority are farmers and they require water to irrigate their land. The wealthy capitalists have seen the necessity of supplying this great want, and knowing there is a great profit in the ownership of water have organized companies to construct ditches, take up water, and sell the same to the land-owners. If kept within reasonable limits as to the prices to be charged for water for irrigation purposes, a vast extent of country will be redeemed from a desert character to settlement and civilization and the support of a large population. But if not in a proper measure restricted in their charges, either by the State legislature or by Congress, they may become oppressive to the people.

The General Government owns the public domain, and in selling its lands to actual settlers should guaranty to each one sufficient of the water running by or through it to irrigate his farm, provided he takes it out in a reasonable time, and no one should be allowed to take it out of a stream for speculative purposes, only under such restrictions as the law may impose, where large capital is necessarily employed in constructing ditches. The water belongs to the land in this country, and much of the land is comparatively worthless without it.

The following gives a description of the large ditches which have been or are now being constructed by incorporated companies in Montana:

1. *Clarke's Fork Bottom Irrigation Ditch.*—This ditch is entirely in Yellowstone country and is 38 miles in length. It was constructed some four years ago by the Minnesota and Montana Improvement Company. It cost $140,000 and will irrigate an area calculated at about 100,000 acres between Young's Point and Billings, on the north side of the Yellowstone River. Its width at top is 30 feet, at bottom 20 feet, and depth 3 feet.

2. *The Dearborn Irrigating Ditches.*—These canals or ditches are entirely within Lewis and Clarke County, and in course of construction by the Dearborn Canal Company, at the head of which is Donald Bradford, esq., of Helena. Arthur G. Lombard is the engineer of the company.

The head of the canal is 36 miles west of the town of Cascade on the Missouri, and the water for the several ditches is taken out of the Dearborn River.

The main canal, as far as completed, is 4½ miles long, and discharges into Summit Lake. From this lake, acting as a reservoir, the series of ditches described hereafter will be supplied with water. The width of the main canal, at top, is 38 feet; at bottom, 20 feet. The slope of the banks is 1½ to 1 foot; grade, 3.1 feet to the mile; current of the water, 3⅜ miles per hour.

After leaving Summit Lake a portion of the water is conveyed a short distance into the head of Flat Creek, the channel of which is utilized as a canal for 22 miles, and the body of water conveyed into it will be 6 by 8 feet square.

A small lateral ditch, 2 miles in length, is taken out of the main canal at Summit Lake, and runs over to Auchard Creek, and in its course will irrigate 5,000 or 6,000 acres of land.

Another ditch, an extension of the main canal, is taken out at Summit Lake and is constructed across the country 15 miles into Sim's Creek, where it makes a fall of 75 feet, which it is intended to utilize as a water power for the propelling of the machinery of grist and saw mills for the benefit of the settlers of the surrounding country. This canal is 32 feet wide at top and 14 feet at bottom. It is calculated to irrigate 30,000 acres of land. The channel of Sim's Creek will be utilized as a ditch for 7 miles, and thence the water will be conveyed through a ditch 4 miles in length to the Little Muddy Creek, through which it will reach the Missouri River 8 miles north of the town of Cascade.

Another ditch will be constructed from the Little Muddy, 15 miles towards the city of Great Falls, to cover the bench lands on either side for that distance, and, with the aid of reservoirs at said suitable points, will irrigate about 16,000 acres of land.

When this whole system of canals and ditches is completed, with their storage reservoirs, it is calculated that it will irrigate 200,000 acres of land between the Dearborn and Sun Rivers down to the Missouri. The upper part of the canal will also be used to float logs and lumber down to the country below.

It will take several years and large sums of money to complete this great work.

The following irrigating canals, with suitable storage reservoirs, are now in course of construction by companies of Helena capitalists, among whom are Ex-Governor S. T. Hauser, A. M. Holter, Henry M. Parchen, John B. Wilson, and others, whose enterprising character and financial ability are a sufficient guaranty that they will be completed:

1. *Sun River Canal* is in Choteau and Cascade Counties—to be 75 miles long—8 miles completed; is 30 feet wide at top, 15 at bottom, and 4 feet deep; grade, 3½ feet to the mile. Water is taken from North Fork of Sun River. Supply is abundant. When completed will irrigate 300,000 acres. Will end on high prairie, a little west of the town of Great Falls. Will cost about $500,000.

2. *The Benton Lake Canals* are in Cascade County, 8 miles west of the town of Great Falls; are 12 feet wide at top and 6 on bottom, and 2½ feet deep. Grade is 2½ to 3 feet per mile. The two canals are 30 and 35 miles long, respectively. The water is taken out of Benton Lake, and will irrigate the bench lands between Great Falls and Fort Benton to the amount of 50,000 acres, and when completed will be together 65 miles long and will cost $175,000.

3. *The Teton Canal.*—This canal is in Choteau and Cascade Counties. The water is taken from the Teton River, about 12 miles above the town of Choteau. It is 16 feet wide at top, 8 at bottom, and 3 feet deep. The canal is finished for 40 miles and is turned into a creek-bed, called the "Muddy," in which it flows for 40 miles farther, and ends about 12 miles above the town of Great Falls. The grade of the ditch is 2½ feet to the mile. It has cost $80,000 and will irrigate about 35,000 acres.

4. *The Florence Canal* is situated in Lewis and Clarke County, and

the water is taken out of the South Fork of Sun River, 6 miles above the town of Augusta. Ten miles are completed, and when finished it will be about 50 miles long and will run to the Little Muddy, a branch of the Missouri. Its width is 30 feet on top and 20 on the bottom; it is 3½ feet deep, and has a grade of 2½ feet to the mile. The 10 miles completed will irrigate 10,000 acres and it has cost about $2,000 per mile.

5. *The Chestnut Valley Canal.*—This canal is situated in Cascade County. The water is taken out of the Missouri River at the head of the Half Breed Island Rapids, 40 miles above the town of Great Falls, on the east side of the river (as the Missouri here runs due north). It is 10 miles long; width at top 20 feet, bottom 10 feet; 2½ feet deep; grade 2 feet to the mile. Will cost $700 per mile and will irrigate 25,000 acres.

6. *The Gallatin Canal.*—This canal is in Gallatin County. The water is taken out of the West Gallatin and is carried 25 miles easterly across the head of Gallatin Valley and emptied into the East Gallatin, 3 miles above Bozeman. The dimensions are 40 feet wide at top, 20 at bottom, and 4 feet deep. The grade is 2½ feet per mile. It will irrigate 50,000 acres of land. It will also be used to convey farm produce and lumber to market. It is just completed and cost $75,000.

J. D. McIntyre is the chief engineer who has built or is now building the above-named canals, and was the engineer who organized the whole system. His brothers, H. L. and Charles, have had charge of the construction. These canals are all owned by incorporated companies, many of whose members are citizens of Helena, Mont.

The foregoing account of the construction of large water ditches shows that the people of Montana are now fully convinced of the necessity of carrying water out of the large rivers on to the bench lands and prairies at whatever cost, and that they most heartily approve of the plan of the General Government to establish storage reservoirs up in the mountains, and also to preserve the forests along the mountain sides, which have so great an influence in protecting the sources of water supply.

Nearly all the water along the small streams which can be easily and cheaply diverted into small ditches has been claimed and taken out. Hundreds of miles of such ditches are found over the Territory. Hence the necessity and importance of preserving the sources of our water supply and of constructing large and expensive canals to distribute water taken out of our large rivers.

STATEMENT OF R. L. UPSHAW, U. S. INDIAN AGENT, LAME DEER.

The Indians under my charge are the Northern Cheyennes and are just emerging from their original nomadic barbarism. They know nothing whatever of irrigation except what they have observed in the past two or three years in the vicinity of the reservation. The Rosebud—a small stream about 25 feet in width and averaging 18 inches in depth—runs through the reservation. One white settler has taken out a ditch from it on the reservation, and quite a number have been taken out north of the reservation between it and its junction with the Yellowstone. Tongue River is a few miles to the east of the reservation. There are quite a number of ditches on it and its tributaries. Tongue River flows into the Yellowstone at Miles City, a place of 2,500 to 3,000 inhabitants. Miles City would probably be a point as a base from which to make observations on the systems of irrigation used upon Tongue River.

STATEMENT OF PETER RENAN, U. S. INDIAN AGENT, FLATHEAD AGENCY.

On this Indian reservation there has been a drought never before experienced. The grass crop is an assured failure, and where there are no irrigation facilities the hay and grain and vegetable crops are also certain of failure. The water in the rivers and brooks is lower than it has been ever before known at this season of the year. Where irrigation has been furnished the crops look green and luxuriant; otherwise they are crisp and burned and will be a total failure.

A few years ago I succeeded in getting an appropriation from the Interior Department to divert a small portion of the waters of the Jocko River from its main channel to a vast plateau of rich agricultural land, which, if properly irrigated and cultivated, would furnish homes for hundreds of families. The amount (about $5,000) appropriated was entirely too small to construct a large ditch or canal, but I completed one of the following dimensions: Two feet deep, 3 feet wide in the bottom, and 4 feet wide on top. The ditch was necessarily constructed, until it reached the head of said plateau, through a rough and rocky cañon for a distance of about 2 miles, and required a good deal of fluming and blasting. The flume, like the ditch, is 3 feet in the bottom, of 2-inch plank; 2 feet high, of inch-and-a-half plank; bottom sills, 4 by 6; side pieces, 4 by 4; cap pieces, 2 by 6, all mortised and tenoned, and, like the ditch, I gave it a fall of one-quarter of an inch to the rod.

About 80,000 feet of lumber was used for the full completion of the flume and ditch, which was constructed along the foot-hills of the plateau for some 4 miles, making in all about 6 miles and covering the fields and farms of the Indian settlers in that locality. The principal work of this undertaking was done by Indians, with the exception of one or two white men who worked on the flume. The leveling, laying off, and engineering of the ditch were done by myself and a placer miner, both of us having had some experience in laying off ditches to mines in a homely way. However, it was successful, and the water runs smooth and rippling to the end. The rise from the river to the plateau was about 200 feet.

The ditch has been a source of water supply for irrigating purposes for the Indians along the line, and those who used it copiously have excellent crops this year, as well as every year since its construction. Unfortunately its capacity was too small for all who needed it, and failures in crops is the result to many farms along the line. The Indians were willing and anxious to earn wages, and the construction of the ditch furnished them profitable employment and was a means of encouragement to labor and also to keep them on the reservation and away from the whisky-drinking towns and the hunting grounds.

This ditch and flume should be greatly enlarged, as there is a never-failing and large supply of water in the Jocko River which could be turned into it all summer. There are also numerous streams and mountain lakes on this reserve which can be utilized for irrigating purposes at small expense, and the immense valleys and plateaus made to yield, without any fear of failure, good crops of all kinds of grain, vegetables, small fruits, and orchards, and to sustain thousands of human beings in one of the most lovely and picturesque countries the imagination can well conceive.

Experience and observation have shown in this country that lands upon which water can be supplied by means of ditches or canals are capable of being reduced to the highest state of cultivation without fear of failure from a season of drought. At present the system of irrigation on this reservation is primitive; but could it be made a possibility to tap the various streams and natural mountain reservoirs, which only await the expenditure of a small amount of money to send it over the plains and plateaus freighted with the richest fertilizing materials derived from decaying vegetation and the soils of the hills and mountains, the result would be to enable the tillers of the soil to gather home at the end of every season an abundant yield of cereals, vegetables, orchards, and meadow lands.

STATEMENT OF M. P. WYMAN, U. S. INDIAN AGENT, CROW AGENCY.

The Indians of this tribe have never practiced and know nothing of the theory of irrigation, save the little instruction received from the whites employed at this agency during the past three or four years. We have but one irrigating ditch on this reserve. This ditch is about 7 miles in length and was alone completed of surveyed ditches 36 miles in extent. The cost of this ditch was about $7,500. It irrigates several thousand acres. It requires constant repairing and most careful attention. I have in contemplation a system of ditches very extensive, but which are absolutely necessary to secure crops in the large and fertile valleys of the Big Horn, Little Horn, Pryor Creek, and the several tributaries of those streams. This matter will be fully explained to your committee on arrival here. On the irrigation of the lands held by the Crows rests solely the question of their self-support. This year there will be an almost total failure of crops. This is a source of great discouragement to the Indians, but such unfortunate events can only be prevented by proper irrigation.

STATEMENT OF C. A. OTIS, COLONEL TWENTIETH INFANTRY, U. S. ARMY, FORT ASSINIBOINE.

I have now been serving almost continuously in that section of country formerly known as the "Great American Desert" for the over period of twenty-two years. I have traversed considerable of that section between the Mississippi River and the Rocky Mountains from our northern international boundary line to the mouth of the Rio Grande.

Twenty-five years ago that portion of the same west of the 95th meridian of longitude was considered of little value for agricultural purposes because of aridity and also insufficiency or poor quality of soil, but a constantly-increasing rain-fall, apparently gradually extending westward, has demonstrated that the great plains and the valleys amid the mountain ranges need timely rains alone to cause them to produce abundantly. It is within the memory of many Minnesota citizens that to the westward of that timber belt which extends from the vicinity of Mankato to Duluth the land was parched and unproductive, and within my own experience that nothing but scanty bunch-grass and cacti grew on the uplands of eastern and central Dakota where now immense fields of grain are yearly harvested.

Like agricultural growth and improvement may be seen at a good distance west of Omaha and Topeka; also conditions to produce the same results in the central portions of the Indian Territory and Texas. The soil is found to be suitable for tillage and very productive in seasons of timely rains, and probably one-half, if not more, of the territory east of the Rockies would yield rich returns to the husbandman under the same conditions regarding sufficient moisture.

In the growth of crops irrigation compensates for the absence of rain. Intelligently pursued, it will cause the land of a dry climate to bring forth a greater increase than that situated within a region of ordinary rain-fall. This conclusion is based upon my slight experience and upon observation of the methods pursued by the Mormons of Idaho and Utah and by the people of Texas and Mexico. They use but little water, do not flood or deluge their land, but merely seek to create and retain the moisture needed. A diminutive stream flowing slowly along a narrow, shallow ditch serves to irrigate a large acreage as it gently and almost imperceptibly falls from the various points where the water is allowed to enter upon the fields. The land is, of course, carefully chosen with a view to systematic irrigation with the least amount of labor, and may consist of only a small fraction of a widely-extended plain—the much greater portion not answering well the purposes, although equally fertile.

By means of an extended system of irrigation a large percentage of our lands east of the Rocky Mountains now called arid might be brought under profitable cultivation, but the labor of construction and repair would be attended by a vast expenditure of money and would require many years for its accomplishment. I doubt not that it will be brought about very gradually by private enterprise, as population increases. Should the dry atmosphere of the plains and valleys of the West continue, Government aid judiciously applied to the public domain might accelerate the work, which should only be prosecuted in certain limited sections of the country at the same time. I think that the broad rich bottoms of the Yellowstone River and some of the bench lands which bound them will before many years be watered by means of large irrigating ditches constructed by private corporations, should no public assistance be extended. That stream is abundant and constant and the fall rapid. It offers numerous points from which needed water could be taken and stored. By selecting available points well up the stream it could be carried across some of the divides onto the deep fertile soil of the depressions, but agricultural industry at the present time is not sufficiently remunerative to justify so expensive a labor.

Almost the same remarks apply to the availability of the Powder, Tongue, and Big Horn Rivers. I understand that a project is now in contemplation to tap the Sun River above Fort Shaw and to carry water about 25 miles below into a large depression, formerly quite an extensive lake and a natural reservoir, from which a considerable area of land can be readily irrigated. Between the Missouri and the Maria's and the Milk River the average distance is probably 50 miles, over a length of more than 200 miles of excellent soil. The whole western half could be fed by the waters of the Upper Maria's or Cut Bank and Milk River and St. Mary's Lakes, where supply is inexhaustible, and the lower portion in all ordinary seasons by the Missouri, the tributaries of the Milk, and the streams from the small mountain systems. I have been informed that the practicability of a canal, to be supplied by the waters of the above-named lakes, following the general direction of the Milk River and entering the Missouri near the Bear Paw Mountains, has been discussed and stoutly maintained.

In a mountainous or broken country the rivers course through defiles, cañons, and along low rocky beds with sharply-defined rocky banks, rising to an elevation of from one to five hundred feet. Frequently above such gorges the banks broaden out widley, diverging for a considerable distance, and then again approach each other, presenting well-constructed basins for the storage of water, which can be utilized by closing the gorges. At such points, if stone and clay are abundant, dams can be readily constructed and ponds or small lakes be formed. The dams can be carried to the height of the banks, if desired, by adhering to the simple rule that the breadth of base must be three times the altitude. In Spain, I believe, they have been carried four or five hundred feet high. Stone is the only material needed in the open dam, and in the close one stone and clay faced with a good layer of clay and revetted with plank. A number of such reservoirs might be constructed along any river fed by mountain streams and lakes, be filled during the spring freshets, and the water stored for use in times of drought. Ordinarily, once filled, they would receive a sufficient constant supply from the usual flow to make up for evaporation and to meet actual demands. The water from these reservoirs might be carried off to localities where it is needed by means of open ditches, or be conveyed through pipe-lines, starting from the base of the dams if necessary, so that all the water of the reservoir could be utilized. During the high water produced in spring by the melting snows the surplus could be piped from these reservoirs many miles distant to natural surface depressions and large artificial lakes be formed, from which the surrounding country could be irrigated when crops demanded it. Where there are large natural basins considerably elevated and in a naturally rolling country with rapidly falling streams, they may be supplied without the aid of dams, using open ditches or pipe-lines for feeders, and taking the water a sufficient distance up the streams to insure a good descent. From such basins the adjacent lands could be irrigated, and the labor and expense attending this method are comparatively small.

But it is in the open prairie country, through which rivers course over muddy and quicksand bottoms and are confined by loamy banks in which the currents are constantly shifting, cutting away the soil upon one bank and making extended accretions upon the other, where the spring floods inundate the lowlands and the atmosphere of summer takes up the moisture from the lands and dries up the streams, that the most difficult problem as to the best methods of irrigation presents itself. The annual supply of water, taken in its entirety, is abundant. All the important rivers flowing from the Rocky Mountain ranges furnish yearly more than sufficient water to irrigate for the growing season all the intermediate lands. Their numerous forks and tributaries are interspersed over the face of the country with marvelous regularity and offer immense possibilities. The season of freshets must, however, furnish the water needed in periods of drought, which must be gathered and stored in some manner in adequate quantities to meet the great loss resulting from evaporation and to supply demands.

In the prairie country most of the rivers have low, distant banks, and when swollen flow with rapidity over slightly and gradually descending beds. The banks are so low and unstable, and the beds so insecure, that it is difficult to place obstructions which would permanently arrest the waters or divert with system any desired portion of them. Cross dams would be undermined or washed out, and, even if they were not, the river banks are too low to permit them to be raised to any useful height. The water must be taken from the swiftly-moving surface many miles above the selected places of storage. The difficulty in doing this consists in the nature of the banks, which, as soon as the currents should be drawn to them, would fall away and render useless contrivances to control the water. Stone walls or cribbing are worthless, unless solid foundation can be found and banks made secure.

I do not know of any contrivance or structure which would prove as effectual as the brush-wing dam projected into the river from 50 to 100 yards, forming an acute angle with the bank from which it is projected, so that the water eddying behind it would keep its level with the stream. The dam should be constructed of fascines from 12 to 16 inches in diameter and from 100 to 200 feet long, laid from three to six thick, stoutly fastened to each other, according to the volume of water and the strength of current, carried to the desired height, and securely pinned to large gabions firmly weighted, standing from 20 to 30 feet apart behind the fascines. The bank should be mattressed above, behind, and below the dam, to protect it against the currents and eddies; not with the Holland device, which fails on our rivers, but with fascines laid tight or with heavy brush strongly wired to firm stays or supports bedded in the earth.

This method is simple, and I believe is more likely to be attended with success than any other which has yet been tried. Our muddy rivers with quicksand bottoms can not be controlled by piles and crib-work. The Lower Rio Grande has thrown out the heaviest piles and strongest crib-work that the accomplished Mexican engineers could place and construct, but its course has been diverted, even at high water, by loose brush fastened to its banks.

This method, too, has the advantage of being economical, an important consideration, and especially so when it is remembered that these prairie water-courses are very unstable, that they sometimes cut new channels for long distances and entirely abandon the old ones, and that they continually shift their currents in their broad beds, and frequently make encroachments on one bank while they pile up the sandy loam upon the other. It will be seen, therefore, that expensive works designed to be permanent are liable to lose their value at some unexpected moment by these unnecessary caprices of the rivers and must be removed and reconstructed to be of further use.

I have spoken of the general character of these rivers. They occasionally flow through low, rocky ways, where water could be elevated by little labor and expense and made to flow out across the land; but this is exceptional. Respecting the Missouri, I do not know of a single instance of this kind below the forty-seventh parallel of latitude. The Lower Platte, the Kansas, the Arkansas, the Cimarron, the Canadian, and the Red Rivers are, I am confident, mostly without such gorges. There are numerous points where a single rocky bank is found, but it generally stands opposite extended bottom land. At these points powerful pumping apparatus might be placed, but the results to be obtained would not be satisfactory, considering the outlay involved and the expense of running, even if cheap fuel could be readily obtained.

Irrigation by means of artesian wells has been considerably discussed, but they would afford only an uncertain and, in most cases, an insufficient supply. No doubt communities and towns, as they increase in wealth and population, will experiment with them in the future as they have during the past few years, and will, if they are not located on important streams, look to them for the water which they require, but I believe that in the majority of instances these wells have been disappointing, either in the quantity or quality of water furnished. Judging from experiments thus far made, any extended and continued irrigation of lands by these means could not be reasonably expected.

In offering these suggestions, I have been under the impression that the subject referred for remark was limited to the most practicable methods of irrigating the land contained in what has been known as the dry or desert belt, and make them suitable for agriculture, and I have not discussed character of soil or climate. I may be under some misapprehension as to the intended scope of the inquiry, and I am not informed how extended is the field which the Senate special committee has under investigation. I am, however, of the opinion that conditions are favorable for remunerative agricultural pursuits in nearly all sections of this extended territory, could systematic irrigation be established.

These lands are destined to be thickly populated. Should an increased rain-fall not attend settlement—and the experience of the past few years would lead us to hope that it will—that population will secure and store, in some way, the waters of its rivers, its rains, and melting snows in sufficient quantities to meet its demands for necessary purposes.

STATEMENT OF J. H. PATTERSON, CAPTAIN TWENTIETH INFANTRY, U. S. A., FORT MAGINNIS.

By the term arid lands I take to be meant the country lying between the one hundredth meridian, the foot-hills of the Rocky Mountains, the forty-ninth parallel, and the Rio Grande River. Though familiar with the meteorological and topographical features of western Kansas, the Indian Territory, and western Texas, I purpose confining my remarks more particularly to that portion of the country referred to which lies north of the forty-sixth parallel and within the eastern and western limits before mentioned. I have had a very much longer service in Dakota and Montana than in either of the Territories farther south.

While the topographical features of the Great Plains are very much the same throughout its vast area, the mean annual precipitation differs as the physical features of particular localities differ. In the immediate vicinity of the larger and more permanent streams, such as the Missouri, Yellowstone, Platte, Arkansas, and Canadian Rivers, the rain-fall is much greater than at points but a few miles removed from the valleys through which said streams have found their way. The physical law that storms are apt to follow the course of flowing streams is a very noticeable feature of the meteorology of the Great Plains. While, for months, at Fort Assinniboine, during the drought of 1886, we had no rain, showers were frequent in the Missouri River Valley 40 miles south.

It is characteristic of the rivers which traverse the Great Plains that they are far below the level of country which rises to the right and left of the valleys or basins through which they flow. This physical feature is particularly noticeable as to the Missouri River. The difference of level is frequently hundreds of feet for miles of its course. It is only the larger and more important streams crossing the Great Plains that can be relied upon for a continuous movement in a dry season. The Missouri River is the only one north of the fortieth parallel. In the drought of 1886, so disastrous to the agricultural and cattle interests of Montana, all streams north of the Missouri River became dry.

With the above brief and, I hope, sufficient preamble, I proceed to the consideration of the practicability of applying irrigation to the arid lands situated within the boundaries which I have defined.

I do not think a general system of irrigation can be applied to the lands referred to, for the following reasons:

I do not think, as affecting large areas remote from the more permanent streams—Missouri, Yellowstone, Platte, Arkansas, and Canadian—a water supply can be obtained in midsummer months—when most needed—which will provide more than will suffice to irrigate the valleys to which said streams are confined. To make my meaning more clear, I desire to make a distinction between local and upland irrigation. By local irrigation I mean the irrigation of the lands located in the valleys or basins of streams; by upland irrigation, the irrigation of lands above and outside the river valleys or basins, where power must be employed to raise water to a height far above its natural level before it can be put upon the land to be irrigated.

The amount or quantity of land bordering the banks of a stream in proportion to the great body of land remote from the stream is almost infinitesimal.

The difference of level between the uplands and the stream from which the water must be taken presents an almost unsurmountable impediment to raising to the great height required the quantity of water necessary for the use intended. This physical impediment should not be overlooked. It will be found upon examination to be general.

To raise water from a stream to the high table-lands bordering its valley, resort must be had to the most powerful pumping machinery, and when done the area of land which can be irrigated will be so small in extent, as to the whole area of the arid lands tributary in drainage to the streams, as to make the effort almost valueless, as affecting the increased fertility of the section of country requiring irrigation.

It has been urged that, by a system of great tanks or reservoirs and great ditches, water can be carried for long distances. What as to the labor required to collect water upon the high table-lands in quantity sufficient to irrigate, say, 20 miles square, and what of the 50 to 100 miles of ditching necessary to distribute the water over so comparatively small an area? I doubt if there is any place on the Great Plains where water can be carried over the surface in open ditches for the distances necessary to irrigate a section of country 20 miles square; that is, where the water is supplied other than directly from a constantly running stream like the Missouri. The question is one of supply more than of flow. I doubt if sufficient water can be tanked on the upland to furnish such supply.

To cover a perfectly flat surface 1 mile square with water to the depth of 1 inch will require 13,939,200 gallons, or 2,234,466 cubic feet. The Croton Aqueduct, by which the city of New York receives its water supply, can deliver 115,000,000 gallons a day. A ditch with the capacity of the Croton Aqueduct will supply only sufficient water to cover about 8 square miles of perfectly flat country 1 inch. Question: How many tanks of the capacity of the Croton Aqueduct will be required to make any considerable increase in the fertility of the arid lands if 1 inch of water in the whole season would be sufficient?

A very large portion of the water which passes into an irrigating ditch is lost en route by absorption; therefore, while absorption by the soil it passes over is desirable, when the water is to be applied I think that its loss en route will materially diminish the amount which reaches its ultimate and intended destination. The question of loss by evaporation while en route for long distances in open ditches, exposed as it must be to the direct rays of the sun in midsummer and the excessive dryness of the air peculiar to the climate of the Great Plains, is not an unimportant consideration in determining the practicability of upland irrigation.

I made at Fort Assinniboine, in the summer of 1886, some simple tests as to the effect of the exposure of water. A vessel containing 4 inches of water in depth, exposed for twenty-four hours to the sun and air, was entirely evaporated. I am therefore of the opinion that through the influences of absorption and evaporation it will be impossible to carry a sufficient quantity of water in open ditches for great distances except by a water-way of such capacity as precludes the possibility of its construction other than by the labor of years and the expenditure of millions of money, making a new stream, as it were, to be applied as other streams to local irrigation.

That there are thousands of localities of small area along the valleys of streams where but one blade of grass now grows two can be made to grow by irrigation I do not doubt; but when such localities are found they can be reclaimed by private enterprise without going in for "the old flag and an appropriation."

I suggest the thought that, in the Northwest particularly, a variety of agricultural products is more dependent upon the mean temperature than the mean precipitation. I take my stand upon the statement that, as applied to great distances from the source of water supply, such as the Missouri, Yellowstone, Platte, Arkansas, and Canadian Rivers, any attempt to carry water by means of open ditches for great distances is entirely and hopelessly impracticable.

The dip of the Great Plains is to the east. It will be remarked that the main streams discharge their waters in the same general direction; that the smaller streams which drain the Great Plains have more of a north- and south direction. This will emphasize a point I desire to present, that, as the land recedes from the larger streams to the north and south, the altitude of the land with reference to the streams from which it recedes increases; therefore the attempt to carry water by irrigating ditches in a direction other than parallel to the course of the stream from which the water supply is taken presents difficulties as to increasing height of level not easily overcome.

It will be observed that I omit mention of all mountain streams proper, which discharge their waters into the larger streams crossing the Great Plains. Local irrigation can be applied to such mountain streams without difficulty. Uplands below the level of the source of such streams can also be irrigated from them to a distance conditioned upon the water supply, and where the flow can be turned into the bank. I include all such lands among those I have mentioned as favorably located for local irrigation.

In discussing the question of the irrigation of the arid lands I have endeavored to be as concise as possible, and may have erred in that particular. I have been placed at a disadvantage in not having at hand any books of authority or reference to which I can refer. I have therefore been compelled to rely upon what some may call mere assertion, though what I have stated to be my views is the result of my conviction predicated upon observations and not a little thought and reading.

Whatever way my opinions may be received I will abide the event with watchful interest. If the proposed attempt is made, it can be done only at a most fabulous and startling expense. I believe it will fail where applied to other than local irrigation, a work which the parties interested can prosecute without Government assistance, and that every physical law which applies to the wisdom of such an undertaking condemns it.

STATEMENT OF P. F. HARVEY, CAPTAIN AND ASSISTANT SURGEON, U. S. A., FORT KEOGH.

Experience has amply demonstrated that the soil of Montana and Dakota possesses the inherent properties of fertility to such a degree that all products suitable to this climate can be produced therein in the highest degree of perfection if sufficient water is supplied to them. The plains will not yield full crops more frequently than once in five to seven seasons by natural rain-fall. There is a plentiful supply of water in the existing water courses, and the only problem that presents itself is as to how that supply shall be distributed. In my opinion and from my observation irrigating ditches afford the speediest, most efficient, and most economical means. Various systems of ditches have been used, differing with the topography and needs in each case. Usually short ditches are in vogue, covering the valleys in the immediate vicinity; but the slope of the country is so great that, by commencing near enough to the headwaters of main streams, the plateaus back of the valleys lower down the stream could readily be supplied. In my opinion the correct system, without entering into details, is the preliminary construction of dams at suitable sites and the subsequent tapping of such dams by ditches, and not by building reservoirs. The latter would be apt to be swept away by sudden deluges of rain, common all along this parallel of longitude. Dams could be built which would allow the high water to flow over them and out of the artificial channels.

STATEMENT OF CHARLES BENTZONI, CAPTAIN TWENTY-FIFTH INFANTRY, U. S. A., FORT SHAW.

My experience in irrigation is rather limited, being mainly derived from my observation for a number of years of the system in use in Mexico and that part of our own country bordering on it. There the belief is that crops may be made to grow on any kind of soil if it is properly irrigated. And my experience in the Southwest, as well as here in the extreme North, where irrigation is being rapidly developed, certainly bears out these assertions. But during my ten years' service in the large tract of country embraced by the Rio Grande, Pecos, and Devil River, in Texas, between 1870–'80, I have often theoretically worked out plans for reclaiming these great stretches of arid lands. My conclusions were, and are now, that by a system of reservoirs and irrigating canals all these great plains can be brought under cultivation. By thus distributing the water and by a judicious system of arboriculture, I have no doubt the rain-fall will soon be increased; and, while I may not live to see it, the time will come when a large population will inhabit what are now nearly useless plains and valleys. Of the technical part of the subject I know too little to warrant any suggestions; but whenever I see a reference to the difficult problem of convict labor I always think that in the carrying out of such a system of improvements here under consideration all such labor could be made useful and productive without coming in competition with what is termed "free labor."

Adjourned.

ON TRAIN AT BUTTE CITY, MONT.,
August 10, 1889.

The committee met pursuant to call of the chairman.

Present, Messrs. Stewart (chairman), Jones, and Reagan; also Director Powell.

STATEMENT OF H. M. WILSON, OF THE U. S. GEOLOGICAL SURVEY.

The **CHAIRMAN**. What is your occupation?

Mr. **WILSON**. Engineer in the U. S. Geological Survey.

The **CHAIRMAN**. Have you been engaged in a survey on the Sun River in Montana?

Mr. **WILSON**. I have been on the Upper Sun River in Montana looking for sites for storage reservoirs.

The **CHAIRMAN**. Will you explain, in your own way, the topography of the country, the sources of water supply, and the land to be irrigated on the Sun River?

Mr. **WILSON**. I prefer to begin with the land to be irrigated. I find that there is an area of bench lands, approximately 50 miles east and west and 25 miles north and south, within the boundaries of the Teton and Sun Rivers and the Rocky Mountain Range and the Missouri River, that could be irrigated if the water could be had. There the bench lands are from 400 feet to 500 feet above the river bottoms, and have a general slope from the Rockies on the west toward the Missouri on the east, which slope is roughly estimated at about 100 feet in 6 miles. The bench lands I have described, between the Teton and Sun Rivers proper, are the finest agricultural land that can be found in Montana. The soil is warm, just enough sand in it, and is sufficiently high to give good subsoil drainage. There frosts do not come so early in the fall nor are they so late in the spring as in the bottom lands, and this land, when water is applied to it anywhere, will raise from 3 to 4 tons of blue-joint hay to the acre. That is the finest hay that is raised in Montana. And the land will raise abundant crops of grain and potatoes and all kinds of vegetables. I can give you the figures: 35 to 40 bushels of wheat to the acre and 3 tons of timothy.

Estimating roughly, these sections contain about 700,000 acres of excellent land that can, most of it, be irrigated. I would not like to state that the whole of it can be irrigated until after the surveys shall have been completed. But at the present time I am inclined to think that there are 700,000 acres of fine agricultural land on those benches that can be irrigated.

West of this land, which, as I said, runs back 50 miles from the Missouri, the bench is of the same topographical character, but the soil is more rocky and I am inclined to think it is not of much agricultural value. But it is of the highest value as grazing land; and to-day it is stocked to its fullest capacity with sheep and cattle.

This grazing belt extends from 10 to 30 miles farther west to the foot of the Rocky Mountains. In the mountains rise the Sun River on the south and the Teton on the north. They have their heads at the summit of the Rocky Mountains west of this bench.

The Teton River does not carry a tenth of the permanent annual volume of water that the Sun River does, as it rests against the foot of the Rockies; but it carries a considerable volume in the spring; whereas the Sun River, having long branches through the Rockies heading around the Teton and Dearborn on the south, has a very large annual flow;

therefore its flood height is proportionately greater. At present, though, this is claimed by every one to be the dryest season known in Montana since it has been inhabited, and the Sun River carries about 260 second-feet of water (meaning 260 feet of water per second), which is approximately 10,000 miner's inches. But very careful measurements of the ordinary flow of water in this river show that it probably carries some 5,000 second-feet during 25 days of flood; and it goes very much higher than that during a few days in each year, and for a number of days lower. But it is never lower than the minimum given, 260 cubic feet per second. I have roughly estimated that the annual flow of this stream is 700 second-feet.

The **CHAIRMAN**. That is the average through the year.

Mr. **WILSON**. I have roughly estimated it—it is a guess; that is, the amount of water that is in that river; and if it could be all stored during the ten months outside of the regular irrigating season it would be equivalent to 400,000 acre-feet. An acre-foot is a cubic foot of water over the surface of an acre of ground, and there are 43,000 odd acre-feet to an acre. I have not yet examined the various branches of the Sun River that head in the Rockies, but I am inclined to think their capacity might be nearly equal that of the main branch just described, making altogether a total of 800,000 acre-feet flowing there ten months, could it all be stored. But it must be remembered that a large percentage of this volume will be lost by seepage and evaporation before reaching the point at which it would be utilized.

Senator **REAGAN**. Are those the tributaries of the Sun River?

Mr. **WILSON**. My measurement was above the forks.

Senator **REAGAN**. That is above the tributaries?

Mr. **WILSON**. Yes. The estimates given heretofore of the capacity of the Sun River are the result of measurements at the cañon mouth above the main tributaries just spoken of.

The **CHAIRMAN**. Are the tributaries mentioned of sufficient altitude to join the main river at any point so that they can be taken on to the table land?

Mr. **WILSON**. I am speaking of those tributaries at the head of the mountains, starting above the land which I have given as my lowest reservoir, the one from which the main canal taking this water on to the bench will be taken. Of course, there is an immense amount of water which falls on this bench below this point. The benches are 80 miles east and west of the water, and of the water that falls on them I have not made any estimate.

The **CHAIRMAN**. Where you describe the water as a foot deep, is it a foot deep for once a year?

Mr. **WILSON**. Once a year. That is ordinarily estimated to be the amount of water necessary to be put on. Twelve inches of water added to the natural precipitation on these agricultural benches which will be irrigated is probably enough in this climate to irrigate the crops.

The **CHAIRMAN**. Does it not require more water to irrigate the first few years than it does afterward?

Mr. **WILSON**. It will require more. That has been my previous experience and observation of irrigation. My previous experience and observations have been in California, and they can reduce the amount of water necessary to irrigate a foot of land nearly one-half in three years.

The **CHAIRMAN** Now, in conclusion of the whole matter, do you give it as your opinion that it is possible to irrigate the bench land which you have described from the sources of water supply you have referred to?

Mr. **Wilson**. I will give you that in detail now. I have shown that you have 800,000 acres of irrigable land, and that from the mountains alone can be obtained nearly 800,000 acre-feet of water annually. It now becomes necessary to describe whether that water can be stored and how much will be lost by evaporation and seepage.

I am convinced from reservoir sites that I have already described and have surveyed on the main fork of the Sun River, that all of the water on those benches can be stored. At present some of it might have to be stored on the bench near Great Falls, or what is known as Benton Lake. To reach it the amount lost by seepage and evaporation will be considerable. But I am in hopes that other reservoir sites will be found in the mountains of sufficient capacity to store the total amount of the flow of the stream. From a hasty reconnaissance of the South Fork and other forks of the Sun River, I believe that reservoir sites can be found to store all the water from those falls.

The cost of constructing the few reservoirs that I have already examined will be relatively low, ranging from $10,000 to $40,000 apiece, each having a storage capacity of from 500,000 to 700,000 cubic feet—a storage capacity of from 10,000 to 12,000 acre-feet apiece.

The **Chairman**. Will you describe some of your reservoir sites that are regarded as specimen sites?

Mr. **Wilson**. One of these reservoirs, which I would estimate to cost perhaps $10,000, would be constructed where the river flows through a narrow rocky cañon 200 feet wide, above which is a flat basin capable of holding, with a dam 60 feet high, about 20,000 acre-feet of water. Because there happens to be a natural waste-weir from this dam is the reason it can be constructed at so low a figure.

The **Chairman**. State what you mean by a waste-weir and its purposes.

Mr. **Wilson**. A waste-weir is a broad channel the height of the dam, over which the flood volumes of water would be carried, thus saving the danger of its falling over the dam itself; it is a necessary and consequent expense of a dam.

The **Chairman**. How must a dam be constructed to allow the water to fall over it? What kind of construction would you require?

Mr. **Wilson**. The opinion among engineers differs very greatly.

The **Chairman**. We do not expect details; but state what are the general protections against undercutting.

Mr. **Wilson**. Dams must be constructed in the most substantial manner, of the best masonry work, and the slope down-stream side should be relatively great. The bottom of the overfall, the foot of the dam on the down-stream side, should be well paved with masonry, to save the foot of the dam from undercutting by overflow.

The **Chairman**. What may be substituted for that?

Mr. **Wilson**. You substitute a waste-weir for that.

The **Chairman**. How could it be constructed where you have an ample waste-weir, so that no water could flow over the dam?

Mr. **Wilson**. A dam of this character in a flat stream may be more cheaply constructed after having taken the necessary precautions of a puddle-bank. A dam of the character mentioned, and of a height of 60 feet, should be constructed of rock. It is not thought necessary that this should have submasonry; a core or center running the height of the dam, and made of some good clay-earth which would be impervious to the passage of water, should be constructed with the dam.

The **Chairman**. Running up in the center of the dam?

Mr. WILSON. The dam built up with a wall through the center. It might be masonry. I am considering in this case that the puddle might be sufficiently good if you had a dam only 60 feet high. I have not looked into the matter sufficiently to know, and before making such a statement I would like to go into the calculations to know whether it would stand it. I am stating my impressions. The loose rock necessary to construct the bulk of the dam can be blasted out of the sides of the cañon adjacent to its abutments, and the canal from the lowest of these reservoirs can be constructed in the cheapest manner through earth, and will be 8½ miles long to reach the summit of the bench between the Teton and Sun Rivers, when it can be carried upon the entire area described as irrigable land. Such a canal, to carry 800 second-feet of water, would not cost over from $3,000 to $5,000 a mile. Should it be found that all this water can not be stored in reservoirs on the river just described, the surplus can be carried into what is known as Benton Lake, situated on the summit of the bench 8 miles west of Great Falls. This lake is all drained by a gate, which has been constructed by private parties at a cost of $1,000. It can be made to store the water of a given area ot 40 square miles to an average depth of 20 feet, and probably with a capacity of 400,000 acre-feet.

The CHAIRMAN. In addition to this—outside of the works that you have described—have you noticed in this vicinity, or in other vicinities which you have examined, small streams and ravines that sink in the valleys, where there are opportunities for making small storage works to bring the land in their basins under cultivation?

Mr. WILSON. I have made a list of twenty-five such.

The CHAIRMAN. In this vicinity?

Mr. WILSON. In other parts, within a hundred miles of that neighborhood and 100 miles south of Great Falls—between there and Livingstone. Each of these twenty-five will store from 10,000 to 30,000 acre-feet of water, and each, I am inclined to think, can be filled. I think that sufficient water will be found to fill them.

The CHAIRMAN. If that should be the case, that will bring under cultivation how much land?

Mr. WILSON. All that is good agricultural land below. They would reclaim 15,000 acres apiece.

The CHAIRMAN. And there are twenty-five of them?

Mr. WILSON. Yes; I give it from 10,000 to 20,000 acre-feet.

The CHAIRMAN. The expense of doing that would be very great.

Mr. WILSON. Not very great. It is, relatively speaking, extremely small. This can be done only in a great way.

I wish to make a remark on another point. Private parties in the Territory of Montana, where they expected to make 200 per cent. per annum on their money, concluded that they could reap a good harvest by constructing works themselves without Government aid of any kind. Such works have been constructed on Dearborn River, and I wish to explain to your committee that such works are being constructed by the Sun River Canal Company and the Benton Lake Company, and I have no doubt that ultimately private parties will construct all these works and make good profits.

Adjourned.

MISSOULA, MONT., *August* 11, 1889.

The committee met pursuant to call of the chairman.

Present: Messrs. Stewart (chairman), Jones, and Reagan; also Director Powell.

STATEMENT OF FRANK H. WILLIAMS, OF MISSOULA

The **CHAIRMAN**. How long have you resided in Missoula?

Mr. **WILLIAMS**. Thirty-odd years.

The **CHAIRMAN**. What is your occupation?

Mr. **WILLIAMS**. Attorney at law.

The **CHAIRMAN**. We would like to have you explain the situation in this country.

Mr. **WILLIAMS**. In reference to Bitter Root Valley proper, which is some 60 or 70 miles in length and varying in width from 4 to 12 miles, I would like to say that there is in that part at the present time sixteen townships, and two-thirds of the land in those sixteen townships is surveyed. Probably one-half of the surveyed portions of these sixteen townships has been entered under the various land laws of the United States, with probably not more than one-fourth of this entered land under cultivation. But the entire area of land in that valley under cultivation is cultivated by means of irrigation.

The **CHAIRMAN**. About how many acres would that be?

Mr. **WILLIAMS**. It would be almost impossible to form an estimate of how much land that would be without getting at some data.

The **CHAIRMAN**. Equal to one entire township?

Mr. **WILLIAMS**. Oh, yes; it is equal to four townships.

The **CHAIRMAN**. That is actually under cultivation?

Mr. **WILLIAMS**. There are four townships under cultivation. These lands are irrigated from lateral streams putting into the Bitter Root River, and four or five ditches which are now constructed from the Bitter Root River. A portion of the land is waste land, rocky and broken; but there is an area of land on the east of the valley-upper bench land, we term it, agricultural land, but entirely worthless at the present time for the reason that there is no water.

The **CHAIRMAN**. What is the area of that land?

Mr. **WILLIAMS**. Three or four townships. Taking it from the stream called Woodchuck to the upper end of the valley there are probably six townships. It is good land, but it lies too high to get water onto it without going to great expense.

Now, in Bitter Root Valley, if a ditch were taken out there some 10 or 12 miles in length it would cover this land. Some parties were there two or three years ago looking at it with a view to taking out a ditch, but the matter fell through. This land that is not now cultivated for the want of water is some of the best land in that section of the country. The warmest and most productive land in this section of country is on these foot-hills—this bench land. The Bitter Root River furnishes a large supply of water, and there is enough to irrigate the entire valley and leave water in the spring.

The **CHAIRMAN**. Are there any valleys on the branches of the Bitter Root above here?

Mr. **WILLIAMS**. Yes, a few valleys; but where there are small valleys on the streams tributary to the Bitter Root, they do not get enough water out of the streams for the irrigation of the land lying on each side of the stream for some distance. But the land lying back from the streams and upon the benches is destitute of water and is now vacant.

The CHAIRMAN. Is there much land of that character?

Mr. WILLIAMS. There is considerable land of that character.

The CHAIRMAN. Have you ever considered the practicability of storing water and irrigating the land on the benches?

Mr. WILLIAMS. I have to some extent, but I reckon that would depend upon the topography of the country. There are some cañons in these mountains, but they are abrupt, and it would be difficult to get places to store water. But there are some places where, if proper reservoirs were built, if dams were built across them during the high season of water, you could get enough to last throughout the entire season.

The CHAIRMAN. Have you been higher up on those streams where they head to ascertain whether or not they head in flats and basins?

Mr. WILLIAMS. I have not been on those streams myself; but I have seen persons who have been, and they say there are a number of streams lateral to the Bitter Root River; and I know from observation of those mountain lakes that if there were some protection in the way of embankments built across their outlet they would form very large reservoirs. I have an instance in my mind in Deer Lodge County. There is a lake there, and for purposes of mining they built a dam across the mouth of it, and they got a large amount of water which they use during mining seasons.

The CHAIRMAN. Without going into detail, from what you have seen state whether you would think it would be useful to have the tablelands of this country on both sides of the valley surveyed with a view to ascertaining whether there was an opportunity of getting water onto them, the cost of doing that at different points, and to have them mapped and pointed out.

Mr. WILLIAMS. I think so.

The CHAIRMAN. Do you think there would be opportunities for individuals to combine to make farms if they knew what the country contained?

Mr. WILLIAMS. I do not think there is any question of it. This tract of land that I speak of on the east side of the Bitter Root Valley is lying vacant because individuals can not take the water up to it.

The CHAIRMAN. How much would it cost to take the water up there?

Mr. WILLIAMS. That is something I do not know anything about.

The CHAIRMAN. How many miles long would the ditch have to be?

Mr. WILLIAMS. If you took the water from the river the ditch would have to be 10 or 12 miles at least.

The CHAIRMAN. How many acres would it cover?

Mr. WILLIAMS. Five or six townships, and of the very best land in the valley.

The CHAIRMAN. In six townships you would have considerably over 100,000 acres. Now, you say you could get water to that land by constructing a ditch 10 or 12 miles long?

Mr. WILLIAMS. I think from 12 to 15 miles—you might put it at 15 miles.

The CHAIRMAN. If you could put water onto that land for $200,000 it would be cheap, would it not?

Mr. WILLIAMS. I think so.

The CHAIRMAN. What is the land which is under cultivation worth there?

Mr. WILLIAMS. It is worth from $10 to $15 an acre.

The CHAIRMAN. Is this other land that you speak of good if it had water on it?

Mr. WILLIAMS. It is equally good.

The CHAIRMAN. Would an average of $20 an acre be about fair?

Mr. WILLIAMS. I do not think it would be too high if there was sufficient water to irrigate both.

The CHAIRMAN. If this land were surveyed so that you could know what to do, are there opportunities where a few men could combine to store water, or could a single individual store water enough to irrigate 50, 100, or 500 acres of land on these benches?

Mr. WILLIAMS. I do not think there are, because all the water supplies are appropriated.

The CHAIRMAN. Is there any water stored here?

Mr. WILLIAMS. No.

The CHAIRMAN. What proportion of water runs to waste, taking the year round?

Mr. WILLIAMS. From the middle of May until the 1st of July, while the snows are melting, there is probably four-fifths of it goes to waste.

The CHAIRMAN. You irrigate here pretty early, do you not?

Mr. WILLIAMS. Yes.

The CHAIRMAN. Are there many small streams from which you could irrigate your farms at the right time if you had stored all the water that comes down them?

Mr. WILLIAMS. Of course there are streams 4 miles west of here in which, during ordinary years from the middle of May until the 1st of July, there is a great body of water which goes to waste. After that time there is only enough to irrigate a limited number of farms. If the water that goes to waste down those streams from the 1st of May could be stored, so that it could be used, it would irrigate a large amount of land that is now idle. And there are fifteen farms that could be irrigated by this creek that are idle to-day because there is no water. We have the water and the land, but we can not get them together.

The CHAIRMAN. If you have water-sheds and land to be irrigated, nature has provided some way to save the water so that you can get it upon the land. Do you think surveys to ascertain what may be done would be useful?

Mr. WILLIAMS. Yes. As I stated before, if reservoirs were built on those streams to catch the water from the melting snow and store it up until late in the season there would be an abundance of water to irrigate the land.

The CHAIRMAN. What is your irrigating season?

Mr. WILLIAMS. From the 1st of May until the middle of July. Of course meadow land they irrigate earlier.

The CHAIRMAN. What is the effect of irrigation in the way of producing crops in this country where irrigation has been practiced?

Mr. WILLIAMS. Irrigation depends entirely upon where we can get the water. With it we produce the finest kinds of crops, and without it nothing at all.

The CHAIRMAN. You can not farm without irrigation?

Mr. WILLIAMS. Except on a few lowlands. The great bulk of our land would be worthless for agriculture without irrigation.

The CHAIRMAN. On the lowlands where there is moisture from seepage you can raise some crops; but there is not sufficient rain-fall at the time the crops are matured to produce good crops.

Mr. WILLIAMS. We have a rain-fall in the spring; but to do away with irrigation there is not enough rain-fall. The rain that falls soon dries out, and if we have not enough water with which to irrigate the crops dry out.

The CHAIRMAN. What would be good crops of barley, oats, and wheat in this country?

Mr. WILLIAMS. I do not know much about barley, but oats here will range from 50 to 70 bushels to the acre, and the wheat will run as high as 50 to 60 bushels and down to 25 and 30 bushels.

STATEMENT OF W. J. STEPHENS, OF MISSOULA.

The CHAIRMAN. How long have you resided in the town of Missoula?

Mr. STEPHENS. Since 1870.

The CHAIRMAN. Has your attention been called to the subject of irrigation?

Mr. STEPHENS. It has.

The CHAIRMAN. State any facts you think would be of interest to the committee.

Mr. STEPHENS. I will state a few facts. In my opinion what we need most is something to start with, perhaps private capital, in storing the water, and to do that a knowledge of the water-sheds of the country is absolutely necessary. But men who have the means do not like to spend their money for the purpose of investigating. But if there were a method devised for storing the water, these business men might use their capital. Hence, if we were aided by a survey, so that the people would know the true condition of our mountains, private capital might take hold of this enterprise, and we could have the water stored without the aid of the Government.

There is another thing. On what we call the west side of the range of mountains most of our streams head in lakes. I venture to say that if you will follow the heads of our streams you will find they merge into swamps, and then form into lakes in the mountains. These lakes invariably have an outlet. This outlet passes under ground, the water seeps away under ground, and does not flow away on the surface to enlarge our rivers. This water which goes under ground would have to be raised somewhat, and if these lakes were investigated and it were ascertained how this water that percolates under ground could be got onto the surface, we could store that water, and could even run it into our streams and use it by ditches. Take this stream, the Rattlesnake, which flows right down here by this town. That creek flows off about four-fifths of the natural water-shed, and no person has attempted to store it, because there has not been a sufficient investigation of the condition of things above. From, say, May, June, and July, that stream runs as a torrent and passes off.

The CHAIRMAN. Do you know anybody who has been up that stream and explored its source? Have you ever done so?

Mr. STEPHENS. I have not been up except for some little distance. There are some persons who have been up it.

As illustrating this matter, I will say that I am part owner of a mining ditch in Deer Lodge County. We sought to build a reservoir above that ditch, and we put a dam in front that would run the water back a mile. But we were under a lake, and the great difficulty with us was this: We wanted the water from that lake, and we thought if we could get the water of that lake so that it would not percolate through the ground under our ditch we could save it. But it would percolate through the ground.

STATEMENT OF CHARLES WINTER, OF MISSOULA.

The CHAIRMAN. What is your occupation?

Mr. WINTER. I am a farmer.

The CHAIRMAN. Where do you farm?

Mr. WINTER. Three miles out of Missoula.

The CHAIRMAN. How long have you been farming?

Mr. WINTER. About three years.

The CHAIRMAN. What was you occupation before that?

Mr. WINTER. I dug ditches for different farmers and have worked in the mines in different places.

The CHAIRMAN. Are you familiar with the country on each side of the river far back?

Mr. WINTER. I am.

The CHAIRMAN. Have you traced any of these streams that are tributary to the Bitter Root?

Mr. WINTER. Yes; a great many of these streams.

The CHAIRMAN. To their sources?

Mr. WINTER. Yes.

The CHAIRMAN. What opportunities have you found above where dams could be constructed for storing water?

Mr. WINTER. After you get to the heads of these streams they flatten out. The heads are on the summit of the mountains, and there would be no place there for a reservoir. The summit of the mountains are flat and the soil there is boggy, and they are small places.

The CHAIRMAN. And the snow falls very deep there?

Mr. WINTER. The snow falls very deep.

The CHAIRMAN. And lies there a considerable time?

Mr. WINTER. Until June or July.

The CHAIRMAN. If you made reservoirs there, there would not be much evaporation?

Mr. WINTER. The summits are flat and level, and they would overflow.

The CHAIRMAN. Did you ever see places selected by mining men for reservoirs? Do you know they often select the top of a knoll?

Mr. WINTER. Sometimes high up, but generally they are down in a gulch.

The CHAIRMAN. A ravine is not a good place for a reservoir, is it?

Mr. WINTER. No. That is the trouble with these places. You must go on the mountains.

The CHAIRMAN. Why not go on the mountains at first and get less evaporation. If you can store water there it is just as good?

Mr. WINTER. But you would lose a good deal of that water. It would seep and run below. It comes out several hundred feet below, in the cañons.

The CHAIRMAN. There are places up there to store the water?

Mr. WINTER. There are places there; but you could not do it without considerable waste.

The CHAIRMAN. Some would waste, perhaps.

Mr. WINTER. A good deal would waste.

The CHAIRMAN. How many streams have you traced up to their source?

Mr. WINTER. The Rattlesnake and Grand Creek.

The CHAIRMAN. What did you find at the head of Grand Creek?

Mr. WINTER. A lake.

The CHAIRMAN. How much of a lake?

Mr. WINTER. A mile and a half wide, and probably a mile and a half long.

The CHAIRMAN. Has that much of a water-shed?

Mr. WINTER. There are mountains on both sides.

The CHAIRMAN. How deep is the lake?

Mr. WINTER. That I do not know.

The CHAIRMAN. Is it a deep lake?

Mr. WINTER. It appears that way.

The CHAIRMAN. Suppose you were to put down a tunnel into it to draw the water up and then construct a dam with gates, would that furnish water at the right time for irrigating?

Mr. WINTER. I should think it would at the proper time. I do not know that it would drain dry.

The CHAIRMAN. It has a water-shed and some water could get into it.

Mr. WINTER. Some water would get into it; but it would overflow into this creek.

The CHAIRMAN. But you would stop the overflow by damming it?

Mr. WINTER. Yes.

The CHAIRMAN. But no one has done it?

Mr. WINTER. There is no one in my country to do it.

The CHAIRMAN. Have you ever estimated the cost, to be able to say how much a man must be worth to do something of that kind?

Mr. WINTER. I have not. I have done some of it myself, on a small scale.

The CHAIRMAN. Have you ever been up the streams on the other side?

Mr. WINTER. No; not much.

The CHAIRMAN. How much water at one time would it take to irrigate the land here—10 inches or a foot?

Mr. WINTER. I should say 300 or 400 inches of water.

The CHAIRMAN. To what depth would you put it on?

Mr. WINTER. If we leave the water on one night that would be enough.

The CHAIRMAN. That is, once a year?

Mr. WINTER. Twice a year.

The CHAIRMAN. Six inches would do that—1 inch, 2 inches; so long as the ground is covered would be sufficient. You calculate by miner's inches?

Mr. WINTER. We do, generally.

The CHAIRMAN. How many miner's inches for an acre?

Mr. WINTER. I should think 20 miner's inches would cover an acre of ground in a night—10 miner's inches would.

The CHAIRMAN. I do not mean for a night, but for a year. How many miner's inches would you want for a year?

Mr. WINTER. Four hundred inches would irrigate 160 acres of ground for a year. But that would irrigate several farms.

The CHAIRMAN. In California they calculate that it will take a miner's inch to irrigate an acre, and they can have as many acres of land under cultivation as they have miner's inches of water. They have gone on and have found by economizing the water, putting it on the land at the proper time, as in San Diego County, that they could do with less—a tenth even.

Mr. WINTER. We always calculate 1 inch. What I am speaking of is the 400 inches to 160 acres. Ten farms could use that water. I would use it one week and my neighbor the next.

The CHAIRMAN. That would be 1,600 acres, would it not?

Mr. WINTER. Yes.

The CHAIRMAN. And that would be a fourth of a miner's inch to the acre?

Mr. WINTER. I probably put that too low. They cut it down one-tenth. A small stream of water has no effect; it does not spread. It takes at least 300 or 400 inches of water to spread over that body of land. Then I would give it up and another ranch would take it.

The CHAIRMAN. What do you raise on your farm?

Mr. WINTER. Wheat and oats.

The CHAIRMAN. What is a good crop of oats?

Mr. WINTER. From 50 to 75 bushels.

The CHAIRMAN. Is that regarded as an average good crop?

Mr. WINTER. Yes.

The CHAIRMAN. How about wheat?

Mr. WINTER. Twenty-five to fifty bushels—sometimes 60 bushels. But the average crop of wheat is 40 bushels to the acre.

The CHAIRMAN. Do you raise potatoes?

Mr. WINTER. Yes.

The CHAIRMAN. How many potatoes will an acre produce?

Mr. WINTER. Five hundred bushels.

The CHAIRMAN. Have you ever known that to be done?

Mr. WINTER. Yes; I raised that many myself last year.

The CHAIRMAN. What do you say in regard to fruits?

Mr. WINTER. Some fruits are good. Apples grow well. Berries also do well—such as gooseberries and currants.

The CHAIRMAN. How about plums?

Mr. WINTER. They do well.

The CHAIRMAN. How with regard to pears?

Mr. WINTER. I do not know anything about pears. We have not had much experience with pears. But there are some gentlemen here who have orchards who can explain.

The CHAIRMAN. You raise almost everything here?

Mr. WINTER. Yes.

STATEMENT OF E. BRYANT, OF STEVENSVILLE.

The CHAIRMAN. How far is Stevensville from here?

Mr. BRYANT. Twenty-six miles.

The CHAIRMAN. What are the general boundaries of this county?

Mr. BRYANT. I believe it is bounded by mountain tops, so far as I know.

I wish to speak for a class of poor men. I represent that class of men. Though we have not as much brains as we ought to have, and no money at all, some of us do a good many hard day's work. I live in a vicinity where there are, perhaps, twenty ranches that are entirely out of water this year, and none of us are raising anything at all. Realizing the necessity of water I individually made a survey from our neighborhood up to the Bitter Root River, and found that it would take a ditch at least 22 miles long, and then it could be continued 22 miles further down to where it would then accommodate fifty farms.

The CHAIRMAN. Containing how many acres of land?

Mr. BRYANT. I could not tell the number of acres. Most of them there would have 160 acres.

As I was surveying, some of the men came to me and said they wanted 160 inches of that ditch when the ditch was built. That ditch would be

20 feet wide, starting out of the river, and 3 feet deep, which would take nearly all the water in the river, and it would be all used by the ranches.

The CHAIRMAN. Did you estimate the cost of construction of that ditch?

Mr. BRYANT. I think that ditch running 22 miles that I surveyed to accommodate the fifty men would cost not less than $40,000. We are poor men. We can furnish the muscle, but not the money. It has been estimated that if we could have had this ditch this year so that we could use the water it would have paid for itself. I got together a lot of the boys at one time, and none of us had $100. Yet we constructed a ditch 22 miles long on the side of the mountains. I surveyed it with a triangle, and the water is running in that ditch to-day. We constructed it by going to work ourselves. Part of us would go to work outside to get supplies, and the balance would work on the ditch. We all did that. But we constructed another ditch that cost $1,500, and we have not the water yet; some other men got the water.

The CHAIRMAN. Have you ever examined that creek to see whether you could store water in lakes above so that you could all get some of it?

Mr. BRYANT. I have not examined to see; I have only guessed at it.

The CHAIRMAN. Have any of the farmers here, when they have a small amount of water, attempted to ascertain whether they could open lakes and increase the water supply?

Mr. BRYANT. I think the general opinion is that if we could get water out of these rivers it would be sufficient, that is, for present wants.

The CHAIRMAN. You say the ditch for which you made a survey would take out all the water.

Mr. BRYANT. It would now, because the water is extremely low.

The CHAIRMAN. Then there would have to be water stored in order to irrigate the whole of this valley.

Mr. BRYANT. There could be enough stored.

The CHAIRMAN. Could there have been enough saved this year to irrigate the valleys on each side, not taking into consideration the benches?

Mr. BRYANT. It would irrigate the lowlands, but not the benches.

The CHAIRMAN. What percentage of this water goes to waste?

Mr. BRYANT. Four-fifths of it.

The CHAIRMAN. Do you utilize one-fifth?

Mr. BRYANT. I think there are ditches that would take one-fifth.

The CHAIRMAN. So that if you had this four-fifths you could extend the area of land which would be under cultivation?

Mr. BRYANT. Yes.

The CHAIRMAN. You are a surveyor?

Mr. BRYANT. I survey by a triangle.

The CHAIRMAN. With what examination you have made, are you able to say whether or not a thorough survey of this region showing the water supply and the land to be covered and the cost of reservoirs, ditches, etc., would be beneficial?

Mr. BRYANT. I think it would be.

The CHAIRMAN. There have been two appropriations made for that purpose, and I wish you to say whether or not you think it would be of sufficient advantage to warrant the Government in going ahead with the surveys.

Mr. BRYANT. Yes. To illustrate: Take this ditch that I surveyed. If we could have had this ditch this year so that we could have used the water it would have paid for itself, and the probability is that further developments could be made with like results.

Director **Powell**. You live in the Bitterroot Valley?

Mr. **Bryant**. Yes; 26 miles up.

Director **Powell**. Most of the small streams go down on the other side of the river?

Mr. **Bryant**. Yes.

Director **Powell**. Are there farming lands on this side?

Mr. **Bryant**. Yes.

Director **Powell**. They are taking up the small streams on the other side of the river?

Mr. **Bryant**. Yes.

Director **Powell**. But they do not take out from the big stream?

Mr. **Bryant**. No; not on the other side. They use all the small streams on the other side, but they would use much more on this side if they could.

Director **Powell**. All the irrigation on the other side is in the same way.

Mr. **Bryant**. Yes.

Director **Powell**. But the great enterprise of taking out the Bitterroot River has not been entered upon to any extent?

Mr. **Bryant**. No.

Director **Powell**. Are there many small streams on this side?

Mr. **Bryant**. Not on this side. There is not a small stream on this side of the river that is putting in a particle of water at the present time. From here 60 miles up it is all taken out and there would be twice or three times as much used if they could get it.

The **Chairman**. How far down is it before this river joins the Clarke River?

Director **Powell**. From the mouth of this stream below where the Bitterroot comes in it is called Missoula. Right here it is Hell Gate, and it is all the Bitterroot. [Addressing Mr. Bryant.] Are all those big streams on both sides used to-day?

Mr. **Bryant**. Not a fourth of the waters on the west side of the Bitterroot are used, but nearly all on the east side, as we call it here. There are three or four ditches taken out 12 feet wide and 2 feet deep where they come out of the river, and they supply the upper part of the valley. Yet if we had several more such ditches they would all be utilized. Much of the land that is now lying vacant would be taken up if the water from the river could be gotten on to it. And if the Government is going to help us at all, it can help us to get ditches out of the stream. Reservoirs may do after a while, but we want the water immediately.

Director **Powell**. You have computed the cost ordinarily of taking out these small streams. How much does it cost per acre to get the water?

Mr. **Bryant**. It has cost us heretofore nearly $4 for an inch of water, a miner's inch. That, judiciously applied, would irrigate nearly 40 acres.

Director **Powell**. So that to take the water from these small streams it costs you from $1 to $1.25 an acre.

Mr. **Bryant**. Yes. I only speak of one ditch—some cost more and some less.

Director **Powell**. Do you know anything about the Fork up here?

Mr. **Bryant**. Yes.

Director **Powell**. How much of the water in that goes to waste?

Mr. **Bryant**. Not any. There is not enough of it.

Director **Powell**. Do you know anything about the head of that stream—the source of it?

Mr. BRYANT. I have never been to the head of that creek. I have been up it some 20 miles, but never to the head.

Director POWELL. It comes out to a cañon?

Mr. BRYANT. Yes. Not all the water, perhaps three-fourths of it, goes to waste; but ordinarily it is all used.

The CHAIRMAN. What is running at the time you want to irrigate is all used?

Mr. BRYANT. Yes. This season there has not been any going up the river.

Director POWELL. Have you any lost rivers in this country?

Mr. BRYANT. No. You mean waters that have sunk into a bed and gone out of sight?

STATEMENT OF E. W. BERRY, OF MISSOULA.

The CHAIRMAN. How long have you resided in Missoula?

Mr. BERRY. It is about 24 years since I came here.

The CHAIRMAN. What is your occupation?

Mr. BERRY. I do most everything. I am county assessor now. I have been farming in the county. I have raised sixteen crops here.

The CHAIRMAN. What is the extent of your county? Can you bound it?

Mr. BERRY. It runs from the Beaverhead, on the south, to the British line, about 225 miles—about 300 miles north and south.

The CHAIRMAN. How much east and west?

Mr. BERRY. Somewhere about 200 miles.

The CHAIRMAN. There is an Indian reservation in this county, I believe?

Mr. BERRY. Yes; the Flathead.

The CHAIRMAN. In assessing, have you traveled over the county pretty generally?

Mr. BERRY. Yes; three times I have been over the county.

The CHAIRMAN. What is the character of the crops produced in the county by irrigation? In the first place state what kinds of crops you raise.

Mr. BERRY. Wheat, oats, barley, potatoes, all kinds of garden truck.

The CHAIRMAN. And fruit?

Mr. BERRY. And fruit.

The CHAIRMAN. What is a good crop of potatoes?

Mr. BERRY. It depends on the character of the land. I have seen 800 bushels to the acre and from that down to 50 right in Flathead last year. I weighed the potatoes myself.

The CHAIRMAN. What would be an average crop on good land?

Mr. BERRY. I suppose it would be 300 bushels.

The CHAIRMAN. What is an average crop of wheat?

Mr. BERRY. About 50 or 60 bushels—well, from 40 bushels up; and some land does not produce 15 or 20.

The CHAIRMAN. What would be an average crop—a general crop?

Mr. BERRY. Perhaps 30 bushels.

The CHAIRMAN. How much of oats?

Mr. BERRY. From 40 to 60 bushels.

The CHAIRMAN. You say you have been farming yourself?

Mr. BERRY. Yes.

The CHAIRMAN. What is the expense of irrigating land after you get the water on it? Is it more expensive to farm land by irrigation than it is in countries where you do not irrigate?

Mr. **Berry**. Why, certainly it is. You have to put in your time irrigating, and that costs something.

The **Chairman**. How is it as to the certainty of crops?

Mr. **Berry**. Without irrigation?

The **Chairman**. With irrigation.

Mr. **Berry**. There is nothing here without irrigation.

The **Chairman**. Are you always sure then of a crop?

Mr. **Berry**. Yes.

The **Chairman**. Have you ever known a failure in this valley where they had water to irrigate?

Mr. **Berry**. No, unless the grasshoppers come.

The **Chairman**. Have they come often?

Mr. **Berry**. No, not very often.

The **Chairman**. They have been here how many times since you have been here?

Mr. **Berry**. I think three times. They were here somewhere about 1865.

The **Chairman**. Barring grasshoppers, there is no failure of crops where you irrigate properly?

Mr. **Berry**. No.

The **Chairman**. In traveling over the county have you had your attention called to the water supply for irrigating the land?

Mr. **Berry**. Oh, yes.

The **Chairman**. What proportion of land in this county is fit for irrigation?

Mr. **Berry**. That is fit for cultivation?

The **Chairman**. For irrigation.

Mr. **Berry**. Oh, I should think—I do not know that I understand you.

The **Chairman**. How much would be good land if it were irrigated—had water on it?

Mr. **Berry**. Take any particular portion, leaving out the mountains.

The **Chairman**. I mean the whole county. Taking all the land in the county, what proportion of it, if irrigated, would be fit for cultivation? Of course you will have to make an estimate.

Mr. **Berry**. That I can not do. The Bitterroot Valley is about 60 miles long.

The **Chairman**. You need not go into details. If you have not considered the matter so as to give the result you need not estimate. How is the water? Is there a sufficient supply to irrigate the land, taking the benches and all?

Mr. **Berry**. Yes, if it were used.

The **Chairman**. Some of the land lies too high, I suppose, to get the river onto it at a reasonable expense. Are there not mountain valleys, elevated valleys, plateaus, benches?

Mr. **Berry**. No, not much of that kind of land. The Bitter Root River could be brought around to irrigate all until you get around to the steep side of the mountains, and there is sufficient water on the west side in the way of streams to irrigate that.

Director **Powell**. If they could use all the small streams on the west side of the Bitter Root River they could irrigate all the land on that side?

Mr. **Berry**. Yes.

Director **Powell**. And then the main stream could be utilized on this side?

Mr. **Berry**. Yes.

Director POWELL. You think enough water could be gotten to irrigate it all if it were taken out aright?

Mr. BERRY. Yes, if it were stored.

The CHAIRMAN. What is the opportunity for storing the water in this county and increasing the flow if necessary?

Mr. BERRY. At the head of the valley there is a good chance for a reservoir. There is a valley up north, 150 miles from here, where I have been living for the last few years, which is 30 miles square and which has very rich soil. We have raised crops there without irrigation—very little of it is irrigated. The Flathead River runs right through it, and heads in the British possessions and ends in a lake. There is where the university lands are.

The CHAIRMAN. Is there plenty of water there to irrigate with?

Mr. BERRY. Plenty, if it were utilized.

The CHAIRMAN. Is there any difficulty in doing that?

Mr. BERRY. No, only want of money. Two creeks that come in from back in the mountains sink before they get to the valley. They are called lost creeks.

Adjourned.

EASTERN WASHINGTON DIVISION.

MOXIE COMPANY'S RANCH,
Yakima, Wash., August 13, 1889.

The committee met pursuant to call of the chairman.

Present: Messrs. Stewart (chairman), Jones and Reagan; also Director Powell.

STATEMENT OF JAMES M. HALL, OF YAKIMA.

The **CHAIRMAN**. What is your profession or occupation?

Mr. **HALL**. Civil engineer.

The **CHAIRMAN**. Have you ever been engaged in surveying for purposes of irrigation?

Mr. **HALL**. Yes.

The **CHAIRMAN**. Where?

Mr. **HALL**. In California and in Washington Territory.

The **CHAIRMAN**. Are you acquainted with the Moxie Company's ranch?

Mr. **HALL**. Yes.

The **CHAIRMAN**. Are you acting as engineer for that company?

Mr. **HALL**. Yes.

The **CHAIRMAN**. How long have you been engaged in engineering for that company?

Mr. **HALL**. About two years and a half.

The **CHAIRMAN**. By what means do they irrigate their farm?

Mr. **HALL**. By means of a canal taken out of the Yakima River.

The **CHAIRMAN**. About how much land is below the canal that may be irrigated by it?

Mr. **HALL**. That I can not say off-hand; about 6 or 7 sections—4,000 or 5,000 acres.

The **CHAIRMAN**. How is it as to the water in the Yakima River? Is there an abundance of it?

Mr. **HALL**. Yes; there is plenty of water for our purposes.

Senator **JONES**. What proportion of the water do you take out of the river where this ditch comes?

Mr. **HALL**. That I can not state, because we have not made any cross-section of the river.

Senator **JONES**. Could you approximate it?

Mr. **HALL**. I would not like to do so without a survey. We do not take one-twentieth, probably not one-fortieth.

The **CHAIRMAN**. What is the character of the land that you irrigate here—what kind of soil?

Mr. **HALL**. It is an ashy loam. The lower bench is a finer soil than the upper. The upper is more coarse—more sand in the upper bench.

The **CHAIRMAN**. Have you a subsoil which is different from the surface soil?

Mr. **HALL**. That I could hardly answer.

The **CHAIRMAN**. There is no underlying strata that holds the water?

Mr. **HALL**. No, not immediately near the surface.

The **CHAIRMAN**. State how you irrigate where the soil is coarse sand and gravel.

Mr. HALL. We have no land of that description under water at present; that is, to amount to anything.

The CHAIRMAN. How could that be irrigated in this valley?

Mr. HALL. That could be irrigated in different ways.

The CHAIRMAN. What would be the best way to irrigate that land?

Mr. HALL. It would depend on what you would plant. If it were grain, I should flood it; if it were trees or anything planted in rows, I should say run the water through rows—plow through in furrows. And that would depend on the nature of the soil. As to furrows, if it were gravelly and sandy, those ditches would be wider.

The CHAIRMAN. Then, as I understand you, if the soil is loose, so that the water will percolate, you may have your ditches or furrows farther apart?

Mr. HALL. Yes.

The CHAIRMAN. And the water will percolate from one to the other?

Mr. HALL. Yes.

The CHAIRMAN. Have you seen any sandy soil with a clay subsoil?

Mr. HALL. No; I have not seen that.

The CHAIRMAN. There is none of that kind here?

Mr. HALL. No.

The CHAIRMAN. Explain the mode of irrigation where the soil is closer.

Mr. HALL. Understand me. Here on the ranch, on the same nature of soil, we irrigate differently different crops. For instance, wheat, alfalfa—grain of any description—we flood; while on the same soil, for orchard or garden truck, we run it through rows, as we call it.

The CHAIRMAN. Explain how you flood.

Mr. HALL. We flood by running contour levels.

The CHAIRMAN. Explain that so that anybody who never saw it done could understand it.

Mr. HALL. We will take a piece of land, find what slope it has, and then we use whatever the soil will stand. For instance, if it were a level piece, we would use 1 foot of elevation. If the land have a slope of 5 feet to the mile, and if we wanted to flood, we would throw contour levels all around a foot above the highest side of the check. Below the main canal we would go down until we gained a foot elevation, and there we would throw a check or level all the way round. If we were going to use a check 17 or 18 inches and allow for settling so that it would be 18 inches when finished, we would continue the whole field in that shape, setting boxes to draw away from one check to another.

The CHAIRMAN. When you irrigate, what do you do?

Mr. HALL. If it be near the main canal, we turn the water through into a lateral that feeds this field—turn it into a box that empties the first check.

The CHAIRMAN. How long do you flood the land?

Mr. HALL. Until the entire check is covered.

The CHAIRMAN. Until all the land in that check is covered?

Mr. HALL. Of course. On the lower side it would be just 1 foot deep, and if it were even, the other side would be just covered, and it would take just according to the size of the check. The more level the land, the larger the check. For instance, if there were 5 acres in a check, it would take two hours and a half of our stream, with the head we run, to fill that check.

The CHAIRMAN. Would not the time depend on the head of water?

Mr. HALL. Yes. We throw a head of water sufficient to fill those checks in two hours and a half.

The **Chairman**. Immediately it is filled, do you commence to draw it off?

Mr. **Hall**. Yes, unless in certain seasons, when they let it remain for two hours. If the land should be dry or it should be some place where the earth was compact and sloped and would not take the water easily, we would let it take up what water it could, and then we would draw it off into the next check.

The **Chairman**. Then you would fill the next check in the same way?

Mr. **Hall**. Exactly. We do not depend on our head of water for the second check—the check immediately above—because we would soon run out of water. And the laterals are so formed that they fill each check. We fill from laterals, from each end, and also from the check above, making three checks and averaging two hours and half to each check.

The **Chairman**. In those two hours and a half you put it on the grain?

Mr. **Hall**. Yes, cover the ground entirely.

The **Chairman**. Does the water being on that length of time injure the grain?

Mr. **Hall**. No, not in this country.

The **Chairman**. How long might it run on the grain in this climate without injury to it?

Mr. **Hall**. When it is necessary to irrigate grain it is always in the spring of the year or late summer, when it is not so hot. I do not think it would injure it were it to remain six or eight hours. We have had it on grain 12 hours without injury.

The **Chairman**. What character of crops do you produce on this ranch?

Mr. **Hall**. We have this season barley and oats. I do not remember whether they put in any wheat or not. Last year we had plenty of wheat and alfalfa, all kinds of garden vegetables, and red and white clover. Red and white clover grow well here.

The **Chairman**. What is an average crop of wheat here?

Mr. **Hall**. That I could not say.

The **Chairman**. What is your crop of barley?

Mr. **Hall**. We will raise a little over 32 bushels to the acre. Some of it went 40 bushels, and so on.

The **Chairman**. How is it with oats?

Mr. **Hall**. I could not say offhand; but Mr. Cunningham can give you the exact figures on that. It was something over 30 bushels.

Senator **Jones**. Did you locate the ditches that are on this plantation?

Mr. **Hall**. All of them except the first four miles of the main line. That was done by Mr. Eldridge, of Colorado.

Senator **Jones**. In locating those ditches, how far down have you examined the soil?

Mr. **Hall**. In depth?

Senator **Jones**. Or any other way?

Mr. **Hall**. In making ditches we have no reason to go down more than 3 or 4 feet.

Senator **Jones**. You have not examined the subsoil more than to that depth?

Mr. **Hall**. Nothing more than where wells have been dug.

Senator **Jones**. Is the soil, so far as you know, uniform in character?

Mr. **Hall**. Yes.

Senator JONES. As far as you have gone down; as far as the ditches have gone?

Mr. HALL. I think so. For 8 or 10 feet perhaps you will strike a little gravel. On the higher benches it is deeper with gravel.

Senator JONES. In coming out of Yakima we noticed some land that was very gravelly, with considerable sized stones in it, and a little more sandy than this is. Would there be any difficulty in putting irrigating ditches through that soil?

Mr. HALL. No.

Senator JONES. Would it be as irrigable?

Mr. HALL. Yes.

Senator JONES. And as productive as this?

Mr. HALL. Yes, in some things. In wheat and alfalfa just as well.

Senator JONES. Are there any farms where the subsoil is so open that it would render irrigation impracticable?

Mr. HALL. No.

Senator JONES. You think the whole valley could be irrigated?

Mr. HALL. Yes. But there are some spots over in the Yakima Valley that are hardly worth irrigating, and some percentage of the land—scabby land they call it—where the rocks are on the surface.

Senator JONES. Are you familiar with the valley of this river down to the mouth of it?

Mr. HALL. No.

Senator JONES. How far down are you familiar with it?

Mr. HALL. I could not say whether I was familiar with it below the Moxie Valley.

Senator JONES. Your information is local.

Mr. HALL. Yes; although what I saw was first-class land.

Senator JONES. Have you noticed the flood volume of this river to say how much greater it is than the low water?

Mr. HALL. Yes.

Senator JONES. Is there much difference in it?

Mr. HALL. A great difference, yes. It covers the whole river bottom. I have seen it when I suppose it was from a mile wide to two miles and a half—something like that. It overflowed the banks.

The CHAIRMAN. Have you ever, in California or here, had your attention called to the storage of water in lakes, reservoirs and flats?

Mr. HALL. Not exactly had my attention called to it; but I have thought of it and read of it.

The CHAIRMAN. After what you have read, in going over the ground have you thought about it when you observed the places where it could be stored?

Mr. HALL. Oh, yes, I have seen pretty good locations in this country for storage reservoirs.

The CHAIRMAN. State where those locations are.

Mr. HALL. In the upper Yakima Valley there are storage sites in the Cowlitz.

The CHAIRMAN. What are they?

Mr. HALL. Lakes and streams.

The CHAIRMAN. What is there at the head of these streams, so to speak? What is the topography of the country?

Mr. HALL. Probably the elevation is something like a thousand feet above the Yakima—from 900 feet to 1,000 feet.

The CHAIRMAN. Have you ever traced one of these streams to its source?

Mr. HALL. I have.

The CHAIRMAN. What did you find at its source?

Mr. HALL. Fine land. Take the south branch of the Cowlitz. I was at the head of that.

The CHAIRMAN. Is there any opportunity there for storing water?

Mr. HALL. The whole of the cañon could be used.

The CHAIRMAN. I do not believe in cañons; do you?

Mr. HALL. Well, it depends on how the cañon is formed. I have no more to say about that; but I think it would be a fine place to store water.

The CHAIRMAN. In looking for places for storage reservoirs what do you bear in mind? Do you look for a flat place?

Mr. HALL. Yes; you want a basin as large as practicable. The size of it depends on the country to be irrigated, of course, from that point. That would be my idea of it; and it would not be altogether necessary to have any particular shape. Of course, if it were very large in area and not such a deep cañon it would lessen the pressure of the water on a dam and make it easy to build and less expensive.

The CHAIRMAN. And safer?

Mr. HALL. And safer. And it would hold as much water.

The CHAIRMAN. With your experience as a surveyor, what would you say as to the usefulness of surveys and maps of all these places and streams where reservoirs could be made? Would or not a knowledge of the facts enable settlers to make farms?

Mr. HALL. I think it would be very useful to have them.

The CHAIRMAN. Showing the cost of construction and having the reservoir sites reserved?

Mr. HALL. Yes; and showing the quantity of water in each stream annually; that is, at its lowest estimate.

The CHAIRMAN. You would want the quantity that could be stored in a watershed and how much land would be covered. Those would be important considerations.

Mr. HALL. And to show the amount of water there was without storing. It would show then whether or not they could depend on water without storage.

The CHAIRMAN. In other words, you think it would be very important to have a survey showing the facts in regard to the various localities?

Mr. HALL. Yes.

The CHAIRMAN. If that were done, would it facilitate the settlement and irrigation of this country?

Mr. HALL. I think it would. That is, if water could be brought to cover all this land that is lying waste, you might say, I think the country would be settled very rapidly.

The CHAIMAN. Are there many places where works could be constructed by private parties?

Mr. HALL. There are a few, but hardly in this age. This is a new country, and $50,000 or $100,000 is quite a sum. In 10 years it will not be considered so much.

The CHAIRMAN. Are there no places where you could perfect a few farms with less expenditure than that?

Mr. HALL. I do not think that there are in this country. The country when you come to get up into the foot-hills or leave the flat, level lands becomes quite rough, and it would be more expensive to construct reservoirs for storing the water—a little more than farmers would want to expend.

The **CHAIRMAN**. While you might not construct reservoirs at once could you not find places where they would be convenient?

Mr. **HALL**. If that were done under a system it would be well, but it would be more costly to the farmer. He would construct a little one at first and then construct a larger one afterward.

The **CHAIRMAN**. But a survey would be necessary to show the facts?

Mr. **HALL**. I would want a survey to show the facts at first, and then the remedy could come afterward.

The **CHAIRMAN**. Are the settlers able to do that themselves, as a rule?

Mr. **HALL**. I should not say that they were at present, on any grand scale. Of course, you could get a nook to catch some little water; but as to the general country that is not possible.

The **CHAIRMAN**. I am talking about the places first. If the facts were known, to what extent could it be done by individuals?

Mr. **HALL**. I have not thought it over in that light. When I look at the matter I think of the whole country.

Senator **REAGAN**. Have you made an estimate of the amount of water that is necessary to irrigate an acre of ground?

Mr. **HALL**. I have always used as a standard one cubic foot for one quarter-section of land.

The **CHAIRMAN**. Per minute?

Mr. **HALL**. Per second.

The **CHAIRMAN**. For how long a time?

Mr. **HALL**. The irrigating season—as long as you are using the water. We estimate 4 cubic feet per second to a section of 640 acres.

The **CHAIRMAN**. Do you require more water for corn than you do for grain?

Mr. **HALL**. I think not. I do not think it takes any more. It takes it in smaller quantities and continually, you might say; because we let it run through the rows almost continually; but in flooding we use so much more at the same time. I think there is a little more water used in flooding than would be in the row.

The **CHAIRMAN**. You use more water on grain than you do on alfalfa and the other grasses?

Mr. **HALL**. Yes. Let me understand you. You ask me whether we use more water on grain than on alfalfa?

The **CHAIRMAN**. Yes, and other grasses?

Mr. **HALL**. No; I think we use more water on the alfalfa than on the grain.

The **CHAIRMAN**. What other grasses do you raise here?

Mr. **HALL**. I do not believe we have anything, except timothy.

The **CHAIRMAN**. Does that grow here?

Mr. **HALL**. Yes, pretty well.

The **CHAIRMAN**. What kind of fruits do you raise on this land?

Mr. **HALL**. I am particularly interested in that part of it; apples, peaches, pears, prunes, grapes, and such things.

Director **POWELL**. What do you think of the economy of flooding as compared with the other system in the utilization of water; which method takes the most water?

Mr. **HALL**. I think flooding takes the most water.

Director **POWELL**. What ratio—what difference do you make?

Mr. **HALL**. That depends on the crop that you are irrigating.

Director **POWELL**. As a general average (I do not ask for details), would a third more water be necessary by flooding than by the row?

Mr. **HALL**. Yes, I think we use a third more by flooding than by the row.

Director **Powell**. How many times do you irrigate wheat?

Mr. **Hall**. I could hardly give an answer to that, because it is owing to the season. Take a season like this last, for instance, when there has been a good deal of wind, which dries out the surface quickly, and we have to irrigate more often than at other times when there are less winds.

Director **Powell**. Have you made any estimate of the cost of your plant? What has it cost per acre on this river to get the water on to the land? I do not mean during a season, but to bring the water into the principal canals and laterals.

Mr. **Hall**. I could hardly say right off hand. We have built the main line here for three miles and a half, or such a matter, at a cost of $4,490, in round figures, per mile, except this around the hill. That Mr. Eldridge did before I came here. It cost in the neighborhood of $4,000 a mile.

Director **Powell**. That would cost from $1.25 to $1.50 an acre to get the water into this ditch?

Mr. **Hall**. Yes.

Director **Powell**. You have water here for 20,000 acres?

Mr. **Hall**. Yes, we have that much land.

Director **Powell**. How many miles of ditching?

Mr. **Hall**. About 7 miles in the main line.

Director **Powell**. Then the ditches cost what?

Mr. **Hall**. Thirteen thousand eight hundred dollars, all told, as shown by the books of the company.

STATEMENT OF B. A. CUNNINGHAM, OF YAKIMA.

The **Chairman**. What is your occupation?

Mr. **Cunningham**. I am secretary to the Moxie Company.

The **Chairman**. How long have you been its secretary?

Mr. **Cunningham**. Nearly two years.

The **Chairman**. What amount of land have you under cultivation on this ranch?

Mr. **Cunningham**. Grain, 203 acres; growing alfalfa, 240 acres; 21 under hops, 14 in corn, and 17 in tobacco. We have 10 acres in garden and orchards and 787 in natural hay in the ranch part, subirrigated by the river.

The **Chairman**. What is the average crop of wheat?

Mr. **Cunningham**. We have raised no wheat to amount to anything. We had a few acres in wheat, but we did not repeat the experiment.

The **Chairman**. Do you know from other experiments in the neighborhood what is the average crop per acre?

Mr. **Cunningham**. There is none raised except by us.

The **Chairman**. What is the average crop of barley?

Mr. **Cunningham**. Forty-five to 47 bushels this year, the second year's cropping from the sage brush.

The **Chairman**. What is the average crop of oats? Have you raised oats?

Mr. **Cunningham**. Yes, we have 35 bushels to the acre on poorer land than that on which the barley was raised.

The **Chairman**. Do you produce corn?

Mr. **Cunningham**. Yes, we have a very fair stand of corn.

The **Chairman**. Have you reaped a harvest?

Mr. **Cunningham**. No. We can not tell about that. The corn grows pretty well.

The **Chairman.** Do you know how many bushels of potatoes you produce to the acre?

Mr. **Cunningham.** No, I can not tell you. We get 1,200 bushels out of the garden; but I could not tell you about the exact acreage.

The **Chairman.** You say you raise tobacco?

Mr. **Cunningham.** Yes.

The **Chairman.** Is that a success?

Mr. **Cunningham.** We have made cigars, and they have been pronounced as good as any domestic cigars in America. We have now four cigar makers at work in the factory.

The **Chairman.** How is the plant; does it grow well?

Mr. **Cunningham.** It thrives luxuriantly. In the opinion of a tobacco expert, who is a resident here, it is a great success. He is this year growing for filers and binders—letting the wrappers alone.

The **Chairman.** What amount of land can be irrigated by your main ditch?

Mr. **Cunningham.** We have about 7 sections down here. I could not tell you that.

The **Chairman.** How many acres of land have you to irrigate below that?

Mr. **Cunningham.** That is not a fair question.

The **Chairman.** You could measure what good land there is below the ditch?

Mr. **Cunningham.** Four thousand acres.

The **Chairman.** About how many acres of land is there to be covered by the main ditch?

Mr. **Cunningham.** About 4,000 acres, I should think. It is all arable. I know that, but I do not know the acreage.

The **Chairman.** What was the cost of construction of the main ditch that brings water to this amount of land?

Mr. **Cunningham.** According to the books it is between $13,000 and $14,000; that is, for the main ditch alone. That does not include any lateral work.

The **Chairman.** Where this land has been prepared by means of checks for flooding what has been the expense per acre to prepare it?

Mr. **Cunningham.** I understand from the engineer $8 an acre, exclusive of the farm work; from $5 to $8 according to location.

The **Chairman.** After it has been once put under check, prepared for flooding, does it have to be checked every year or are they permanent works?

Mr. **Cunningham.** These are permanent works.

The **Chairman.** Then what is the cost of irrigating by flooding the land after you have it once checked with permanent works?

Mr. **Cunningham.** Two men will run over that whole checked field in four days.

The **Chairman.** Then the expense is light after it is checked.

Mr. **Cunningham.** Yes; the expense is very trivial.

The **Chairman.** What is the cost of irrigating your land by flooding as compared with the cost of irrigating by means of furrows through the land?

Mr. **Cunningham.** The land that we have irrigated by furrows is so small and trifling in extent we can not compare the expense. I do not suppose 5 per cent. of the land is irrigated by furrows.

The **Chairman.** You have not compared the expense?

Mr. **Cunningham.** No; we have not compared it.

Senator **JONES**. How often do you irrigate crops?

Mr. **CUNNINGHAM**. Alfalfa twice to each cutting; that is to say, once immediately before the hay is taken and once during the growth of the crop.

Senator **JONES**. What time do you begin?

Mr. **CUNNINGHAM**. We begin according to the season. I think it was about the middle of March or beginning of April we started this year.

Senator **JONES**. When did you make your first cutting?

Mr. **CUNNINGHAM**. About the 20th of May.

Senator **JONES**. When did you make your second cutting?

Mr. **CUNNINGHAM**. Exactly five weeks afterward, and the next four weeks afterward.

Senator **JONES**. When will you cut your fourth crop?

Mr. **CUNNINGHAM**. This week.

Senator **JONES**. How many more will you cut?

Mr. **CUNNINGHAM**. Two.

Senator **JONES**. And two irrigations to each crop?

Mr. **CUNNINGHAM**. Yes.

Senator **JONES**. How much do you get per acre out of each cutting?

Mr. **CUNNINGHAM**. From a ton and a quarter to a ton and a half. The middle cutting is the best cutting we have had yet.

Senator **REAGAN**. Four and six times a year?

Mr. **CUNNINGHAM**. Yes; or we shall have cut four times this week, and will have cut six times before the season is out. The age of the oldest field is three years.

Senator **REAGAN**. Do you use the hay on the farm or do you sell it?

Mr. **CUNNINGHAM**. We use it for our own range cattle in the winter and for our horses.

Senator **REAGAN**. Does it improve with age?

Mr. **CUNNINGHAM**. It has every year.

Senator **REAGAN**. Do you know how long it will improve with age?

Mr. **CUNNINGHAM**. No; it has improved every year. We sowed a third of clover with alfalfa, and calculate that the fourth year the roots will kill the clover and still give us a heavy crop.

Senator **JONES**. How often do you irrigate your other crops—barley and wheat?

Mr. **CUNNINGHAM**. If the wheat will sprout with the natural moisture of the season, a good spring, you do not need to irrigate it over three or four times during the season. If you have to irrigate the sprout to bring the grain from the ground, you have to irrigate more.

Senator **JONES**. Do you sow wheat in the spring or in the fall?

Mr. **CUNNINGHAM**. Altogether spring wheat—barley—we have no wheat.

Senator **JONES**. You irrigate how often, if it should sprout without irrigation?

Mr. **CUNNINGHAM**. We irrigate about three or four times if it should come up above the ground without irrigation.

Senator **JONES**. You sow how soon?

Mr. **CUNNINGHAM**. So soon as the frost is out of the ground.

Senator **JONES**. What time is that?

Mr. **CUNNINGHAM**. February or March.

Senator **JONES**. How do you irrigate your hop fields?

Mr. **CUNNINGHAM**. By furrows.

Senator **JONES**. How frequently?

Mr. **CUNNINGHAM**. We have to irrigate the hops more than any other crop.

Senator **JONES**. Then it requires more water for hops than for any other crop?

Mr. **CUNNINGHAM**. Yes.

Senator **REAGAN**. What is the alfalfa worth this year?

Mr. **CUNNINGHAM**. Ten dollars in the stack. A man across the river sold a cutting the other day for $10.

Senator **JONES**. Do you feed any other stock with alfalfa except horses?

Mr. **CUNNINGHAM**. Yes, we feed it to hogs.

Senator **JONES**. Green?

Mr. **CUNNINGHAM**. Yes, green as green can be.

Senator **JONES**. Regularly during the season?

Mr. **CUNNINGHAM**. We have done it ever since the alfalfa was high enough to cut. We would like to show you the hogs that have been fed on alfalfa. And the expense is very trivial.

Senator **JONES**. Do you give them other feed?

Mr. **CUNNINGHAM**. None, unless it is a brood hog, suckling pigs, and then alfalfa hurts the milk and hurts the pigs.

Senator **JONES**. How much of the year do you feed hogs on alfalfa?

Mr. **CUNNINGHAM**. We have fed them ever since about the middle of April.

Senator **JONES**. Up to what time?

Mr. **CUNNINGHAM**. Up to now, and propose to go on feeding them with it up to October, and then we will put them on dry cracked barley. That is about five weeks. We expect to produce bacon here for 4 cents a pound.

The **CHAIRMAN**. The whole cost of raising the hogs and all?

Mr. **CUNNINGHAM**. Yes, everything.

Senator **JONES**. You stated that the cost of the main ditch on this plantation was between $13,000 and $14,000. What is the length of that ditch.

Mr. **CUNNINGHAM**. I can not tell you.

Senator **JONES**. Do you know the windings of it? You know whether it is more than 1 mile or less than 50? Does that include the ditch that was constructed by some other engineer prior to Mr. Hall's coming here?

Mr. **CUNNINGHAM**. I understand it includes the whole cost of the works, as per the ledger.

Senator **JONES**. The company's main ditch is a little over 7 miles?

Mr. **CUNNINGHAM**. Yes.

Senator **JONES**. What is the size of the main ditch?

Mr. **CUNNINGHAM**. It is about 8 feet on the bottom and 2 feet on the slope. It carries 2½ feet of water.

The **CHAIRMAN**. That depends on the size of the ditch?

Mr. **HALL**. If it stood on a height or steep bluff we would not use more than a foot to a foot and six-tenths. But on land like this you can use 2 feet.

The **CHAIRMAN**. How is that different?

Mr. **HALL**. It is more liable to cut on the side of the hill. The nature of the ground on each side of the hill is different to what it is on a flat; and to make it safe we use a smaller gate. The exact cost of the ditch is $4,490 a mile from here down. We constructed it for 9 cents a yard.

Adjourned.

NORTH YAKIMA, WASH., *August* 13, 1889.

The committee met pursuant to call of the chairman.

Present: Messrs. Stewart (chairman), Reagan and Jones; also Director Powell.

STATEMENT OF JOHN T. KINGSBURY, OF NORTH YAKIMA.

The **CHAIRMAN.** How long have you resided in Washington Territory?

Mr. **KINGSBURY.** Ten years.

The **CHAIRMAN.** How long have you lived in the arid region?

Mr. **KINGSBURY.** Since 1869.

The **CHAIRMAN.** What is your profession?

Mr. **KINGSBURY.** I am a civil engineer.

The **CHAIRMAN.** Have you traveled pretty generally over the mountain regions of the West?

Mr. **KINGSBURY.** Pretty well.

The **CHAIRMAN.** What Territories have you traveled over and are you most familiar with?

Mr. **KINGSBURY.** Wyoming, Nevada, Utah, Oregon, Washington Territory, California, Arizona, New Mexico, Texas, and Kansas. For thirty years I have been acquainted with those.

The **CHAIRMAN.** Have you given much attention to the subject of irrigation?

Mr. **KINGSBURY.** Yes.

The **CHAIRMAN.** And to the topography of the country?

Mr. **KINGSBURY.** Yes.

The **CHAIRMAN.** And to the water supply for irrigation?

Mr. **KINGSBURY.** Yes.

The **CHAIRMAN.** What extent of land approximately should you suppose there is in Washington Territory that can be irrigated and that requires irrigation? Is it a large or small area?

Mr. **KINGSBURY.** Quite a large proportion of the whole quantity of land.

The **CHAIRMAN.** To what extent has irrigation been practiced in Washington Territory and how long has it been practiced? Of course I do not wish you to enter into details, but state generally.

Mr. **KINGSBURY.** About less than twenty years from the start. In a very small way some farmers have combined and taken out small and easy ditches together at a little cost.

The **CHAIRMAN.** Have there been any large enterprises set on foot in that respect?

Mr. **KINGSBURY.** No.

The **CHAIRMAN.** Are the opportunities for small enterprises of that kind exhausted, if you take into consideration the storage of water and utilization of all the land that can be reclaimed by small enterprises?

Mr. **KINGSBURY.** No.

The **CHAIRMAN.** Would a survey which would designate the works to be constructed and the places where water could be stored be of service to this section of the country, and to what extent would it aid in the development of new enterprises with moderate capital, that would be useful in utilizing the water for irrigation?

Mr. **KINGSBURY.** It would develop a very large area for a nominal sum, you might say, in comparison with what it would accomplish.

The **CHAIRMAN.** What is the impediment to settlers coming here now and utilizing these available places? Is it the want of exact information which could be had from surveys and estimates?

Mr. KINGSBURY. It is almost entirely for the lack of knowledge, and that knowledge would be acquired by surveys, so that the people living here and those that are to come could tell at what cost the work could be done and how it could be done and where it could be done.

The CHAIRMAN. That is the principal difficulty, as I understand you, in the settlement of the arid region where irrigation is not expensive?

Mr. KINGSBURY. Yes; so far as small outlays are concerned.

The CHAIRMAN. Without attempting to be accurate, state what is the extent of the possible irrigation with small outlay.

Mr. KINGSBURY. Take, for instance, the valley of the Yakima. There could be in a distance of 150 miles along its course 200,000 acres probably brought under cultivation at small expense; then with a combination of capital that could be extended into a million.

The CHAIRMAN. You mean into a million acres that might be watered by this water shed?

Mr. KINGSBURY. Yes; and even a million and a half.

The CHAIRMAN. A million and a half might require larger works and reservoirs in the mountains to store water?

Mr. KINGSBURY. Yes.

The CHAIRMAN. When you have been in the mountains have you observed the opportunities for storing water?

Mr. KINGSBURY. Yes.

The CHAIRMAN. Are they good?

Mr. KINGSBURY. There are splendid opportunities at reasonable expense for such works. Of course the easier places for storage would be used first, and then the number of reservoirs would increase as population increased.

The CHAIRMAN. There is no question of the productiveness of this soil, I suppose, when water can be had?

Mr. KINGSBURY. None whatever.

The CHAIRMAN. Do you find true of other places in the Territory and in the arid region what you find true here?

Mr. KINGSBURY. To a great extent.

The CHAIRMAN. I mean particularly; do you find true on other rivers in Washington Territory what you find true on this river?

Mr. KINGSBURY. Yes.

The CHAIRMAN. And so through the arid regions generally?

Mr. KINGSBURY. Yes.

The CHAIRMAN. Then would you regard as valuable to the people a survey by the Government of its land with a view to irrigation and reserving places for hydraulic works and storage; also giving estimates of cost, with exact information of any other character that would enable the people to see what could be done toward increasing the facilities for agriculture?

Mr. KINGSBURY. Most assuredly. I regard that as the first and most important subject for the development of this section of the country.

The CHAIRMAN. A great deal of the public land would be disposed of quickly to settlers if they had exact information of that character, would it?

Mr. KINGSBURY. Yes; people would come here by the hundreds and thousands, if they could be informed of the probabilities of irrigation. If the people of Yakima could write east and give exact information of this character, eastern people would come here in large numbers.

The CHAIRMAN. Is the amount of land in eastern Washington that does not require irrigation very extensive, compared with that which does require irrigation?

Mr. **Kingsbury**. The amount of land that will produce cereals in Washington is quite large.

The **Chairman**. Is there a large amount of land that will produce all-around crops?

Mr. **Kingsbury**. Yes. There is very little of the eastern portion of Washington Territory that would grow crops without artificial irrigation.

The **Chairman**. Then is it your opinion that the portion now producing cereals in abundance would be largely benefited by irrigation?

Mr. **Kingsbury**. Yes; it would produce twice as much at least, even in the first year. Any ordinary work of irrigation that might be done would pay the first year in a very much larger yield of grain and other crops.

The **Chairman**. Have you ever seen farming in any other country?

Mr. **Kingsbury**. I was raised in New York and have been in the Southern States.

The **Chairman**. How would you compare in productiveness a well-cultivated and irrigated farm here, where irrigation has been properly done, with a farm in western New York?

Mr. **Kingsbury**. I was raised in Genesee, N. Y. Without doing much in the way of irrigation the people here can more than double the eastern crop.

The **Chairman**. Does this refer to the cereals and all-around crops?

Mr. **Kingsbury**. It refers to both; although as to corn I would not say that. We here can not reach Kansas or Illinois with corn crops.

The **Chairman**. How is it as to potatoes?

Mr. **Kingsbury**. We raise as good potatoes here as anywhere in the world.

The **Chairman**. What would be a good crop of potatoes on irrigated land here?

Mr. **Kingsbury**. Five to six hundred bushels to the acre.

The **Chairman**. What would be a good crop of wheat?

Mr. **Kingsbury**. About 35 bushels.

The **Chairman**. And what a good crop of oats?

Mr. **Kingsbury**. Sixty bushels.

The **Chairman**. Of barley?

Mr. **Kingsbury**. Barley would give 50 bushels; that is rather a small yield for barley, but in the experience that I have had here I have never seen barley at its best.

The **Chairman**. Do you raise some alfalfa here?

Mr. **Kingsbury**. Yes.

The **Chairman**. After that has been well set and is two or three years old, so that you get a fair crop if properly irrigated, how much can be produced on the acre each year?

Mr. **Kingsbury**. From 6 to 10 tons. Six would be a small yield. I should say 7 tons as an average.

Senator **Jones**. You stated that you knew of fine opportunities to irrigate tracts of land in a small way with a reasonable outlay. I would like to ask you what a reasonable outlay, in that sense, would be? What would you consider a reasonable outlay per acre for the irrigation of land such as you have spoken of?

The **Chairman**. You mean the outlay to be made in order to get the water to the land?

Senator **Jones**. Yes. Those general expressions do not convey a very definite idea.

Mr. **Kingsbury**. From $3 to $5 an acre would be what I should call a reasonable outlay, to start with.

Senator **Jones**. What proportion of the entire area of Washington Territory is susceptible of cultivation with or without irrigation?

Mr. **Kingsbury**. I can not tell you how it is west of the mountains so much as I can on this side.

Senator **Jones**. This side of the Cascade Mountains, do you mean?

Mr. **Kingsbury**. Yes.

The **Chairman**. What proportion of the Territory on this side is susceptible of cultivation?

Mr. **Kingsbury**. With the storage of water that could be effected we could cultivate three-fourths of the land east of the mountains.

Senator **Jones**. Of all the land east of the mountains?

Mr. **Kingsbury**. Of all the land in Washington Territory east of the mountains.

The **Chairman**. Would all that require irrigation?

Mr. **Kingsbury**. The higher lands would not; that is, for the crops that would grow. But the greater portion of that, or at least 50 per cent. of that, would need water.

Senator **Jones**. And would be practically valueless without water?

Mr. **Kingsbury**. Yes; practically valueless for farming purposes. Take the water away from it and it would be of no value.

The **Chairman**. I will say to the gentlemen who are present that this committee is seeking information as to whether it would be profitable to the Government to have surveys made which would locate reservoirs and lines of ditches for irrigation purposes, and to ascertain the cost of such works. Reservoir sites and sites for ditches are now by act of Congress reserved so that the Government can take them, and individuals can acquire no title to them. The inquiry we are prosecuting is to what extent, if these surveys are made, the people will be able to avail themselves of the lands, and of the water, and to make homes. The Government has not undertaken, nor has it been suggested that the Government should itself undertake, such works by direct Government appropriation.

The first thing to do is to ascertain what we have. We want such information as shall indicate whether these surveys would be useful, and whether it would pay the Government to expend money for them. We do not want the idea to go abroad that the Government is going to turn the rivers or anything of that sort. The idea is to enable the people who come here to have exact and definite information as to how irrigation can be practiced at a reasonable expense. When the population shall have increased largely, the question of enterprises that involve great expense will be considered. If they are not taken hold of by private enterprises, then it will be a problem for the State or the nation to consider hereafter. I will suggest to this board of trade that it might collect information as to the particular streams in this locality and the means of storing water, and send it to the committee within a reasonable time.

STATEMENT OF LUTHER S. HOWLETT, OF NORTH YAKIMA.

The **Chairman**. Can you give the committee some information on the subject which it is investigating?

Mr. **Howlett**. The Tietan River is one of the principal feeders of the Nachess River. This Tietan River is fed by the snows of the Cascade range, and as it comes on to join the Yakima River it runs through a deep gorge, which would make a most excellent natural reservoir. That gorge can be made into a little inland lake. If that were done it would bring the water to the rim of an immense basin.

The CHAIRMAN. Could that not be tunneled through so as to draw pretty much the entire lake to begin with?

Mr. HOWLETT. There is no lake there. The dam of the Tietan River would make a lake that would hold an immense body of water that now runs entirely to waste.

Senator JONES. How much?

Mr. HOWLETT. I will ask Colonel Cock to say how much.

Mr. COCK. It would be a space of 3 or 4 miles wide and 6 or 7 miles long.

Mr. HOWLETT. It would be fully as large as that. That would bring it to the rim of the lake, where private enterprise could take it and water the sides of the mountains. It has occurred to me that that is the one great scheme right in our immediate valley. Of course on the other side the Columbia River could be drawn upon *ad libitum*. An exhaustless supply of water can be brought from that onto the east side of the Yakima River. From the west an immense storage lake could be made, which would water the mountain sides all around us.

The CHAIRMAN. What is the general character of the land on the east side of the Columbia River, if the Columbia River could be taken out?

Mr. HOWLETT. I am not familiar with that.

Senator JONES. Is there any land immediately in the valley of that river where you propose putting down this dam that would be reclaimed by irrigation?

Mr. HOWLETT. There are thousands of acres.

Senator JONES. How large a country is there in the valley of that stream that would be tributary to that lake?

Mr. HOWLETT. Not any in the valley of that stream. That stream would be cut off near where it empties into the Yakima.

Senator JONES. What quantity of land would there be that would be reclaimed by the water stored in the lake, and how near would it be?

Mr. HOWLETT. There would be at least twenty-five townships.

Senator JONES. Each 6 miles square?

Mr. HOWLETT. Yes. It could be carried across into the reservation, which we hope will soon be opened. It could be carried clear to the Columbia River. I have understated rather than overstated the possibilities in that respect.

Senator JONES. Would you include in those twenty-five townships all this valley down to the mouth of the river?

Mr. HOWLETT. No. Twenty-five townships really understates what can be done.

Senator JONES. I should like to know what amount would be in proximity to this lake, that would be reclaimed by it; I don't mean what land would be reclaimed by a large expenditure of money.

Mr. HOWLETT. There would be a piece of land 20 miles one way by 11 or 12 the other.

Senator Jones. In the immediate neighborhood of that lake?

Mr. HOWLETT. Yes; right between the town and the lake.

Senator JONES. Is that land comparatively level?

Mr. HOWLETT. No; it is rolling land, but all excellent land.

Senator JONES. Would it be practicable to irrigate it?

Mr. HOWLETT. Yes.

Senator JONES. It is not too rolling to irrigate, you think?

Mr. HOWLETT. No; some of our best farms are of that character.

STATEMENT OF J. R. LEWIS, OF NORTH YAKIMA.

The **CHAIRMAN.** You understand the purpose of the committee's inquiry. Will you please state anything that will be of service to us in that connection?

Mr. **LEWIS.** I have resided in this Territory since 1872. I traveled in the eastern part of this Territory as judge of this district for three years, and I went all through eastern Washington. In these valleys of the Yakima, including the Nachez Valley and the Yakima Valley proper, and the valleys tributary to the Yakima, the irrigating season commences in the months of May and June principally. Very little land west of the Columbia River, in what is known as the Columbia River basin, is susceptible of cultivation without irrigation except, perhaps, for hay. Many people produce hay along the river by sub-irrigation. In May and June, when we need water ordinarily, our streams are higher than at any other season of the year. The short season for cropping in this country is when very little snow has fallen during the preceding winter, because in that season you find the mountain streams almost dry. There was no snow last winter.

With regard to the question of storage of water, the finest storehouse we have is our snow-clad mountains. Fort Adams is an everlasting store-house. The waters of the Yakima and the Tietan flow in there in ordinary seasons, and without any storage whatever those would irrigate an extremely large area of country.

People coming here from the States east look upon irrigation as practically implying starvation. They do not know anything about it. People from California and Colorado adapt themselves readily to this country. They know what irrigation means. With a moderate expenditure of money by the Government surveys could be made all over the valleys of the Yakima, the Tietan, the Atanah, and through the Indian reservation, and would furnish information to settlers as to the proper places from which to get water and to which to take it. That would aid very much, in my opinion, in the immediate settlement of this country. As it is, everybody who comes here is at sea, and has no idea of what is the proper thing to do. The line of inquiry, therefore, on which this committee is engaged is one that if it results in an exhaustive survey of the country will greatly add to the development of the arid region.

Upon the question of the production of crops my experience and observation show me that for a wheat crop 45 to 50 bushels is a fair average on the base of the Blue Mountains. In this country 40 bushels is a pretty large crop of wheat. You can get 60 bushels of oats here on well-irrigated land, and from 60 to 75 bushels of barley on well-irrigated land, but there is very little ground in this vicinity that is properly irrigated. The Kittitas Valley is well irrigated, and you will find men talk of 75, 80, and 100 bushels of barley, and truthfully so, because they have the system established. On the Indian reservation just below us here, which must shortly be opened, there are 300,000 acres of land that can be irrigated. I do not think I overestimate it. There are 200,000 acres that are sub-irrigated and produce hay now. There is plenty of water here now in ordinary seasons to irrigate some of the land.

Senator **JONES.** What do you mean by sub-irrigation?

Mr. **LEWIS.** Sub-irrigation is seen where the land lies along the streams and the water percolates under the soil and spreads out from the stream some considerable distance, say from a quarter to half a mile. While on that subject I will call the attention of the committee to this fact: That if you go over to Moxie, where you were this morning, you will find that the soil can not be properly irrigated without flooding. The water will not percolate through it. I own a ranch in this neighborhood myself, and ran a ditch through it, the water of which percolates into the soil, and I got my crops entirely by irrigation.

The **CHAIRMAN.** As to the economical use of the water and to avoid disputes arising from questions of priority of right and so forth, is it or not important that the survey should proceed with the idea that the people would want to take out the most water and cover the most land possible in the beginning? Is there anything in that idea, or is it just as well to let them take it out as they please? You may state to the committee, if you have formed a judgment, what system you would recommend.

Mr. **LEWIS.** My experience develops positively this fact, that we use about twenty times as much water on every farm as there is any necessity of. Out of 20 parts there are 19 parts wasted. That is a small estimate. If you have surveys made the people will know exactly where to take that water and where to put it back again, and thereby they will get the most value out of the least quantity of water, simply by knowing how to do.

My experience has been a little expensive in that matter. With a few other gentlemen I expended several thousand dollars in surveying on the Moxie. After expending that money we found we could not do what we wanted to do. If the Government had done that surveying we would have had the thing done by the Government. A pioneer wants to make a living with the smallest possible expense. If he has a survey at hand he knows exactly what he can do. If the pioneers can not make a combination of capital, they can make a combination of muscle; and if the Government will give them the survey the settlers will furnish the muscle.

Senator **JONES.** Why did you expend several thousand dollars on the Moxie scheme?

Mr. **LEWIS.** We undertook to carry water out from the Yakima, beyond the Home ranch on the Moxie farm, several miles out, and we discovered after making the survey that we would have to spend several hundred thousand dollars to make a flume. I donated the survey to the railroad—the only thing I ever gave the Northern Pacific. My remembrance is that that thing cost us $5,000. If the Government will put some money into a proper survey it would, in my opinion, be a very good way to apply a part of the money in the Treasury.

The **CHAIRMAN.** I understood you to say that those coming here from irrigated regions were better prepared to enter into the business of irrigation than those coming from Europe or the East?

Mr. **LEWIS.** Yes; the people of the States west of here understand the subject better.

The **CHAIRMAN.** People coming here from the East and from Europe are unprepared to do farming by irrigation or to undertake irrigation works, because they have not the inclination or the money to make surveys or explorations?

Mr. **LEWIS.** Yes.

The **CHAIRMAN.** If they had accurate information as to what should be done and what can be done, what is to prevent the people of the East from coming here and making good homes?

Mr. **LEWIS.** Nothing. They would adapt themselves immediately to the country, because a farm of 40 acres in this country, if irrigated, will produce more clear money than a section in the Western States put down in grain.

Mr. HOWLETT. And the farmer would save three or four years' time.

Mr. LEWIS. A California or Nevada man will come in here and will take a farm somewhere by a stream and will have it irrigated in three weeks, and have it blooming in a very short time. He knows just how to go to work at it and what to do with it. But take a man from the Eastern States; he comes here and looks over the country and concludes that starvation stares him in the face, and if he has money enough to go back he goes.

The CHAIRMAN. Then your conclusion is that a survey is very important?

Mr. LEWIS. Exceedingly so.

Senator JONES. It is "exceedingly important," as I understand you, in order to save private individuals from wasting money in foolish experiments?

Mr. LEWIS. More than that. It is not only to save them from wasting money, but also to prepare the country for immediate development. The settler can not come here because he knows not what to do.

Senator JONES. I have an idea that if irrigation were proceeded with in a proper way a large amount of land could be used by means of irrigation; whereas, if it is done in a thoughtless way, it is possible to waste large sums of money. I do not regard as a public purpose any expenditure on the part of the Government as being in order to save private individuals from getting their fingers burnt in bad investments. This country should be made to support families and develop homes as quickly as possible, but I think private individuals should expend their money in making farms and developing their own property. It ought not to be done at the expense of the Government.

Mr. LEWIS. My idea is this: A settler comes up the Naches River to make a home. He has no money to make surveys. If he had he might waste the money and not succeed in making any farm. If the Government had surveyed the property and mapped out a plan of irrigation, a settler could come in there and go to work at once and develop as far as belongs to his property the details of the system of irrigation mapped out by the survey. In that way he could at once make his farm available for crops, because he would know how and where the water was to be had.

STATEMENT OF H. D. COCK, OF NORTH YAKIMA.

The CHAIRMAN. Please state to the committee anything that occurs to you in connection with the need of this Territory for irrigation.

Mr. COCK. I would call the attention of the committee to what we see immediately around us. Four years ago the town of North Yakima was a sage plain. There was but one little cluster of trees here to prove that it was not absolutely a sage plain. You see what has been done by one small stream in four years. We are carrying through the town about 900 inches of water, not as the miners measure it, but by actual flow. We find that a ½-inch hole will admit water enough to irrigate a town lot 50 by 150 feet, if properly handled.

The CHAIRMAN. Without pressure?

Mr. COCK. Yes; without pressure. It is simply the natural flow. The trees which you see here along the street prove to your own eyes, without any statements from anybody, what can be done through this whole valley by a little irrigation. Every tree in this town I set out in

May, 1885—just four years ago. I think that fact is stronger than any argument that can be adduced in support of irrigation.

The **Chairman**. What are the dimensions of the supply ditch?

Mr. **Cock**. It is 7 feet wide on the bottom now and 10 or 12 feet wide on the top. It varies a little in the flow. It is now flowing through a gate, and runs about 900 inches. By actual measurement to-day at my head-gate we are carrying 800 inches, and we have a surplus.

Adjourned.

ELLENSBURGH, WASH., *August* 13, 1889.

The committee met pursuant to call of the chairman;

Present: Messrs. Stewart (chairman), Jones, and Reagan; also Director Powell.

STATEMENT OF S. W. BAKER, OF ELLENSBURGH.

The **Chairman**. Mr. Baker, I understand you are secretary of the Board of Trade, and speak by request for the people of Ellensburgh.

Mr. **Baker**. I do.

The **Chairman**. What is the extent of the arable land that can be irrigated in this valley, of which Ellensburgh is the principal town?

Mr. **Baker**. Two hundred thousand and eighty acres.

The **Chairman**. Have you a sufficient supply of water to irrigate all the lands which can be covered by the flow of the streams?

Mr. **Baker**. Yes.

The **Chairman**. Is there any portion of the valley which can not be covered by the flow of the Yakima River? If so, are there any other streams which can be utilized?

Mr. **Baker**. No.

The **Chairman**. Has any attention been paid by persons engaged in irrigation to the question of storing water in reservoirs? If so, what are the opportunities for such storage?

Mr. **Baker**. Little or no attention has been paid to this matter, but there are excellent opportunities for such storage, as all of the smaller streams flow from narrow cañons easily dammed.

The **Chairman**. Would an accurate survey, showing the source of supply of water, the means of obtaining it, whether by ditches alone or by ditches and reservoirs, and also showing the extent of land that could be irrigated and the estimated cost, be beneficial in enabling settlers to make homes in this valley or in this part of the Territory of Washington? Inquire into this branch of the subject carefully and give as much detailed information as possible touching the benefits of such survey, it being the object of the committee to ascertain whether the United States would be justified in making surveys in view of the expense and the benefits to the settlers and to the Government in disposing of its lands. Give the results of irrigation, the kinds of crops produced, the average yield of the various crops when the land is properly cultivated, and state to what extent fruits and vegetables of all kinds can be raised; giving as nearly as practicable the number of acres under cultivation, and stating some cases of what has been done by individual farmers in this vicinity in reclaiming lands without the aid of capital.

Mr. **Baker**. Yes, such survey would do a great deal toward settling what are now called dry portions of the valley. Thousands of acres now considered worthless, except for grazing, would be proven to be cultivatable, and efforts would be made to construct the necessary canals. The Kittitas Valley without water is but a sage-brush desert; but upon being irrigated it becomes a garden spot and produces bountifully of cereals, fruits, and vegetables, which can be equaled no where else in the Territory. About 22,000 acres of land are under cultivation in the valley, the average production of wheat being about 42 bushels to the acre; oats, 70 to 80. All small fruits, as well as apples, plums, pears, etc., grow to perfection; peaches do not do so well, except in localities bordering on the Columbia and Wenatchee Rivers. Vegetables of all kinds and of the finest quality are grown upon every farm, and are noted in the Puget Sound country for their great size and flavor. It is nothing uncommon for cabbage to weigh 50 pounds and upward; onions, 5 pounds, etc. Every farm in the valley is an example of individual effort in reclaiming the desert with muscle and water.

The CHAIRMAN. What is the cost per acre of the original plant for irrigation, and what does it cost per acre to irrigate the lands annually?

Mr. BAKER. Where water is bought from the farmers' ditch, the only one in the valley, the charge for water is $1.50 per miner's inch, it being estimated that it takes 1 inch to the acre for a season's irrigation. One man can irrigate 160 acres, the expense for work being nominal. Our system is very simple, requiring no previous knowledge whatever, the water being usually allowed to run through the fields in small ditches a rod or more apart. Flooding is not practiced here.

The CHAIRMAN. State whether or not there is any permanent arrangement about this matter of irrigation, whether the farmers are at the mercy of the owners of the water, and whether the latter can refuse to give the water to the farmers and regulate the price thereof.

Mr. BAKER. As stated previously, there is but one ditch owned in the valley, the majority of the stock in same being held by farmers. The owners charge what they please for water, and have refused in some instances to allow persons not owners of such stock to use water from the ditch.

Adjourned.

WALLA WALLA, WASH., *August* 15, 1889.

The committee met pursuant to call of the chairman.

Present: Messrs. Stewart (chairman), Jones, and Reagan; also Director Powell.

STATEMENT OF W. H. REED, OF WALLA WALLA.

The CHAIRMAN. What is your occupation?

Mr. REED. I am a farmer and a grain commission merchant.

The CHAIRMAN. How long have you resided in Walla Walla?

Mr. REED. Eleven years.

The CHAIRMAN. Are you familiar with the country in this vicinity or any portion of the country in eastern Washington or Oregon?

Mr. REED. I am familiar with everything south of the Snake River and east of the Columbia.

The CHAIRMAN. Describe the Walla Walla River and its branches first. What kind of country is that section and how much is there of it?

Mr. REED. The Walla Walla River rises in the Blue Mountains, which are situated about 20 to 25 miles south of the town of Walla Walla.

The CHAIRMAN. How prominent a range is the Blue Mountain range?

Mr. REED. It is from about 5,000 to 6,000 feet high, and runs for about 100 miles through this part of the Territory.

The CHAIRMAN. Is it a spur of the Cascades or is it an independent range?

[A VOICE.] It is an independent range.

The CHAIRMAN. What other streams head in the Blue Mountain range?

Mr. REED. There are numerous streams between the Snake River and the base line of the Territory. All head in that mountain range; but they are comparatively small streams—what we call creeks.

The CHAIRMAN. What is the character of the country to the north, where it is watered by these streams—the general character? Is it agricultural land?

Mr. REED. It is agricultural land. It is all rolling table-land. That is practically all there is here and along the bottom of these streams—bottoms, flat country.

The CHAIRMAN. Do they raise crops over this country without irrigation?

Mr. REED. Yes; that is to say, wheat, barley, and rye.

The CHAIRMAN. Do they raise all-round crops—vegetables, fruit, etc.?

Mr. REED. No; they require irrigation. The vegetables will grow without irrigation, but most of them require irrigation. And fruits require irrigation, except in the mountains.

The CHAIRMAN. Has irrigation been practiced much in this region?

Mr. REED. Not to any great extent. Along these streams there are bottom-lands lying contiguous to the streams that are to a small extent irrigated, and they grow crops of fruit, but to a very limited extent.

The CHAIRMAN. Is water abundant for the purpose of irrigation?

Mr. REED. That is the great difficulty, the water is not abundant. We are already having trouble about the lack of water in the city, because so much of it is taken from the creeks that the mills are unable to run. Notwithstanding the small amount of irrigating that we are doing, we are in trouble with our water supply.

The CHAIRMAN. Mills can be run without water, can they not?

Mr. REED. They can be run by steam. But these mills can not, because they have not the steam.

The CHAIRMAN. But with desert land you can not do much without water?

Mr. REED. No.

The CHAIRMAN. So that in this country, I think, in time the water for irrigation purposes will take the place of water for domestic purposes. Have you ever examined the matter with the view of establishing reservoirs and increasing the water supply?

Mr. REED. No.

The CHAIRMAN. You have never thought about that?

Mr. REED. No. There are tracts of land in the Blue Mountains, areas of a section, half a section, a thousand acres, that there is no doubt could be utilized in that way if water could be got on to them.

The CHAIRMAN. What is the character of those tracts of land?

Mr. REED. Level spots, some timbered and some untimbered. Some of them are meadows.

The CHAIRMAN. They could by dams be turned into lakes?

Mr. REED. Well, I do not know how the water could be gotten into them.

STATEMENT OF JOHN M. HILL, OF WALLA WALLA.

The CHAIRMAN. Are you familiar with the country lying east of the Cascade Mountains, the country comprising eastern Washington and Oregon?

Mr. HILL. I am pretty well acquainted with the country east of the Columbia River and south of the Snake River. I have been living here 18 years.

The CHAIRMAN. Describe the country in regard to its water and land, stating anything you may know about irrigation so far as it has gone.

Mr. HILL. I think Mr. Reed has pretty well described the portion of land in this vicinity. In fact, that is the general character of the country on the base of the Blue Mountains right through. There are small streams or creeks putting out of those mountains at very short distances and taking in the Walla Walla. You have spoken of the Walla Walla. That is the stream just south of us. That is the largest stream in this vicinity. Then we have, some 40 miles on the east of us, the stream known as the Tukannon.

The CHAIRMAN. And between the two rivers numerous streams?

Mr. HILL. Yes. The first is the Tukannon and the next is the Touchet.

The CHAIRMAN. Has any effort been made to use these streams for irrigation?

Mr. HILL. Not to any great extent, with the exception of a few farmers living immediately on the creeks. After they get out of the mountains, out on to what we call the flat mountains, at the foot of the mountains along the base till we get to an elevation of 1,500 feet, right in this immediate vicinity, they do not require this irrigation.

The CHAIRMAN. How is the ground moistened there; by rain or seepage from the snows?

Mr. HILL. By rain. The rain increases.

The CHAIRMAN. As you get to a higher altitude?

Mr. HILL. When you get back on the mountains. We have from 4 to 6 feet of snow back in these mountains every winter. We had 4 feet in the vicinity of a saw-mill in which I am interested. The snow, as a general thing, melts very rapidly. It does not melt slowly enough, that is, to give moisture to the ground.

The CHAIRMAN. When you get farther away from the mountains, I understand you need irrigation.

Mr. HILL. We need irrigation, that is, to raise all classes of crops.

The CHAIRMAN. Can you raise small grains every year without irrigation?

Mr. HILL. We follow the plan of summer fallowing here, to some extent. We have better success and are more sure of crops by summer fallowing. Between here and the Columbia River it would be well to have irrigation; it would increase the quantity and quality of the crop every year.

The CHAIRMAN. For vegetables you need irrigation everywhere?

Mr. HILL. Except on the creek bottoms and the lands near the snow. It does not require irrigation on these heavy loamy bottoms.

The CHAIRMAN. Have you given any thought to the matter of the irrigation of the country generally?

Mr. HILL. I have not given any great amount of attention to it. I have given attention to it since this question has been agitated. Having read of it in the papers I have been looking at the streams in the mountains to see what my judgment would amount to.

The **Chairman**. What do you say on that subject?

Mr. **Hill**. I think our country is well adapted to the establishment of reservoirs. I think we have as nice a place for establishing reservoirs as any country.

The **Chairman**. Now, I wish to ask you whether or not you think a survey of this country for the purpose of ascertaining the points where reservoirs could be established and having them and the lines of ditches designated, with estimates of doing the work, would be beneficial to the people, and whether it would tend to increase the immigration and thus enable the Government to dispose of its land and settle up the country?

Mr. **Hill**. I think it would. I think the establishment of reservoirs through our country would make it certain and sure of bringing a good deal of this land that is now raising poor crops of grain to produce fruits and vegetables.

The **Chairman**. And grain too?

Mr. **Hill**. Yes; better crops of grain.

The **Chairman**. Have you any idea of what is done in the way of crops on an acre of irrigated land either by seepage or by having the water turned on to it?

Mr. **Hill**. The papers published a statement, which I can not now call to mind, to the effect, however, that where irrigation is used the crops are enormous.

Senator **Reagan**. What character of crops do you raise here?

Mr. **Hill**. Our principal crop is wheat. We raise some oats and barley, but the exports are principally wheat and barley. We ship barley east.

Senator **Reagan**. Are those crops raised on irrigated land?

Mr. **Hill**. Not generally; raised on land that is not irrigated.

Senator **Reagan**. What would be the crop per acre with irrigated land?

Mr. **Hill**. That is not the general way of raising those small crops, so I would hardly be able to answer that question.

Senator **Reagan**. What is the average yield on unirrigated land?

Mr. **Hill**. It ranges all the way from 20 bushels to 60 bushels of wheat.

Senator **Reagan**. Without irrigation?

Mr. **Hill**. Without irrigation. That is owing to the slope of our country. The higher we get the more wheat we get.

Senator **Reagan**. What is your crop of barley?

Mr. **Hill**. From 40 to 100 bushels. I have raised 40 and I can raise 100.

Senator **Reagan**. Will corn grow and mature here?

Mr. **Hill**. Yes, it does.

Senator **Reagan**. How much corn do you raise?

Mr. **Hill**. I can not answer that question, because the raising of corn is not generally followed in this country.

Senator **Reagan**. What other crops besides wheat and barley do you raise here?

Mr. **Hill**. We raise some oats on these high lands.

Senator **Reagan**. What is the yield per acre on high land?

Mr. **Hill**. That I am unable to answer, because I can not answer positively that we will raise a given crop of oats.

Senator **Reagan**. Have you seen experiments to determine how much would be the increase of production upon this land if it were irrigated?

Mr. HILL. I think it would be double.

Senator REAGAN. What kind of fruit do you raise here?

Mr. HILL. I think we raise almost any kind that there is anywhere, except tropical fruits. We raise peaches and plums. The peach crop is not a sure crop every year, but prunes, plums, grapes, and fruits of that kind grow well.

Senator REAGAN. Do apples grow well?

Mr. HILL. Apples grow quite well.

Senator REAGAN. Do the small fruits, such as strawberries and raspberries, grow well?

Mr. HILL. Strawberries and raspberries grow as well here as they do any place in the world.

Senator JONES. How long have you lived here?

Mr. HILL. I was born on this coast. I have lived at Walla Walla eighteen years.

Senator JONES. What is your business?

Mr. HILL. I am interested in the milling and flume business. I also do some cattle farming, and am concerned in the street railway in the city.

Senator JONES. Do you reside in this town?

Mr. HILL. I do.

Senator JONES. How many inhabitants have you here?

Mr. HILL. Between 6,000 and 7,000.

Senator JONES. Is this the county seat?

Mr. HILL. Yes.

Senator JONES. What is the population of the county?

Mr. HILL. Eleven thousand.

Senator JONES. Then more than half the population of the county live in this town?

Mr. HILL. Yes.

Senator JONES. About what is the size of the county?

Mr. HILL. We have been cutting it up—seventy-two school sections and just half the number of townships—thirty-five townships.

Senator JONES. About what proportion of the land in this county is arable; that is to say, if it have tillage?

Mr. HILL. Three-fourths of it at least. Of course a great deal of it is rolling country, but we farm rolling land and very steep land.

Senator JONES. What proportion of what is suitable for tillage is fit for agriculture with irrigation?

Mr. HILL. Half of it, at least.

Senator JONES. How much land in the immediate vicinity of this town is under cultivation and irrigation?

Mr. HILL. The greater portion of our land in the immediate vicinity of Walla Walla is farmed in some shape or other, either in raising grains or fruits.

Senator JONES. Is it irrigated?

Mr. HILL. Not the grain land.

Senator JONES. The grain land is not irrigated?

Mr. HILL. No.

Senator JONES. Are some parts of every farm irrigated and some parts not?

Mr. HILL. No; the farms irrigated are only those lying along these creeks.

Senator JONES. Those back from the creeks are not irrigated?

Mr. HILL. Those back from the creeks. First we have a small hill and then we have the table and rolling land.

Senator **JONES**. Is there any grain in the county that is irrigated?

Mr. **HILL**. There is west of us on the Walla Walla River. They used to irrigate considerable there, and also on the Touchet.

Senator **JONES**. How long has irrigation been practiced to any great extent in this vicinity?

Mr. **HILL**. Ever since I have been in the country there has been some.

Senator **JONES**. How long has it been practiced to any considerable degree?

Mr. **HILL**. It is only within four or five years that we have received complaints by the mills of a shortage of water.

Senator **JONES**. Is there any desire on the part of the people on the bottoms to irrigate them?

Mr. **HILL**. I have no doubt there is a desire, but there is a lack of water. So far as getting water onto this table land is concerned it is a short distance. Our country falls to the west all the way from 50 to 80 feet to the mile. So that in taking water out of these streams you would not go a great distance before you would get water on these table lands.

Senator **JONES**. You think they could get water on these table lands?

Mr. **HILL**. I think so, if there were a water supply.

Senator **JONES**. You have not observed any comparison between land cultivated without irrigation and the same land subsequently irrigated?

Mr. **HILL**. No; I have not. I do not call to mind anything of that kind at present.

Senator **JONES**. You have a general idea that it would double the crop. Of course, there is land here that will raise no vegetables at all without irrigation. But when you put water onto it it will raise the finest kinds.

Mr. **HILL**. Fruits are successfully raised where they irrigate.

Senator **JONES**. On the table lands?

Mr. **HILL**. Yes.

Senator **JONES**. Do they raise peaches and pears up there without irrigation?

Mr. **HILL**. Oh, yes.

Senator **JONES**. Then fruit-growing is not confined to irrigation districts?

Mr. **HILL**. No; not entirely.

Senator **JONES**. Have you any idea of the relative value of land with and without water; what it would be worth? Take a tract of 40 acres worth $10 an acre without water, what would it be worth with water? What would be the increase in the value of the land?

Mr. **HILL**. Double—I say that at once—if not three times. I know a short time ago I bought 10 acres and paid $350 an acre for it, because it is right near town. I bought it for a home, and then it has a nice stream of water running through it.

STATEMENT OF C. A. ELMER, OF WALLA WALLA.

The **CHAIRMAN**. What is your occupation?

Mr. **ELMER**. I am the editor of The Daily Union.

The **CHAIRMAN**. Have you given any attention to the effect of irrigation in this vicinity?

Mr. **ELMER**. Other than the collection of a certain amount of statistics in reference to the cultivation of grain and vegetables, I have not.

I have something to refresh my memory in regard to the vegetable line. You have alluded to the value of irrigated lands and the total amount of crops from irrigated lands, and I have a statement that I made from information that I got together from the gardeners. It is as follows:

The first efforts to grow trees between the Cascades and Rocky Mountains were by Missionaries Spaulding on the Clearwater River, and Whitman at his residence on the Walla Walla River; both these attempts were made in the spring of 1837, when seeds were sown. In this connection Mr. Philip Ritz, the oldest resident tree-grower, says: "I remember seeing some of the apple trees about the year 1866, and they run over a foot in diameter and nearly 30 feet high. Some of the fruit was of very good flavor; these, I believe, were the first apple trees to come into bearing on the Pacific coast, and known and spoken of from Victoria to San Diego."

After this first effort by the missionaries there was not much done in the way of fruit-tree culture until 1861, when Mr. A. B. Roberts, of Walla Walla, and Mr. James W. Foster, at the foot of the mountains, both of whom planted large orchards, some of which are bearing fruit now.

The third attempt at fruit-growing was by Red Wolf, a chief of the Nez Percé tribe of Indians, at the month of the Alpowa Creek; Rev. Spaulding planted the seed for him in the spring of 1838. In the spring of 1859 Mr. Clark set out a nursery about 1½ miles south of the town of Walla Walla, on Yellow Hawk Creek. In the fall of the same year James W. Foster brought fruit trees from over the Cascade Mountains and set them out on his present ranch. Thus Mr. Clark became the first nurseryman, and Mr. Foster the first to set out an orchard, after Missionaries Spaulding and Whitman, between the Cascade and Rocky Mountains. In 1860 A. B. Roberts planted a nursery and set out what is now known as the Ward orchard in the city limits.

In the fall of 1861 Mr. Ritz delivered a number of orchards east of the Cascade Mountains from his Oregon nursery, the shipment consisting of between 30,000 and 40,000 trees, many of which are at present, and have been for years, bearing excellent fruit. In 1862 Mr. Ritz moved his nursery from Corvallis, Oregon, to this valley. He started a nursery about 1½ miles from Walla Walla, planting about 60,000 trees, which in 1872 was increased to nearly 1,000,000 trees.

To-day Mr. Ritz has 70 acres in trees and cultivates all varieties adapted to this northern climate, having in his nursery 400 different varieties of apples, pears, and prunes, and has in bud 250,000 plum and prune trees ready for next year's planting. This, we believe, is the largest stock ever grown by one man north of California. These trees will bear fruit within two or three years from planting.

As to vegetables and small fruits, I offer the following facts, gathered by me during the past season:

There was during the past season, within a radius of 2 miles of Walla Walla, over 1,000 acres cultivated as vegetable and small fruit gardens, and the value of their product was to exceed $400,000, all of which was marketed in this Territory, Idaho, Montana, eastern Oregon, and points to the southeast as far away as Denver.

The writer, desiring to get some figures showing the average yield of the garden lands of Walla Walla and their marketable value, called on W. S. Offner, the leading market gardener, and received the following information in regard to average yields of "garden truck," under ordinary cultivation, by the acre:

Onions, 25 tons, at $12	$300
Potatoes, 20 tons, at $10	200
Carrots, 50 tons, at $6	300
Cabbage, 15 tons, at $15	225
Table beets, 20 tons, at $15	300
Stock beets, 40 tons, at $6	240
Grapes, 10 tons, at $60	600
Strawberries, 10,000 pounds, at 6 cents	600
Blackberries, 12,000 pounds, at 7 cents	840
Raspberries, 5,000 pounds, at 7 cents	350
Melons, 300 dozen, at $1	300
Asparagus	300
Tomatoes, 600 boxes, at 30 cents	180

This gives a total for 13 acres of garden for one year's crop, of $4,735. Mr. Offner further said, the cost of the land would not exceed $2,600 with a good fence around it; $500 will pay for necessary improvements, such as the planting of the berries, grape vines, and asparagus, and $500 will purchase a team and the necessary implements to cultivate the garden. This makes a total investment of $3,600. The cost of planting, cultivating, gathering, and marketing the crop from a garden of 13 acres will not exceed $1,500. Taking this as an experiment, the total investment up to the end of the year 1888 would have been $5,100, and the receipts for one year's crop would be $4,735. The profit upon the investment would be $3,235, or nearly 100 per cent.

Our informant was the first to commence gardening upon a large scale, and the smaller gardeners laughed at him, believing that he would glut the market with his products and thus produce his own downfall. Instead of that, in the first year he could not fill the orders received, and he doubled the size of his garden. The next year it was the same, and he again increased the size of his garden. Still he says that the only difficulty experienced in retaining his customers is because he can not half fill the orders received.

One of the reasons, besides the advantage of location, why Walla Walla fruits and vegetables have a market is because of the early season here. Berries and vegetables are in the market here as early as they are in California, and are of even finer quality.

The CHAIRMAN. What has been your observation and your opinion as to the need of irrigation?

Mr. ELMER. In my opinion there is no demand for it in the higher portion of the valley, on the high lands. There the grain yields largely without irrigation.

The CHAIRMAN. Nearly every year?

Mr. ELMER. Yes.

The CHAIRMAN. But from here down to the river. How would it be there?

Mr. ELMER. Much of it produces small crops, because of a lack of water at the right season. That is to say, if they had the water to put on from May until the grain was ripened, the yield would be much greater.

The CHAIRMAN. With regard to the production of crops other than small grain. How does irrigation affect them?

Mr. ELMER. There are no crops of grain of which I know in this vicinity that are irrigated.

The CHAIRMAN. I speak of crops other than grain.

Mr. ELMER. As many potatoes and vegetables are raised in many portions of the valley without as with irrigation. In some portions, where there is alkali, water is required.

Senator JONES. Where these crops grow there is moisture either by seepage or from rain-fall?

Mr. ELMER. Yes; there is a natural irrigation in certain portions of the valley.

The CHAIRMAN. How is it with fruits?

Mr. ELMER. Much the best fruit that I have seen in the valley is raised without irrigation. But that which is marketed at the present time is raised by irrigation.

The CHAIRMAN. Where is the land situated on which you can raise fruit without irrigation?

Mr. ELMER. Most of it is above, near the mountains, within a few miles of the city. There, when you rise above a hill, you will see a rolling bench.

The CHAIRMAN. Is there more rain-fall as you gain an elevation?

Mr. ELMER. Yes.

The CHAIRMAN. That is general here—the lower the land, the lower the rain-fall.

Mr. ELMER. Yes; that is the need all over this section.

STATEMENT OF H. S. BLANFORD, OF WALLA WALLA.

The **CHAIRMAN.** How long have you resided in Walla Walla?

Mr. **BLANFORD.** I have been here since November, 1885, as Signal Service observer. I am a sergeant in that corps.

The **CHAIRMAN.** To what extent are you familiar with the country about here?

Mr. **BLANFORD.** I have lived all through the valley from here to the Cœur D'Alene Mountains, and for two years I was at Dayton. That is in the Walla Walla Valley. I am pretty familiar with the Walla Walla Valley—climate and rain-fall especially.

The **CHAIRMAN.** Where is the rain-fall in this valley?

Mr. **BLANFORD.** It increases as you go up the valley, gain a higher elevation, on the upper slope. For instance, here we have 18 inches annually on an average, and at Dayton, 30 miles away, it is 27 inches.

Senator **JONES.** How much higher is Dayton than it is here?

Mr. **BLANFORD.** Walla Walla has an altitude of 1,000 feet, and it rises 60 feet to the mile.

Senator **JONES.** How much of this valley is table-land and suitable for raising small grain without irrigation?

Mr. **BLANFORD.** Most of it. The land between here and Wallula is pretty light. After you go down here 6 or 7 miles it is very light—sage brush will grow up to the town within 2 or 3 miles.

Senator **JONES.** Do you regard sage-brush as indicating bad land?

Mr. **BLANFORD.** It is drier land. At Wallula the rain-fall is 9 inches.

Senator **JONES.** Sage-brush land is dry land. But how as to its fertility?

Mr. **BLANFORD.** With plenty of water it will produce fine crops of fruits and berries.

Senator **JONES.** You have not seen it irrigated with small grain?

Mr. **BLANFORD.** No; I have not. I have had no experience with irrigated land on which there is grain.

Senator **JONES.** On what portion of this valley do you raise fruit without irrigation?

Mr. **BLANFORD.** Almost any part of it. There are some few belts that have very peculiar climates, where you can not raise peaches. But they raise fine peaches in Dayton. Dayton is famous for its peaches, and they are up 1,675 feet. They raise apples there also.

Senator **JONES.** Without irrigation?

Mr. **BLANFORD.** Yes.

Senator **JONES.** There you have 18 inches more of rain-fall?

Mr. **BLANFORD.** Yes.

Senator **JONES.** Does it come every season?

Mr. **BLANFORD.** It rains almost exclusively every day from the middle of September until January. June has a little rain-fall. I think the larger orchards are not irrigated at all, but the garden peaches and the small berries in a great many instances are irrigated.

Senator **JONES.** What is the difference between those irrigated and those not?

Mr. **BLANFORD.** Of course, where the land is light and irrigated, you get as good crops as you do on land not irrigated. Water seems to be essential.

Senator **JONES.** What are the chances of getting water on to these lands where it is required?

Mr. **BLANFORD.** I should say that the water supply is not sufficient to irrigate all the land that might be irrigated. There is such a fall of the creek that you could get water almost any distance.

Director **Powell**. Suppose we go down 25 miles on the Walla Walla, what would be the rain-fall there?

Mr. **Blanford**. Down the valley?

Director **Powell**. Yes.

Mr. **Blanford**. If you go down 25 miles you would get 10 inches.

Director **Powell**. What at this place?

Mr. **Blanford**. Eighteen inches—17¾.

Director **Powell**. Going up the river 10 miles, what would be the rain-fall?

Mr. **Blanford**. Twenty or 21, easy. If you were to go straight across here to the foot of the mountains you would get 30 inches.

Director **Powell**. If you were to go 35 miles east what would it get?

Mr. **Blanford**. Thirty-five miles, at the city of Dayton, you would get 27 inches; that is at the foot of the bluff.

Director **Powell**. Are there any rain-gauges on the top of the mountains?

Mr. **Blanford**. No; none.

Director **Powell**. How high up the Blue Mountains do you have rain-gauges?

Mr. **Blanford**. This is the highest here. A man in Pendleton had a rain-gauge, but I do not know exactly what it is there. But we had observations at Dayton for five years, and we made the average about 27 inches.

Director **Powell**. And Dayton is the highest point where you have had rain-gauges?

Mr. **Blanford**. Yes. At Lewiston, that is in the Snake River Valley, they have 14 inches. But Dayton has a bluff, and on the top of that hill there must be a great deal more rain-fall than in the valley. That is the finest wheat land in the world.

Senator **Jones**. How high are the Blue Mountains?

Mr. **Blanford**. I should say from 4,500 to 5,000 feet.

Senator **Jones**. Have you any distinct idea about the rain-fall over on the mountains?

Mr. **Blanford**. No; except that it increases very fast between here and the mountains.

Senator **Jones**. But you have no data as to the increase?

Mr. **Blanford**. No.

Senator **Jones**. It is very much larger than it is at Walla Walla?

Mr. **Blanford**. Yes. Fifteen miles across here you would get double the Walla Walla rain fall. I should like to present as part of my statement the following in relation to the weather for last year, 1888.

The **Chairman** (examining). Let it be filed.

The statement is as follows:

The month of December, 1887, was mild and equable. Its mean temperature was 40°; the highest 63° on the 7th, and the coldest 20° on the 22d.

Winter weather set in January 4, after which date there followed twenty days of cold weather, which was all the winter we had. Of these twenty days, ten had temperatures below zero, the coldest being 17° below zero on the 16th. The weather during this cold snap was generally calm, dry, and clear, and few knew how cold it was until they inspected a thermometer. January had a mean temperature of 22° above zero—quite cold for us—but we have the consolation of thinking that we were in such distinguished company as Boston, 20°; New York, 26°; Cleveland, 22°; St. Louis, 24°, and Salt Lake City, 23°, and that our winter lasted less than three weeks, while theirs approximated four months.

The chinook came January 2, and King Winter abdicated in favor of Gentle Spring. Thenceforth mild weather continued. February had a mean temperature of 45° and its coldest day's lowest temperature was about the freezing point. Its highest temperature was 65°. Only nine days were cloudy and the continued sunshine and warm winds made lilac and fruit trees leaf out. There were little snow-squalls on the 28th and 29th which did no harm, the snow melting immediately.

March had spring-like but capricious weather. A little cold wave came over on the 6th, 7th, and 8th, the temperature fell to the freezing point and a sprinkle of snow fell. After this the weather was delightfully pleasant. The month had twelve cloudy days, a mean temperature of 45°, and a highest temperature of 71°.

April was warm, sunshiny, and comparatively dry. The mountains invested themselves with the deep-blue atmosphere which indicates the rapid evaporation of their snows by the warm chinook; the hills put on their springtime verdure; trees attained full leaf and, many of them, full blossom, and the chinook wind, whose advent during the winter months was hailed with delight, lost its identity. Our mean temperature for April was 58°.

May was warm, blooming, altogether charming. Walla Walla strawberries were in the market May 5 and new potatoes on the 28th, by which time everything pertinent to the season in the temperate zone could be had in abundance from local market gardens.

June was cool and unusually wet. July, August, and September were warm and dry. The highest temperatures of the summer were 102°, on July 18 and August 21.

October was warm and pleasant. The first frost of the season occurred October 18, and killed strawberries ripening on the vines and terminated the season of the green peas and other tender vegetables. Rain fell quite heavily during the last week of the month. October had a mean temperature of 56°, and no temperature as low as the freezing point.

Fine autumn weather continued to November 12, when a cold wave came over and a little winter set in and continued, except for occasional mild chinooks, through the month. The highest temperature was 61°, the lowest 18°, and mean 38°. There was no snow and the precipitation was considerably below the normal.

December was mild and cloudy and frequently foggy. Its mean temperature was 36°; the highest 64°, and lowest 18°. About an inch of snow—the first of the winter—fell on December 23. The rain-fall for the month was 2.19 inches, nearly an inch below the normal. The total deficiency in precipitation for the year 1888 was 3.78 inches, which classes among the "dry years" of this country.

As a whole the year has been warm and comparatively dry. The mean annual temperature was: The highest temperature 102°, the lowest 17° below zero. The prevailing wind from the southwest. The total snow-fall, 19 inches; the total precipitation, 13.50 inches; the last frost of spring occurred March 29; the first frost of autumn occurred October 18, with temperature between 45° and 60°; chinook wind blew on 66 days between November 5 and April 30; thunder-storms, 3; clear days, 187; fair days, 115; cloudy days, 113; rainy days, 86; foggy days, 4.

The careful study of the records for the past fifteen years would seem to warrant the observation that when, as in the present year, there is a period of cold weather in the latter part of November and early in December, the remainder of December and most of January will be mild and pleasant. There is nearly always a month of cold weather either in January or February.

Mr. Blandford. Allow me to add a few words on the general subject. Walla Walla does not consider herself in an arid district. While it is undoubtedly true that abundant irrigation would greatly increase crop-yields and enhance the value of lands, it is equally true that our unirrigated lands are as productive as any in the Northwest and do not strictly *need* irrigation. Without irrigation we can raise, per acre, 40 to 100 bushels of wheat and barley, 6 to 8 tons of hay, 500 to 700 bushels of potatoes and onions, 100 tons of plums, peaches, apples, etc., and very heavy crops of berries and all small fruits and vegetables. Irrigation, of course, would increase these yields and assure good crops every year, other conditions being favorable.

The secret of getting good crops in the Walla Walla Valley depends on thorough irrigation. My own investigations have shown that, on properly plowed and pulverized summer-fallowed land, there is a continuous stratum of moist earth from the surface to bed-rock. The native bunch-grass sod-land dries out, by evaporation, to a depth of more than 4 feet in a single summer. In other words, all the seasonal rain-fall is evaporated during the season. In this land it is necessary to dig 10 feet or more before reaching the permanent moist earth, while well-harrowed fallow will give continuous moist earth from 4 to 6 *inches* beneath the surface. There are wheat fields in the vicinity of this city which have, for the past twenty-five years or more, given a splendid crop of 35 to 45 bushels of wheat per acre each year in that period. The farmers declare the soil is practically inexhaustible with proper conservation of the annual rain-fall. The same is true of all the good land on the west slope of the Blue Mountains in Washington Territory, where the altitude and yearly rain-fall is equal to or greater than here at Walla Walla.

Table of rain-fall and temperature taken from the records of the United States Signal Service Office at Walla Walla, Washington Territory.

[Compiled for the Senate Committee on Irrigation.]

MEAN TEMPERATURE.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Sums.	Annual mean.
1886	25.8	43.2	44.5	52.0	61.4	68.0	76.7	73.9	64.0	50.2	39.8	39.7	......	53.3
1887	41.0	23.0	49.6	51.5	60.9	63.9	75.5	72.2	61.2	51.9	40.8	39.9	......	52.6
1888	22.1	45.4	44.7	58.1	64.8	65.1	72.8	77.0	69.0	56.3	38.4	35.6	......	54.2
1889	28.2	36.0	53.2	57.0	61.2	70.8	78.0	......	......	......	......	......	......	......

PRECIPITATION (in inches).

1885	......	......	......	......	......	......	......	......	......	......	......	1.92	......	......
1886	3.45	1.29	1.06	1.66	0.67	0.73	0.02	0.12	0.06	1.95	0.78	4.41	16.20	......
1887	2.36	1.78	1.83	1.57	1.08	2.12	0.03	0.71	1.55	1.52	3.06	2.83	20.44	......
1888	2.21	0.80	1.44	0.69	0.21	2.37	0.46	0	0.02	2.33	0.87	2.19	13.59	......
1889	0.47	0.79	1.39	1.51	4.04	1.23	Trace.	......	......	......	......	......	......	......

The average annual precipitation of Walla Walla, as taken from the private record of Mr. Isaac Straight, from 1873 to 1886, is 17.85 inches.

STATEMENT OF GEORGE T. BERRY, OF WALLA WALLA.

The **CHAIRMAN**. How long have you resided in this vicinity?

Mr. **BERRY**. Since 1864. I have lived in Washington Territory since 1853.

The **CHAIRMAN**. Describe this valley, its land; how it is situated with reference to its rivers and mountains.

Mr. **BERRY**. It has been very correctly described by Mr. Reed and Mr. Hill. It has a fall of 60 to 75 feet to the mile, until you get into the mountains; then the streams are from 50 to 60 feet.

The **CHAIRMAN**. The Blue Mountains are of what altitude?

Mr. **BERRY**. From 3,000 to 3,500 feet.

The **CHAIRMAN**. Are there numerous streams coming out of those mountains?

Mr. **BERRY**. Yes.

The **CHAIRMAN**. For what distance?

Mr. **BERRY**. The Walla Walla River runs back into the mountains 25 miles from the base.

The **CHAIRMAN**. Have you been along the ridge to know the topography of the country there?

Mr. **BERRY**. I have been all through the mountains clear up to the head of the streams. It has been my business to be there. The streams are confined to cañons, and the cañons break very abruptly from one creek to another. The heads of the rivers there come very close together and spread out as they come toward the valley. But there are not many table-lands, only in a few places. There are a few meadows, and they go off into the Grande Ronde. But the cañons are many.

The CHAIRMAN. Have you ever been further south than the table-lands—the lands beyond the Blue Mountains?

Mr. BERRY. Yes, I have been clear around the Blue Mountains on the south.

The CHAIRMAN. As far south as the California line?

Mr. BERRY. No. I have been out close to the border line of California, though.

The CHAIRMAN. What is the character of the country?

Mr. BERRY. As you get between the Blue and Cascade Mountains it is high table-land.

The CHAIRMAN. Are there any streams of water through it?

Mr. BERRY. No, not many streams of water; it is a dry country till you get to the John Day's River.

The CHAIRMAN. That comes out of the Blue Mountains?

Mr. BERRY. Yes; it heads in on the southwest side.

The CHAIRMAN. When you get beyond that, there is a region of what you would call desert land.

Mr. BERRY. Yes; on high country.

The CHAIRMAN. What would be the altitude; too high to raise crops?

Mr. BERRY. No; the vegetation is good there and the soil is good, with water on it.

The CHAIRMAN. Is there a large region of country in there?

Mr. BERRY. Yes.

The CHAIRMAN. What is it used for?

Mr. BERRY. Grazing purposes—stock-raising.

The CHAIRMAN. Have you given your attention to the subject of irrigation in this valley?

Mr. BERRY. I have, in this valley.

The CHAIRMAN. What effect has it upon the crops?

Mr. BERRY. It has a very preceptible effect. It increases the yield of everything that we put water on—small grain, fruit, and vegetables.

The CHAIRMAN. How much will it increase the yield of small grain?

Mr. BERRY. I should say that it would double the yield.

The CHAIRMAN. In an ordinary year?

Mr. BERRY. Yes.

The CHAIRMAN. How would it be with potatoes?

Mr. BERRY. It would do that with potatoes, with this amendment; I will say, as Mr. Elmer said, that up near the mountains it would not, because it is heavier, richer soil.

The CHAIRMAN. They do not need irrigation there; they have enough rain-fall to not need it?

Mr. BERRY. Yes.

The CHAIRMAN. But how about below that?

Mr. BERRY. Then it increases very rapidly.

The CHAIRMAN. Clear down to the river?

Mr. BERRY. Yes; I know I planted an orchard ten miles from town on sage-brush land. I drew water out of the Walla Walla River, and it gave an abundant yield. That is the effect of irrigation. It increases the yield of vegetables and small fruits.

The CHAIRMAN. Have you ever given any attention to storing water below the mountains in ravines and small places?

Mr. **Berry**. I have often thought the matter over, but never made any surveys for that purpose. In the cañons it could be stored, but there is no way of doing that on the summit of the mountains.

The **Chairman**. Could you not turn it out and make a reservoir on your own farm?

Mr. **Berry**. No, not successfully. We ought not to tamper with the water, because the people will enjoin us.

The **Chairman**. You will have more difficulty here in getting out of the law, because you will have some of the European facts to contend with—you have rain-fall to do something with.

Mr. **Berry**. There have been lawsuits already. There have been some in regard to the water in this stream. The people could not get water on to the table-lands, because the persons owning the mills will not allow them to take it out. Those are the facts. And we have not had an opportunity of trying it on a very large scale. But everybody would have water if they could get it. That is the truth of it. It would increase the value of the land. Land worth $25 an acre to-day would be worth $300 with water on it. And I call on any gentleman here to verify that statement.

The **Chairman**. Do you not think the people will get plenty of water sometime?

Mr. **Berry**. Yes.

The **Chairman**. Do you not think that the Government of the United States could help some by surveys and the designation of places where reservoirs could be constructed?

Mr. **Berry**. I think so.

Major Powell, at the request of the chairman, spoke briefly on irrigation matters.

STATEMENT OF CHARLES HENRY, OF WALLA WALLA.

The **Chairman**. How long have you resided in Walla Walla?

Mr. **Henry**. About ten years.

The **Chairman**. What proportion of land in this vicinity is public land, and how much has been entered?

Mr. **Henry**. I can not state exactly how much has been, but I am aware of the fact that there is more vacant and unoccupied Government land is this county than any other in the Territory.

The **Chairman**. What is the character of the unoccupied Government land?

Mr. **Henry**. It is chiefly arid land; that is the reason it has not been occupied. It lacks moisture.

The **Chairman**. To what extent could moisture be put upon it?

Mr. **Henry**. If proper efforts were made to catch and store the waters that are wasted in the winter and spring, thousands and thousands of acres could be utilized.

The **Chairman**. Of public land?

Mr. **Henry**. Yes. If it could be demonstrated to the people that water could be stored and utilized this country would bloom up very quickly. There is an immense scope of country to the west and north that if it had a very little moisture at the right time of the year would afford homes for an immense population.

The **Chairman**. Could this be done by individuals, or would it require associations and a large expenditure of money?

Mr. **Henry**. I think that if it were clearly demonstrated that water could be applied to the land people would come here and would make efforts themselves to get the water in. In some places it might require some money to do very much.

The **CHAIRMAN**. What do you say of the effect of irrigation in this vicinity?

Mr. **HENRY**. It has been stated here by some gentleman who preceded me that he believed that it would double the yield of our small-grain crops. I believe that it would do more than that, in this way; it would assure us a crop each and every year. As it is now one-half of our land has to lie fallow one year, and it is very unsatisfactory to have to do that. It would be far better for the Government if the people had only small farms of 100 acres and have those well farmed and producing a crop each year, than to let people have 640 acres with one or two hundred lying fallow. You can travel here for miles and miles and you will not see a clothes-line. The land is owned by men of large means, who own it in large quantities, and it is cultivated one part this year and another part next year. It would be much better for the Government and the people if it were farmed in small pieces and farmed thoroughly.

STATEMENT OF W. P. GRAY, PASCO, FRANKLIN COUNTY.

The **CHAIRMAN**. Where do you reside?

Mr. **GRAY**. In Pasco, Franklin County.

The **CHAIRMAN**. Have you paid any attention to the subject of irrigation?

Mr. **GRAY**. Yes.

The **CHAIRMAN**. Where?

Mr. **GRAY**. Where I live; in Pasco.

The **CHAIRMAN**. What is the character of the soil about Pasco?

Mr. **GRAY**. It is a sandy loam.

The **CHAIRMAN**. Have you ever experimented as to the effect of putting water on the soil?

Mr. **GRAY**. Yes.

The **CHAIRMAN**. With what results?

Mr. **GRAY**. With good results. The soil here will produce, if watered, anything that can be produced in semi-tropical climates.

The **CHAIRMAN**. It is rich soil, is it?

Mr. **GRAY**. Yes.

The **CHAIRMAN**. Have you heard people discussing the question whether it was possible to get the Columbia River onto that land or not?

Mr. **GRAY**. The matter is being agitated now by several parties. I took a party of capitalists from Chicago up into our Territory, up to Aprees Rapids, two weeks ago. My opinion is that there is hardly fall enough in the Columbia to bring it down successfully.

The **CHAIRMAN**. From Aprees Rapids?

Mr. **GRAY**. Yes.

The **CHAIRMAN**. How far is it from those rapids until you reach another rapids?

Mr. **GRAY**. Forty-five miles.

The **CHAIRMAN**. How much is the water-fall at this place?

Mr. GRAY. At Cabinet Rapids it is about 10 feet and at Rock Island about 20 feet.

The CHAIRMAN. How much is it at Aprees Rapids?

Mr. GRAY. About 75 feet in 9 miles.

The CHAIRMAN. There is not much fall in the river from there down to Pasco?

Mr. GRAY. Very little.

The CHAIRMAN. Is there about as much as you want in a ditch?

Mr. GRAY. Yes.

The CHAIRMAN. Is there much difference between that part of the river and the part that we see in traveling along the line of the railroad?

Mr. GRAY. No.

The CHAIRMAN. Is there not considerable of that land that is less than 75 feet above the river?

Mr. GRAY. On the Franklin County side, or rather on the Douglas County side——

The CHAIRMAN. That is on the east side?

Mr. GRAY. On the east side. I would estimate that a ditch taken out at the head of Aprees Rapids would cover 30,000 acres of lowland before it got to the eddy at White Bluffs. At that point there would be no land covered for about 20 miles; then about 4,000 would be covered; then for 10 miles more no land would be covered; then there would be covered about 15,000 acres to carry it to the Snake River.

The CHAIRMAN. Making in all about 50,000 acres?

Mr. GRAY. A little more than 50,000 acres. On the west side of the river in the first 30 miles between 40,000 and 50,000 acres can be reclaimed by a ditch from the head of the rapids.

The CHAIRMAN. Have you ever estimated the cost of a ditch of that kind?

Mr. GRAY. The gentlemen who were with me made a very preliminary examination. They had no instruments with them, but took a carpenter's level and put up a tripod of their own; but I do not know what the result of the investigation was.

The CHAIRMAN. Have you looked into the question of irrigation as to the storage of water and the utilization of the small streams?

Mr. GRAY. I have studied the topography of the country somewhat. Near Pasco there are quite a number of coulées or cañons that could be used for storage at a very small cost.

The CHAIRMAN. Is there sufficient rain-fall on the water-sheds?

Mr. GRAY. There is not much rain-fall. You might call it snow-fall. I suppose our average snow-fall is about from 8 to 18 inches. We have two other ways to get water. One is to bring in Moses Lake, which is an alkali lake lying about 60 miles due north, but the supply is hardly enough to justify the expense of bringing the water down.

The CHAIRMAN. How much of a lake is it?

Mr. GRAY. It is about 18 miles long and from 1 to 3 miles wide. It is fairly deep.

The CHAIRMAN. Is there any way of getting a tunnel into it?

Mr. GRAY. Hardly.

Senator REAGAN. There is an artesian well being bored at Pasco, I believe?

Mr. GRAY. Yes.

Senator REAGAN. How deep have they got with it so far?

Mr. GRAY. Five hundred and twenty-seven feet. They found gravel after about 135 feet down, and the remainder is basalt; that goes down to 350 feet.

The **CHAIRMAN**. They have not got through the basalt yet?

Mr. **GRAY**. No.

Senator **REAGAN**. You have no completed well there?

Mr. **GRAY**. No. But I will say that there is a well at Fulman, which is in Whitman County; and they also have a well on the other side of us at Roslyn. It is about 120 miles to Fulman and about 150 to Roslyn. I understood that the depth of the Fulman well was about 75 feet and the Roslyn well about 350 feet; but that is hearsay.

Senator **REAGAN**. Is the flow large?

Mr. **GRAY**. In the Fulman well it is 13 to 18 feet, and at Roslyn I understood it was 8 feet, about. They struck the flowing well, and then went a little farther and struck gas, and now they are throwing together.

STATEMENT OF MARION G. EGBERT, OF WALLA WALLA.

Mr. **EGBERT**. Irrigation with us exists only in its infancy, being used only for orchards and gardens, and the little that is done in this way soon exhausts all available water, viz, that of the small mountain streams here; but this is especially true during a season that has been so dry as this has been. This is also true in all sections of this country. There are large arid tracts about us which, to the view of the ordinary mortal, will always remain so, for he can not see how water can ever be put upon them, for the reason of their altitude and distance from any large body of water.

At Pasco, some 35 miles from here, is a magnificent body of land, large as a State back East, that produces, with water, wonderful crops, that without it are indeed arid and valueless. Its elevation is but 355 feet, with the great Columbia bisecting it. Yet the people, ever so willing, don't seem to know what to do, where to go to work, to reclaim this beautifully lying and superbly situated body of land. The section named would make the finest orchard land on earth if water was but placed upon it.

Adjourned.

STATEMENT OF JOHN GIBBON, BRIG. GEN. U. S. ARMY, COMMANDING DEPARTMENT OF COLUMBIA.

My attention was directed to irrigation and reclamation of arid land very early in a long term of service on the plains since the close of the civil war. At three of the posts where I was stationed a more or less perfected system of irrigation was kept up, with very great benefit to the garrisons, in the shape of shade trees, grass, and flowers. At Fort Sanders, in the Laramie plains, a stream of water flowing from a large, cold spring several miles above the post was, by means of a graded ditch, conducted along the edge of the valley into and around the post with the usual result—grass, trees, and flowers. This was in 1867.

At Camp Douglas, in 1869, a stream of water from the mountains was running through the post, the water being used to irrigate the lands of the valley below. It was conducted about the post in various directions with the usual result; wherever the sage-brush was cleared off and the water put on good crops followed. Irrigation in Utah was then an old story, for the Mormons had for years made use of it with the finest results.

But the most marked results were obtained at Fort Shaw, Mont. On arriving there in 1870 the post was found to be situated on a dry, arid plain, with scarcely any grass, and not a tree or bush in sight except in the river bottom 70 or 80 feet below. The year following a ditch 7½ miles long was constructed, tapping the Sun River several miles above the post, running across the broad valley, reaching the foothills and skirting along them, until by a well-graded line it reached the plateau occupied by the post, around which it was conducted in every direction with the usual results. The difficulties here were enhanced by the fact that the ground on which the post was located was a hard conglomerate, into which we were obliged to dig holes for the trees and supply them with some soil, but the hardy, quick-growing cottonwood speedily took root, and water to it being the great essential, it grew rapidly, and a few years afterward the post, on approaching it, was seen to be perfectly embowered in a forest of trees 30 and 40 feet high, forming a marked contrast to its appearance in 1870.

These, however, were not the most important results following the construction of this irrigating ditch at Fort Shaw. It demonstrated the value of the high bench lands for agricultural purposes when supplied with water. In running over the plateau above the post good rich soil was encountered. A portion of this was broken up and irrigated from the ditch. The finest kind of vegetables of all kinds were the result, and the company gardens were at once removed up from the bottom land where they had previously been located, and where vegetation had always been very much retarded from the soil being cooled by the infiltration of the snow water from the flooded river. The bench lands proved much warmer and on them the frost came later in the fall and ceased earlier in the spring, thus giving a longer season. At that time Montana was very sparsely populated, and a large portion of the people were engaged in mining. For this purpose large and long ditches had been constructed, but most of the land cultivated was in low ground and few experiments had been made with the bench lands. So marked was our success with vegetables, that the soldiers sent specimens to the Territorial fairs and carried off the prizes for two successive years for bench land vegetables.

The moistening of the dry, compact earth resulted in the appearance of that important assistant in agriculture, the common earth-worm. The earth-worm soon brought birds, especially the robin red-breast, which not only came to feed in our yards, but built their nests in the trees and raised their broods. All these transformations took place by the simple introduction of water, and exhibit on a small scale the typical changes which will take place on a large one by a more extensive system of irrigation.

The time required for surveying and locating this Fort Shaw ditch was almost as great as that for constructing the ditch itself. The vast region lying immediately around Fort Shaw and north, east, and south of it comprises thousands of acres of rich soil, needing only water to convert it into fine agricultural land. Streams are numerous and the supply of water ample. All that is needed is to conduct the water to the right places, and this can be done only by extensive and accurate surveys, the definite location of canals, and the construction of these and minor ditches to conduct the water onto the land. What is true of this particular region is true of a vast territory extending 18 or 20 degrees north and south, and 12 or 15 degrees east and west. Within these limits there are thousands upon thousands of acres which, without water artificially supplied, can never be used for agriculture, but with it can be made to produce the finest crops of all kinds. Land in this country is becoming rapidly more and more valuable, and more and more people yearly require it for subsistence. This land, now useless except for scant pasturage, will be an absolute necessity in the near future, and must be made available.

Whatever difference of opinion there may be regarding the constitutional power of the Government to go to work digging canals, there can, I think, be none with reference to its power to make surveys of its own land and mark out where its citizens of the future can most advantageously place canals for conducting upon its lands what alone can make them of value as food-producers.

MEMORANDUM RELATING TO EASTERN OREGON.

Oregon, Washington, and Idaho have a good supply of water in the form of rainfall. Most of this water falls during the fall, winter, and spring, and during the summer months there is generally a time of extreme dryness, in most parts east of the Cascade Mountains no rain falling for two or three months. Crops having deep roots do very well in most parts of this area; of course there are seasons when one crop or another fails or is extremely poor. This is not always due entirely to droughts, but may occur from want of knowledge or care in planting and cultivating; particularly is this the case with farmers coming from parts of the country where moister summers prevail.

Irrigation by private parties or companies has been successfully tried in a number of valleys, viz: The Klamath River Valley, both in Oregon and Northern California; the Boisé River Valley, Idaho; the Snake River Valley, Washington and Idaho; the Colville River Valley, Washington; and, I understand, in the Rogue River Valley, Oregon.

The rivers of this region are large and would furnish enough water to supply systems of irrigation ditches which could be supplemented by storage reservoirs if necessary, or when the demands increase.

The region around Walla Walla (the Walla Walla wheat country) is a rich and productive country, and north of this is the area called the Great Plains of the Columbia, which, although not so well known, is a promising country. Both these regions are poorly supplied with water, at least during the summer months. The topography of this section is so imperfectly known that it is impossible to determine, without surveys, the practicability of irrigating by ditches or whether it would be necessary and practicable to make use of reservoirs. There is reason to believe that a sufficient supply of water would make this section a very fine agricultural country.

The Snake River above Lewiston has falls and rapids, and thus may afford an opportunity of running irrigation ditches to the lower lands below.

EXTRACT FROM AN ARTICLE BY GENERAL JOHN GIBBON ON THE NECESSITIES OF IRRIGATING PUBLIC LANDS, PUBLISHED IN THE OREGONIAN, 1887.

In the open beyond the mouth of the Port Neuf Cañon, at the junction of the Oregon Short Line and the Utah Northern (a narrow gauge extending away up into Montana), stands the little town of Pocatello, and 25 miles beyond we cross Snake River and catch a moonlight view of the American Falls, and then roll all that night and half the next day through the dusty, sage-brush desert of the Snake River Valley. For miles upon miles nothing is to be seen but the dry, dusty ground, in places alkaline, and the monotonous scraggy sage-brush. Here and there, where water can be had, the green fields and fences of settlers demonstrate the good quality of the soil and what could be done with it if only water could be placed upon it. The good quality of the soil is already shown by the growth of sage-brush, always a sure indication of richness. This sage-brush is a peculiar plant, and is found growing in places where scarcely anything else will grow under the same circumstances. Nature, however, provides it with the means of obtaining the requisite moisture not possessed by many other plants. It possesses a tap-root whose length seems to depend entirely upon the needs of the plant. I have seen in the Yellowstone Valley, where the bank has caved in, these tap-roots left exposed and running down 10, 12, and 15 feet. The sage-brush will not grow upon poor soil; hence the richness of most of this vast Snake River bottom is demonstrated. It needs only water to enable it to blossom as the rose and produce the finest crops of grain, for sage-brush land produces the best of wheat.

Already private companies have been organized for the construction of irrigating ditches in some portions of this vast valley, but now that our increasing population is calling for more land, a more extended and thorough system of irrigation should be instituted, looking forward to the time when every acre of the public land which can be, should be, made to produce crops of food. Such an extended and general system is entirely beyond both the means and foresight of private corporations. Besides the great valley of the Snake River there are immense tracts of country throughout the Northwest which could be made productive simply by placing water upon them. Along the Upper Missouri and its tributaries, along the Platte and its branches, and near various other streams there is an immense amount of land which might by this means be cultivated. Much of this is known as "bench-land," and now lies entirely above any water supply by ordinary means. All of that immense region which lies south of the British line and north of the Missouri River west of Fort Benton is of this character and could be brought under cultivation by tapping the streams high up near the mountains, and, by skillful engineering, conducting them by canals to the high ground from which the water might be distributed systematically to the lower levels. Recurring again to the Snake River Valley, the higher tributaries of that stream should be tapped well up towards the mountains, and good-sized canals constructed to skillfully lead the waters to those positions where they would be most useful.

These canals would not only serve for irrigating purposes, but they could be usefully employed in floating down from the mountains the valuable timber which exists there in such vast quantities and placing it where it could be used for the benefit of mankind, rendering a more extensive net-work of railways less essential. For this extended system of irrigation there would be needed, besides the canals themselves, aqueducts for conducting the water across streams, gorges, etc., and sometimes, though not often, tunnels. As a preliminary step, therefore, extensive and accurate surveys should be made and the routes of the canals in the various valleys laid out just as the line of a railroad is designated. This part of the work should be done by the Government through its capable, skillful engineer corps, whether it ever constructs a canal or not. The routes of the various canals, their dimensions, probable cost, etc., could all thus be determined beforehand, just as was done in regard to the Pacific railroads.

But it would be a paying investment for the United States Government to go further and actually build these irrigating canals. To get its money back it need not even resort to the expedient of taxing the people either for using the canals or the water which they carry. Much of the land which such a system would render productive would never otherwise be bought or settled upon, and should the expense of the system justify it the price of the land thus brought under cultivation could be doubled just as is now done with land near railroads and much more appropriately with canal lands, since these would be directly benefited by the canals. Besides this, another consideration should be taken into account. The Government is now spending vast sums every year to improve the navigation of our great rivers. They dredge out here, cut away there, and build dams and breakwaters in other places to guard against the action of floods in high-water seasons, and at this very time we are constructing at the headwaters of the Mississippi vast dams to hold and store up the waters accumulating in the wet season to be used in the dry, to decrease the amount of water for navigation purposes during one period and increase it at another. Man's whole effort is directed towards getting under his control, as far as possible, the forces of nature. He will be assisted in this by the system of canals which I propose.

When the snows of winter commence to melt in the mountains in the spring and to swell the streams of the lower country by their floods, a considerable portion of this water will be deflected from the river beds and led to flow quietly and peacefully to fructify the fields of man's industry in place of coming in floods to destroy them and other property.

But here I am dreaming again, not in retrospect but prospectively, and all because I prefer to think of this great Snake River Valley as a blooming, productive region filled with green farms and orchards to having it as it is, a vast, dusty wilderness, where as we whirl through it our eyes, mouth, ears, and hair are filled with the impalpable dust in which our noses detect the odor of alkali.

The work referred to must ultimately be done, for the time will soon come when we can not afford to allow all this fine land to remain idle. But it is now well worth the attention of the Government, whilst most of it to which the system is applicable is still under Territorial government and the settling up of the desert places can be hastened. Experience demonstrates that as a country is settled up and subjected to cultivation a remarkable and gradual change takes place in the climatic conditions. Regions in which, in a state of wildness, scarcely enough moisture was deposited to support a scanty growth of grass, under cultivation are provided, as by a miracle, with rains sufficient for all kinds of crops, until the process of irrigation, at first a necessity, becomes no longer essential.

IRRIGATION INCORPORATIONS IN WASHINGTON.

The following list was furnished the committee by the Secretary of Washington Territory.

Atalman Irrigating Ditch Company, Yakima; capital stock, $6,000: J. W. Morrison, J. S. Bounds, and J. H. Miller, trustees, residing at Yakima City, Yakima County.

Ahtanum and Wide Hollow Ditch Company; capital stock, $600; trustees, H. D. Winchester, A. Percival, and S. J. Shaw, Wide Hollow, Yakima County.

Brock Creek Flume Canal and Irrigating Company; capital stock, $2,000; trustees, Amos Underwood, Edward Underwood, and Jefferson Underwood, county of Skamania.

Eureka Water Supply and Irrigating Company; capital stock, $10,000; trustees, F. F. Adams, W. C. Painter, J. C. Isacs, George W. Bradbury, and T. M. Speed, all of Walla Walla, Walla Walla County.

Moxsee Ditch Company, Yakima, Yakima County; capital stock, $1,200in, creased to $10,000; trustees, P. S. Burke, C. P. Fowler, and W. F. Jones, all in Moxsee Valley, Yakima County.

Natchez and Cowichie Ditch Company; capital stock, $1,000.

Oriental Ditch Company; capital stock, $600; place of business, Ellensburgh, Yakima County; trustees, David Ford, A. Wilty, and T. D. Irvin.

Union Ditch Association, Yakima County; capital stock, $500; trustees, Frank Parker, J. T. Simmons, W. D. Beck, J. M. Emery, and G. W. Goodwin.

West Side Ditch Company; capital stock, $5,000; trustees, G. W. Goodwin, E. R. Welch, J. K. Millican, and Martin Schicher, all of Yakima, Yakima County.

Yakima Valley Water Association, Yakima, Yakima County; capital stock, $200,000; trustees, R. B. Kinner, C. M. Holton, Thomas McAuslan, T. B. Nelson, Howard C. Watters, J. M. Adams.

Yakima Farm and Water Company; capital stock, $50,000; trustees, George Kinnear, Baily Gatzert, J. R. Lewis, W. R. Brambley, and J. T. McKnight, all of Seattle, Wash.

Broad-Gauge Ditch Company; capital stock, $4,000; trustees, Joseph Bartholet, Mariah L. Ferguson, and Charles F. Navarre, all of North Yakima, Yakima County.

Coleman Creek Reservoir and Irrigation Company; capital stock, $10,000; trustees, M. H. Peterson, Tillman Hewser, and Harvey Heoss, all of Ellensburgh.

Iowa Flat Ditch Company Yakima County; capital stock, $1,500; trustees, W. R. Taylor, H. S. Maning, and V. Ritter.

Last Chance Ditch Company, Moxsee Valley, Yakima County; capital stock, $2,500; trustees, C. V. Fowler, Z. T. Fowler, and T. H. Fowler, all of North Yakima.

Manastask Water Ditch Company; capital stock, $1,500; trustees, Samuel Packwood, J. W. Shelton, and A. M. Stevens, all of West Kittitass, Wash.

The Watt Ditch Company, Kittitass County: capital stock, $2,000; trustees, J. W. Brooks, T. G. McDowell, W. H. Beck, West Kittitass Valley, Kittitass County.

Yakima Irrigating Land and Chilling Company; capital stock, $100,000; trustees, D. M. Drumletter, J. M. Allen, Alvooh Chirchill, J. B. Piavis, and Edward Whitson.

Fowler Ditch Company; capital stock, $7,500; Moxsee, Yakima County; trustees, Henry B. Sclender, C. O. Fowler, and T. H. Fowler.

Natchez and Cowicihe Ditch Company, North Yakima stock, $8,000; trustees, J. F. Stewart and Paul Yola.

Schanno Ditch Company; capital stock, $12,800; trustees, M. Bartholet, S. Lawton, S. O. Mosford; North Yakima.

Wanatchee Ditch Company; capital stock, $50,000; trustees, Zadock A. Lawham, Joseph T. Miller, and George W. Blair, all of Wanatchee, Kittitass County.

Valley Land and Irrigating Company; capital stock, $500,000; North Yakima, place of business; trustees, Chester A. Cowgdon and Henry P. Barborn, of St. Paul, Minn., and Roland B. Kine, of North Yakima, and Frank A. Sears and Theodore C. Sears, of Tacoma.

Yakima Irrigating and Improvement Company; capital stock, $400,000; trustees, J. W. Dudley, Hurbert S. Hudson, A. A. Knight, all of Tacoma; Hector Campbell, Niagara Falls, Niagara County, N. Y.; Frank A. Dudley, Niagara Falls, Niagara County, N. Y.

West Side Irrigating Company; capital stock, $10,000; J. R. Thorp, S. R. Giddis, W. A. Steavens, J. N. Burch, E. S. Coleman, Ellensburgh, all trustees.

Old Union Ditch Company; capital stock, $2,600; trustees, Joseph Strout, W. L. Splawn, James Foster, J. H. Hathway, James T. Simmons, all of North Yakima.

Settlers' Ditch Company, Kittitass County; capital stock, $12,000; trustees, Edward A. Haley, Toleman Tripp, and George W. Blair, of Ellensburgh, Wash.

Tenemas Ditch Company; capital stock, $2,000; trustees, James E. Bates, S. T. Packwood, and J. H. Stevens, of West Kittitass Valley, Yakima County.

Tenaway Ditch Company; capital stock, $50,000; trustees, T. H. Wilkins, Thomas T. Wilson, W. J. McAusland, R. P. Lijopern, J. D. Olmstead, Ellensburgh.

Wenas Ditch Company, Yakima County; capital stock, $1,000; trustees, Jacob Rogers, T. Manning, and J. McGlothlan.

Adjourned.

OREGON DIVISION.

ON TRAIN AT THE DALLES, OREGON,
August 15, 1889.

The committee met pursuant to call of the chairman.

Present, Messrs. Stewart (chairman), Jones, and Reagan; also Director Powell.

STATEMENT OF T. S. LANG, OF THE DALLES.

The CHAIRMAN. How long have you resided at The Dalles?

Mr. LANG. Sixteen years.

The CHAIRMAN. Will you explain to the committee the condition of the country immediately east of the mountains, and make such suggestions about irrigation that may occur to you?

Mr. LANG (indicating on a map). This is the line of mountains along through here. That is Mount Hood. I have walked over all that country and followed the water-courses, and they follow Mount Hood to the south and Mount Jefferson. All these turn their waters into the Des Chutes River and empty into the Columbia about 12 miles above The Dalles. That river never rises nor falls over 7 feet, and has very warm water, no matter how cold the winter may be.

The CHAIRMAN. What is the name of the other river?

Mr. LANG. The John Day's River.

The CHAIRMAN. That is near what place?

Mr. LANG. Near Blalocks, about 35 miles above The Dalles. These rivers run parallel to each other, and there is an area of country between them averaging 40 miles wide. That country has a deep soil. I have gone down to the subsoil on every half mile for 100 miles, and it is from 2½ to 14 feet deep before you come to the dead soil. Any of the soil which is turned up here on these farms will bear good grain. It simply requires water to make it reliable. Between the two rivers it is a perfectly splendid soil. You will find deposits of alluvial soil on this portion [indicating]; and on the west side of the Des Chutes River there are a few places, high plains, that are watered by snow melting—up along through there [indicating].

The CHAIRMAN. Is that a reservation [indicating]?

Mr. LANG. Yes; it is the Warm Spring Reservation, and here [indicating] are the high plains.

The CHAIRMAN. How is it to the north of the reservation and between it and the Columbia River?

Mr. LANG. There is a whole township there—22,500 acres—that grows very good crops without irrigation. The land is very good between the Des Chutes and the John Day's Rivers. There [indicating] the soil is very rich, and the water for irrigation can be taken from the high streams which run out of the mountains. White River runs out from a solid cliff nearly 300 feet high, and the water is about 2½ feet deep, and there will be an inch of ashes in it coming out of the mountains.

The CHAIRMAN. How far back from the river going south and between the two rivers does this land extend?

Mr. **LANG**. About 80 or 90 miles.

The **CHAIRMAN**. Have you been further south in Oregon?

Mr. **LANG**. No; I am not familiar with that. I have been one trip down to the California State line north of Klamath Lake. That land grows very excellent grass and is a good grazing country.

The **CHAIRMAN**. How is it supplied with water?

Mr. **LANG**. Portions of it have plenty of water, and portions have not. Take the portion on this meridian, around through Klamath, and there is plenty of water. About midway between the Columbia River and the California State line it is deficient of water, and that country would be benefited very materially by irrigation.

The **CHAIRMAN**. Is it a warm country, so that irrigation would be beneficial to crops?

Mr. **LANG**. There is no question about that.

The **CHAIRMAN**. Have you examined it with the view of ascertaining whether water could be gotten to it?

Mr. **LANG**. No; I have not examined it with that view.

The **CHAIRMAN**. Going east of the John Day's River, what is the character of the country? Are there other streams making into the Columbia along there?

Mr. **LANG**. Yes; the Umatilla.

The **CHAIRMAN**. How far is that from the John Day's River?

Mr. **LANG**. About 45 miles.

The **CHAIRMAN**. What country does the Umatilla River drain?

Mr. **LANG**. Umatilla and Gillam Counties would be very largely benefited by irrigation.

The **CHAIRMAN**. How is that country in the direction of requiring irrigation?

Mr. **LANG**. It would require irrigation to be thoroughly successful each year.

The **CHAIRMAN**. Do they raise crops there without irrigation?

Mr. **LANG**. In portions of Umatilla County they raise crops; but they have not sufficient water to keep it up.

The **CHAIRMAN**. Are the low bottom-lands irrigated by seepage from the river?

Mr. **LANG**. No; some of them are close up to the timber, where they get the benefit of the timber which sustains the springs.

The **CHAIRMAN**. What will be the effect in that country, of cutting timber off the land?

Mr. **LANG**. It would be disastrous to that country, just as it would be here, where they have been cutting timber and burning it up.

The **CHAIRMAN**. Do they burn it up pretty rapidly?

Mr. **LANG**. Yes; the people go into it and set off their fires.

The **CHAIRMAN**. Have you any suggestions to make on the subject of timber in eastern Oregon?

Mr. **LANG**. I do not know what you can do except to make local laws governing the people and preventing them from going into the woods and building fires.

Adjourned.

ON TRAIN, BAKER CITY, OREGON.
August 16, 1889.

The committee met pursuant to call of the chairman.

Present, Messrs. Stewart (chairman), Jones, Reagan; also Director Powell.

STATEMENT OF MR. C. M. FOSTER, OF BAKER CITY.

The CHAIRMAN. How long have you resided in Baker City?

Mr. FOSTER. Twenty-seven years.

The CHAIRMAN. Does the country here require irrigation to produce all around crops?

Mr. FOSTER. It does.

The CHAIRMAN. What is the extent of the arable land in this valley?

Mr. FOSTER. About nine townships.

The CHAIRMAN. What stream runs through it?

Mr. FOSTER. Powder River.

The CHAIRMAN. Is there sufficient water in the Powder River to irrigate all the land in those nine townships?

Mr. FOSTER. No.

The CHAIRMAN. Is there any other water supply?

Mr. FOSTER. Only small mountain streams on the west side of the valley.

The CHAIRMAN. Could the amount of water be increased by storage?

Mr. FOSTER. It could be.

The CHAIRMAN. Does a large amount of water run to waste?

Mr. FOSTER. It does in the early part of the season.

The CHAIRMAN. Do you utilize the small streams in the valley?

Mr. FOSTER. Yes; all of them.

The CHAIRMAN. Has there been any effort to increase the quantity of water in those small streams?

Mr. FOSTER. No.

The CHAIRMAN. You have no storage reservoirs?

Mr. FOSTER. No.

The CHAIRMAN. Has your attention been called to that subject?

Mr. FOSTER. We have reservoirs for mining purposes, but not for farming purposes.

The CHAIRMAN. You say there is a large amount of water that runs to waste?

Mr. FOSTER. Yes.

The CHAIRMAN. If it were all stored would it irrigate the whole valley?

Mr. FOSTER. Yes.

The CHAIRMAN. Are there any opportunities in the mountains for building reservoirs to hold back portions of the water? Are you familiar with the mountains?

Mr. FOSTER. Yes.

The CHAIRMAN. Are there places in the mountains where you could construct reservoirs?

Mr. FOSTER. Yes; there are places for storage-reservoirs in the valley that would increase the utility of the water very much.

The CHAIRMAN. You have engaged in storing water for mining purposes?

Mr. FOSTER. Yes.

The CHAIRMAN. That has to be stored at a very high altitude?

Mr. FOSTER. Yes.

The CHAIRMAN. Are you familiar with the sources of the Powder River?

Mr. FOSTER. Yes.

The CHAIRMAN. What is the chance for storing water there?

Mr. FOSTER. Very good.

The CHAIRMAN. What advantage would it be to have the Powder River and all the little streams that flow into it surveyed, and the places indicated as reservoir sites reserved, with estimates of the cost of the land to be covered? Would that have any effect in enabling settlers to make homes without any other expenditure of money?

Mr. FOSTER. Not in the Powder River Valley. The Powder River Valley is all claimed and bought up already. Of course, what you intimate would help to increase the water supply. But for new-comers there would be no land; it would be only on the side of dry hills.

The CHAIRMAN. Are there small hills and creeks coming down them?

Mr. FOSTER. Yes.

The CHAIRMAN. Would there be much of that land?

Mr. FOSTER. Thousands of acres of it.

The CHAIRMAN. Is it good land?

Mr. FOSTER. Good soil; all it needs is water.

The CHAIRMAN. If it could be ascertained that water could be stored there to irrigate the land would other settlers go there?

Mr. FOSTER. Yes.

The CHAIRMAN. The Government has started in to survey the arid land with a view of setting apart reservoir sites, designating the lines of ditches, and estimating the cost of constructing them. The problem of taking out the large rivers we have not yet reached. We want to know what effect it would have in the way of settling up the public lands—what advantage would such data be to settlers?

Mr. FOSTER. You will find more unoccupied lands over in the southern part of the county than in the northern part. There are thousands of acres there to be reclaimed.

The CHAIRMAN. What is the difficulty about reclaiming it now?

Mr. FOSTER. None.

The CHAIRMAN. Do the people not know how?

Mr. FOSTER. They know how, but it takes money, a great deal of money—more money than most persons are aware of.

The CHAIRMAN. Then surveys would not help the people?

Mr. FOSTER. No. But those canals would help them.

The CHAIRMAN. That is, the main valley. Are you aware that you would have to construct canals before you could do anything?

Mr. FOSTER. Yes, it would require canals all around to get to these places. It would take miles of ditches.

The CHAIRMAN. During the winter is there snow in the mountain?

Mr. FOSTER. Yes. But here to the westward of Powder River Valley there are low hills. The snow lies there, but does not make much water.

The CHAIRMAN. What does irrigation do in the way of producing crops in the Powder River Valley?

Mr. FOSTER. It produces a good crop where otherwise it would not give good crops.

The CHAIRMAN. State what kind of crops it produces?

Mr. FOSTER. It will produce a crop of wheat 20 to 25 bushels to the acre, where you would not get any without irrigation.

The CHAIRMAN. How as to alfalfa?

Mr. FOSTER. Three crops, where without it you would not get one.

The **CHAIRMAN**. How much alfalfa would you raise in the year?

Mr. **FOSTER**. Eight to 9 tons to the acre if you have water; if not, you would get about three.

The **CHAIRMAN**. You think the whole area could be irrigated with a sufficient expenditure of money?

Mr. **FOSTER**. Yes.

The **CHAIRMAN**. You are an engineer?

Mr. **FOSTER**. I am.

The **CHAIRMAN**. Have you ever made an estimate of the cost per acre for putting water onto the land?

Mr. **FOSTER**. Not about Powder River Valley.

The **CHAIRMAN**. How much of the land here is irrigated?

Mr. **FOSTER**. It is all irrigated more or less. No crop is certain without irrigation.

Senator **JONES**. How is this Powder River Valley occupied?

Mr. **FOSTER**. All the land is bought up and owned by private parties.

Senator **JONES**. Are the holdings in large tracts, or do they vary?

Mr. **FOSTER**. They vary from 16,000 acres, held by the railroad company, down to 160 acres, held by individuals. Most of it is in small holdings.

Senator **JONES**. But is the land generally used? Is it farmed, stock raised on it, or is it lying idle?

Mr. **FOSTER**. About half of it is lying idle—held for speculation.

Senator **JONES**. Can you give any reason why the people are holding this land for speculation when it is not improved? Why do they not bring water onto it?

Mr. **FOSTER**. The railroad company owns 16,000 acres, and it will not make any effort to bring water onto this land. It will sell the land for $4 or $5 an acre.

Senator **JONES**. Do other land-owners make any effort to put water onto their land.

Mr. **FOSTER**. No, except the farmers themselves.

Senator **JONES**. They hold land in small quantities?

Mr. **FOSTER**. Yes; 160 acres.

STATEMENT OF C. HINDMAN, OF BAKER CITY.

The **CHAIRMAN**. What is your occupation?

Mr. **HINDMAN**. Stock-raising.

The **CHAIRMAN**. Have you examined the subject of irrigation?

Mr. **HINDMAN**. Yes.

The **CHAIRMAN**. What effect has irrigation upon the production of crops in the valley?

Mr. **HINDMAN**. It washes the alkali out of the ground and fertilizes it so that it will improve vegetation.

The **CHAIRMAN**. Can you produce crops in the valley without irrigation?

Mr. **HINDMAN**. No, you can not.

The **CHAIRMAN**. Do you farm by irrigation?

Mr. **HINDMAN**. I do.

The **CHAIRMAN**. What kind of crops do you raise?

Mr. **HINDMAN**. I am not what you would call a farmer; my principal business is stock-growing; but I raise some grain. Oats will go as high as 45 bushels to the acre and wheat 30 bushels to the acre.

The **CHAIRMAN**. With irrigation?

Mr. HINDMAN. Yes.

Senator JONES. How much will the land produce without irrigation?

Mr. HINDMAN. Not more than 10 bushels in some localities.

The CHAIRMAN. Do you raise fruits in the valley?

Mr. HINDMAN. Yes.

The CHAIRMAN. All kinds?

Mr. HINDMAN. We raise apples, pears, plums, and peaches. They all do well, and so do the small fruits.

The CHAIRMAN. You say you are a stockman. Have you traveled through the mountains and noticed the sources of the river?

Mr. HINDMAN. I have.

The CHAIRMAN. What proportion of the water runs to waste in high tide—in flood time—water that is not used at all?

Mr. HINDMAN. I think three-fourths of the water from the mountains runs to waste during the season.

The CHAIRMAN. Have you ever taken into consideration the subject of utilizing that by storing it in reservoirs?

Mr. HINDMAN. I have given it a good deal of thought.

The CHAIRMAN. What are the opportunities for doing that?

Mr. HINDMAN. I think they are very good for agricultural purposes. The cañons go well down into the valleys where you can build your reservoirs, while for mining purposes you have to go up high. You can store the water down in these deep cañons before you come to the river.

The CHAIRMAN. Are there small streams and places about the valley where there are public lands and where water could be stored for the use of small farms?

Mr. HINDMAN. At the foot-hills east of the valley there are plains and some places where in the spring there is a good deal of water from the melting snow. There are three channels there, and they are very easy places to build these reservoirs.

The CHAIRMAN. Could that be done without a large expenditure of money?

Mr. HINDMAN. Yes. There are two Powder Rivers that run through the valley, one east and the other west; one south of the mountains and one north. At the south of the mountains it forms what is called the Snake and makes a large valley there, and before it strikes this valley it comes near these cañons. There you could build a reservoir to hold an immense amount of water, sufficient to irrigate this land.

The CHAIRMAN. It is good land?

Mr. HINDMAN. It would be if it were irrigated.

The CHAIRMAN. Is that private land?

Mr. HINDMAN. That is public land, not entered, because valueless for want of irrigation.

The CHAIRMAN. How did the railroad company become possessed of that land? There was no grant to it.

Mr. HINDMAN. No, they bought it. It was State land, State donation.

Senator JONES. How did the State own it?

Mr. HINDMAN. It was donated to the State, I suppose.

The CHAIRMAN. Do you know any other fact you would like to state?

Mr. HINDMAN. I think it would almost double our population if those reservoirs were built for agricultural purposes.

STATEMENT OF I. D. HAINES, OF BAKER CITY.

The CHAIRMAN. How long have you resided in Baker City?

Mr. HAINES. About twenty years.

The CHAIRMAN. What is your occupation?

Mr. HAINES. Lawyer and rancher.

The CHAIRMAN. Have you traveled over the country so that you are familiar with its topography and its water supply?

Mr. HAINES. Yes.

The CHAIRMAN. Have you practiced irrigation?

Mr. HAINES. Yes, I have irrigated for the last twenty-odd years.

The CHAIRMAN. What effect does irrigation have upon agriculture?

Mr. HAINES. It adds to the fertility of the land and increases the crop 50 per cent.

The CHAIRMAN. Can you raise all kinds of crops in the valley without irrigation?

Mr. HAINES. No.

The CHAIRMAN. What kind can you raise?

Mr. HAINES. Grain, wheat, barley, oats, rye, and some alfalfa. It is not so good for alfalfa as it is down on the Snake River.

The CHAIRMAN. And you could raise some without irrigation?

Mr. HAINES. Yes.

The CHAIRMAN. Could you raise alfalfa without irrigation?

Mr. HAINES. Yes, by putting it in in the fall. But it does not do well.

The CHAIRMAN. When you do not irrigate it the gophers spoil it?

Mr. HAINES. Gophers and mice work up the soil and spoil the alfalfa and timothy meadows. If you do not irrigate they will throw the dirt up, and you can not use the mower.

The CHAIRMAN. The best of your land under irrigation would improve 50 per cent.?

Mr. HAINES. About.

The CHAIRMAN. How about all-around crops?

Mr. HAINES. All-around crops the same way, especially in Malheur and Harney Counties, to the south.

The CHAIRMAN. How are the counties to the south?

Mr. HAINES. They have not much. The water rises there in the mountains and sinks like it does in the Umatilla Valley.

The CHAIRMAN. The streams, as they get down to the valley, sink?

Mr. HAINES. Yes. By storing up water in the mountains and putting in ditches they could use a good deal of it in irrigating the land and producing crops. Where streams are now they go down and evaporate. They take the water out in a good many places in these lakes, ponds, and sinks.

The CHAIRMAN. Would Government surveys help in those valleys to the south of this of which you speak?

Mr. HAINES. They would help in this respect—by finding out how much water there was and introducing some system for utilizing it. If farmers are going to take up water-rights for their whole land, in ten or fifteen years one farmer will get four times as much as he needs, and will want to sell to his neighbors.

The CHAIRMAN. As it is, there is not a fair distribution?

Mr. HAINES. No.

The CHAIRMAN. And the water is wasted?

Mr. HAINES. If not wasted, it is a matter of speculation. A man kes all the water he can get. There is a good deal of water there if e land were taken up where the water comes out of the mountains, nd if it were stored in reservoirs it could be let on the land which now not taken—land belonging to the Government of the United States.

The CHAIRMAN. If the facts were made plain by maps, would it inuce emigrants to settle there?

Mr. HAINES. Yes; the lands are good enough, but they can not use he water. Now, when an emigrant comes along, not having money nough to make a ditch and construct a reservoir to store the water, e goes farther down to hunt a ranch. There is a good deal of land n these valleys not occupied on that account.

The CHAIRMAN. Are there many places where the settlers could ombine and take up water?

Mr. HAINES. Yes; they do it up on the Owyhee River.

STATEMENT OF J. W. STURGILL, OF BAKER CITY.

The CHAIRMAN. How long have you resided in Baker City?

Mr. STURGILL. Twenty-five years.

The CHAIRMAN. Are you familiar with the topography of that country?

Mr. STURGILL. Yes.

The CHAIRMAN. And the counties south, Malheur and Harney Counties, have you ever been over the whole of that country?

Mr. STURGILL. Yes.

The CHAIRMAN. Who occupies those south valleys?

Mr. STURGILL. Principally stockmen.

The CHAIRMAN. Do they cultivate the soil?

Mr. STURGILL. They cultivate it in this way, they put it down in hay.

The CHAIRMAN. Do they irrigate?

Mr. STURGILL. Yes; they can produce no crops without irrigation.

The CHAIRMAN. To what extent do they irrigate?

Mr. STURGILL. Not to any considerable extent.

The CHAIRMAN. Do they make any efforts to increase the water supply?

Mr. STURGILL. No.

The CHAIRMAN. Are there any public lands in that locality?

Mr. STURGILL. Yes, plenty of them.

The CHAIRMAN. Are there public lands that could be taken up by a combination of settlers?

Mr. STURGILL. Yes, large bodies of them.

The CHAIRMAN. Is it a good climate?

Mr. STURGILL. Yes; a fine climate and a productive soil.

The CHAIRMAN. I understand from these other gentlemen that the valley part of Powder River is all private land.

Mr. STURGILL. It is.

The CHAIRMAN. How are the foot-hills on either side of Powder River Valley?

Mr. STURGILL. There is considerable vacant land there.

The CHAIRMAN. Is there any chance to irrigate it?

Mr. STURGILL. Only by storage reservoirs.

The CHAIRMAN. Is it good land?

Mr. STURGILL. Yes; very good land. The best in the valley.

The CHAIRMAN. How does that land compare with the valley itself, as a quantity?

Mr.

Mr. **Sturgill.** I can not tell that.

The **Chairman.** What do you say as to the effects of irrigation, as far as you have observed them?

Mr. **Sturgill.** Without irrigation we could raise nothing. There have been a few seasons in the last twenty-five years in which crops might have been produced without irrigation, but they have been very few.

The **Chairman.** With irrigation, what kind of crops do you produce here?

Mr. **Sturgill.** Grain and garden crops.

The **Chairman.** State whether the yield is large or small.

Mr. **Sturgill.** The yield is large. We get 25 to 50 bushels to the acre; the same of oats; two tons and a half of hay, and 6 or 8 tons of alfalfa.

The following was received from the secretary of Washington Territory and ordered filed, being a provision of the newly framed State constitution:

Article XXI.—Water and water rights.

Section 1. The use of the waters of this state for irrigation, mining and manufacturing purposes shall be deemed a public use.

Adjourned.

IDAHO DIVISION.

ON TRAIN AT PALMER, IDAHO,
August 16, 1889.

The committee met pursuant to call of the chairman.

Present: Messrs. Stewart (chairman), Jones, and Reagan; also Director Powell.

STATEMENT OF HOWARD SEBREE, OF CALDWELL.

The CHAIRMAN. Are you engaged in farming by means of irrigation?

Mr. SEBREE. Yes.

The CHAIRMAN. What water have you turned and what land have you irrigated? Give your experience.

Mr. SEBREE. I have within the last three years built an irrigating ditch 23 miles in length, and diverted the water from the Boisé River, at a point in Caldwell, carrying it in a southeasterly direction to the mouth of the Boisé, then turning down the Snake. The ditch is 20 feet on the bottom and 30 feet on the top, at the head-gate where we divert the water, running about half the distance, then reducing to 12 and 15 feet the balance of the distance.

The CHAIRMAN. How much land does that ditch irrigate?

Mr. SEBREE. About 25,000 acres.

Senator JONES. Is that the full capacity of the ditch?

Mr. SEBREE. Yes; but of course we can make it greater.

The CHAIRMAN. What was the cost of the ditch?

Mr. SEBREE. Sixty-five thousand dollars.

The CHAIRMAN. How much would it cost per acre, including the lateral ditches, to put it on the land?

Mr. SEBREE. The cost of the lateral ditches is very trifling—about 25 cents an acre.

The CHAIRMAN. You have raised crops under that ditch by means of irrigation?

Mr. SEBREE. Yes; up above this bench-land where you are traveling, 2 miles back from this point (the railroad), is the line of the irrigating ditch. That land between us and the big ditch is taken up and the farmers are clearing away the brush and raising crops.

The CHAIRMAN. What is the result where you have irrigated?

Mr. SEBREE. This year there have been already 4 tons of alfalfa taken off per acre.

Senator JONES. And from land that would have been worthless but for water?

Mr. SEBREE. Yes; entirely so. I have cut the second crop from my land. I have 640 acres, and all of it fenced. There are 320 acres of it cleared of sage-brush; 200 acres ditched, and in alfalfa, of which we are cutting the second crop now.

The CHAIRMAN. The stand is how old?

Mr. SEBREE. The stand we are now cutting is six weeks old.

The CHAIRMAN. From the time it was planted?

Mr. SEBREE. Yes; April and May of this year.

The CHAIRMAN. And you have cut that much?

Mr. SEBREE. Yes; and we get about 6 to 8 tons to the acre where we get a good stand. But 4 tons to the acre I can get off the entire section. The last cutting we made was when it would stool out.

The CHAIRMAN. How old was the alfalfa?

Mr. SEBREE. We planted in April, May, and June of this year.

The CHAIRMAN. What is a good yield during the whole year for alfalfa?

Mr. SEBREE. Taking the whole field of 200 acres, it will average 4 tons to the acre. You will get a little less in some places, but it will average 4 tons. Six tons are very common—2 tons each cutting.

The CHAIRMAN. Do you raise wheat?

Mr. SEBREE. Yes.

The CHAIRMAN. How is that?

Mr. SEBREE. Good; an average crop being 40 bushels to the acre.

The CHAIRMAN. How about barley?

Mr. SEBREE. Sixty bushels to the acre.

The CHAIRMAN. Do you raise potatoes here?

Mr. SEBREE. Yes.

The CHAIRMAN. What would be a good crop of potatoes?

Mr. SEBREE. An average crop would run from 300 to 400 bushels to the acre.

The CHAIRMAN. Do you raise fruits?

Mr. SEBREE. Yes; and they are good.

The CHAIRMAN. What character of fruits do you raise?

Mr. SEBREE. Apples, peaches, plums, pears, and all kinds of small fruits—strawberries, blackberries, currants, gooseberries.

The CHAIRMAN. Do you raise grapes?

Mr. SEBREE. Yes; a splendid quality of grapes.

Senator JONES. Are the land-owners along the line of this ditch the owners of the ditch?

Mr. SEBREE. The largest bodies of land are held by owners along the line of the ditch.

The CHAIRMAN. Have they an interest in the ditch?

Mr. SEBREE. We lend the water to the people. They take up the land in homestead, pre-emption, and timber-culture claims, and make homes, and then we sell them the water annually for so much—$1 an acre each per year.

Senator JONES. Can you charge the people any price you may please for the use of the water?

Mr. SEBREE. There is no price fixed by law; custom regulates it.

Senator JONES. You can charge them only a reasonable price. But suppose a company occupying the same position that you do should not be reasonable, would they not have the people at a disadvantage?

Mr. SEBREE. No; that would not be the case. I have lived in this country where irrigation has been entirely used, and there never has been any extortion. When you get a reasonable profit on your investment the law stops you. That has been the case in Colorado.

Senator JONES. Is there a local statute here which will protect the people in their rights?

Mr. SEBREE. No; I think not; not to my knowledge.

Senator JONES. How much water do you want on your land—how much in depth?

Mr. SEBREE. A half inch to the acre is what we are using.

Senator JONES. What do you mean by an inch?

Mr. SEBREE. An inch is a miner's inch under a 4-inch pressure.

Senator REAGAN. How long has that to flow?

Mr. SEBREE. That is continuous only when we have to close the head-gates for causes, for repairs, etc.; and in winter.

The CHAIRMAN. Otherwise it runs the year round?

Mr. SEBREE. Yes.

The CHAIRMAN. Do you irrigate in the winter and fall?

Mr. SEBREE. We have good winters in this valley. I have plowed all winter—every month in the year.

The CHAIRMAN. What season of the year do you irrigate?

Mr. SEBREE. May, June, July, and August.

STATEMENT OF D. W. BUTLER, INDIAN AGENT AT WARM SPRING AGENCY, OREGON.

My views are mostly arrived at by comparing the places that I have seen irrigated. There is an abundance of water available. I assisted in the survey of a ditch a few years ago which is intended to supply the Oak Grove plains with water; the survey was made by John A. McQuinn, of Portland, Oregon, a practical surveyor and engineer, who estimated, if I remember right, the cost at $900 per mile, and the length at 8 miles. The water, or stream at this place that can be used, is 25 feet wide and 1 foot deep, and this is a very low stage of water. I do not understand the rules of measuring water, but I am sure that there is an abundance for all purposes. Oak Grove plains are situated in the southern portion of Wasco County, Oregon, and in the following townships: Township 5 south, range 11 east; township 5 south, range 12 east; township 4 south, range 13 east; township 4 south, range 14 east; township 6 south, range 11 east; township 6 south, range 12 east; township 6 south, range 13 east; containing an area of about 100,000 acres. The next is a district lying on the opposite side of White River from the above described country, and in township 4 south, range 11, 12, and 13 east, and containing 40,000 or 50,000 acres of land, with a good portion being cultivated by a successful system of irrigation.

There is a large district of country lying on the east side of the Deschutes River and known as the Agency Plains, which are 6 miles wide and about 25 miles long, and water can be furnished by a ditch from the Deschutes River south of the second standard parallel and running north through township 12 south, 13 east; township 11 south, 13 east; township 10 south, range 13 east; township 9 south, range 13 east, and township 9 south, 14 east.

I deem it absolutely necessary, if the Warm Spring Indians are to become self-supporting, that the lands on this reservation should be made susceptible of cultivation through irrigation. I will give you the amount of land as near as possible by reference to the maps of survey: Township 7 south, range 11 east; township 8 south, range 11 east; township 8 south, range 12 east; township 9 south, range 12 east; township 9 south, range 12 east, containing near 100,000 acres, and lying in Wasco and Crook counties.

STATEMENT OF THOMAS PRIESTLY, INDIAN AGENT AT YAKIMA AGENCY, FORT SIMCOE, WASH.

About all irrigation plans and practices as to reclaiming arid lands here have originated with, and have largely been controlled by, the Indian agents in charge of the reservation. From them the Indians have learned the value of irrigating their farms and hay lands. They display some engineering skill in such work, but tell me that they can not make the "water run up hill as some white men do." Their mode of irrigation is to dam the streams and cut ditches from such water supply to their farms. They generally club together and make a large ditch to or near the locality of their ranches, and the water supply is then divided equally between those who have constructed the ditch; each one then constructs a ditch from the main one to where he wants his water used, making lateral ditches through his field. The distance between these lateral ditches through their farms is governed by the nature of the soil and kind of crop. Gentle flooding of some lands is beneficial to some crops, while the same practice in others on different kinds of soil is almost certain destruction.

Some of the streams from which the Indians obtained water for irrigation have dried up much earlier than usual this season by reason of the unusual light fall of snow and rain in the mountains, their source of supply. The Indians who have depended on obtaining water from such streams will have no crops of grain and but little hay. In order to make these lands productive every year some system of saving the large surplus of water which flows through the reservation in winter and early spring will have to be adopted.

The rule I have adopted with these Indians as to distribution of the water supply is that of those constructing a ditch; the person at the lower end thereof shall not be deprived of his share of the water supply by reason of others locating above him; men who so locate can have water if they increase the supply by labor on such main ditch or dam to the extent of the amount used, or pay in labor by keeping ditch and dam in repair; if ditch contains enough water for use of all, a just proportion of constructing it.

STATEMENT OF S. G. CARPENTER, CAPTAIN FOURTEENTH INFANTRY, COMMANDING FORT KLAMATH, OREGON.

Within the Klamath Basin east of the Cascade Mountains the aridity of the climate invites irrigation. The gradual but certain drying of the lakes has left much more area of open bottoms exposed than is now covered. These are fertile and becoming inhabited. These gentle slopes, meandered by numerous streams, together with the differences in level of the series of lakes, give peculiarly favorable opportunities for irrigation. On the Middle Klamath Lake, at Linkville, Oregon, an irrigating ditch leading from the upper lake now waters several thousand acres. It is estimated that when all ditches now under construction there are done about 45,000 acres will thus receive moisture.

Since the feeders to these lakes are mostly subterranean, debouching in full volume from the rim-rock about the lake beds, there is little opportunity for building increased storage for these waters. Indeed, so good are the natural adaptations within the Klamath River Basin for irrigation, that private enterprise can be depended on alone for this, I believe, without expenditure of any public moneys.

The peculiar topography, which permits the Deschutes River to drain all the streams coming from the eastern slopes of the Cascades to the north of the Klamath Basin in Oregon in a trough parallel and close to the foot-hills of the range, makes it doubtful if the Government will be ever called on to do any work worthy of it in this zone.

Committee adjourned to meet on call of chairman.

BOISÉ CITY, IDAHO, *August* 17, 1889.

The committee met pursuant to the call of the chairman.

Present, Messrs. Stewart (chairman), Jones, and Reagan; also Director Powell.

STATEMENT OF ALANSON SMITH, OF BOISÉ CITY.

Mr. Chairman and gentlemen, there is no question about an affirmative answer being proper in regard to the supply of water for the whole Territory, because it is undoubtedly full and complete in most of the Territory, especially this portion of it. It will require irrigation; but the sources of supply are abundant, and it is only a question in the way of finances to bring the water on to the land.

I have been through the Territory while acting as United States attorney for a period of nearly four years—have traveled from north to south, and have been over the mountains. Therefore, I can speak from personal observation and experience, and I desire to add my knowledge to that which will be communicated to you in a more direct way, and perhaps plainer form, in regard to the resources of this Territory. They are beyond those of any State or Territory in which I have lived, with the exception of California. I lived in that State for a long time, as Senator Stewart knows, and in Oregon and Nevada. For seventeen years I have lived in this Territory.

In regard to the water supply, the sources of that supply are the contiguous currents of the Arctic region with the Pacific currents, precipitating on our mountains with snows. Our rivers are always full, less this year than ever before that I know of for the last seventeen years. The only question about the use of water is the ability of procuring the money necessary to create the ditches with which to distribute the water. British America bounds this Territory on the north, with Nevada and Utah on the south, and the mountain regions lie west, and are the source of all the streams. The great Snake River has its source in the great plateau of the continent, by Professor Hayden said to be the first great upheaval of this continent. It is 12,113 feet above the level of the sea.

I have taken the liberty of making these few remarks and thank you for the permission.

STATEMENT OF JOSEPH C. STRAUGHAN, SURVEYOR-GENERAL OF IDAHO TERRITORY.

The CHAIRMAN. Have you made an examination and survey, so far as you are able, in regard to the irrigation of this Territory?

Mr. STRAUGHAN. No. The Governor and myself, acting in compliance with your request and that of Engineer Hinton, have gotten reports from all over the country, from surveyors and representative citizens, on the matters pertaining to irrigation. I have had those reports compiled in my office, so as to present the statistics, with a map of each county, very fully, and also prepared in connection with it a general report.

The **CHAIRMAN**. Have you the general report in your hand?

Mr. **STRAUGHAN**. Yes.

The **CHAIRMAN**. Perhaps it would be well to read that, and then if there be questions the committee would like to ask they can be propounded. That general report will give us an idea of the situation in a more condensed form.

Mr. **STRAUGHAN**. I think so. I present, before reading the report, copy of letter sent from my office, at the suggestion of Engineer Hinton, with the committee and by the wish of its chairman.

DEPARTMENT OF THE INTERIOR, UNITED STATES,
SURVEYOR-GENERAL'S OFFICE, DISTRICT OF IDAHO,
Boisé City, June 15, 1889.

To ——

DEAR SIR: The sundry civil bill enacted by Congress at its last session, approved March 2, 1889, included an item of $250,000 "for the purpose of investigating the extent to which the arid region of the United States can be redeemed by irrigation and the segregation of irrigable lands in such arid region, and for the selection of sites for reservoirs and other hydraulic works necessary for the storage and utilization of water for irrigation and for ascertaining the cost thereof."

By request of its chairman, Hon. William M. Stewart, of Nevada, I am preparing for the United States Senate Committee on Irrigation certain statistics on that subject. Will you please aid me in this by an early reply to the following:

First. On what streams in your county has irrigation been effected, and to what extent?

Second. On what streams is irrigation practicable, and to what extent?

Third. For what length of time, per yearly average, does each stream furnish sufficient water to irrigate its irrigable lands? And—where the water in streams is insufficient—are there sites for reservoirs wherein large bodies of water may be impounded at a moderate cost?

It will be sufficient to give the distance irrigated and irrigable in miles along the several streams, and for width an average according to your judgment and recollection or as you may find by inquiry from others.

I send you, per this mail, a map of Idaho. Where it notes the names of streams please give said names in your report. Where names of streams are not shown on the map please state the local designation thereof and properly describe its location, that I may enter it upon my office map.

All facts are desired which you may be able to gather and formulate relating to the storage, sources, and distribution of water, and all precipitation for use in agricultural and pastoral operations.

The number of ditches, their length, area surveyed, duty of water, value of crops, sources of water, irrigable areas, etc., will be of great service.

The views of all practical and competent observers on the problems involved will also be of importance.

I herewith inclose a circular letter of this date, from his excellency, Governor Shoup, bearing upon this subject, and which is self-explanatory. Careful perusal thereof is earnestly requested.

This matter of irrigation is of vital importance to Idaho, and I can not urge upon you too strongly the need of gathering all obtainable information and data for the purpose stated.

Please give the matter immediate and careful attention, if possible, and transmit your report to this office, together with the map, in time for receipt here not later than July 15 next, as the Senate committee will be at Boisé City early in August.

In the inclosed letter of Governor Shoup you will find the name of a representative gentleman in your community who will doubtless assist you.

Hoping and anticipating your active co-operation for and on behalf of irrigation of Idaho, I am,

Very respectfully, yours,

JOSEPH C. STRAUGHAN,
United States Surveyor-General for Idaho.

The report itself is as follows:

ENERAL IRRIGATION REPORT OF JOSEPH C. STRAUGHAN, UNITED STATES SURVEYOR-GENERAL FOR IDAHO.

OFFICE OF UNITED STATES SURVEYOR-GENERAL,
Boisé City, Idaho, August 17, 1889.

GENTLEMEN: In the subjoined report upon the arid region of Idaho I do not include the counties of Idaho, Latah, Nez Percé, Shoshone, and Kootenai, which are not arid and do not require artificial irrigation except to the extent stated by Messrs. C. P. Coburn, W. P. Bell, G. A. Manning, and William Ashley, copies of whose reports are herewith submitted.

The remainder of Idaho Territory occupies an approximate area of 50,286 square miles (or 224 miles square), four-fifths of which is high mountain table-lands, which accumulate during the winter a depth of from 4 to 8 feet of "packed" snow. On the Sawtooth Range twice this depth is reported. Of the remaining one-fifth about 1,091 square miles are now irrigated or in process, whilst the rest, being 10,904 square miles, or 7,002,000 acres, remains unreclaimed desert land of superior quality when irrigated.

Looking out over this 6,500,000 of acres we have an abundant water supply on the mountains, at sufficient elevation and convenient distance, leaving only the one problem for our solution of how best to bring this water upon these lands.

In the prosecution of so great a work it is usual and generally expected that some great obstacle may intervene, some questionable means be resorted to, or some costly structures be required; but in this case there is nothing of the kind. Our task is only to choose between the use of storage or not to use it in the several localities.

On this subject the reports from the several counties furnished my office by the surveyors and representative citizens of each present a bird's-eye view of the whole, by which it is seen that there are four or five main districts, each having its own distinctive features.

The Sawtooth Mountains and their extension, the Bitter Root Range, appear to form a climatic division. On the east it is arid and on the west humid; hence the county of Lemhi needs irrigation for half a million of acres, whilst the counties west, as above stated, require no irrigation.

Coming to the great valley of Snake River, with its vast volume of water, one's first thought would embrace the whole by a duplex canal, which should skirt the foot hills on either side, requiring only to be long enough to reach the lower end at the Weiser and Owyhee Rivers, and large enough to carry all the water needed.

With artificial storage at its head near the National Park, reenforced by reservoirs along its route, this plan may prove the cheaper, if we assume that all the good arable lands shall be reached and supplied with water; but if we adopt for storage any of these sites that we find so feasible and inviting along the foot-hills on both sides, there are high table-land districts that would thus be sufficiently supplied without a main canal from the Upper Snake River.

The topography of all this valley, from the mouth of the Weiser up to the confluence of the Teton, some 500 miles, presents three great planes of inclination. The upper one, from Teton to the American Falls, descends at an average rate of about 6 feet per mile; from the American

Falls to Glenn's Ferry, an average of 14 feet, and from Glenn's Ferry to Weiser an average of 4 feet per mile.

Across the whole valley, from foot-hill to foot-hill, at the American Falls, there is a dike of very hard volcanic rock, over which the river has cut for itself a weir and at once descends about 50 feet; again, at the Twin Falls, 90 feet; and at the Great Shoshone Falls, 3 miles below the Twin Falls, it leaps off in a cascade of 310 feet.

It is the river and not the surface of the valley that shows this "break of grade" at those points. Above the American Falls the valley lands are not much higher than the river; below the American Falls the river is continuously in a cañon of variable depth, but always too deep to be tapped for irrrigating the high plains of Cassia, Owyhee, Elmore, and Logan Counties.

Thus it is seen why the northern part of Bingham County has so great an amount of irrigation; this, too, through their unaided effort, by what they call "home companies." The north part of Bingham County reports 245,500 acres now irrigated and in process, to cost when completed $435,000. As this portion of the county reports about 2,250,000 acres more of irrigable lands, it is very doubtful whether Snake River can furnish any excess over and above what will here be needed, unless largely aided by storage at Eagle Rock. The river was gauged by Mr. A. D. Foote, of the U. S. Geological Survey, in July last, and found to discharge only 4,450 cubic feet per second; but the river contains only about one-half as much water as ever before known at its lowest stage.

The region above the dike at American Falls has features peculiar to itself; it is where the people are cheerfully helping themselves to water. The region or district next below has only the supply from lateral streams coming from the mountains in Utah. This supply comes earlier than they need it, and fails a month sooner than does Snake River, which comes from the very high mountains in the vicinity of the National Park.

In Owyhee, Cassia, and Logan Counties, the people have under cultivation all the lands their unaided streams can supply, and the light snows of the past two winters caused such a deficiency of water as to discourage all their settlers, driving many away.

Irrigation in the counties of Cassia, Owyhee, Logan, and Elmore has reached its limit. The lateral streams are now fully utilized in so far as their normal flow will permit. A supply must come from upper Snake River, or from reservoirs yet to be constructed. They contain 2,384,000 acres of good arable land belonging to the Government, which is offered gratuitously to homesteaders who shall settle upon and reclaim it by bringing water thereon. It is irony to offer an actual settler a section of land if he will go up into the mountains and build a $10,000 reservoir. Let this offer be made to the State of Idaho for all the lands; and, orphan as she is, she will cheerfully accept it. The sale of the lands will amply refund the outlays, and leave the water a source of revenue abundant for all State purposes forever.

Localities for reservoirs are found more numerous, larger, and less expensive than I could have anticipated. The construction of any one of them would be as remunerative as stock in any well conducted business or enterprise, and with almost no danger of loss in the investment.

A perusal of the several reports from these counties, detailing the localities and imparting much information respecting storage in general, will convince any one that the whole ground for the water supply, both by storage and the normal flow of all the streams, must receive an intelligent and faithful survey before any safe decision can be reached.

Just such a survey is now being made, and the object of this report to the honorable gentlemen of this committee is, not to advocate any theory or plan by which to get enough of our mountain snow upon our parched lands, but to furnish you with the facts and conditions really existing, by means of which you may convince your brother Senators how it is that we are practically at a stand-still now, and what a trifle it is for which we ask, that would at once populate our millions of acres of sage brush arid area.

Coming to the lower plains of Snake River Valley, as before described, we find the Boisé and Payette Rivers capable, by the aid of reservoirs, of accommodating all the arable lands within their reach, except perhaps a few high plateaus of small extent.

That the Boisé will soon be largely diverted through the "New York canal," belonging to the "Idaho Mining and Irrigation Company," is highly probable. Besides the 350,000 acres of arable land within hearing of the church bells of this city, there is a body of 20 or 30 sections of placer lands, needing only the water with its pressure exerted through modern appliances for mining, to wash out millions of dollars in gold.

The Payette, plus reservoirs, is also ample for its own territory. The people there can co-operate and build all needed canals and ditches. They have done so to the extent of low-water capacity of the rivers; but they can not also construct the reservoirs. The north fork of this river contains the so-called "Long Valley," 60 miles in length and 9 miles wide, with water enough for all the land without storage. Its settlement commenced only five years ago and now the population is nine hundred, while reports indicate all their land irrigated or in process by means of "home companies," every land owner being a part ditch owner. They ask no aid in any way and look with suspicion upon the outside interference as encroaching on their acquired privileges, if not upon their rights.

Washington County has also improved to the extent of the low-water capacity and beyond it; consequently her people are now in great need of storage reservoirs which they are not able to construct, nor will they become able if such dry winters continue much longer as were the last two.

Lemhi County is also a district of irrigation by itself, the only one whose drainage is in the Salmon River that needs irrigation, because it lies east of the Sawtooth Mountains, the atmospheric dividing line before mentioned. Its total area is 4,300 square miles, of which 18 per cent., or one-half million acres, is arable.

This percentage is very large, considering its close proximity to the very crest of the Rocky Mountains on the one hand, and the equally high Sawtooth Range on the other.

The valleys of the Lemhi and the Salmon Rivers contain all or nearly all the arable land in this district. Near to these rivers are narrow strips or fringes of low bottom land easily irrigated, and now containing the only settlements of farmers. The bench or second bottom lands occupy a plane 50 to 100 feet higher, onto which the river water might and must be brought; but the expense has been too great for the present settlers.

Along the many creeks intersecting these table lands irrigation on a small scale is practiced to the extent of their low-water capacity, which may be largely increased by storage on each. For such purposes the sites in most instances are good.

At the head of the Lemhi is a good location for a large reservoir. It is about 2,000 feet above Salmon City, 49 miles distant, or an average of 40 feet per mile. The fall in Salmon River in this county averages about 15 feet per mile.

It is reported that no natural obstacle would prevent the supply for the Lemhi Valley coming from a storage basin on the summit by means of a canal on each side. To these canals might be added as many lateral reservoirs as shall be found necessary and when found necessary. In either case the irrigation of the Lemhi Valley will cost less, computing by ratio per acre on the land reclaimed, than any valley of equal extent in Idaho.

Along the Salmon River Valley explorations, with the view of large canals, have not been made; but as the fall is so great and the quantity of water very abundant, it is a foregone conclusion that this valley is among the most favorably located for purposes of irrigation.

In order that the information on the subject of irrigation and the topography of Idaho thus obtained by this office may be briefly shown, I have caused all the regular reports from the surveyors and prominent citizens in the several counties, to be engrossed on type-written copies, for convenient reference when desired.

From these reports, and from all available sources, I have compiled condensed statistics and salient facts as to the respective counties separately. Each county report is accompanied by a map to illustrate the statements of the report, all arranged in portfolio form.

The matter is thus presented as fully as possible, under the circumstances, all of which is respectfully submitted.

Very respectfully, your obedient servant,

JOSEPH C. STRAUGHAN,
United States Surveyor-General for Idaho.

THE UNITED STATES SENATE COMMITTEE ON IRRIGATION.

ADA COUNTY.

REPORT BY L. F. CARTER.

BOISÉ CITY, IDAHO, *July* 12, 1889.

SIR: Your letter of the 8th ultimo, with inclosures, came duly to hand; the map of Idaho was also received, and is herewith returned to your office.

The subject-matter of your letter, the irrigation and reclamation of arid lands in the southern portion of Idaho, is of vital interest not only to the Territory of Idaho but to the General Government.

I deeply regret that circumstances beyond my control have prevented me from devoting any time to the subject other than making the estimates and embodying them in this communication, in answer to the following questions submitted in your letter:

First. On what streams in your county has irrigation been effected, and to what extent?

Second. On what streams is irrigation practicable, and to what extent?

Third. For what length of time, per yearly average, does each stream furnish sufficient water to irrigate its irrigable lands? And where the water in streams is sufficient are there sites for reservoirs wherein large bodies of water may be impounded at a moderate cost?

In answer to the first question, I will say there is not a stream in the county, and scarcely a spring or rivulet that has not been utilized for irrigating purposes; and outside of the Boisé and Payette Rivers there are over 100 miles of small ditches, and where the supply in its natural flow is not sufficient to irrigate the lands now in cultivation; but were the waters impounded, there would be sufficient for many thousand acres now entirely worthless.

Our two large streams before named, Boisé and Payette, furnish the main supply of water for irrigating and manufacturing, and the volume is ample for all time, without a question to the contrary.

There are some locations in the county where it will be impracticable, without very large expense, to irrigate the land and the time has not come that will warrant the outlay.

On the Boisé River there are about thirty-six ditches aggregating 308 miles, with a carrying capacity of over 300,000 cubic inches, sufficient for 400,000 acres of land, if used with care and the irrigation be done on correct principles.

There are on the Payette twenty-three ditches aggregating something over 180 miles, with a carrying capacity of 56,000 cubic inches, but the stream has volume enough to irrigate all the lands adjacent to its banks, and the table lands adjoining.

There are only a few locations in the county where water can be impounded with practical results. The Willow Creeks, Five, Ten, and Fifteen Mile Creeks, Dry Creek and one or two of its branches.

Respectfully, your obedient servant,

L. F. CARTEE,
United States Deputy Mineral Surveyor.

JOSEPH C. STRAUGHAN, Esq.,
United States Surveyor-General for Idaho.

REPORT BY E. A. STEVENSON.

BOISÉ CITY, *July* 16, 1889.

SIR: By request of Hon. George L. Shoup, governor of Idaho, I have the honor to furnish your department a brief statement of the present and proposed system of irrigation in the county of Ada.

I also annex hereto much valuable information furnished me by E. H. Hesse, esq., county surveyor of this county, in which is detailed "water supply, canals in operation, their length, name, capacity," and other valuable statistics.

Boisé River rises in the high mountains of Boisé County, and runs almost directly west through the entire length of Ada County, and is the main water supply for the southern portion thereof. Out of this beautiful, never-failing mountain stream the water has been taken to reclaim all the lands known as Boisé Valley, including this city, which was, before reclamation, one of the most desolate, arid, and worthless portions of our desert lands; and yet the water supply of the river, if properly utilized, is ample to irrigate 150,000 acres of table-land, lying on the south side of the river and covered by the proposed New York canal. This vast tract of most excellent agricultural land is most admirably adapted to fruit raising and farming, and, if properly cultivated, will produce from 30 to 49 bushels of wheat and from 5 to 7 tons of hay per acre. Apples, pears, plums, peaches, grapes, and berries will grow in abundance, but all must depend on the water for irrigation.

Probably no other section offers better facilities and inducements for the development of a practical system of irrigation than does this.

The only other river of importance in this county is the Payette, situated in the northwestern portion. It has almost an unlimited amount of water at all times, more than ample to irrigate all the lands within its reach.

If two large canals were taken out of this river, about 6 miles above Emettsville, one on each side of the river, it would reclaim more than 200,000 acres of most excellent agricultural land and furnish homes for thousands of actual settlers, who would soon surround themselves with all the comforts of civilization, so easily obtained in the mild and uniform climate of Idaho.

Again, this river runs for more than 150 miles through an almost inexhaustible forest of the finest pine, fir, and spruce timber in the Territory; hence the great water-power of this magnificent river must, at no distant day, be utilized, not only for irrigation but manufacturing purposes as well.

The only streams in this county where the water could be impounded by dams and reservoirs to any great advantage are Dry Creek, which enters into Boisé River about 10 miles below this city, Willow Creek, which also empties into Boisé River about 25 miles below here, and the Big and Little Willow Creeks, which empty into the Payette River about 6 miles above its mouth.

In each of these streams is a large volume of water in the winter and spring months which, if properly impounded and saved, would be ample to reclaim many thousand acres of most excellent land in the valleys of each of these streams.

Two or three substantial dams and reservoirs on each of these creeks could be constructed at small cost to the Government, which would reclaim some of the very best land in Idaho.

In order that people may fully realize what virtue there is in water on these arid lands, which are worthless until reclaimed, I would here state that since my residence in Idaho, Boisé City and the beautiful farms above and below the city have been changed from the very poorest portions of our desert lands to fine residences, embowered in trees and vines, and surrounded with grass, flowers, and orchards bending with their loads of apples, pears, peaches, plums, and prunes, of almost every variety, in abundance.

In addition to the names and number of ditches mentioned in the able report of Surveyor Hesse, I would state that almost every farmer, where the water was easily taken from the rivers, has constructed private ditches for his own use, which are omitted in Mr. Hesse's report.

All the locations where water could be taken from the rivers by canals at small expense, have long since been appropriated by the early settlers.

The three large canals before referred to, viz. one canal from Boisé River about 12 miles above this city, and one on each side of the Payette River 6 miles above Emmett, will reclaim at least 350,000 acres of good agricultural land, but the construction of these canals will be expensive and beyond the reach of our home capital. It is therefore to be hoped that the United States Government, out of her great wealth, will approprite sufficient money to make these vast tracts—of now worthless lands—productive and valuable.

I am confident, if the proper showing is made to the very able committee of the United States Senate who have in charge this great subject of irrigation, Idaho will be treated honestly and fairly.

Respectfully, yours,

E. A. STEVENSON.

JOSEPH C. STRAUGHAN,
United States Surveyor-General.

REPORT BY E. H. HESSE, COUNTY SURVEYOR.

COUNTY SURVEYOR'S OFFICE,
Boisé City, Idaho, June 14, 1889.

SIR: In compliance with your request, to gather and prepare statistics referring to the present and prospective system of irrigation in this county, the extent of the canals now in operation, and other points in this connection, I beg leave to submit to you the following items:

GENERAL FEATURES.

I will give a few outlines of the frame-work of this county to qualify the descriptions following on the subsequent pages:

Ada County is chiefly an agricultural county, embracing the spacious valleys of Snake, Boisé, and Payette Rivers. The northeastern corner is mountainous, interspersed with beautiful smaller valleys, such as Dry Creek, Willow Creek, etc. In the northwestern portion the extensive plateau of rich and fertile soil has not yet been touched by the plow. The western portion, between Boisé and Snake Rivers, embraces the Deer Flat country, which is as good in quality as it is vast in extent. Considerable energy is now displayed in bringing this section under water and plow. The southeastern portion is similar in character of soil, but the elevation of this plateau will not permit any water to be brought upon it, excepting from canals, heading at Snake River in the vicinity of the falls. All the above-mentioned high plateaus and hills afford good grazing.

IRRIGATION SYSTEM—WATER SUPPLY.

Boisé and Payette Rivers are the only streams that will supply the necessary amount of water for the available lands in this county. Owing to the fact that they reach our boundary from high mountains the water diverted may be successfully conducted to the high plateaus.

Snake River runs along this county in a deep gorge with hardly any more fall than the general contour of the country.

The former two rivers are—and will be with an increased demand—sufficient in volume for this supply, leaving out only the mountainous portion and the southeast flat, which latter is entirely dependent on Snake River as before stated.

CANALS IN OPERATION—BOISÉ RIVER.

South side.—The first canal emanating from Boisé River, nearest the eastern boundary of the county, is the Costin canal, heading at the mouth of the cañon about 8 miles above Boisé City. The water right which attaches to it warrants a stream 12 feet wide at the bottom. It now extends but a few miles in length as far as its capacity will permit.

The next, following down the river, is the Boisé and Nampa canal, better known as "Ridenbaugh ditch," heading about 3 miles below the former. It gradually ascends the benches and appears opposite Boisé City about 70 feet above the level of the river. The general course is westerly, and for the first 7 miles the bottom measures 20 feet in width. This is the terminus of the enlargement recently completed, and from this point it feeds a number of natural drains, from which the scattering ranches take water. The supply thence is lost by "seepage," by evaporation, and returns to the Boisé River.

The extension of this canal is under survey at present. The proposed line will cross the Oregon Short Line Railway between Kuna and Nampa, and reach Deer Flat at a very high point.

A small canal built by M. E. Payne and others comes next. It answers the purpose for which it was constructed, irrigating about six ranches.

The Settlers ditch, although not in operation yet but fast approaching completion, is next in rotation. It will cover a beautiful scope of agricultural country. Leaving the river about 4 miles below Boisé City, it reaches the top of the bench about 4 miles farther, passing through a cut 25 feet deep, thence it takes a southwesterly direction following the contour of the country, and below the proposed extension of the Ridenbaugh ditch, to Deer Flat. It is provided with head-gates for 20,000 miner's inches of water, but will in the beginning have a capacity of only 9,000 inches. The total length will be, like that of Ridenbaugh canal, between 30 and 40 miles.

The Caldwell canal heads about 18 miles below Boisé City, runs westerly some 15 miles, and covers the lower bench lands. It measures about 6 feet in the bottom and returns the surplus water into Boisé River.

Below Caldwell some minor attempts have been made, conveying the water only into natural drains, in which it runs to points where it is needed and taken out. The "Methodist ditch" was constructed but is not in operation.

North side.—The oldest canal, known as the "Walling ditch," takes its water about 4 miles above Boisé City. Two miles from the head it operates a saw-mill, from which a stream in a 10-foot channel is conveyed over the higher lands around Boisé City, which derives almost exclusively her water supply from this source; and a great deal of the verdant beauty of our town is owing to this ditch. Beyond the city it is used until the supply is absorbed. It is calculated to extend this canal to the Dry Creek Valley, and eventually to Willow Creek, a total length of about 30 or 40 miles.

Several miles below start the "Ellis and Jacobs" ditches, which flow through the lower streets of Boisé City, and one covers several hundred acres beyond, while the other runs a flouring-mill.

Dry Creek canal is taken from the river 5 miles above the mouth of Dry Creek. It recedes from the river until reaching the foot-hills, which it follows until attaining a total length of about 20 miles. The "Moore and Stephenson ditch" is taken out of this, which covers several hundred acres of land above the main canal.

Foote's Mill ditch, still below, has only a limited scope of country, besides running his flouring-mill at Middleton.

Opposite Caldwell emanates the "Sebree canal," which, if I am not mistaken, is 14 feet wide at the bottom, and is destined to cover all the lower lands as far as Snake River.

PAYETTE RIVER.

South side.—Only a small ditch has been taken out at a point called Black Cañon, about 5 miles up from the town of Emmett. This, however, can not do very great service, because of not reaching high enough.

The "Kelly and Bush canal" leaves the river 4 miles below Emmett, and continues in a northwesterly direction about parallel to the river towards Snake River, where it will terminate when finished. The land under it is of excellent quality, but only scattered portions are under cultivation. The main part of the ditch is 6 feet wide at the bottom for a distance of 10 miles, balance 3½ feet, and the total length about 30 miles. A reservoir is built at McFarland gulch, which will overflow 160 acres from 5 to 8 feet deep.

The Stevenson and Noble canal is taken out of the river about 6 miles below Emmett. It is 8 feet wide on the bottom, carries 5,000 inches of water, and extends in a westerly direction about 20 miles. Cost of construction $20,000. The canal is an entirely private enterprise, and is owned by E. A. Stevenson and William B. Noble. It covers about 8,000 acres, of which 2,200 acres belong to owners of the canal. Only surplus water is furnished to outside parties.

North side.—On the north side of the river only one canal can be mentioned—that of the Payette Company, heading about 8 miles above the town of Payette, and covering the settlements along this valley to the northern county boundary. Its dimensions are not over 6 feet at the bottom, and the length to the county line about 12 miles.

PROSPECTIVE CANALS.

All our great hopes of populating the larger portions of the desert land with bona fide settlers have been attaching to the early completion of two large canal systems, one from the Boisé River—the Idaho Mining and Irrigation Company; the other from the Payette River—the Payette Irrigation Company; the latter with two main canals, one on each side of the river. Both schemes are beyond capital, which fact makes their construction a mere possibility unless the Government assists.

The plans of the first-mentioned enterprise show a system of main and lateral canals of about 130 miles, with a tributary area of agricultural and mineral land of nearly 300,000 acres.

The plans of the second enterprise have not yet assumed any definite shape, but the estimated quantity of land to irrigation and reclamation would exceed 255,000 acres.

The projected Phyllis canal has had some work done. Starting on the south side of Boisé River about 10 miles below Boisé City, it has for its objective point the Deer Flat country. It is intended to cover the lower lands, which would be too remote for the Settlers and Ridenbaugh ditches.

Besides the unparalleled advantage of water-power for manufacturing purposes, the log-floating traffic, on the larger canals, would be no unimportant affair. Both rivers head in almost inexhaustible timber regions, and the cheap transportation of logs to the carriage of the saw-mill would encourage this industry greatly.

PLACER MINING.

The placer interest connected with the construction of canals is but little inferior to the agricultural. All of the three rivers have placer ground, but especially Snake River; and since its waters are not available and other resources are at best problematical, the placer field lay an idle waste of dormant wealth. In this county several hundred square miles of placer ground may be estimated.

NOTES.

The canals in operation and those under contemplation in this county are inadequate to the service, while the water is permitted to flow unused through this great drainage channel, Snake River.

Allowing the duty of water to be double that contemplated by the desert act, to wit, one miner's inch for 2 acres, or 1 cubit foot per second for nearly 100 acres, it has been demonstrated in this county that, when continuous stretches are irrigated, heavy crops have been raised and the duty of water becomes much larger. The underlying clay accounts for this.

CROPS AND CLIMATE.

Since the soil in this county is equally as rich as that of other surrounding counties, I refer this point of productiveness and crops to abler and more experienced pens, while the climate is much more effectually enjoyed personally than by the proxy of written reports.

In submitting these lines I would apologize for all defects, inasmuch as I was unable to secure all the information desired in the time allotted.

Very respectfully, your most obedient servant,

E. H. HESSE,
County Surveyor, Ada County, Idaho.

Hon. E. A. STEVENSON,
Boisé City, Idaho.

REPORT BY C. H. TOMPKINS, JR.

BOISÉ CITY, *August* 15, 1889.

SIR: In accordance with your request the following statement of the works and plans of the Idaho Mining and Irrigation Company is respectfully summitted:

The point of diversion of the main line of the Idaho Mining and Irrigation Company's system (often referred to as the "New York Canal") is on the left bank of the Boisé River, about ten miles above Boisé City. There exists at this point an excellent location for dam, waste-weir, and head-gates, all of which can be founded on solid rock.

The lands to be covered lie in Ada County, between the Boisé and Snake Rivers. They are of the first quality and have an area of about 350,000 acres

There is also, under the line of canal, a large body of place lands, extending for many miles along the Snake River, above the mouth of the Boisé. The length of canal, from head to mouth of Boisé River, will be about 70 miles. Dimensions at head: 65 feet wide at surface of water and 10 feet deep; grade, 2 feet per mile. Estimated capacity, 2,915 cubit feet per second, or about 140,000 miner's inches. For the supply of the lower portions of the tract, and for a quick line to the placers, is being constructed the Phyllis Canal or "lower line" of the company's system.

This will take water from the Boisé River at the lower end of Eagle Island, about 14 miles below Boisé City.

The length of the Phyllis line is about 50 miles. Dimensions at head, 22 feet wide at water surface and 5 feet deep. Capacity, 175 cubic feet per second, or about 8,500 miner's inches under a four-inch pressure.

The company has been very thorough in its preliminary work, including careful and detailed surveys. There have also been selected, in a trip made for that purpose, reservoir sites on Smith, Blind, and Fall Creeks, for husbanding the spring supply of the river if it should prove necessary to do so. These sites are unusually favorable, and reservoirs of large capacity can there be cheaply constructed.

Of the Phyllis or "lower line" about 2 miles have been completed. Work on the main line has thus far been confined to the upper 2 miles, which is in cañon, with much work in loose rock and large bowlders, but no solid rock cutting. The work has been, until recently, in charge of Mr. A. D. Foote, now irrigation engineer for the Snake River division of the U. S. Geological Survey.

Over the whole of the proposed system, the surveys show no difficulties of magnitude, and the lands can be covered at very moderate cost.

Respectfully submitted.

C. H. TOMPKINS, JR.,
Engineer and Manager.

J. C. STRAUGHAN,
Surveyor-General, Territory of Idaho.

Summary of Ada County works.

Canals and ditches completed.	Length.	Size on bottom.	Location of head and remarks.
Boisé River.	*Miles.*	*Feet.*	
Coston	6	12	8 miles above Boisé City, south side; is to be extended.
Ridenbaugh	7	20	5 miles above Boisé City, south side; is to be extended to Deer Flat; in all, 35 miles.
Payne's	4	5	Above Boisé City, south side; accommodates five or six ranches.
Settlers (in progress)	35	18	4 miles below Boisé City, south side; is half built.
Phyllis (in progress)	38	14	Heads at Eagle Island, south side; is half built.
Caldwell	15	6	18 miles below Boisé City, south side.
Walling	12	10	4 miles above Boise City, north side; runs through Boisé City; is to be extended.
Jacobs & Co	4	5	Runs through Boisé City; serves 600 acres land and a grist mill.
Dry Creek	20	6	5 miles above Dry Creek.
Payette River.			
A small ditch	4	4	5 miles above Emmett at the Black Cañon.
Kelly & Bush	30	6	4 miles below Emmett; has a reservoir 160 acres.
Stevenson & Noble	20	8	6 miles below Emmett; has capacity for 5,000 inches—private property.
Payette Company	12	6	8 miles above Payette.
	207		
CANALS PROPOSED.			
Idaho Mining and Irrigation Company:			
Main canal	76	24-14	Starts out from Boisé River 12 miles above city, south side; elaborate surveys and estimates made and the work progressing slowly; 300,000 acres will be covered and a great placer-mining district near the mouth of Boisé River.
Laterals	55	6-10	
Payette Irrigating Company:			
Two main canals	75	20-14	Starts at the Black Cañon on the Payette; surveys incomplete; will cover 255,000 acres.
Laterals	45	5-8	

Acres irrigated: 60,000; irrigable: 900,000.

ALTURAS COUNTY.

REPORT BY JOHN B. HASTINGS, UNITED STATES DEPUTY MINERAL SURVEYOR.

KETCHUM, IDAHO, *August* 9, 1889.

SIR: Regarding irrigable areas and ditches in this county, there are between Sawtooth and East Fork of Wood River practically no areas under cultivation. Other portions of the county Messrs. Mandell and Burkhardt say they will report upon.

Ditches in this part of the county.

Locality.	Length.	Acres cultivated.	Capacity.
	Miles.		*Inches.*
From Trail Creek	3⅛	200	1,700
Do	2	100	1,700
Do	1	20	200
From Wood River	1¼	200	1,000
Do	1½	50	1,000
Do	3⅛	50	1,000
Do	1	20	500

Total crop value of all these areas, $10,000. Trail Creek and Wood River carry sufficient water all the year for above ditches.

Ten miles above Ketchum, on Wood River, there is a quite recent lake bed; a dam 400 feet long, 100 feet high would convert it into a reservoir 2 miles long, half a mile wide. Such dam would cost $150,000 or less. These measurements do not pretend to accuracy. There are no other suitable sites for cheap reservoirs, to my knowledge, except such as will be reported by Messrs. Burkhart and Mandell.

Very respectfully, yours,

JOHN B. HASTINGS.

JOSEPH C. STRAUGHAN,
United States Surveyor-General for Idaho.

REPORT BY H. Z. BURKHART AND FRANK C. MANDELL.

HAILEY, IDAHO, *August* 10, 1889.

SIR: In compliance with your request of June 8, asking for information respecting the supply of water for irrigation, etc., we have the honor to report that Wood River furnishes ample water in ordinary seasons for the irrigation of all arable land traversed by it in Alturas County.

The supply of water, however, is insufficient for purposes of irrigation of land a few miles south of Hailey, in Logan County.

Eleven miles north of Ketchum there is an excellent natural site for a dam and storage reservoir, which can be constructed at comparatively small expense, and which would be amply sufficient to supply the entire arable territory tributary to Wood River.

Deer Creek, East Fork, and Trail Creek, branches of Wood River, are insufficient in dry seasons to supply the valleys through which they run.

Upon these streams there are favorable locations where dams and storage reservoirs can be built at no great expense. All of the land covered by these streams is very productive when well watered.

There is a small portion of Alturas County and a large part of Custer County lying within the valley of Big Lost River, comprising a large tract of land now wholly unproductive for want of water. We are reliably informed that the topography of the country affords sufficient natural sites for saving and utilizing the water, which otherwise runs to waste during the spring freshets.

Within the present limits of Alturas County there are no lands requiring irrigation other than those adjacent to the streams already mentioned.

All of which is respectfully submitted.

H. Z. BURKHART,
Committeeman.
FRANK C. MANDELL,
County Surveyor.

GEORGE L. SHOUP, *Governor.*

SUPPLEMENTAL REPORT BY FRANK C. MANDELL, UNITED STATES DEPUTY MINERAL SURVEYOR.

HAILEY, IDAHO, *August* 14, 1889.

SIR: Herewith I send map showing approximate locations of dam and water storage sites upon the principal streams of Alturas County.

Upon Lost River, at the Narrows, about 11 miles above its junction with Pass Creek, and also on Pass Creek just above where it joins Lost River, are very favorable locations for dams and storage reservoirs.

In the valley of Lost River there is an area of upwards of 100,000 acres of land capable of producing fine crops with water; 5,000 acres are now tilled, and the river, in average seasons, furnishes water for about 7,000 acres more, *i. e.*, a total capacity for about 12,000 acres.

Deer Creek has a tributary territory of 2,500 acres. It will irrigate 1,000 acres in favorable seasons, and about that amount is cultivated, if we include hay lands.

East Fork irrigates about 800 acres of the 2,000 acres in its valley capable of cultivation.

Trail Creek embraces 1,000 acres and waters about 500 acres.

Upon all these creeks good sites for storage-dams can readily be shown. The 12,000 acres of arable land within the present Alturas County, and within the valley of Wood River, can be readily watered by Wood River. About 7,000 acres are under cultivation. Wood River, however, falls short of irrigating its tributary territory within the county of Logan. At the dam location cited in report, the valley narrows to about 350 feet, and just above this place a broad extensive meadow tract affords the best facilities for an artificial lake or storage reservoir.

Very respectfully,

FRANK C. MANDELL,
United States Deputy Mineral Surveyor and County Surveyor.

JOSEPH C. STRAUGHAN,
United States Surveyor-General, Boisé City, Idaho.

Summary of Alturas County report.

Localities.	Lands—		Remarks.
	Irrigated.	Irrigable.	
	Acres.	*Acres.*	
Lost River	5,000	100,000	Might irrigate 7,000 acres more.
Wood River	7,000	12,000	One very good dam-site.
Trail Creek	500	1,000	Good dam-site.
Deer Creek	1,000	2,500	Do.
Other small streams	1,000	2,500	Do.
	14,500	118,000	

Recapitulation.—Total area of county, 2,100 square miles; ordinary snow-fall, 20 feet (Sawtooth Mountains); ten ditches, 18 miles long, average capacity, 1,700 inches.

BEAR LAKE COUNTY.

REPORT BY J. C. RICH, COUNTY SURVEYOR.

Georgetown.—Four main canals; length, 16 miles; size, 6 by 2 feet; cost, $2,500; owned in common by inhabitants; amount now irrigated, 1,200 acres; amount yet vacant for want of water, 2,000 acres; cost of reservoir (estimated), $5,000.

Dingle.—Two main canals; length, 10 miles; average size, 12 by 2 feet; cost, $5,000; owned in common by inhabitants; amount now irrigated, 2,000 acres; amount now vacant that could be irrigated by reservoir, 2,000 acres.

Preston.—One main canal 8¼ miles long; size, 12 by 4 feet; cost, $10,000; owned in common by inhabitants; total amount irrigated, 1,500 acres; cost of reservoir, $5,000 (estimated); amount of land now vacant that could be irrigated from reservoir, 3,000 acres.

Montpelier.—Five main canals; length, 10 miles; average size, 8 by 2 feet; cost, $5,000; owned in common by inhabitants; total amount of land now irrigated, 1,000 acres; cost of reservoir (estimated), $4,000; amount of land now vacant that could be irrigated from reservoir, 2,000 acres.

Bennington.—Two main canals, ten lateral canals; total length, 16 miles; average size, 4 by 2 feet; cost, $1,000; owned in common by the inhabitants; amount of land now irrigated, 1,000 acres; cost of reservoir estimated at $5,000; amount of land now vacant that could be irrigated with reservoir, 5,000 acres.

Liberty.—Four main canals; total length, 21 miles; average size, 4 by 2 feet; cost, $6,000; owned in common by citizens; amount of land now irrigated, 2,000 acres; cost of reservoir estimated at $10,000; amount of land now vacant that could be irrigated from reservoir, 3,000 acres.

Ovid.—One main canal; length, 10 miles; average size, 6 by 2 feet; cost, $4,000; owned in common by the inhabitants; total amount of land now irrigated, 800 acres; amount of land now vacant that could be irrigated from Liberty Reservoir, 1,000 acres.

Nounan.—Five main canals; total length, 10 miles; average size, 4 by 2 feet; cost, $1,000; owned in common by inhabitants; total amount of land now irrigated, 1,000 acres; cost of reservoirs (estimated), $5,000; amount of land yet vacant that can be irrigated from reservoirs, 1,000 acres.

Thomas's Fork.—Four main canals; total length, 14 miles; average size, 10 by 2 feet; cost, $5,000; owned in common by inhabitants; total amount of land now irrigated, 1,500 acres; cost of reservoirs estimated at $5,000; amount of land yet vacant that could be irrigated from reservoir, 10,000 acres.

St. Charles.—Eight main canals; total length, 20 miles; average size, 6 by 2 feet; cost, $10,000; owned in common by the inhabitants; amount of land now irrigated, 3,500 acres; cost of reservoir estimated at $1,000; amount of land yet vacant that, might be irrigated from reservoir, 1,500 acres.

Paris.—Four main canals; total length, 12½ miles; average size , 6 by 12 feet; cost $10,000; owned in common by the inhabitants; amount of land now irrigated, 2,000 acres; cost of reservoir estimated at $5,000; amount of land yet vacant that could be irrigated from reservoir, 5,000 acres.

Fish Haven.—Five main canals; total length, 13 miles; average size, 4 by 2 feet; cost, $4,000; owned in common by the inhabitants; amount of land now irrigated, 1,000 acres; cost of reservoir estimated at $5,000; amount of land yet vacant that could be irrigated from reservoir, 1,000 acres.

Bloomington.—Four main canals; total length, 15 miles; average size, 6 by 2 feet; cost, $8,000; owned in common by the inhabitants; amount of land now irrigated, 2,000 acres; cost of reservoir estimated at $2,500; amount of land yet vacant that could be irrigated from reservoir, 2,500 acres.

Individuals.—About ten isolated canals owned by individuals. Total length, 30 miles; average size, 4 by 2 feet; cost, $2,000; amount of land irrigated, about 1,000 acres.

RECAPITULATION.

Districts.	No.	Miles.	Size.	Cost.	Irrigated.	Irrigable.	Cost of reservoirs.
			Feet.		*Acres.*	*Acres.*	
Georgetown	4	16.0	6 x 2	$2,500	1,200	2,000	$5,000
Dingle	2	10.0	12 x 2	5,000	2,000	2,000	5,000
Preston	1	8.5	12 x 4	10,000	1,500	3,000	4,000
Montpelier	5	10.0	8 x 2	5,000	1,000	2,000	5,000
Bennington	2	16.0	4 x 2	1,000	1,000	5,000	5,000
Lateral	10	......	......	......	......	......	......
Liberty	4	21.0	4 x 2	6,000	2,000	3,000	10,000
Ovid	1	10.0	6 x 2	4,000	800	1,000	......
Nounan	5	10.0	4 x 2	1,000	1,000	1,000	5,000
Thomas's Fork	4	14.0	10 x 2	5,000	1,500	10,000	5,000
St. Charles	8	20.0	6 x 2	10,000	3,500	1,500	1,000
Paris	4	12.5	6 x 2	10,000	2,000	5,000	5,000
Fish Haven	5	13.0	4 x 2	4,000	1,000	1,000	5,000
Bloomington	4	15.0	6 x 2	8,000	2,000	2,500	2,500
Individual	10	30.0	6 x 2	2,000	1,000	......	......
	69	206.0	......	73,500	21,500	39,000	52,500

Crops.		Yield per acre.
Wheat	Bushels	30
Oats	do	45
Barley	do	40
Rye	do	25
Alfalfa, timothy, red-top	Tons	2

All kinds of hardy vegetables and small fruits a good yield.

Exports: Cattle, horses, sheep, lumber and all kinds of farm products.

Timber on the mountain abundant, convenient. Range for stock good. Irrigation season May, June, July, and August.

Snow-fall, average 6 to 8 feet on mountains. Water supply, great deficiency in 1888 and 1889.

Elevation, average, 5,800 feet above sea level.

BINGHAM COUNTY.

GENERAL DESCRIPTION.

Bear River.—Bear River runs for 14 miles through a narrow cañon, commencing below mouth of Cottonwood Creek, and does not offer many good locations for canals south of said cañon.

Port Neuf River.—As Port Neuf runs for nearly 50 miles through a narrow cañon, and as the lands along its lower course from Pocatelleo to Snake River will be more practicably irrigated by Snake River water, a canal should be constructed to run south along the foot-hills of Port Neuf Range to irrigate T. 9, 10, 11, and 12, S. of R. 37 E., and, if possible, Round Valley, in T. 13 S. of R. 38 and 39 E.

Blackfoot River.—The amount of water sufficient for its irrigable lands can only be obtained by the construction of reservoirs in the basins of John Day's Lake, in order to drain Cariboo Range, and in the narrow cañons of the spring branches emptying into Spring Forks of Big Blackfoot, in order to drain Preuss and Cariboo ranges.

Summary of Bingham County report (north part).

[Compiled from reports of Hon. W. H. B. Crow and others.]

Localities.	Lands.		Canals.	Length.	Width of bottom.	Cost.
	Irrigated.	Irrigable.				
	Acres.	*Acres.*		*Miles.*	*Feet.*	
From South Fork, Snake River:						
Willow Creek and its tributaries.	1,000	30,000	Eagle Rock and Willow Creek.	60	20 to 30	$100,000
			System and laterals.	110	4 to 10	....
South Fork Snake River, from mouth of cañon down.	1,000	10,000	Farmer's Friend, main.	6	20	5,000
			Laterals	5	5	....
Lyon Creek, from Hot Springs down.	400	2,000				
Moody's Creek, from main valley up.	1,500	4,000	Cedar Hollow (in progress).	25	25	75,000
			Burgess canal	15	20	8,000
Teton River, from the cañon up to head.	*16,000	80,000	Rigby canal	5	18	6,000
			Louisville canal	8	16	10,000
Fall River, "Middle Fork," and tributaries, Conant & Co.	600	60,000	Market Lake County, main.	3	20	7,000
			Laterals	6	6	....
North Fork, Snake River and tributaries, up to Henry Lake.	*75,000	350,000	St. Anthony, costly.	14	30	14,000
			Egin, west side	10	14	8,000
Snake River Valley, east side, from South Fork down.	*100,000	400,000	Rexburgh, main	7	16	17,000
			Laterals	12	10	....
Snake River Valley, west side, from Market Lake to American Falls.	*50,000	500,000	Fall River canal	8	30	10,000
West side of Bingham County, Camas Creek, Big and Little Lost Rivers, etc.	....	800,000	Lymantown canal.....	6	24	5,000
			Tanthauer canal.......	20	25	20,000
			Colorado, at Eagle Rock.	15	....	75,000
			Porter County, at Eagle Rock, west side.	18	20	75,000
Total	245,500	2,236,000	....	353	....	435,000

*In process of construction.

Summary of Bingham County (south part).

[Compiled from Report of Oscar Sonnenkalb, United States deputy surveyor.]

Valleys.	Land irrigated.	Area.	Canals.		Land irrigable.	Acres.
		Acres.	*No.*	*Miles.*		
Snake River.						
Hulls, Boone, and Donaldson Creeks.	Along east bank, 17 miles, scattering.	1,500	....	17	Along east side for 35 miles..	100,000
	Along west bank, 12 miles, scattering.	1,000	5	12	Along west side for 35 miles..	30,000
	Along west bank, scattering.	3,000	3	13	Along west side	10,000
Salt River tributaries.						
Crow Creek; John Coy's Creek; Smoky Creek; Roney's Creek; Tin Cup Creek; Punch Bowl Creek; Grand Cañon Creek; Palisade Creek.	Small ditches on small farms.	1,000	3	10	No more irrigation needed..	....
Willow Creek.						
John Day's Creek and Lake.	Scattering localities.	200	3	10	Irrigation practicable for...	500
Eagle Creek	....	....	....	.....	....	....
Big Blackfoot River......	Along north side 20 miles.	2,000	8	20	Main valley 20 by 60 miles; North Fork 18 by 2 miles.	10,000
South Fork............	Along marsh......	1,200	2	4	Further irrigation impracticable.	....
Middle Fork............	....	1,000	1	3	......do	....
Little Blackfoot River.						
North Branch............	Along 3 miles.....	2,000	1	6	......do	....
East Branch............	Along 2 miles.....	1,000	1	5	......do	....
Formation (Corral) Creek.	....do	1,000	1	5	......do	....
Grave Creek............	....do	600	1	2	......do	....
Wolverine Creek	....do	600	2	4	......do	....
Port Neuf River	Numerous small ditches.	6,000	(?)	(?)	Including table lands for 50 miles.	65,000
North and South Spring Forks.	Small tracts along each.	1,000	2	10	More irrigation impracticable.	....
Willow Creek	....do	200	1	2	......do	....
Fish Creek	....do	50	1	1	......do	....
Dempsey Creek............	Small tracts	2,000	2	10	A bench of land 25 miles by one-halfmile.	7,000
Marsh Creek	....do	100	(?)	(?)	More irrigation impracticable.	....
Garden, Woodland, and Nine-mlie Creeks.	Small tracts along each.	900	3	5	......do	....
Mink Creek............	Small tracts	50	2	3	......do	....
Bannock Creek	Three large, and many small ditches.	2,000	5	20	....	....
Bear River............	....	6,000	(?)	24	In T. 9 S., R. 39 and 40 E. and T. 10 S., R. 40 E., and Gentile Valley.	45,000
Soda Creek	Scattering tract...	300	2	8	More irrigation impracticable.	....
Sulphur Creek............	....do	100	1	5	......do	....
Whiskey Creek......	....do	50	1	3	......do	....
King Creek............	....do	50	1	1	......do	....
Burton Creek............	....do	50	1	1	......do	....
Trout Creek............	....do	300	2	6	......do	....
Warm Creek	....do	200	1	5	......do	....
Bridge Creek	....do	800	1	5	......do	....
Cottonwood Creek........	....do	500	2	5	......do	....
Mink Creek............	....do	800	2	20	......do	....
Battle Creek............	....do	500	2	6	......do	....
Deep Creek..	....do	(?)	(?)	......	......do	....
Stockton Creek	....do	300	1	3	......do	....
Gooseberry Creek........	....do	300	1	3	......do	....
Oxford Creek	....do	500	1	3	......do	....
Total	....	39,250	68	264	....	267,500

RECAPITULATION (SOUTH PART).

Whole number of canals and ditches		70
Whole length of canals and ditches..	miles..	264
Whole area now irrigated..	acres..	39,250
Whole area capable of irrigation	do....	267,500

BOISÉ COUNTY.

REPORT BY S. M. SISK AND BENJAMIN H. SMITH.

VAN WYCK, IDAHO, *July* 5, 1889.

EAR SIR: I am in receipt of your circular letter of June 15 in reference to infor-
tion to come before "the United States Senate Committee on Irrigation." I have
ited till the last moment, expecting the map mentioned and promised in your let-
, but it has not yet arrived, which I very much regret. In absence of such map I
ve prepared a small pen map of Long Valley, by reference to which you will be
tter able to understand the purport of this letter.

You are of course aware of the fact that Boisé County, Idaho, is not mainly an
ricultural county, but it is rather more noted for its mining interests.

(1) Garden Valley is situated partly on Middle Fork, and partly on South Fork of
ayette River. The whole valley is about 8 miles in length and 1 mile in width.
has been in cultivation for several years, and where irrigation is needed it is sup-
ied from the intersecting streams.

(2) Squaw Creek Valley is already in cultivation, and under a system of home ir-
gation sufficient for all purposes. It is a small valley containing about 40 home-
eads.

(3) Horseshoe Bend and Squaw Creek Flat contains more than two dozen home-
eads, but abundantly watered by ditches usually from the Payette River.

The main portion of Boisé County that can be used for agricultural purposes, in-
uding hay and grazing, is included in Long Valley.

(4) Long Valley is about 60 miles in length and 9 or 10 miles in width, extending
a general direction from north to south, bearing a little eastward along North
ayette River. From the upper lakes to the southern terminus there is an almost
radual descent, estimated at about 400 feet for the whole extent.

By reference to the map you will see the several main ditches already commenced
y the enterprise of the citizens, who are forming home companies for the purpose of
general water supply, which may be needed in time of scarcity of rain-fall or of
nelting snow, viz:

(1) Lake Fork Ditch extends from near the source of Lake Fork Creek, about 10
niles south; and it is to be produced as far as Gold Fork. When completed it will
vater an area of about 10 miles long by 3 miles wide.

(2) Gold Fork Ditch commences far up Gold Fork and is to be extended south-
vard about 10 miles, emptying into the falls of Payette River. When completed it
vill water an area of about 10 miles long by 3 miles wide.

(3) Big Creek Ditch is taken out of Big Creek toward the foot-hills and extends
westward about 2 miles. When completed it will water an area of about 3 miles long
and 1¼ wide or less.

(4) Clear Creek Ditch is taken out of Clear Creek, and intended to run westward into Payette River, and when completed it will water several hundred acres of land.

(5) Tamarak Falls Ditch is to take its supply out of Payette River, at Tamarak Falls, and run southward along the western side of the valley, extending about 10 miles and emptying into Payette River. When completed it will water an area of about 10 miles long and 3 miles wide.

(6) Kimball Ditch takes its water out of Hazard Creek, and runs eastward to Payette River. It is in operation, and waters an area of about 2 miles long and 1 mile wide.

(7) There are many private ditches both in operation and in prospect, which will be completed at but little expense to individuals, and will, in most cases, water areas of from 1 to 100 acres. Under these systems the whole valley can be supplied.

As to storage supply, I would say that as the time in which irrigation can be most profitably employed is about two months, the water supply from the sources above mentioned during that period will always be abundant, or easily made sufficient when required.

I have been at some pains to consult with the citizens of Long Valley, as far as practicable, in reference to the matters elicited in your letter, and at their earnest general request, as well as accepting your timely suggestion, I would beg leave to submit the following:

(1) Long Valley began to be settled, though sparsely, as far back as five or six years ago. Several of these settlers have been improving their prospective homesteads ever since, in hope of obtaining their title in due time.

(2) The main lines for township purposes, which were surveyed several years ago, have been of great assistance ever since in helping the settlers to guess at the probable location of their claims.

(3) The immigration has steadily increased, year by year, until there is an estimated population of nine hundred.

(4) The uncertainty of the location of section lines, yet to be surveyed, causes an earnest desire that the work of completing the survey, be prosecuted as soon as possible.

(5) As these settlers are usually a poor, but thrifty, industrious, law-abiding class of people, many of them veterans or sons of veterans, in their country's service, seeking to secure and improve homes for themselves and their families, they anxiously hope that nothing may be done by any of our public officials, or by the Senate committee, to retard the realization of those cherished anticipations, nor to frustrate their final attainment.

But if, in the judgment of the surveyor-general for Idaho and of the Senate committee, moiety of aid is deemed advisable to be appropriated, without jeopardizing our homes, or entailing burdens by way of future rental expenses, to the people, it would be duly appreciated by the citizens.

Your obedient servant,

S. M. SISK.
BENJ. H. SMITH,
Assistant.

JOSEPH C. STRAUGHAN,
United States Surveyor-General for Idaho.

Summary of Boisé County reports.

Ditches.	Length.	Irrigates.	Remarks.
	Miles.	*Acres.*	
Lake Fork ditch	10	19,200	Begins at head of Lake Fork Creek; constructing.
Gold Fork ditch	10	19,200	Begins far up Gold Fork; ends at the falls; constructing.
Big Creek ditch	2	3,000	Begins at Big Creek.
Clear Creek ditch	2	800	Begins on Clear Creek and goes west.
Tamarack Falls ditch	10	20,000	Begins at the falls, on west side; constructing.
Kimball ditch	3	1,200	Begins at Hazard Creek; runs east; completed.
Many private ditches	(?)	(?)	Watering from one to one hundred acres.
Total on Long Valley	37	63,400	
Garden Valley	....	5,100	Has had whole valley irrigated for some years.
Squaw Creek Valley	....	9,000	Is fully irrigated, and has about forty homesteads.
Horseshoe Bend and Squaw Creek Flat.	....	6,000	Are fully irrigated from the river; has thirty homesteads.
	....	83,500	

Total area of country, 3,024 square miles.

CASSIA COUNTY.

REPORT BY T. A. STARRH.

DEAR SIR: I beg leave to submit the following in reply to the questions asked in your circular letter of June 15, 1889.

Cassia County, with a climate unsurpassed by any Territory in the Union and equaled by few, situated in longitude 37° west from Washington and latitude 42½°, contains 5,100 square miles of land, about one-fourth of it mountainous, with a little timber, one-half undulating grazing lands of great excellence, and one-fourth level and very fertile farm lands. Products: Cattle, wool, horses, hay, grain, vegetables, and fruits. Snake River, Raft River, East Rock Creek, Sublette, West Rock Creek, and Salmon River are its principal streams, thus making it is one of the best-watered counties in the Territory, upon all of which, except Snake and Salmon Rivers, agriculture is successfully carried on, and the entire amount of water these streams produce is used upon the land, except that which runs to waste during the months of January, February, March, and April, which could be held in storage by a system of reservoirs and fully supply the present settlers; and on some streams reclaim thousands of acres that could never be reclaimed in any other way, as the elevation would be such as the advent of a canal from Snake River could not reach them. The past three years have been seasons of continued drought. The past winter much less snow has fallen than has been the case within the knowledge of the earliest settlers, consequently decreasing the already-depleted streams, thereby reducing very much the annual production of all crops.

It is thought, from the best sources of information we have at hand, that a system of storage reservoirs in this county, at a cost of about $50,000, located at the heads of the aforementioned streams, would reclaim 10,500 acres of valuable land that never can be reclaimed in any other manner, and furnish water for at least 5,000 acres already settled upon; whereas without such aid the settlers will have to emigrate to some other locality and leave their homes and other improvements. A canal from Snake River, taken out at the proper elevation, say the South Fork of Snake River, would reclaim at least (in this county) 400,000 acres of the very best lands. The cost of said canal would be difficult to estimate until the completion of the surveys, but it is thought would not exceed $5 per acre for all lands covered by the canal, and it could be extended into the adjoining county on the west (Owyhee) and would cover the Bruneau Valley.

Salmon River Valley, 4,200 feet above the sea, is not under cultivation, but has a fine climate, that adapts it to the raising of hay and grain and all kinds of fruits. This valley is 52 miles long by an average of over 30 miles wide, and contains many hundred thousand acres of fine land. The Salmon River, at a point at Rock Creek Station, has an elevation of 4,200 feet. This river to the west of Rock Creek takes its rise on the eastern slope of the Bruneau Mountains, in the State of Nevada, flows east for some distance, then flows nearly due north a distance of 100 miles, and empties into Snake River one-half mile above Payne's Ferry. It flows through one of the finest bodies of land in the country, but it is in a deep cañon from the time it debouches in the valley 6 miles below the Brown ranche, where it would require an extensive dam to raise it to the level of the land. The material—rock—is very plenty and near by. This would amply repay a liberal expenditure of money to reclaim, as its usual flow far exceeds any stream in the county. Its flow in flood time is equal to 60,000 miner's inches of water. Some 4,000 acres of hay is cultivated upon the upper waters. This valley is capable of sustaining 10,000 people. Number of ditches, fifteen; length of them, 20 miles.

Rock Creek takes its rise upon the northern slope of a spur of the Goose Creek Mountains, flows a distance of 35 miles, and empties into Snake River 33 miles west of Shoshone Falls.

Dividing the county into water districts, we begin with the West Rock Creek and Dry Creek as No. 1, which contains, during the ordinary irrigation seasons, about 3,000 inches of water and about 35,000 acres of valuable farming land. About one-half of it is in a good state of cultivation, producing hay, grain, vegetables, and fruit, yielding per acre—timothy hay, 2½ tons, value per acre $20; wheat per acre, 40 bushels, value $24; oats per acre, 50 bushels, value $15; barley per acre, 45 bushels, value $13; potatoes per acre, 200 bushels, value $60; alfalfa per acre, 6 tons, value $36. Number of ditches in district, thirty; length, 25 miles. There is a very favorable situation for a reservoir at what is termed "The Forks," which could be built for about $5,000, and would enable those who are now deprived of water to have sufficient and reclaim about 500 acres of land.

Goose Creek, in water district No. 2, takes its rise in Goose Creek Mountains, and first flows in a northeasterly direction, then runs almost due north to Snake River emptying into it about 32 miles east of Shoshone Falls and 5 miles above Starrh's Ferry; contains in ordinary seasons about 12,000 inches of water; it has many small streams that flow into it: Birch Creek, Basin Creek, Trapper Creek, and other small streams. Goose Creek Valley at Oakley has an elevation of 4,440 feet above the sea; at the island 4,341 feet. It contains about 300,000 acres of the finest land in the Territory. It has a length of about 27 miles north and south, and an average breadth of about 20 miles east and west. There are about 14,000 acres under cultivation. The average yield of crops in ordinary seasons is, viz: Wheat per acre, 40 bushels; value, $25; oats per acre, 50 bushels; value, $15; barley per acre, 45 bushels; value, $14; potatoes per acre, 200 bushels; value, $60; alfalfa per acre, 6 tons; value, $36; timothy per acre, 2½ tons; value, $20.

The water supply for irrigation begins to fail about the 20th of June to about one-third of needed supply, but there has not been one-third the amount required this year at any time of the season. About 8 miles up the Goose Creek Cañon, above the mill, there is a very fine location for a storage reservoir.

The bluffs approach on each side of the cañon to within 150 feet, above which an extension flat spreads out of slight grade. A dam built between these bluffs at a height of 50 feet would form a reservoir 2 miles long by three quarters to 1 mile wide and cost about $12,000. In ordinary seasons there is in Goose Creek above this point 10,000 inches of water. Another very favorable location is on a tributary of Goose Creek called Trapper Creek. With an outlay of about $15,000 a reservoir could here be built that would be three-fourths of a mile wide by 1 mile long, with an average depth of 20 feet; this location would be desirable, as its depth would prevent a rapid evaporation. On the west side of Goose Creek is a stream called Cottonwood. In ordinary years this stream flows about 2,000 inches of water until about the 21st of May, when the supply diminishes to about 400 inches. A reservoir at this point could be built at small cost. It is the opinion of many that an outlay of $20,000 on Goose Creek and tributaries would cause the reclamation of at least 5,000 acres more land than can ever be cultivated without it, besides furnishing water to many who will have to move away unless they can get water. The retention of large bodies of water in reservoirs would cause new springs to burst forth and enlarge and feed the others. There are now five canals running from Goose Creek, with an aggregate length of 40 miles and capacity of about 3,000 inches. The other ditches number about fifty; length, 50 miles; water required to irrigate 1 acre of land of average crop 1 inch to the acre.

District No. 3, Marsh Valley, is situated in the mountains at an elevation of 4,700 feet above the sea at Albion, which is our county seat. The valley is about 15 miles long, its greatest width, at Albion, about 7 miles. Its main streams are Marsh Creek, Land Creek, and Howell Creek and their tributaries. Marsh Creek takes its rise in a spur of the Goose Creek Mountains, the summit of which is Mount Harrison; elevation above the sea, 10,000 feet. In ordinary years the snow falls to a great depth upon this spur of the Goose Creek Range and furnishes an abundant supply of water. Fifteen hundred feet below Mount Harrison is Lake Cleveland, one of nature's natural reservoirs and the main source of Marsh and Land Creeks. Five thousand dollars expended upon this lake would store an area of water covering about 30 acres at a depth of 20 feet above low-water mark. Green Cañon, about 1,500 feet below the lake, is another favorable storage reservoir, and could be built at a cost of about $5,000. At Cow Gulch, a point where both Summit and Howell Creeks can be utilized, another storage reservoir can be built at a cost of about $3,000.

The three reservoirs above mentioned would store a sufficient quantity of water to enable every settler upon Marsh Creek and its tributaries to have sufficient water to irrigate all the land claimed and in cultivation by them. Without such aid many will have to leave their homes and improvements. Some few have already done so, migrating to British Columbia, others seeking employment in the mines of this Territory and Montana. Marsh Creek has a length of 17 miles from its source to where it empties into Snake River, 10 miles above the mouth of Goose Crrek. The amount of land claimed and fenced along this stream is about 13,000 acres, with about 4,500 acres under cultivation. Number of ditches, ninety; length, 88 miles. Marsh Creek and tributaries have such heavy grades that the waters flow very rapidly during the flood-tide. In ordinary years there flows into Snake River for the months of January, February, March, and April the largest body of water that runs in the streams during the year. It is calculated that the flow of the waters of Marsh Creek amount to 15,000 inches under a 4-inch pressure, thus furnishing, if stored in reservoirs, sufficient water to irrigate all the lands claimed and under cultivation. After the 4th of July this stream is reduced to almost nothing. At this elevation corn is produced and all the fruits, apples, pears, plums, cherries, and small berries in the greatest abundance with surpassingly fine flavor. Yield of crops in ordinary years: Wheat, per acre, 45 bushels; value, $27. Oats, per acre, 55 bushels; value, $17. Barley, per acre, 45 bushels; value, $15. Corn, per acre, 35 bushels; value, $13. Potatoes, per acre, 250 bushels; value, $65. Alfalfa, per acre, 6 tons; value, $36. Timothy, per acre, 2¼ tons; value, $20.

Cassia Creek, in district No. 4, takes its rise at the base of Mount Independence, at a point where the general trend of the Goose Creek Range trends to the west. At an elevation of 10,500 feet above the sea, its summit, in ordinary years, is white with snow until in August. It is fairly covered with timber and its sides deeply furrowed with ravines, which prevent the sun from melting the accumulated snows which drift into these ravines in the winter to a great depth. This is the main reason why Cassia Creek furnishes the largest and most continuous volume of water in the county for its size. Its volume in the three spring months is equal to 15,000 inches of water, and at times to 20,000 inches, but diminishes very much by the 1st of July. This stream, from Mount Independence, flows almost due east a distance of 12 miles and empties into Raft River, near the center of the town of Malta, at Conant's store. The valley has an elevation of 4,700 feet above the sea. Near the base of Mount Independence are three natural depressions, or small lakes, with an area of about 20 to 25 acres (the depth varying from 15 to 20 feet), which would make three reservoirs, each at a cost of about $10,000. There are other favorable locations where reservoirs could be built, lower down on the stream, at a reasonable cost. The storage of water at this elevation would furnish water for all the available lands on Cassia Creek, and some bench lands below the junction of Cassia Creek and Raft River, which, without such aid, will probably never be reclaimed. Amount of land owned and fenced, 5,100 acres; amount under cultivation, 2,200 acres; number of irrigating ditches, fifty-six; length, 45 miles.

Average yield and value of crops in ordinary years, viz: Wheat, per acre, 45 bushels; value, $26. Oats, per acre, 56 bushels; value, $17. Barley, per acre, 45 bushels;

value, $16. Corn, per acre, 30 bushels; value, $13. Potatoes, per acre, 250 bushels; value, $65. Alfalfa, per acre, 6 tons; value, $20. Timothy, per acre, 2½ tons; value, $20.

Almo Creek, altitude about 5,000 feet, in district No. 5, takes its rise in a spur of the Goose Creek Mountains, to the west and south of Mount Independence, and flows almost due south into Raft River. There is a fine site for a reservoir at the head of the stream, which would reclaim 400 acres of fine land and enable those already settled there to have sufficient for their wants. Amount of land in cultivation, 600 acres; average production per acre and value the same as Cassia Creek.

Raft River Valley, in district No. 6, one of the most extensive valleys in the county, has a length of 45 miles, average width of 11 miles. There are about 300,000 acres of land susceptible of cultivation; altitude at the bridge, 4,650 feet above the sea. Raft River has a flow of about 15,000 inches in ordinary years until July, when the supply diminishes very much. The South Fork of this river takes its rise in Utah Territory, at the southwest end of Junction Valley, in a spur of the Goose Creek range of mountains. The North Fork takes its rise in the Goose Creek Mountains, in Idaho. These forks form into one stream at what is called the narrows; from its source this stream flows east about 20 miles, then runs nearly due north, emptying into Snake River 9 miles below Fall Creek, at Bonanza Bar.

There are a number of fine locations for reservoir sites. The best one would be upon the South Fork at the south end of Junction Valley. It would require at least about $20,000, but the result would justify the outlay, as it would form a lake some 3 miles in length to 1 mile wide, and any desired depth, according to height of the dam. The same could be done at the North Fork, so the amount of land to be reclaimed by the two reservoirs mentioned would depend upon the heights of the dams at each reservoir. The altitude would be about 4,980 feet above the level of the sea; amount of land owned and fenced, 15,000 acres; amount under cultivation, 6,500 acres. Number of ditches, sixty; length of them, 70 miles. Average yield of crops, viz: Wheat, per acre, 45 bushels; value, $26. Oats, per acre, 55 bushels; value, $17. Barley, per acre, 45 bushels; value, $16. Corn, per acre, 30 bushels; value, $13. Potatoes, per acre, 250 bushels; value, $65. Alfalfa hay, per acre, 6 tons; value, $30. Timothy hay, per acre, 2½ tons; value, $20. Natural hay, per acre, 1½ tons; value, $9.

Raft River, like all other streams in the county except Sublette Fall Creek and East Rock Creek, takes its rise in the Goose Creek Mountains or spurs of the same. At the sources of the streams their altitudes are very nearly equal and the annual snow and rain fall very near the same, furnishing a uniform amount of water very nearly supplying the wants of the settlers until the 25th of June or 4th of July, when the supply diminishes very rapidly.

District No. 7: Clear Creek, a tributary of Raft River, takes its rise in the Clear Creek Mountains in Utah Territory, and flowing nearly due north a distance of 30 miles, empties into Raft River a short distance below the bridge. It has much valuable land and has an elevation of 4,700 feet above the sea. Land in cultivation, 3,000 acres, principally in hay. Number of ditches, twelve; length, 20 miles. Clear Creek contains in average years of snow-falls about 5,000 inches of water during the early part of the season, and diminishes to a very small stream after the month of July. There is a favorable site for a reservoir at the mouth of Clear Creek Cañon. Five thousand dollars would build a reservoir that would store sufficient water to reclaim 1,000 acres more land. The Clear Creek Mountains are a lofty mountain range 9,000 feet above the sea, and in ordinary years the snow falls to a great depth in the cañons and on its summits.

District No. 8: Sublette is a fine mountain stream, takes its rise in the Sublette Mountains, and flows for a distance of 12 miles to the west and empties into Raft River a short distance below the town of Malta, at the mouth of the cañon. Two reservoirs can be built at a cost of about $5,000. That, it is thought, would store sufficient water to reclaim 400 or 500 acres of very fine land. Altitude above the sea, about 4,750 feet. There is under cultivation about 400 acres of land in grain, hay, etc. Value per acre and quantity about the same as that of Raft River, of which it is a tributary. It has an ordinary flow of 600 inches of water until about the 1st of July, when, like all the other streams, the supply diminishes.

Hagler Creek in district No. 9, a short distance to the north of Sublette, takes its rise in the same mountain range and flows almost due west for 11 miles into Raft River. This, though a small stream in the spring months, furnishes a fine body of water until June 20, when it becomes quite small. The mouth of this cañon, called Hagler, affords a fine site for a reservoir, which could be built at a small cost. No land under cultivation on this stream.

Fall Creek, in district No. 10, is a fine mountain stream of tepid water, takes its rise on the western slope of a spur of the Bannock Mountains; flows into Snake River at Bonanza Bar, and is used for placer mining. No land suitable for cultivation.

East Rock Creek, situated a few miles east of Fall Creek, takes its rise in the same range of mountains, is a strong mountain stream only a few miles long, empties into Snake River 2 miles above Bonanza Bar. The land is cultivated to a limited extent, and it is also used for placer mining. A reservoir can be built in the cañon at small cost that would reclaim all the land near the Snake River, about 300 acres.

The streams of Cassia County, except Salmon, Sublette, East Rock Creek, and Fall Creek, take their rise in the Goose Creek Mountains and spurs therefrom. The altitude where the streams take their sources is very near equal to the usual fall of snow and rain in ordinary years, and effect each about the same. It has been impossible to obtain any exact data in regard to the annual snow and rain fall, as there never has been any post of observation where such knowledge could be obtained. The only way to arrive at any approximate conclusion is by noticing the rise of the streams during different years. During what is termed "good years" all of the streams at flood tide, sometimes February, generally in March and April, have had a flow of about three times as much as the usual flow. In fact, it is generally the case, for the three years last past have been noted as amongst the poorest for at least fifteen years, this year being the most trying of all. Snake River this year is the fair indication of the falling off in the water supply, and would be a fair sample of the streams in our county.

At Starrh's Ferry (altitude 4,075 feet above the sea, 5 miles below the mouth of Goose Creek), Snake River is 800 feet broad. Its usual rise at this point is 5.5 feet; its unusual rise is 6.5 to 7 feet. The rise begins a month later, say April, than in the other streams of the county, and lasts until about the 1st of August. As a rule at its greatest height about the 10th to 20th of June, at which time the other streams begin to fail. Snake River's rise this year was only 2 feet, and began to fall again by the 1st of July.

During a residence of fifteen years in this county I have very often seen, in the months of March, April, and May, the different streams carrying unusual quantities of water. Salmon River over 100,000 inches of water; Rock Creek, 10,000 inches; Dry Creek, 6,000 inches; Goose Creek, over 30,000 inches; Marsh Creek and Cassia Creek the same; Raft River at least 40,000 inches, the balance in the same proportion. So it will be seen at once no more desirable location, could be asked than we have in this county for the storage of water; and as a rule, we have had the water to store, but it ran into Snake River before it could be used; and the result has been when it was needed there was not enough. The duty of the water varies according to the kind of soil, the variety of crops, and the length of time the soil has been cultivated. One inch of water to the acre is needed for new land, and some soil will absorb more for the first two years. The irrigating season begins for hay about the 15th of April to the 1st of May, and for grain from the 1st of May until the 15th of July. The irrigating season for grain lasts sixty days. Alfalfa requires irrigating after the first crop, say 20th of June; and again after the second crop, say 15th of August, one good irrigating being sufficient to produce a fair crop. Small fruit and fruit-trees require water about every ten days, two "irrigatings" is considered ample to produce a good crop of potatoes. Three "irrigatings" are sufficient to mature grain crops, especially so, if the land has been cultivated for two years. Lands where the hard pan is 24 inches below the surface, when once saturated to that depth, produce better crops and require less water than when the hard pan is only 15 inches from the surface. I am indebted to Mr. Frank Riblett for corrections upon the altitudes at different points. I have also consulted with our county surveyor, Charles Chapin, whose map and my report correspond very closely on all material facts stated in the foregoing.

Very respectfully, yours,

T. A. STARRH.

JOSEPH C. STRAUGHAN,
United States Surveyor-General for Idaho.

REPORT BY A. B. ROBERTS.

BASIN, CASSIA COUNTY, IDAHO, *July* 29, 1889.

DEAR SIR: As I learn you are collecting information on the subject of irrigation and the storage of water, etc., for the Senate committee, I thought that a little item from this locality might be of interest from one who has some knowledge and experience in connection with the subject.

I will describe our location, which is on Goose Creek, about 6 miles above Oakley, where there is a cañon about 500 feet high on each side, above which the valley widens out to about a mile and is quite level, so that from a distance of 3 or 4 miles are large meadow-lands. At this point water could be stored for irrigation at a cost not to exceed $1.50 per acre for the amount of land susceptible thereon, I think. As fine stone for construction of a dam is at hand, this place is a very desirable one. The water-shed which would furnish this reservoir is very extensive. The lands below are very fine and so situated that they are easily irrigated, and of a character that requires the minimum amount of water for raising a crop, and are in a good climate for producing all of Idaho's best products. The body of land available is unlimited.

I am acquainted with several other places where I have, during the last few years, looked out sites for storing water and figured upon the cost in the matter; and if any such information from me would be desirable I might give you some more items.

Yours, respectfully,

A. B. ROBERTS.

Governor GEO. L. SHOUP.

REPORT BY FRANK RIBLETT, CIVIL ENGINEER.

BOISÉ CITY, IDAHO, *August* 15, 1889.

SIR: In compliance with your request I report the following items relating to the systematic and thorough construction and maintenance of reservoirs and canals in southern Idaho, particularly in Cassia County. Since our committeeman, Mr. T. A. Starrh, made his very able and comprehensive report, large reservoir sites have been reported near the head of Cedar Creek, Trapper Creek, Rock Creek, Goose Creek, and Basin Creek; also at the forks of the Sublette and other places where large bodies of water could be stored at moderate cost. Numerous favorable sites can be found all over the county, and no doubt the entire flood volume of the Cassia County streams can be stored in these places. Materials for construction are everywhere convenient, labor is not high, evaporation and "seepage" would not be excessive, foundations, abutments, and places for waste river or overfall are the very best. Contrary to the general belief these mountain basins would hold water comparatively well. The bottoms are composed of gravel, sand, and impervious clay.

The foundation of the shore slopes would generally be similar, although in some cases it would be mixed with some float, bowlders, and rock, and in other cases would be a lava precipice. But even where bounded with escarpments there is no great danger, for the fractures or seams of this rock in the mountains are generally filled with a hard cement or other impervious material; but seepage is not so objectionable, for the largest percentage of the water escaping in this way would burst out in springs below where it could be used for irrigation. Where water for irrigation is abundant it finds its way back into the original channel by percolation again and again, where it can be used for irrigation several times.

In Idaho, as well as in other irrigating countries, after a term of years the ground becomes more or less saturated with water and acts as a storage reservoir, keeping up the supply of water late in the season. This has been practically shown on Goose Creek, Raft River, and other streams in Cassia County. Reservoirs and ditches lose less from year to year.

On the deserts, in the spring of the year, are found many natural lakes or ponds; some of these are perennial, others having a depth of from 3 to 5 feet disappear with the advance of the season, indicating about that depth of evaporation and "seepage" for three months. Again these factors of loss would be partially compensated for by waste water, ordinarily flowing into the reservoirs during the winter months. The waste-weir or overfall can always be conveniently made separate and apart from the main dam, a consideration of no little magnitude. The foundations can with no very great amount of excavation be placed on the everlasting bed rock.

I will mention a typical reservoir on Goose Creek: near the corner to townships 14 and 15 south, of ranges 21 and 22 east, is a basin with an area of about 900 acres having its outlet in a very narrow gorge. A dam having a length at the bottom of 30 feet and at the top of 200 feet, with a height of 140 feet, would cover this basin with an average depth of 100 feet of water. All materials for construction except timber are found in abundance on the location. Timber would have to be hauled from 6 to 10 miles. Above this site a few miles is another nearly as good, and still farther up, across the Territorial line, is the grandest site of all, said to be 6 miles in length by 1¼ in width, having a narrow outlet in which a dam 200 feet high could be constructed at a cost not exceeding that of the location first mentioned; but this upper place I have never seen and could not vouch for. It is in Nevada and the land is said to be private property. The dam first mentioned could be constructed for $100,000, and the reservoir would probably furnish water for the irrigation of 40,000 acres of land.

At many other reservoir sites in Cassia County timber would be much more convenient. The reservoir sites on Cottonwood Creek, Cassia Creek, Marsh Creek, and other places have been mentioned by Mr. Starrh.

The duty of water varies, but averages about 100 acres per second-foot where land has been brought under complete cultivation. The first two years will require more. The water sheds of Cassia County streams vary in character. Salmon Creek, Cedar Creek, Cassia Creek, Marsh Creek, and some other streams head in high snow ranges, while Goose Creek and others either head on low mountains or table lands. The Goose Creek catchment basin in Idaho, Utah, and Nevada, although comparatively low, is very extensive, covering about 1,000 square miles of territory upon which the average depth of well packed snow and ice, at the close of an ordinary winter, is estimated at from 3 to 4 feet by trappers, hunters, and stockmen residents in the country. This snow and ice would probably average one-half water. In an average season the total flow of the flood waters of the Cassia County streams can not be less than 45,000,000,000 cubic feet; of this amount Goose Creek would furnish about one-ninth. This would be sufficient for the irrigation of 500,000 acres of land; 300,000 acres of this amount would be above the line of any Snake River canal.

As a canal from Snake River would irrigate 700,000 acres, a grand system of canals and reservoirs would irrigate at least 1,000,000 acres in Cassia County at an expense of less than $5 per acre. This by no means exhausts the arable lands of this magnificent section, for large areas of fertile lands more elevated than the main valleys, ranging from 5,000 to 6,000 feet elevation, may yet be reclaimed by artesian wells and water pumped by mechanical appliances. In the grand work of irrigation, the transmission of electrical power for the running of improved pumps may yet bear its part. As the county becomes older the duty of water will increase and other factors will spread the area of cultivated lands, until the great American desert will exist only in history. Pardon this digression; I promised to confine myself to facts.

On the 22d day of July, 1889, Snake River, at Story's Ferry, stood 2¾ feet below ordinary low-water mark, 13¼ feet below ordinary high-water mark, and 16¼ feet below maximum high-water mark. On said date I assisted Mr. E. B. True, civil engineer and United States deputy mineral surveyor, to measure the said stream. We estimated it at 5,500 second-feet. In high water, with added depth, width, and velocity, it might exceed 50,000 second-feet.

Among other enterprises, I will mention that of a proposed canal from Snake River, heading at Story's Ferry. This enterprise (a private one) dates back to January, 1880, at which time I ran a few lines and levels and, with others, made location of water-right and ground. At subsequent times I made further investigation and joined with others in locations. This was kept up for eight years, with results generally unsatisfactory. In the summer of 1888 we learned we had one of the very best sites for an immense dam, of a kind that could be constructed at a reasonable cost. This was the "key to the situation." A full reconnaissance of the ground was made, full and complete notices of location of water-right and ground were posted and recorded. A local association, known as the Snake River Land and Canal Company, was organized and efforts resumed. Up to the present time said company has done representative work to the amount of from $3,000 to $4,000. At present the intention is to raise the river 37 feet at a point about three-fourths of a mile above Story's Ferry. Here one canal will be taken out on the north side, irrigating about 85,000 acres in Logan County, and another on the south side, irrigating about 15,000 acres in Cassia County, besides developing hundreds of placer claims and immense water-power, at a cost of less than $400,000. Having sufficient fall, it is the intention to run a line of levels to Shoshone, county seat of Logan County; also, down Snake River on both sides.

If these lines should prove feasible much more land can be covered and placer claims developed. In regard to reservoir sites in counties lying adjacent to Cassia, including Logan, Oneida and Owyhee, I say this: that their topography is fully as favorable as that of Cassia County. In connection with this and other matters, I refer you to my report made on the preliminary survey of the Great Snake River Canal in January, 1888; also to an additional report submitted the following spring. These reports were published in the Cassia County Times and other papers. While thorough surveys will be required to ascertain the feasibility of a system of reservoirs for the storage of the surplus waters of the small streams, as compared with a system of canals from Snake River, still it is the opinion of the majority of our citizens that moderate appropriation for reservoirs, made in the near future, would be advisable. Some steps should be taken for the relief of citizens who have taken up and brought under cultivation large areas of the public domain, whose lands are now subject to destructive droughts three years out of ten.

Very respectfully,

FRANK RIBLETT,
Civil Engineer.

JOSEPH C. STRAUGHAN,
United States Surveyor-General.

Summary of Cassia County reports.

Localities.	Lands.		Ditches.	Length.	Amount of water flowing.	Remarks.
	Irrigated.	Irrigable.				
District No. 1.	*Acres.*	*Acres.*		*Miles.*	*Inches.*	
Rock Creek and Dry Creek.	17,500	17,500	30	25	3,000	A reservoir at "the forks" would supply present deficiency and reclaim 5,000 acres additional.
District No. 2.						
Goose Creek	14,000	300,000	*50	50	12,000	A dam 150 feet long, 50 feet high, costing $12,000, would form a reservoir of 1,000 acres; another good site on Trapper Creek, costing $15,000, would add 5,000 reclaimed and supply present deficiency. Settlers are leaving this valley on account of drought.
District No. 3.						
Marsh Valley	4,500	27,000	90	89	......	Is 15 miles long and at Albion 7 miles wide; elevation, 4,700 feet. Cleveland Lake (8,500 feet) for a reservoir, costing $500,000, would cover 30 acres 20 feet deep. Good sites for water storage are also on Mark Green and Cow Gulches. Settlers are leaving this valley on account of drought.
Fenced	13,000	......	......	......	......	
District No. 4.						
Cassia Creek	2,200	10,000	56	45	......	Has three good locations for reservoirs, each of 20 to 25 acres, 15 to 20 feet deep, costing in all $10,000.
Fenced	5,100	......	......	......	......	
District No. 5.						
Almo Creek (5,000 feet).	600	400	......	......	......	Has good site for a sufficient reservoir.
District No. 6.						
Raft River (4,650 feet).	6,500	300,000	60	70	15,000	Has two sites for reservoirs (4,980 feet, each covering 2,000 acres and costing $20,000 each.
Fenced	15,000	......	......	......	......	
District No. 7.						
Clear Creek (4,700 feet).	3,000	1,000	12	20	5,000	Site for one good reservoir; now has water enough until middle of July. Chief crop, hay.
District No. 8.						
Sublett Creek (4,750 feet).	600	500	......	......	600	Has sufficient water until July 20; $5,000 would build two small reservoirs, sufficient for this valley.
District No. 9.						
Hagler Creek	......	......	......	......	......	Has a good site for small reservoir; no cultivation reported.
District No. 10.						
Fall Creek and East Rock Creek.	......	......	......	......	......	Small, rapid mountain streams used chiefly for placer mining at Bonanza Bar, on Snake River; about 300 acres might be reclaimed by a small reservoir.
	82,000	656,400	298	299	......	

* Canals, 5; miles, 20.

RECAPITULATION.

Land irrigated	acres..	82,000
Land irrigable	do....	656,400
Number of canals and ditches		298
Length of canals and ditches	miles..	299

Altitude from 4,500 to 5,000 feet above the sea. Area of the county, 5,100 square miles or 3,264,000 acres. One-half undulating; good grazing. One-quarter level; good farming. One-quarter high mountain; much snow.

Yield per acre.—Wheat, 45 bushels, $27; Oats, 55 bushels, $17; barley, 45 bushels,

$15; Corn, 35 bushels, $13; potatoes, 250 bushels, $65; alfalfa, 6 tons, $36; timothy, 2¼ tons, $20.

Fruits abundant and very fine.

Salmon River Valley (average altitude 4,200 feet) has nearly 1,000,000 acres now desert. The land is very superior.

CUSTER COUNTY.

REPORT BY L. H. JOHNSTON.

I am unable to give a correct description of the land in Custer County, Idaho, that could be made profitable for farming by having water conveyed upon it. The information I have obtained has been given me by the settlers of the different valleys. Pahsamaroi has the most agricultural land of any of the valleys, and is the best watered of any by natural streams; but many of the streams emptying into this valley sink in a short distance after leaving the mountains, creating small sections of choice farming land where the streams sink; but there is a large part of the bench land which it is impossible to cultivate, unless the water is diverted from the present channels.

Where the streams leave the mountains the cañons are narrow and steep, so that reservoirs at the mouth of the cañons would hold but small quantities of water.

Lost River Valley, in the southern part of Custer County, is similar in its character to Pahsamaroi Valley, excepting that in ordinary seasons Lost River sinks in places and rises again lower down the valley.

Antelope Valley has no stream of any size at the head of the valley.

Salmon River passes through Round Valley, and carries sufficient water for irrigating all the land in the valley, even at the lowest of stage of water; but portions of the bench land lie so high that the taking out of the water costs more than individuals are able to expend.

There are no sites where I could recommend the building of reservoirs, but I think some 10,000 acres of land could be reclaimed in Lost River Valley by the digging of a canal and diverting the water from the present channel, thus carrying it along the bench higher up the valley, and about the same quantity of land might be reclaimed in Pahsamaroi Valley, about 5,000 acres also in Round Valley.

There is no county surveyor in Custer County, and I could not give any estimate as to what these canals would cost, but I am informed that a great portion of the work, in both Lost River and Pahsamaroi Valleys, could be done with plow and scraper.

Very respectfully, etc.,

L. H. JOHNSTON,
Challis, Custer County, Idaho.

ELMORE COUNTY.

REPORT BY ELMER C. TOWNE.

ROCKY BAR, IDAHO, *July* 8, 1889.

SIR: In answer to your circular of June 8 referring to irrigation and water supply, I would respectfully submit the following:

Nearly all of Elmore County situated north of the "base line" is mountainous, the people devoted to mining pursuits, and the area adapted to agriculture limited.

I have personally examined the country along the Big Smoky and South Boisé Rivers to the junction with the main Boisé, and find along said streams bottom and low bench land, the soil of which is well adapted to the growing of all agricultural products common to this altitude in Idaho. Twenty thousand acres can be irrigated from these streams at an estimated cost of $10,000. No practicable site for any storage reservoir was found, and the water supply is sufficient for all the land that can well be covered by canals or ditches from these streams. Could Government aid be obtained for constructing the main canal the expense connected with all lateral ditches could easily be borne by settlers.

These lands would then become very valuable, as their close proximity to the mines insures a good and permanent market.

I had intended making a report upon the lands adjacent to and bordering on Snake River, but I have been informed that E. C. Helfrich, esq., of Mountain Home, has already made a report upon the same, and he being familiar with that section of the country (while I am not) would doubtless best understand its wants and requirements.

Most respectfully, yours,

ELMER C. TOWNE,
United States Deputy Mineral Surveyor.

JOSEPH C. STRAUGHAN,
United States Surveyor-General for Idaho.

REPORT BY E. C. HELFRICH.

MOUNTAIN HOME, IDAHO, *July* 11, 1889.

DEAR SIR: Your circular of June 15 received. I have conversed with many of our citizens in this county on the irrigation topic, and only one suggestion is made or offered, namely: The Great Snake River must be taken out from the eastern part of the Territory if the lands of southern Idaho are ever cultivated.

The South Boisé River passes through part of Elmore County, but does very little benefit. The lands that are irrigated therefrom are located high in altitude, and only hay and a few vegetables can be raised, and to bring this river to cover the lands in this vicinity would cost an enormous amount of money.

The area of land tributary to Snake River in this county is 450 square miles, and there are fully 210,000 acres of good farming land. To give you an idea of the Snake River in the very lowest, it is 550 feet wide and 30 feet deep on an average, and has a good steady fall; and at the same time when the water is the highest is the very time when the irrigation would be wanted, providing a canal were made and water thus taken from the river. As it now remains no one has any value from this stream, as its banks are high above the water.

The land and climate of Snake River Valley can not be excelled anywhere. They will produce anything that can be raised in this country if water is brought thereon.

Five years ago Mr. Frank Ake located on a one-fourth section 3 miles from here in the very heart of the sage brush. He cleared it off, set out fruit trees and berry and grape vines, as well as alfalfa. Being located near a creek he made a ditch and covered the spot with water, and to-day that ranch is a model place. The trees are loaded with fruit and his vines with grapes; but the creek is now dry, the first time that we can remember or can hear of. Other nice homes are near by, but are unable to have water, and this year being one of drouth makes it hard on all the persons who are not favored, and there are very, very few who can say they are amply supplied with water.

Take the ranch of Charles Howetth, 18 miles from here; he has living springs on his place, and on 50 acres he cuts alfalfa four times a year and 2 tons at each cutting to each acre. This is the effect of plenty of water; and all our land is in the same condition if water could be had thereon. Also refer you to Frank R. Coe's ranch, where springs abound and there is hay in abundance.

We have numerous ranches within a radius of 20 miles, but they depend upon the creeks that come from the mountains, and as no water came this spring all are suffering; not even a reservoir could be filled this past spring, so that all of our people look forward only to the great relief, and that is a canal from Snake River, where water never fails.

Storage reservoirs will be uncertain, judging from the past winter, as far as Snake River Valley is interested and depending on them is concerned. We have no ditches or canals in this county, for we could not secure water from Snake River except by building 250 miles of canal, and that we are not able to do. This statement also applies to South Boisé River, where we would be obliged to tunnel through the mountain, although the river is not over 30 miles from us, with ample fall to cover miles of this valley.

This county is completely on the desert and our only hopes for the future are in the Government aiding us, for certainly the money is not here to do the work that is required; but the land is here to pay for it as soon as a canal is completed, even if theprice is made at $10 per acre with water.

I remain, yours respectfully,

E. C. HELFRICH.

JOSEPH C. STRAUGHAN,
United States Surveyor-General for Idaho.

SUMMARY OF ELMER COUNTY REPORTS.

[Compiled from reports of Elmer C. Towns, United States deputy mineral surveyor, and Hon. E. C. Helfrich.]

In this county, about 12 miles southwest from Rocky Bar, there is found locations for five reservoirs, with a gross capacity of nearly 1,000,000,000 cubic feet of water.

These reservoirs are tributary only to the South Fork of Boisé River and can not serve to irrigate any of the irrigable lands of this county. But they would abundantly re-enforce Boisé River and render it absolutely sufficient to irrigate the 900,000 acres in Ada County, if the plan should be found cheaper than by the extension of the great Snake River Canal.

To Mr. A. D. Foote we are indebted for the discovery of these reservoir sites, and for the survey sufficient for an accurate estimate of their capacity and cost.

Boisé River will some day be called upon not only to irrigate its half million acres of land, but also to wash out every extensive placer grounds near its mouth on Snake River.

For this reason the following is extracted from Mr. Foote's report, viz:

Discharge of Boisé River at Foot's Cañon; averaged for five years.

January, 1,200, varying to 1,500, cubic feet per second.
February, 1,200, varying to 1,500, cubic feet per second.
March, 1,500, increasing to 5,000, cubic feet per second.
April, 5,000, increasing to 15,000, cubic feet per second.
May, 15,000, increasing to 30,000, cubic feet per second.
June, 30,000, decreasing to 10,000, cubic feet per second.
July, 10,000, decreasing to 3,000, cubic feet per second.
August, 3,000, decreasing to 1,200, cubic feet per second.
September, 1,200, varying to 2,000, cubic feet per second.
October, 1,200, varying to 2,000, cubic feet per second.
November, 1,200, varying to 2,000, cubic feet per second.
December, 1,200, varying to 2,000, cubic feet per second.

At the points selected for the reservoirs I found the peculiarities of a former lava flow have rendered the contruction of enormous reservoirs a matter of trifling expense, compared with the cost usual for such structures elsewhere.

The lava is in the form of immense dikes across the valleys, in some places resembling the work of man, through which the creeks have broken narrow channel-ways. It is only necessary to fill up these channels with earth, which is abundant and near at hand, thus raising the water until it shall flow over the lava walls for its indestructible waste-weirs.

Table showing estimated capacity, cost, and value of reservoirs located on the upper waters of Boisé River.

Name of reservoirs.	Capacity in cubic feet.	Days' supply at 1,000 cubic feet per second.	Capacity in 24 hour-4-inch miner's inches.	Cubic yards in dam.
Upper Fall Creek	522,720.000	6.05	290,400	76,852
Lower Fall Creek	418,176.000	4.84	232,220	51,569
Smith Creek	1,672 704,000	19.36	929.280	69,154
Upper Blind Creek	6,690,816,000	77.44	3,717,120	241,667
Lower Blind Creek	313,632,000	3.63	174,240	96,666
Total	9,618,048,000	111.32	5,343,260	535,908

Total area of county	square miles..	2,700
Land irrigated	acres..	10,000
Land additional irrigable	do ..	230,000

IDAHO COUNTY.

REPORT BY A. F. PARKER.

GRANGEVILLE, IDAHO, *June* 17, 1889.

MY DEAR GOVERNOR: Referring to yours of June 8, conferring appointment upon me to gather information relative to irrigation, etc., I beg to say that our area of agricultural land is so limited and so situated that irrigation in Idaho County is not a factor in our wealth, present or prospective. Our principal agricultural settlement, Camas Prairie, is situated on the summit of the low divide between Clearwater and Salmon Rivers, and as these streams run through great cañons, at least 2,000 feet below us, you will readily perceive the impracticability of bringing water thereon.

Moreover the rain-fall here is usually sufficient for all agricultural purposes.

Salmon River seems to be the dividing line between the arid and moist belts of Idaho.

The subject of irrigation is altogether out of our jurisdiction in Idaho County, but if I can be of use, please command me.

Very truly, yours,

A. F. PARKER.

REPORT BY E. C. SPEDDEN.

GRANGEVILLE, IDAHO, *July* 14, 1889.

DEAR SIR: Your circular letter to United States deputy mineral and county surveyors was received on the 4th instant.

After making considerable inquiry concerning the land which is adaptable to irrigation in this county, I have concluded there is none worth reporting to the Senate committee.

Respectfully, yours,

E. C. SPEDDEN,
County Surveyor, Idaho County.

J. C. STRAUGHAN,
Boisé City, Idaho.

LOGAN COUNTY.

REPORT BY HON. JOHN HAILEY.

STANTON, LOGAN COUNTY, IDAHO, *August* 4, 1889.

DEAR SIR: By request of Governor George L. Shoup I herewith send you answers propounded in your circular of June 15, 1889, in reference to irrigation of arid lands, etc., in the northern and northeastern portions of Logan County.

I regret very much that my time has mostly been taken up attending to other matters, and have not, therefore, been able to give this subject the thorough examination its importance demands. I have made some personal examination and inquiry on Camas Prairie, on Big and Little Wood Rivers, and on Silver Creek.

This being an unusually dry season, on account of very little snow or rain having fallen either in the valleys or mountains near here for the past eighteen months, I find most of the streams that usually afford a generous supply of water for irrigating purposes are dry, and have been for several weeks past. The only stream that appears to have kept up its usual amount of running water is Silver Creek, which is fed entirely from springs breaking out in numerous places in the valley south of Bellevue and between the two Wood Rivers. Silver Creek empties into Little Wood River; in fact it furnishes most all the water of Little Wood River below its junction in the dry season of each year.

About the 1st of July I went, in company with Mr. L. D. Hopson, of the U. S. Geological Survey, to a point on Silver Creek below where all its tributaries come together, and there Mr. Hopson measured the flow of water and found it to be 176 cubic feet per second, or about 8,468 miner's inches.

I was at the same place again yesterday and could discover no change in the quantity of water. From the point of measurement to its junction with Little Wood River is about 8 miles, and but little of the water from this point down is used, it mostly going into Wood River, and the greater portion of it is lost in the lava before it reaches the agricultural lands further down the river. This, I think, might be remedied by proper work being done on the bottom of the channel where it crosses the lava, by filling all cracks and leaks.

Big Wood River has only furnished a very limited supply of water this season south of Bellevue, where it is mostly needed. The bed of this stream is washed out in holes in many places, where there appears to be nothing but bowlders and coarse sand, and the water runs through and is lost. I think the bed of this stream could be improved so as to save the water from loss, all of which is very much needed. At this time there are several thousand inches of running water in this stream at and above Bellevue; but a few miles south, where water is needed most, it is entirely dry, and has been for a month.

On Camas Prairie there are numerous small streams coming down gulches from the mountains on the north, and crossing the prairie to the south, flowing into what is commonly called Camas Creek, which empties into Wood River. But these streams are all dry, or nearly so, this season.

Referring to the matter of storing up water in reservoirs for irrigation purposes, there are several streams here on which this experiment might be tried at reasonable expense with a fair prospect of good results. Among the most favorable places I have seen to try the reservoir experiment is at the foot-hills on Soldier Creek about 3 miles north of the village of Soldier.

I think, however, that it would be well for Congress to try the experiment of boring artesian wells for irrigation; if it were shown that artesian wells could be sunk with a good strong flow of water and at reasonable expense, private enterprise would take hold and much of the arid land that can not be reached by water from streams would be reclaimed and farms made for many poor families. I respectfully recommend that Congress make an appropriation to defray the expenses of sinking several artesian wells in Idaho, as there are favorable localities in this county where water, if found, could be utilized for good purposes. I recommend that one such well be sunk near the foot-hills between Soldier and Corral Creeks on Camas Prairie; that one be sunk at the foot-hills about 7 miles southeast of Bellevue; that one be sunk on what is known as the "burn," between the two Wood Rivers, about 20 miles south of Bellevue. Here lies one of the most beautiful strips of good land in Idaho. It is about 15 miles long, north and south, and in width it ranges from three-fourths of a mile to 3 miles, and has an almost perfectly smooth surface with a slight down grade to the south. All that is wanting on this to make fine and cheap homes is water. Although the lava comes up on both sides there is no rock on this strip, the once heavy sage brush has been burnt up entirely, and it is all ready for the plow if water could be had for irrigation.

While on Camas Prairie a few weeks ago I met Hon. W. Y. Perkins, who resides near Soldier and is engaged in farming, stock-raising, etc. He, at my request, has sent me a letter giving some valuable information in reference to irrigation on Camas Prairie. His letter is hereto annexed, and I recommend that you give it due consideration.

Very respectfully,

JOHN HAILEY.

JOSEPH C. STRAUGHAN,
United States Surveyor-General for Idaho.

[Answers to questions propounded in surveyor-general's circular of June 15, 1889.]

Answer to first question: On Big and Little Wood Rivers, Silver Creek, Spring Creek, Rock Creek, Willow Creek, Elk Creek, Soldier Creek, Corral, and some other smaller streams, to only a limited extent.

Answer to second question: On the streams mentioned above to a very much larger extent than at present.

Answer to third question: Water usually, in ordinary seasons, begins to decrease in most of the streams about the 15th of May; this year very much earlier. Some sites for reservoirs; other places the beds of streams might be improved so as to stop "seepage," while in other places artesian wells may be sunk. There is of good land that could be irrigated with a reasonable expense between the towns of Bellevue and Shoshone, along and between the two Wood Rivers; in a distance of 15 miles width by 50 miles length, at least 125,000 acres; and on Camas Prairie there is about 200,000 acres of good land which can be irrigated with reasonable expense and made very productive.

At present, not to exceed one-tenth of the amount named here has been reclaimed by irrigation or put into cultivation.

There is probably about 120 miles of ditches in and about the two Wood Rivers between Bellevue and Shoshone, covering perhaps 18,000 to 20,000 acres of land, and nearly the same amount on Camas Prairie.

SOLDIER, IDAHO, *July* 16, 1889.

DEAR SIR: I was called away from home a few days after you were here, and on that account have not made a summary of the information you requested me to until now, and I fear it will be rather late. On Camas Prairie, from best information I can get, there are about 140 miles of ditches conveying water to farms.

In ordinary seasons these ditches water something like 15,000 acres of good land. A great deal of this has never been broken and the water has only been used heretofore to irrigate the native grass for hay; perhaps it would not water quite so much land thoroughly for grain. I have made some personal examinations of the streams emptying into the valley from the north since you were here, and I am fully satisfied now that the idea of putting reservoirs or dams along the foot-hills to store the water for summer is practicable, and enough water can easily be held to irrigate every acre of land lying north of the Malad, from Baison Creek to Corral. Beginning at Corral, coming this way, you have in order Three Mile, Soldier, Deer, Elk, and Camp Creeks, all having the very finest kind of natural basins suitable for the enterprise.

It is useless for me to say to you that every foot of this land, on an average 15 miles wide and 30 to 40 miles in length, is of the best of soil and will yield as much as any land in the Territory, with proper irrigation.

But I have always been of the opinion that a system of artesian wells would be most valuable, and less expensive than any other means of irrigation in this valley. This of course depends upon the depth and cost of driving or boring. I am confident that if the Government would put in some test wells it would lead to a general system of private wells sufficient for all purposes.

Say, place one such well on the east end of the prairie, one on the west, and one about the center, showing the cost, practicability, etc., and should this plan prove to be reasonable it would not be two years until almost every farm on the prairie would be watered by them. The people are poor and are not able to make the proper experiments without positive assurance of the feasibility of the enterprise. Numbers would at once attempt it, had they the means. A few of the citizens at Soldier made a trial last summer, and after going near 200 feet in sand and gravel, in which there was an abundance of water, they were forced to abandon the project for the want of funds.

I remain, very truly yours,

W. Y. PERKINS.

Hon. JOHN HAILEY,
Spring Creek.

REPORT BY W. C. B. ALLEN.

SHOSHONE, LOGAN COUNTY, IDAHO, *August* 8, 1889.

DEAR SIR: Pursuant to request of Gov. George L. Shoup I forward briefly some suggestions and facts regarding the necessities and opportunities for irrigation enterprises, storage, reservoirs, etc., in Logan County. By previous arrangement my colleague from this county, by appointment of the governor, Hon. John Hailey, has agreed to report upon the northern half of the county, including Camas Prairie and the section lying adjacent to the Wood River range of mountains. I also transmit herewith the reports of the county surveyor, the county auditor, and the county treasurer upon this subject.

Logan County is formed from the southern half of old Alturas County, and is bounded on the south and east by Snake River. On the south side of Snake River lies Cassia County.

The Snake River Valley and Plains constitute an empire in extent, being from 450 to 500 miles long, and from 50 to 100 miles in width. I think from 10,000,000 to 12,000,000 acres are contained within the drainage area of Snake River and its tributaries.

The area from which the waters and snow fall is derived to produce the volume flowing through the channel of the Snake may be estimated at 40,000,000 to 50,000,000 of acres, or more. Owing to the uniform fall in the valley of the Snake it is probable that by means of storage reservoirs in the upper valley and several dams at convenient points along the river many millions of acres of these arid lands might be made of great value for cultivation and for grazing purposes on both sides of the river. Logan County is nearly in the center of these plains, and is traversed from east to west by the Oregon Short Line Railway, crossing the river at American Falls.

In building this line water had to be hauled by teams from 10 to 20 miles; but on its completion wells were sunk through the lava rock at various points, and the water tanks and stations are supplied by means of wells and pumps. It is demonstrated by this means that a subterranean water supply can be found at depths varying from 100 to 500 feet for a distance of 100 to 200 miles west of American Falls, in what is known as the Lava Beds. At several points there are evidences of water-courses flowing beneath the lava, and in some instances this water comes near the surface. From the abundance of information on this point it is reasonable to infer that artesian wells may become an important feature in reclaiming and supplying the desert with water stations, at least for stock-growing.

A recent project has been started and a company organized for the purpose of constructing a dam at Storey's Ferry, on Snake River, 6 miles south of Minidoka Station, Oregon Short Line Railway. This company—the Snake River Land and Canal Company—propose to divert waters of the river by means of a rock dam and by raising the stream about 35 feet. They can thus reclaim a large body of land on both sides of Snake River, aggregating perhaps 200,000 to 300,000 acres. The line as surveyed in Logan County can be carried as far west as Shoshone Falls. Besides opening up to settlement and cultivation a large area of most fertile fruit and farm lands there are numerous extensive placer mines which such a canal would supply water for, and enable thousands of miners to find profitable employment all the year in working the rich "flour gold" deposits found in the black sand. These gold deposits extend for hundreds of miles along the banks of Snake River, and hundreds of millions of dollars lie hidden in easy reach provided an ample water supply could be obtained.

If the General Government will either construct a comprehensive system of storage reservoirs and canals throughout the Snake River region, or in lieu of this grant to the Territory of Idaho one-half or more of these arid lands, this section has sufficient resources and advantages of climate to become one of the wealthiest and most prosperous valleys in the Union. It is the feeling among the people that Congress should at once make the necessary appropriations to carry on this great work of development, or else transfer the title of these now worthless lands to the Territory or State of Idaho, and not longer prevent the advancement and settlement of the largest and most healthful valley of the Pacific slope.

Yours, truly,

W. C. B. Allen.

J. C. Straughan,
United States Surveyor-General.

REPORT OF THE COUNTY SURVEYOR.

Shoshone, Idaho, *August* 7, 1889.

Dear Sir: Complying with your request to furnish information in regard to irrigation in Logan County, I have the honor to report as follows:

Irrigation has been effected on the following-named streams, viz: Big Wood or Malad River and tributaries, Little Wood River and tributaries, Fish Creek, and Clover Creek.

This stream, Big Wood River, which rises in the mountains in Alturas County and is fed by snows, went dry during July of 1888 for a distance of over 100 miles (counting the windings) from its mouth, and has been dry ever since, except during a space of about ten days during the month of June last, when late snows in the mountains caused a freshet. There are about sixty ranches on this part of Wood River (Big). To irrigate these does not make any perceptible difference in the volume of the stream during a freshet. These ranches are now without any water and the crops planted in the spring are dead. The majority of the settlers have taken their families and stock to the mountains. Some have left the country, while a few who still remain on their ranches depend upon the water of stagnant pools along the river, which is all that is to be had for domestic use.

On the north side of Big Wood River, and beginning in T. 3 S., R. 17 E., Boisé Meridian, is a body of good land reaching to Clover Creek, a distance of 36 miles, and having an average width of 8 miles, but little of which is surveyed, and less still settled because of the scarcity of water. In the foot-hills bordering this land on the north are several small streams formed by springs, each of which is almost a river, during two or three months in the early spring of each year, but does not afford sufficient water to flow out of the cañon during the summer months. Here are various reservoir sites, all easy of construction; and at a moderate cost all the lands in this body (over 180,000 acres) could be reclaimed.

Little Wood River, which rises in the Wood River Mountains, though having many springs along its tributaries, is mainly fed by snows. During the past two years the snow-fall in the mountains has been very light, in consequence of which Little Wood River, except during freshets, has only flowed a few miles beyond the cañon through which it emerges from these mountains. At the mouth of this cañon, northeast of Tikura, is a body of good land, about 20,000 acres in extent, a very small part of which is cultivated. The crops here are a total failure this present year and were last year, on account of lack of water.

In the cañon of Little Wood River is a reservoir site, situate in section 14, T. 1 N., R. 20 E., of which I made a preliminary survey a short time ago. Here I find that a dam 600 feet in length will reach across the cañon, the walls of which are 63 feet high on the west side and 103 feet on the east side. A hill approaches near to the cañon on the west side, so that a dam may be raised to the height of 100 feet if wanted.

Within the cañon walls and just below the dam-site lie many hundreds of thousands of cubic yards of basaltic rock, broken from the cañon walls in blocks from 2 to 6 feet square; more than sufficient material to construct a dam of any needed dimensions. Just above this dam-site the cañon opens to a width of half a mile, and holds this width for a distance of 6 miles upstream.

The fall of the river over this same ground is 20 feet to the mile. Hence a dam 100 feet high at this point would impound sufficient water to irrigate 100,000 acres of land. No great natural obstacles are in the way, neither are difficult feats of engineering to be performed in order to conduct the water from this reservoir site onto the lands on the Snake River Desert to the east and south of the town of Shoshone.

On the Snake River Desert south and west of Shoshone is a body of good land of over 200,000 acres. Beginning near Shoshone, and within 4 miles of Little Wood River, is a depression in which is a well-marked water-course which runs the entire length of this land, reaching Snake River at a point near Salmon Falls. Along the line of this water-course and within easy reach of it are a number of lake beds, every one of which could, at moderate expense, be changed into a reservoir, to be filled from Big and Little Wood Rivers when those streams are "flush." Private parties began the construction of a canal over a year ago, intending to use this system of reservoirs, but owing to lack of capital have ceased work.

Silver Creek, a tributary of Little Wood River, flows into the channels of that stream about 20 miles below its present sink just south of Tikura, and is a stream formed entirely by springs which rise in a valley in the northern part of Logan County about 10 miles south of Bellevue. This stream furnishes about 7,000 miner's inches of water, and flows (following the meandering) about 100 miles, does duty for about 6,000 acres of cultivated lands, and but for the bad methods of irrigating in vogue here would do duty for twice as many acres.

Fish Creek and Clover Creek each have large bodies of good land along their course, but neither furnishes sufficient water to irrigate 500 acres during the summer months. Snake River forms the southern boundary of Logan County for a distance of about 200 miles. No irrigation has been effected from this stream as yet, owing to the fact of the expense of conducting the water to the irrigable lands being too great for private enterprise.

Within the cañons of Snake River, which in Logan County extend along the stream for a distance of over 75 miles, there is a body of land containing rich placer mines, ranging in width from one fourth of a mile to 2 miles, part of which is under cultivation and is irrigated from springs, of which there are a great number flowing from out of the wall-rock of the cañon. Many of these springs can be conducted to the lands outside of the cañon by means of flumes of from 2 to 3 miles in length.

The irrigable lands in Logan County are variously estimated at from 1,000,000 to 2,000,000 of acres. I myself believe that the latter estimate is nearer correct than the former. But a tithe of lands in the immediate vicinity of streams is claimed as yet.

On questioning old residents in the mountains I find the annual snow-fall of the mountains estimated at from 20 to 30 feet. Certain it is that most, in fact all, of our now dry streams are impassible rivers during from one to three months in the early spring of each year. This water, which flows to the Columbia and thence to the sea, would if stored in reservoirs for future use enable us to offer homes to some of the many thousands of immigrants, who are constantly passing through Idaho to look for homes in other lands.

I had intended to give you some statistics in regard to the products of Logan County, but have not had time to look up anything of the kind.

In conclusion, will say I have been in Minnesota and Mexico and in all of the States lying between, but in none of those places have I known a climate so equable or a soil so productive of all grain, grasses, vegetables, and fruits as are grown in this temperate region of Idaho.

Respectfully yours,

MILL SANDERSON,
County Surveyor, Logan County, Idaho.

Hon. W. C. B. ALLEN,
Of Idaho Irrigation Committee.

SUMMARY.

Total area of the county	square miles..	5,200
Total area of irrigated land	acres..	50,000
Total area of irrigable land	do...	1,250,000

REPORT OF COUNTY TREASURER.

SHOSHONE, IDAHO, *August* 7, 1889.

DEAR SIR: In reply to your inquiry, we have in Logan County nearly 3,500,000 acres of land contained in about one hundred and fifty townships. It has been estimated from reliable sources that fully one-fourth to one-third of this land is capable of producing good crops if irrigated. Some of the best land lies in the southern portion of the county and could all be reclaimed by a canal taken out from Snake River and from storage reservoirs. Of the 1,250,000 acres of good agricultural land in this county there is not to exceed 50,000 acres now under cultivation, the remainder being Government land.

Yours truly,

CHAS. S. DOAN,
Treasurer Logan County.

MR. W. C. B. ALLEN.

REPORT OF COUNTY RECORDER.

SHOSHONE, LOGAN COUNTY, IDAHO, *August* 7, 1889.

DEAR SIR: In regard to your inquiry as to the number of acres of "irrigable lands" in Logan County, I have the honor to say there are about 3,500,000 acres of land in Logan County, about one-third of which (1,000,000 acres) is susceptible of cultivation and would be valuable land if irrigated.

W. B. GEORGE,
Recorder Logan County, Idaho.

W. C. B. ALLEN,
Shoshone, Idaho.

REPORT OF DEPUTY ASSESSOR.

SHOSHONE, LOGAN COUNTY, IDAHO, *August* 7, 1889.

DEAR SIR: Yours of inquiry in regard to the number of acres of tillable land in Logan County, Idaho, at hand. In reply I have the honor to say there are about 3,500,000 acres of land in Logan County, about one-third of which is susceptible of irrigation and cultivation.

Respectfully yours,

R. S. TUCKER,
Deputy Assessor Logan County, Idaho.

MR. W. C. B. ALLEN,
Shoshone, Idaho.

LEMHI COUNTY.

REPORT BY HON. J. W. BIRDSEYE.

SALMON CITY, IDAHO, *July* 15, 1889.

DEAR SIR: Considering your communication referring to irrigable lands in Lemhi County and their extent, I will say that it has been impossible for me to arrive at an absolutely correct estimate, as the time has been too limited for me to visit all sections of the county; but I have made inquiries of intelligent and practical men residing in different locations, and with my own knowledge can arrive at a fair estimate.

First. Irrigation has been effected on the Salmon River, the Lemhi River, and on a number of the smaller streams flowing into the above named rivers, but not to any great extent.

Second. Irrigation is practicable on nearly all the streams in Lemhi County, and to an extent sufficient to cover most of the irrigable area.

Third. Most of the streams furnish a large surplus of water from May until July, after which the supply is not equal to the demand. There are sites on all the streams where large quantities of water can be impounded at a moderate cost.

The length of the Lemhi Valley, through which the Lemhi River flows, is about 70 miles, and the width of the bottom lands from one-half to 2 miles. The extreme width of the valley is from 5 to 12 miles. Above the bottom lands are the bar or table lands, and still further back, toward the base of the mountains, are hundreds of acres of irrigable lands lying along the different streams.

The bottom lands, to a small extent, have been irrigated throughout the length of the Lemhi Valley, and some irrigation has been effected on the table lands and also on the lands along the stream flowing into the Lemhi and Salmon Rivers.

The land along Salmon River and within Lemhi County is irrigable for a distance of 70 miles; but, owing to the expense of conveying water from the river, but few ditches have been constructed. One tract of land, comprising about 6,000 acres and adjoining the town site of Salmon City, could be covered by a ditch from Salmon River not to exceed 15 miles in length.

The Salmon and Lemhi Rivers furnish a sufficient amount of water without impounding, but it is not practicable to raise the waters of these rivers above the bottom lands without incurring more expense than the ranchmen are able to pay.

The table lands, so far as cultivated, and also the lands lying along the creeks have been dependent entirely upon the streams running from the mountain cañons, and these streams do not furnish a sufficient amount of water for three months each year; but by a system of reservoirs, whereby water can be impounded, it will be practicable to furnish water for a large amount of the irrigable land during the entire season. In my reference to the table lands I mean the first rise above the Lemhi and Salmon Rivers bottom lands, and also higher benches. The first rise is usually an abrupt one of from 50 to 100 feet. With water these benches are very productive; in fact, superior for grain raising to the bottom lands.

On every stream from Carman Creek to Kinney Creek, on the east side of the Lemhi River, is a large amount of good land; but the streams after the middle of July do not furnish one-fourth the water necessary for proper irrigation.

A large ditch, taken from the Lemhi River 30 or 40 miles up the valley and running along through the foot-hills, in connection with impounding the water of the smaller streams, would be a great benefit to this section of the county.

On the headwaters of the Lemhi River there is a large amount of land which, with irrigation, would be very productive; also in the southern portion of the county and in the Pahsimeri Valley are large tracts of very fine land.

I would estimate the amount of land in Lemhi County susceptible of cultivation with irrigation at 500,000 acres. I can not state with accuracy what amount is at present under cultivation, but, from the best information I can gather, the hay crop last season amounted to 8,000 tons, and the grain crop to 100,000 bushels, of which about 400,00 bushels was wheat and 60,000 oats; the value of hay from $6 to $10 per ton, wheat $1 per bushel, and oats from 1 cent to 1¼ per pound.

Wheat will yield from 30 to 50 bushels per acre; oats, from 40 to 70 bushels. Vegetables of nearly all kinds can be raised in abundance, and fruit trees are doing well.

Our water sources are the Rocky Mountains and Salmon River Range for the small streams. The Salmon River heads in the Saw Tooth Range about 150 miles south of Salmon City, and the Lemhi River heads in a spur of the Rocky Mountains known as the Birch Creek Range, about 75 miles southeast.

The amount of water flowing in the mountain streams varies from 100 to 300 inches at low water to as many thousand during high water.

We do not depend upon rain, but upon the melting snow in the mountains. No dependence can be placed upon the rain-fall for agricultural purposes, but for grasses growing upon all the ranges rain is the only reliance. The land in Lemhi County lies particularly well for the distribution of water, and nearly all the lands fit for agricultural purposes can be reached.

Respectfully submitted.

J. W. BIRDSEYE.

JOSEPH C. STRAUGHAN,
United States Surveyor-General.

SUMMARY OF LEMHI COUNTY REPORTS.

This county has about two hundred and fifty ditches used for agricultural purposes, each from one-half mile to 6 miles long; for mining purposes, about one hundred ditches, with a total length of about 200 miles.

Products for 1888.—Hay crop, 8,000 tons, worth $6 to $10; wheat, 40,000 bushels, worth $1; oats, 60,000 bushels, worth 35 to 50 cents. Fruits and vegetables of all the hardy varieties abundant.

Yield per acre.—Alfalfa clover, 4 to 5 tons (2 crops); red clover, 3 to 4 tons; timothy, 2 to 3 tons; wheat, 30 to 50 bushels; oats, 40 to 70 bushels.

Snow-fall usually 6 to 8 feet (last year very light). "Duty of water," 1 miner's inch per acre. Irrigation season, May 15 to August 15.

Area now irrigated, 9,715 acres. Area of good irrigable land, 500,000 acres. Area of the county, 4,300 square miles.

NEZ PERCE COUNTY.

REPORTS BY C. P. COBURN AND W. P. BELL.

LEWISTON, IDAHO, *July* 20, 1889.

SIR: In response to your circular letter of June 8 instant, I have given the subject of irrigation considerable attention.

The Snake and Clearwater Rivers lie too low to be available for irrigation in this immediate vicinity. When the Nez Percé Reservation is opened it may be practicable to bring water from either of these streams for irrigation purposes. But, owing to the little fall of the streams and the steepness of the banks on each of these rivers, it requires too long ditches; consequently too great an expense to be practicable at present.

There is now a ditch taken from Clearwater River about 4½ miles in length, covering the Clearwater bottom, comprising about four sections of lands, and the water thus brought is used for irrigation and milling purposes.

In company with W. P. Bell, county surveyor, we have made a preliminary survey of a ditch from the South Fork of Sweetwater Creek to the table lands southeast of Lewiston, and find it in every way practicable, and water can be brought on the plateau, covering a large body of excellent land, at a small expense compared to the benefit that would be derived therefrom, and this it would benefit fully $100,000 and it could be completed at an outlay not to exceed $9,000.

In this connection I will say that the reason this has not been undertaken as a private enterprise long since is on account of objections raised by former Indian agents of the Nez Percé Reservation, to wit: That this stream, although having its source upon unoccupied Government land, it flowed on to the reservation and might in the future be required for irrigation or milling purposes. But we find that none of the water of the stream is used for irrigation, and that the other branches furnish all the water required, and in fact far more than is used for either irrigation or milling purposes. We therefore earnestly recommend that an appropriation be made for this purpose.

There is also a large tract of valuable land, comprising 15,000 or 20,000 acres, southeast of Lewiston susceptible of irrigation by artesian wells, and could the fact be once demonstrated that it is feasible, and flowing water be obtained, it would increase the value of this large tract a hundred-fold.

From a careful examination of all the surroundings we deem it in every way feasible, and have no doubt flowing water can be obtained by artesian wells. We therefore earnestly recommend that an appropriation be made by Congress to test the matter fully.

Respectfully yours,

C. P. COBURN,
W. P. BELL,
County Surveyors.

Governor GEORGE L. SHOUP,
Boisé City, Idaho.

REPORTS BY FRANCIS F. PATTERSON AND CHARLES M. FORCE.

LEWISTON, IDAHO, *June* 26, 1889.

DEAR SIR: In reply to your circular letter of the 14th instant we have to say that our information on the subject of irrigated and irrigable lands is very meager, but are glad to furnish you with what little information we have.

In reply to your first question we would state that there is practically no irrigation in this part of the Territory. It is not necessary, in the first place, and in the second place it is hardly practicable. There are some tracts of land which would be improved by irrigation, but by far the larger part of the agricultural land in this section does not need irrigation to raise large crops of grain, vegetables, and, in many places, fine fruit.

The agricultural land of northern Idaho lays principally on the high table lands, which are cut by more or less deep cañons in which run the rivers. There are a few of the smaller streams that flow through more or less wide and fertile valleys which could be irrigated, but do not need irrigation in the least, while the land which needs irrigation most is so far above the water-courses that irrigation is not practicable. There is, in fact, almost no land at all which might be called agricultural land where irrigation is absolutely necessary to raise crops, and it was long ago decided that the "desert land act" did not apply to this land district.

Very respectfully,

FRANCIS F. PATTERSON,
Register.
CHARLES M. FORCE,
Receiver.

J. C. STRAUGHAN,
United States Surveyor-General of Idaho.

ONEIDA COUNTY.

REPORT BY D. W. STANDROD AND H. R. EVANS.

MALAD CITY, IDAHO, *August* 8, 1889.

DEAR SIR: Your circular letter of the 14th of June last, together with the letter of Governor Shoup appointing us as the authorized officers for this (Oneida) county to prepare a report on the facilities afforded in this county for increased irrigation, together with statistics of amount of water supply in the county and the acreage of lands under irrigation, was duly received and considered. A careful report of the matters was prepared by us and mailed to you on the 31st day of July, but we have since been informed that said report has not been received at your office, we therefore respectfully submit the following:

NAMES OF STREAMS ON WHICH IRRIGATION HAS BEEN EFFECTED AND TO WHAT EXTENT.

Big Malad Creek.—Extent of land irrigated by it, 1 mile in width by 5 miles in length. This stream rises in a large spring situated down in the valley, and its water supply rarely, if ever, varies with the season. About 1 mile below its source is a large gulch or basin, through which it flows, that affords a most practicable and inexpensive site for a storage reservoir, which can be constructed by building a dam of earth taken from the sides of the gulch, and which is capable of storing sufficient water to irrigate thus three times as much land as is now irrigated by it. Several sections of land lie around this stream that are wholly unutilized, covered with sage brush and absolutely valueless as it is, but comprising the richest and most productive soil in Malad Valley—a soil that has been tested and, when brought under the advantages of irrigation, been proved to be the most productive of fruits, grain, and vegetables.

Mill Creek, Birch Creek, Devil Creek, and Marsh Creek, all running into one ditch.—Extent of land irrigated by them, three-quarters of a mile wide by 10 miles long. On each of these streams are most excellent sites for reservoirs, which can be built at a comparatively small cost, and we are safe in saying the water supply could be trebled, the irrigable lands being fully sufficient also to utilize all of it.

Little Malad Creek.—Extent of land irrigated by it 1 mile wide by 4 miles long. This stream rises in the mountains high above Malad Valley and flows for a long distance. The water supply from it is greater than that from any other small stream in the valley, it ordinarily being a strong stream and furnishing a large volume of water for several miles above Malad Valley proper. This stream runs down a small valley ending at its lower end by a "narrows" which affords a most delightful site for a reservoir. Such reservoir could be built by means of an earthen dam of 175 feet long and 30 feet high, and could be erected at a cost of $2,000, which will fill a basin of water to the height of 20 feet and cover an area of 160 acres with 10 feet of water. It is difficult to say how much land could be irrigated with the water so stored, but the water supply of said stream would be increased at least fourfold. Lying below said reservoir is a large tract of rich black sandy loam, covered by immense forests of sage brush and left in its desert condition.

Deep Creek.—Extent of land irrigated by it one-half mile wide by 3 miles long. We desire to call especial attention to the facilities for increase in the water supply of this stream. It furnishes the water supply for Malad City, containing a population of 2,000 persons, and in the early spring is used for irrigating hay lands situated below said town. It is one of the most useful streams in the valley, and does not furnish one-fourth of the water absolutely necessary for the wants of citizens which it was intended to supply.

About 8 miles north of Malad City, and where the headwaters of said stream flow from the mountains, is a site for a reservoir which can not fail to attract attention when observed as the most natural site for a storage basin that could have been prepared by the hand of nature; a small valley covered with sod, impenetrable by water, and furnishing a most excellent bottom for a basin of this kind; a natural place for constructing a dam of earth and forming a basin 1 mile or more in length by an average of 80 rods in width, with comparatively little pressure on the dam and having a safe outlet. No investment could be made that would derive better profits and afford relief to a community than the construction of this reservoir. Many places along said stream above Malad City furnish excellent sites for smaller reservoirs, which could be constructed at small expense, whereby the water might be increased immensely.

Two Mile Creek.—Amount of land irrigated by this stream is one-half mile wide by one-half mile long. This stream lies above a district of most excellent hay lands, which are several school sections. It runs through an immense gorge with high cliffs on either side, and reservoirs could be constructed on it in many places at comparatively little cost, the great walls of the mountains on either side furnishing ample material for the construction of said dams. Especially would these reservoirs be practicable and a great saving store, on account of the flow of water from the snow on the high mountains above.

Cherry Creek and Henderson Creek.—Amount of land irrigated by them, half a mile long and half a mile wide. These creeks lie above a firm section of natural hay-producing country; and while the water supply afforded by them is quite limited, yet the high mountains from which they flow furnish immense streams in the early spring during the melting season. This water, of course, is lost and goes off too early to furnish any substantial irrigation. Splendid sites for reservoirs are situated on these streams and could be easily built, whereby the water could be increased many fold.

We desire to say further that Malad Valley comprises, as we believe, the richest soil and the most productive region of Idaho. It is one of the oldest settled valleys in the Territory, the population composed of thrifty farmers, and yields in grain the finest quality and largest quantity per acre of any lands we are acquainted with in the Territory.

The one great drawback to its prosperity and increase of population is the scarcity of water supply. The lucerne yield itself will enrich the farmer and has been a mighty factor in the encouragement of stock growing. Where the water supply is furnished farmers never fail to produce three crops of this hay per season, yielding from 6 to 8 tons per acre. We do not believe there are more than one-fourth of the lands of said valley under cultivation, the cause of which is wholly due to the insufficiency of the water supply. It is in extent about 10 miles wide by 20 miles long.

Weston Creek.—Extent of land cultivated by it 1 mile wide and 6 miles long. This is a strong stream, running a distance of 5 miles through a cañon, passing out at Weston Valley. Many excellent sites for reservoirs can be found along the valley from which it flows. A few years ago a reservoir was constructed on this that has been successfully managed since, and clearly demonstrates the great saving of water that can be had in this way. The reservoir is situated about 3 miles up the cañon above the valley and is built by constructing a dam of earth across the valley. We are informed that this reservoir cost about $2,000 and is situated near the southeast corner of T. 15 S., R. 37 E. The dam is about 15 feet in height by about 300 feet long. It is claimed by the farmers, who take water from this reservoir, that the water saved in the reservoir irrigates three times as much land as was irrigated by the stream prior to constructing the reservoir. An extensive area of land lies below this reservoir susceptible of irrigation that remains in its desert state and public land of the United States.

Five Mile Creek.—Extent of land irrigated by it 1 mile wide by 6 miles in length. This stream is small but could be trebled by constructing a reservoir in a cañon through which it flows. Sufficient land lies below it, that is now desert, on which all the water so increased could be used.

Clifton Creek, in the same neighborhood, is similar in all respects to Five Mile Creek.

Cub River.—Extent of area irrigated 1 mile wide by 6 miles long. We append herewith a map showing the position of Cub River and Mink Creek, and points on same where reservoirs can be constructed, and estimated cost of same. The country that this water would irrigate is very rich, and is a fine fruit-growing section. A large area of land lies under it that is now desert and only lacks irrigating facilities to make it blossom like the rose.

Warm Creek.—Extent of land irrigated by it 1 mile wide and 5 miles long. We append herewith an article prepared by the Hon. Frank Campbell, a man in vast experience in irrigation, he having been a former citizen of Nevada. We submit it as a report covering the Rock Creek, Warm Creek, and American Falls country, and I vouch for its correctness.

In conclusion we desire to call attention to a vast section of country lying on the west side of Bear River in this county, comprising T. 15 and 16 S., R. 38 E. While these lands do not differ in richness and productiveness from that we have herein described, it is the most thoroughly arid and desert country in the county, having no springs or small streams arising upon or flowing through it. Bear River could easily be conducted by means of a canal to and upon these lands.

From present indications capitalists in the East are endeavoring to divert all the waters of Bear River at a point called the "Narrows," about 20 miles below the lands above referred to, and use the same for irrigating lands in Utah and supplying Ogden City with water. One-third of this stream would fully irrigate the lands in this county above referred to, and we deprecate the fact that unless the water is soon diverted for the lands above referred to it will all be appropriated for Utah Territory, thereby depriving us of what would seem naturally due to us.

The expense of taking this water from Bear River for the lands in Idaho is comparatively light, when considered with the vast expenditure that will be acquired to apply it to the uses in Utah above referred to.

Respectfully submitted.

D. W. STANDROD.
H. R. EVANS.

JOSEPH C. STRAUGHAN,
United States Surveyor-General for Idaho.

REPORT BY FRANK CAMPBELL.

The northern portion of Oneida County includes two considerable bodies of land that possess a surface capable of being irrigated, the "Snake River Plains" and "Rock Creek Valley." The first extends west from the Portneuf River 20 miles, and skirting Snake River on the south, with an average width of 2 miles. The largest and best half of this land, together with all the waters of Portneuf River and Bannack Creek, is embraced by the Fort Hall Indian Reservation. Situate between this strip of arid bench land and Snake River there are about 4,000 acres of river bottom land that produce wild hay by the overflow of the river, the yield of which could be greatly increased by irrigation.

Warm Creek, containing about 200 inches (miner's), is the only stream outside of Fort Hall Indian Reservation that can be used upon this strip of sage-brush land until the waters of Snake River are diverted by a canal commencing near Eagle Rock, about 60 miles distant.

At Warm Creek about 2,000 acres of land have been settled upon and the natural flow of the stream fully utilized. The result is about 400 acres in grain, vegetables, and alfalfa. This stream is supplied by a never-failing spring (or springs). The freshets resulting from melted snows are small and variable, some years amounting to nothing.

A reservoir site exists, sufficiently high on the stream to cover a vast number of acres. A dam 100 yards long and 12 feet high, average width about 12 yards, aggregating about 15,000 yards of earth, could be built at a cost of 10 cents per yard, amounting to $1,500, that would impound 40 acres of water, with an average depth of 20 feet, which, it is safe to estimate, would irrigate 1,500 acres additional land. The reservoir site is private property and would cost about $2,000.

Bear Creek Valley is about 20 miles long, and settled the entire distance. About 7,000 acres are in the hands of private parties. The stream furnishes 1,000 miner's inches for irrigating purposes, and is fully utilized, resulting in the cultivation of 2,000 acres in grain, vegetables, and alfalfa.

There are several thousand acres of Government land that can not be cultivated for lack of water. I am not prepared to report upon any natural reservoir sites in this valley, but understand there are three or four small ones, containing from 10 to 40 acres each.

Snake River contains an inexhaustible supply of water that must be made to do duty in rendering the barren plains beautiful and habitable for man.

The feasibility of using it has been demonstrated by private enterprise. The duty of the United States Government in the premises is to demonstrate practicable routes for canals for conveying water out upon these plains; also survey and report the number of acres along the route suitable for irrigation, with such data as a basis upon which private capital would quickly avail itself of the rich rewards that would surely follow. The distribution of this immense body of water upon the plains of Idaho is a gigantic enterprise that will give full employment to the skill and energy of our citizens for the next generation.

Respectfully submitted.

FRANK CAMPBELL.

Summary of Oneida County report.

[Compiled from reports of D. W. Standrod, H. R. Evans, and Frank Campbell.]

Localities.	Lands.		Remarks.
	Irrigated.	Irrigable.	
	Acres.	*Acres.*	
Big Malad Creek	3,200	9,000	Flows from a large, permanent spring, and has a site for reservoir capable of supplying 9,000 acres more good land.
Mill Creek Devil Creek Birch Creek Marsh Creek	4,000	12,000	Connected by one ditch. Very good location on each creek for reservoirs.
Little Malad Creek	2,640	10,000	Has a great amount of water. Site for reservoir very good. A dam 30 feet high, 175 feet long, costing $2,000, will cover 160 acres 10 feet deep, or 68,000,000 cubic feet of water.
Deep Creek	1,000	5,000	Supplies Malad City (population, 2,000) and lands around it. Eight miles above the city a very good site for a dam that would cover 160 acres 15 feet deep at small expense.
Two-Mile Creek	160	5,000	Site for reservoir very good.
Cherry Creek	160	5,000	Site for reservoir very good. Both of these streams would cover much high land that is very productive in hay—6 to 8 tons per acre annually.
	11,160	46,000	
The above streams are all in the so-called Malad Valley. There are smaller streams and large tracts of good land not herein reported upon. As a whole Malad Valley has a body of good irrigable land (with sufficient water storage), that is, 20 miles long and averaging 10 miles wide, or 128,000 acres.			
Weston Creek	4,000	....	Has a reservoir 800 feet long, 15 feet high—cost $2,000—and it increases farming area from 1,200 acres to 4,000 acres.
Five-Mile Creek	4,000	12,000	Small streams; capable by means of reservoirs of irrigating three times as much.
Clifton Creek	4,000	12,000	
Cub River	4,000	10,000	Both have much water; good sites for reservoirs, and much good land thus made irrigable.
Mink Creek	4,000	12,000	
Warm Creek	3,200	12,000	Capable of treble its present capacity by means of storage.
Snake River	4,000	....	A small strip on south side of river; overflowed.
Warm Creek, a tributary of Snake River	400	4,000	Main supply is from a spring. Can not be improved by reservoirs, as the floods are uncertain. Some 20,000 acres might be irrigated by a canal from Eagle Rock.
	27,600	62,000	
Total	38,760	108,000	

GENERAL DESCRIPTION.

Total area of Oneida County 2,600 square miles, exclusive of the reservation.

In general, this county is now irrigated in so far as it can be without resort to storage reservoirs on its small tributary streams, and the construction of a canal from a point on Bear River, in Bingham County.

Both methods seem to be advisable. In some localities, reservoirs will be cheapest, and on some large tracts, notably T. 14 and 15 S., R. 38 E., a canal from Bear River is the only available method.

These lands are so excellent that it is the interest of that populous neighborhood and of the Territory of Idaho that they should be reclaimed, and thus help to bear the burdens of the State.

In the report of Messrs. D. W. Standrod and H. R. Evans they say that an eastern syndicate are about to monopolize all Bear River and conduct it into Utah, against which they strongly protest.

OWYHEE COUNTY.

REPORT BY FRANKLIN W. HULETT.

SILVER CITY, *July* 8, 1889.

SIR: In reply to your circular letter of June 8, 1889, I herewith submit the following:

Streams where irrigation has been effected.	Extent of lands.		Ditches.	
	Irrigated.	Irrigable.	No.	Length.
	Acres.	*Acres.*		*Miles.*
Jump Creek	75	8,000	1	½
Squaw Creek	200	12,000	1	1
Reynolds Creek	600	13,000	9	17
Sinker Creek	500	....	4	5
Castle Creek and tributaries	1,100	17,000	18	19
Shoo-Fly Creek	200	10,000	3	3
Dry Creek	300	20,000	4	5
Bruneau River, Bruneau Valley, and adjacent land west*	1,500	100,000	7	23
Big Flat or Upper Bruneau River*	800	50,000	(†)	
	5,275	230,000	47	73½

NOTE.—Length of time each year—average three months. There is sufficient water to irrigate its irrigable lands.

* By Snake River Canal.

† Not known.

During the months of February, March, and April of each year, average, there is sufficient water in all the streams mentioned to irrigate all the lands of value just at the time when irrigation is not necessary. Usually irrigation is commenced about the middle of May, and is continued (if there is sufficient water) until about the 1st of October. There are large tracts of fine land lying westerly from Bruneau Valley, extending as far as Birch Creek. There is a practicable route for a canal, beginning at a point near the south boundary of T. 7 S., R. 6 E., on Bruneau River; thence in a westerly direction to the last-mentioned creek.

Respectfully,

FRANKLIN W. HULETT,
United States Deputy Mineral Surveyor.

JOSEPH C. STRAUGHAN,
United States Surveyor-General for Idaho.

REPORT FROM S. J. PRITCHARD.

Robertson's Fork of Bruneau.—Extent of irrigation, 7 by 1 miles; practicable, 10 miles square; furnishes sufficient water about three months yearly; has five ditches, average 1 mile; good site for reservoir.

Three Creek.—Extent irrigated, 3 by three-fourths miles; practicable, 6 by three-fourths miles; furnishes sufficient water about three months yearly; good site for reservoir; has three ditches 1¼ miles long.

Bruneau River.—Extent irrigated, 12 by 1¼ miles; ten ditches from 1 to 8 miles long; furnishes water about six months. There is an excellent site for storage of water, and the water from this stream can be made to cover thirty sections of good agricultural land.

Shoo-Fly Creek.—Extent of irrigation, 3 by 1 miles; practicable, 8 by 1 miles; three ditches from 1 to 3 miles; furnishes sufficient water about two months yearly; excellent site for reservoir.

Birch Creek.—Practicable for 9 miles long and from one-half to 2 miles wide; excellent site for storage of water; sufficient water for about two months yearly, with a small stream the greater part of the year.

Castle Creek.—Irrigated for 8 by one-half miles; practicable fifteen sections; furnishes water until about 1st of May; thirteen ditches; one-half to 3 miles long; excellent site for reservoir.

Catherine Creek.—Irrigated for 7 by three-fourths mile: ten ditches, 1 to 2 miles. Excellent sites for reservoir.

Pickett Creek.—Irrigated 4 by one-half mile; seven ditches, from 1 to 2 miles. Excellent site for reservoir. These last two streams join, and with water stored could be made to cover about fifteen sections of good fertile land.

Sinker Creek.—Six miles by one-half miles.

Reynold's Creek.—Irrigated, 12 miles long, land one-half mile wide. Practicable about fifteen sections. Excellent storage site. Furnishes sufficient water about two months yearly.

Cow Creek.—Irrigated 3 by one-half mile.

Jordan Creek.—Irrigated 8 by 1 miles. Sufficient water the entire year.

There has been some land located and irrigated, and water-rights located upon and water diverted from all the following streams: Dead Wood, Brown's, Squaw, Jump, Trout, Williams, South Mountain, Boulder, Lone Tree, and Cherry Creeks.

In nearly all these streams in this county there is a great body of water for several months in the spring, so that where reservoirs could be constructed there would be sufficient waste water during these periods of high water to fill the various reservoirs.

There are about one hundred irrigation ditches, averaging about 2 miles long. There are about 12 ditches used for mills and mining averaging about 3½ miles long.

These streams generally have their sources in the mountains, and are fed by springs (usually formed from the rains and melted snows incident to mountains), and from the melted snow and rains.

At least one-half of the settlers of Owyhee County are settled upon unsurveyed lands.

The average value of crops per acre is about $40. If Snake River were diverted, it could be made to cover 60 square miles of good agricultural land in one body in Owyhee County.

Respectfully submitted.

S. J. PRITCHARD.

SUMMARY OF OWYHEE COUNTY REPORTS.

Localities.	Lands.		Ditches.		Remarks.
	Irrigated.	Irrigable.	No.	Length.	
	Acres.	*Acres.*		*Miles.*	
Bruneau River (and land west.	1,500	100,000	10	45	Has water for six months; very good site for reservoirs.
Robertson's Fork of Bruneau.	4,500	6,500	5	5	Has water for three months; very good site for reservoirs.
Three Creek	1,500	3,000	3	5	Do.
Shoo-Fly Creek	200	10,000	3	6	Has water for two months; very good site for reservoirs.
Dry Creek	300	20,000	1	2	
Birch Creek	....	7,200	....	....	Has water for two months; very good site for reservoirs.
Castle Creek	1,500	10,600	13	25	Do.
Catherine Creek	3,200	9,600	10	15	Has water for three months; very good site for reservoirs.
Pickett Creek	1,200		7	10	Has water for two months; much-needed reservoir.
Jump Creek	75	8,000	....	....	
Sinker Creek	500	....	....	....	
Squaw Creek	200	12,000	1	1	
Reynolds' Creek	600	12,000	....	....	Has water for two months; very good site for reservoirs.
Cow Creek	1,000	....	....	....	
Indian Creek	5,000	....	....	....	Has water for twelve months.
Mining and Milling ditches.	....	....	12	42	Has water for four months.
Snake River	....	40,000	....	....	In one body. Can only be supplied by a long canal from Snake River.
	21,275	248,500	66	153	

RECAPITULATION.

Acres irrigated	
Acres irrigable	21,275
Number of ditches	248,500
Miles of canals and ditches	66
Average season	153
Total area ....months	2½
....square miles	7,812

KOOTENAI COUNTY.

REPORT BY GEORGE A. MANNING.

SIR: In reply to the questions in your circular of June 15, in regard to irrigation in Kootenai County, I would in answer say first: That owing to the formation of the country, it being generally mountainous, it is not possible to irrigate any considerable amount of land in the county, and would further state I do not know of any land in the county being irrigated at the present time, and further it is not considered necessary to irrigate in order to raise fair crops of cereals, vegetables, or fruits. There are three considerable rivers running through parts of Kootenai County.

The most northerly, the Kootenai River, runs through the northeast corner of the county, the country being mountainous, with some very fine bottoms along the river which mostly overflow during the spring and early summer, caused by the melting snows in the mountains. After the water recedes from these bottoms grasses of good quality quickly spring up, and the cut of hay from them will average 2 or 3 tons to the acre; on the higher parts of the bottoms fine vegetables grow. About the middle of September last year I saw corn, pototoes, squash, pumpkins, and tomatoes thoroughly matured and ripened on the ranch of Mr. Long, about 2 miles above Bonner's Ferry.

The Pend d'Oreille River, after leaving the lake of the same name, runs about 25 miles through Idaho. The character of the country is about the same as Kootenai River, with much the same kinds of bottom-lands.

The Spokane River runs through the county a distance of about 13 miles, from the foot of Coeur d'Alene Lake to the Washington line. The lake and river being so much lower than the surrounding lands, it would be impossible to take the water out for irrigating purposes, and the only lands that could be benefited by irrigation is thus deprived of it.

The land that I refer to extends from the Washington line east for about 12 miles and a distance of about 25 miles north from the Spokane River; is mostly open prairie, with occasional small groves of pine. The soil is gravelly loam, and it produces fair crops of grain and vegetables. It stands the drought well, but is absolutely without water, with the exception of two lakes, as marked on the plat (Hayden Lake and Fish Lake). Hayden Lake is much below the surface of the prairie, consequently irrigation from that source is practically impossible. There is no outlet to the lake and no streams of any consequence running into it. Its principal supply is from the melting snow on the surrounding mountains.

Fish Lake is a body of water about 5 miles long, with an average width of about 1 mile, during the spring rains and melting of the snows in the spring. A small stream issues from it, but it runs along the base of the hills on much lower ground than the surrounding prairie and sinks in the gravelly soil after running a few miles. The prairie is nearly all claimed and fast being brought under cultivation. The great drawback is the want of water for domestic purposes, farmers having to haul their water from 1 to 6 miles. Three wells have already been sunk, one on the ranch of E. R. Childs near Post Falls, about 2 miles north of Spokane River. He found water at a depth of about 172 feet, which he proposes to raise by a windmill. About 4 miles north of Mr. Childs's place Mr. Eisch found water at a depth of 225 feet. He has a windmill in successful operation, but the amount of water raised is small; still he has enough for domestic uses. About 4 miles northeast of the last well Mr. Henry Reiniger sank 311 feet, finding a supply of water at that depth, which he proposes to raise by windmill.

With a supply of water for domestic purposes and for watering stock the prairie referred to above can be successfully cultivated, which would add materially to the wealth of the county and Territory. It is generally thought that artesian wells could be bored on the prairie that would furnish an abundant supply of water, but as the cost would be considerable, no one feels able to take the risk of a failure; but could the fact be demonstrated by sinking a well the farmers could club together and sink others, thereby securing an ample supply for all their wants.

I am, very respectfully, yours,

GEO. A. MANNING.

JOSEPH C. STRAUGHAN,
United States Surveyor-General for Idaho.

REPORT BY WM. ASHLEY, JR., COUNTY SURVEYOR.

KOOTENAI, IDAHO, *July* 15, 1889.

DEAR SIR: Your favor of 22d ultimo and map received, but was sent to Murray and I did not get it until the 27th, as my post-office is Kootenai.

There is very little irrigating done in Kootenai County. In the northern part there is abundance of water to irrigate all irrigable lands, but in the southern portion water is scarce and the land is very gravelly, so that it is hard to dig ditches.

I would suggest that artesian wells will be more practicable than irrigation ditches or canals.

The Kootenai River, Pack River, Clark's Fork, and the Pend d'Oreille Rivers afford abundance of water for all the land irrigable, but the bottom-lands generally overflow during high water.

Yours, very respectfully,

WM. ASHLEY, JR.,
County Surveyor.

JOSEPH C. STRAUGHAN,
Surveyor-General.

WASHINGTON COUNTY.

REPORT BY THOMAS C. GALLOWAY.

WEISER, IDAHO, *July* 2, 1889.

SIR: Water has been appropriated in two hundred and seventy ditches, from the Weiser River and its twenty-five tributaries.

Most of the ditches are small and short, and are only intended for private use along the alluvial bottom-lands.

The Pence ditch, from the Payette River, intended to cover about 10,000 acres of rich, level sage-brush land on Snake River, above the mouth of the Weiser, is 12 miles long.

The Mill ditch, on the north side of the Weiser, is 5 miles long, and has a capacity of about 1,000 inches. The Weiser canal is 17 miles long, and is intended to irrigate 16,000 acres on the north side of the Weiser River and on Snake River below Weiser City.

Owing to four successive dry years, and no means of storing and holding back from the very abundant spring supply, many of the smaller ditches are dry, and the larger ones have not sufficient head to maintain a full and uniform flow, which is necessary.

With but comparatively little expense water could be stored on any of the small streams in great abundance, or dams could be easily, cheaply, and safely built in the narrow cañons between the different valleys on the main Weiser. Water stored anywhere above would benefit all below.

The price charged, where water is sold, is $1 per miner's inch, a very indefinite quantity, but expected to be enough to irrigate 1 acre. The irrigable land in Washington County is about 500,000 acres. The water-shed is in the shape of a horseshoe, 30 miles across and 100 miles in length.

Land, where the supply of water is certain, is worth from $15 to $20 per acre; land without water is worthless.

Unless means are devised for holding back and a better way established for distributing and using water in this county, the larger and longer ditches will be abandoned, while the smaller ones will become sources of local strife and litigation.

Very respectfully, yours,

THOS. C. GALLOWAY.

JOSEPH C. STRAUGHAN,
United States Surveyor-General for Idaho.

WEISER, *August* 11, 1889.

DEAR SIR: Yours of the 5th instant, with map inclosed, at hand to-day. It is impossible to designate the numerous ditches on the map in this county.

I have marked one Pence ditch from Payette River, which I consider very important, as the large body of land, at least 10,000 acres, is No. 1, and without water.

No. 2, Mill ditch. No. 3, Weiser canal. No. 4, Middle Valley.

There are fourteen ditches on Manns Creek, now all dry. No water in Pence ditch. The Weiser canal takes all the water in the river and only affords at this time a small quantity, probably enough to water stock, orchards, and gardens.

The water is lower now than for twenty-six years to my knowledge. The question of prior and riparian rights has not been adjudicated; and as the upper valleys do not use water, only when it is short, this works a great hardship here and will do so until some means is devised for storing the spring supply—which always has been abundant.

Respectfully,

THOS. C. GALLOWAY.

JOSEPH C. STRAUGHAN.

NOTES ON WASHINGTON COUNTY.

The irrigable lands in Washington County lie in a horseshoe form, about 100 miles long on its outer line and 30 miles across the chord of its inner segment, embracing an area estimated at 500,000 acres. Less than one-tenth of this is yet irrigated, and this one-tenth but poorly supplied with water. The improved lands here that have water are worth $20 per acre.

The mountains that supply this valley are not high nor extensive; their snows melt away in the early spring, the flood water is soon gone, and the dry season begins early, and the inhabitants of the lower valley find that the settlers above can absorb all the water at this season when it is of much use.

Sites for storage reservoirs are reported as existing in almost every lateral tributary, and to these sites I respectfully call attention in order that this valley may obtain the earliest attention and relief.

This county is bounded on the east by a low range of mountains, and on the west by Snake River, which is in a deep valley, too low to be brought out for irrigation. The Weiser River with its twenty-five tributaries are all within this county, and the county embraces the whole of the Weiser drainage and no more. It is therefore a separate district for irrigation and the storage system is unquestionably the only proper plan, and it is in this locality a great and pressing want.

REPORT OF BORINGS FOR LOCOMOTIVE SUPPLY WELLS ON OREGON SHORT-LINE RAILROAD, IDAHO.

POCATELLO, *August* 8, 1889.

DEAR SIR: Yours of yesterday duly to hand, and with return mail send you herewith depth of our wells west of Pocatello. I name them in their order proceeding westward:

Wapi well, 250 feet deep—through lava and in sand.

Minidoka well, 335 feet deep; Kimama well, 335 feet deep; Owinza well, 483 feet deep; Bliss well, 450 feet deep; Bisuka well, 390 feet deep; Mora well, 380 feet deep; Nampa well, 154 feet deep. Not through total thickness of lava.

This, I am afraid, is but meager information, but it is all I have on hand. The wells were put down a long time ago and all records of section of strata, if any were kept, are in Omaha.

Hoping this may be of some service to you, I am, very respectfully, yours,

V. C. ROEDER,
Division Engineer.

JOSEPH C. STRAUGHAN, Esq.,
Surveyor-General of Idaho.

STATEMENT OF V. C. ROEDER, ENGINEER IN CHARGE OF IDAHO DIVISION UNION PACIFIC RAILWAY, POCATELLO, IDAHO.

By a glance at a map of this part of the Territories, it will be noticed that the Oregon Short Line Railway is located for more than half its distance along streams of considerable size which never run dry during the summer months, such as Hamsfork, Bear, Portneuf, and Snake Rivers. At stations on those portions of the railroad the question of a supply of water is easily answered by springs in the adjoining hills, permitting of a gravity supply, or by pumping from wells 10 to 30 feet deep, or directly from the streams.

From American Falls to Caldwell, however, a distance of 228 miles, the railroad runs through an arid country of lava, which in general is covered by a deep, rich soil, and now yields, owing to the absence of water, only sage brush, but which, with a supply of water, with our mild and equable winters, would yield fruits and grain in abundance. On this desert the railroad company were compelled to sink, at regular intervals, deep wells 8 inches in diameter, and varying in depth from 150 to 485 feet. These wells are not, strictly speaking, "Artesian" as the water does not rise or overflow in the same, but must be brought to the surface by deep well pumping machinery.

Characteristic features of the Snake River Valley are the rifts and crevasses in the lava rock, which vary from an inch to several feet in width and extend to a depth of several hundred feet below the surface. It is into these crevasses that the waters of the northern portion of the Snake River Valley sink, and in all probability it is this water that is tapped by the deep wells referred to.

Should these wells be carried deeper and below the lava overflow subterraneous water would no doubt be reached and flowing wells obtained.

Of these deep wells there are nine on the Oregon Short Line Railway, in the region referred to, and located at the following stations:

	Feet deep.		Feet deep.		Feet deep.
Wapi	340	Owinza	400	Bisuka	390
Minidoka	425	Bliss	483	Mora	380
Kimama	325	Clift	450	Nampa	150

In regard to the cost of these wells I can obtain no data here, nor do I think that their cost, being driven six years ago or more, could be used as a fair basis for an estimate of similar work to be done now or in the future.

There is no storage system in use on this division. The surface supply is good, except in the district above mentioned, but owing to the nature of the lava which overlies the greater portion of Idaho, the banks of the streams are nearly always vertical and quite high, so that dams and reservoirs would have to be resorted to to bring the water on the adjoining lands. The great number of large springs would seem to indicate an abundant subterranean water supply. There are no large irrigating enterprises on lands near the railroad line. There are only small private ditches irrigating lands immediately adjoining the rivers.

STATEMENT OF JOSEPH C. STRAUGHAN RESUMED.

The **Chairman**. You have here the reports from the various counties?

Mr. **Straughan**. Yes.

The **Chairman**. I would like to inquire whether they do not generally irrigate in Latah and Nez Perces Counties? Is it certain that irrigation would not be beneficial to them?

Mr. **Straughan**. The reports from those counties state that if the Indian reservation is thrown open to settlement, irrigation will operate to advantage on some sections of that reservation. From Kootenai County they also report some few districts where the artesian-well system will probably apply.

The **Chairman**. Latah and Nez Perces counties have plenty of streams passing through them if they desire to irrigate?

Mr. **Straughan**. Yes; but the reports mostly state briefly that no irrigation is needed; none required.

The **Chairman**. There are some gentlemen here from that section who wanted to make a statement in regard to it. Are those the reports? [Indicating the papers in the hand of Mr. Straughan.]

Mr. **Straughan**. Yes, those are the type-written copies of the original reports.

The **Chairman**. Will you explain the maps which you prepared?

Mr. **Straughan**. Ada County, for example, pretty much explains itself. There is a general description and recapitulation accompanying each map. (This is embraced in the testimony.) We realized that the time of the committee was limited, and that it had to cover a very large territory in its investigations. Therefore, we prepared a comprehensive and brief statement.

STATEMENT OF C. B. COBURN, OF LEWISTON.

The CHAIRMAN. How long have you resided at Lewiston?

Mr. COBURN. About twenty-seven years.

The CHAIRMAN. That is in northern Idaho?

Mr. COBURN. Yes.

The CHAIRMAN. What streams of water pass through the agricultural section of Nez Perces and Latah Counties?

Mr. COBURN. The Clear Water and Snake rivers pass through Nez Perces.

The CHAIRMAN. Is Latah County an agricultural county?

Mr. COBURN. Yes.

The CHAIRMAN. Are there streams from the mountains passing through that county?

Mr. COBURN. Yes; from the north side of the Clear Water.

The CHAIRMAN. What are the streams?

Mr. COBURN. Different branches of the Clear Water. What they call the Potlatch Creek is quite a large stream coming in from the north.

The CHAIRMAN. What is the rain-fall that you have in those counties?

Mr. COBURN. I can not give you the statistics, but it is about the same as it is in this county.

The CHAIRMAN. You raise crops there without irrigation?

Mr. COBURN. The small grains generally, particularly in Latah and Idaho Counties. They have never adopted any system of irrigation. The table-lands in Nez Perces are drier.

The CHAIRMAN. Latah and Idaho Counties have sufficient rain-fall?

Mr. COBURN. Generally, until this season.

The CHAIRMAN. Have they not had it this season?

Mr. COBURN. This is the only exception.

The CHAIRMAN. They have sufficient rain-fall for small grain?

Mr. COBURN. Yes.

The CHAIRMAN. The Nez Perces County table-lands are higher and drier?

Mr. COBURN. Yes; those lands could be irrigated advantageously.

The CHAIRMAN. Is the rain-fall so small that you do not get a good crop of grain each year?

Mr. COBURN. Not each year.

The CHAIRMAN. How often do they fail to get a good crop?

Mr. COBURN. Every other year. As you get back toward the foothills, toward the mountains, they have never had a failure.

The CHAIRMAN. That is where the snows are melting?

Mr. COBURN. Yes.

The CHAIRMAN. How is it with regard to all around crops—potatoes, corn, etc.—farm products?

Mr. COBURN. They are good.

The CHAIRMAN. Do they grow under irrigation?

Mr. COBURN. They do up in the drier plateaus.

The CHAIRMAN. Would the country be materially improved by irrigation?

Mr. COBURN. Very much, indeed.

The CHAIRMAN. Have the people considered that subject?

Mr. COBURN. They have.

The CHAIRMAN. Have the people practiced it any?

Mr. COBURN. We have done so, and the lower bench of the Clear Water is irrigated to quite a considerable extent.

The CHAIRMAN. How much land is under cultivation? Take the counties of Idaho, Latah, and Nez Perces—the counties under that water-shed?

Mr. COBURN. I am unable to give you the figures.

The CHAIRMAN. How much have you in Nez Perces?

Mr. COBURN. There must be 25,000 acres.

The CHAIRMAN. How much in Latah?

Mr. COBURN. Latah has fully as much, if not more. The Indian reservation cuts out a large portion of the best part of Nez Perces County—the reservation which they are now taking steps to have thrown open to settlement.

The CHAIRMAN. How many Indians are there?

Mr. COBURN. About 1,200. They are now taking steps to locate the land in severalty, and they have been for the last two months.

STATEMENT OF GOVERNOR E. A. STEVENSON, OF BOISÉ CITY.

Senator JONES. I would like to have go in the record a short statement about the time this town was settled, the character of the land when the people came here, its character before the water was put on it, and perhaps the governor would be the proper person to state those facts so far as he may know them.

Mr. STEVENSON. This town was settled in 1863, but very little agriculture was attempted until 1864 or 1865. When I first saw this town this portion around here was as poor a sage-brush place as you would find in Idaho—a miserable sandy place that nobody imagined would grow anything. This ranch that we went over this morning, Mr. Moore said he rode over it when it was a regular bed of sand, and this year they have raised 5 tons of red clover to the acre on that ranch.

The CHAIRMAN. Have they cut that much?

Mr. STEVENSON. Yes. It was that way all along this valley. There was a little strip along the river where some grass grew and where there were some willows and trees. The first men who came here settled on that low bench land, and they have the poorest farms in the country. Those who went back on the sage-brush plains have land that is worth five times as much as the other. And so it is in Washington Territory, at Walla Walla. All those men who went on the Touchet, and all those streams, have poor farms; those who went on the high lands have good farms. But this land without irrigation would produce nothing. It might, if it should rain in the fall, produce a crop of rye, but there is no dependence to be placed on it. But rye will grow almost any place. Right up between this and the penitentiary is a tract of country that we consider better than any place. It was covered with gravel. Now it is almost as fine a farm as there is any place. Mr. Costin told me that he cut, on a portion of that land, 7 tons to the acre.

I have had some experience with irrigation. My partner and I dug a ditch 22 miles long down on the Payette River. We took some water on to some desert land that we have there, and in five years we have raised orchards with lots of fruit. I have cut the grass there twice this year already, and there is a regular forest where there was not a tree in sight in the country. In a short time, five years, these trees were 5 inches through.

Senator **Jones**. What kind of trees do you grow?

Mr. **Stevenson**. Apple, pear, plum, peach, apricot, prune, and these poplar trees; box-elder, walnut, locust and all these different varieties. I took small trees in a two-horse wagon down there. I told some persons that five years ago I took in a two-horse wagon all the trees that are growing there to-day, and they were thunder-struck. A man can not imagine that it could be done. But it is marvelous how the trees grow there.

The **Chairman**. How much land is covered by your ditch?

Mr. **Stevenson**. I suppose it would cover, if the ditch were extended, 50,000 acres. I think it covers 40,000 acres now.

The **Chairman**. To what extent is that land under cultivation?

Mr. **Stevenson**. I have only about a hundred acres under cultivation. I have 2,200 acres of land.

Senator **Reagan**. State what that land was worth before it was irrigated and what it is worth now.

Mr. **Stevenson**. It is not worth anything unless it is irrigated.

Senator **Reagan**. What is it worth now that you can apply water to it?

Mr. **Stevenson**. I do not know the value of it.

The **Chairman**. Have you ever farmed in other countries so that you can compare this with other countries?

Mr. **Stevenson**. Yes; in California. I do not think you can raise cereals where you have to irrigate and compete with a country that does not. But in all other kinds of crops, vegetables, I think we can.

The **Chairman**. How about fruits?

Mr. **Stevenson**. Yes; we raise all kinds of fruits and vegetables. We raised those potatoes which are below, which you do not see in other countries. [Referring to an exhibit of vegetables in the court-house.]

The **Chairman**. Does not an irrigated country require more population?

Mr. **Stevenson**. Certainly; the holdings in an irrigated country should be small. A small farm will support a good family if it is well irrigated. The system of irrigation is crude. They do not understand it. Some give too much water and some too little.

The **Chairman**. What would be the proper extent of a farm for a man and his family to attend to—an ordinary family—to the best advantage?

Mr. **Stevenson**. From 80 to 160 acres. Some farmers might live on 60 acres. But I think it would be better for the country to cut it up into 80 acres.

The **Chairman**. Would it not be better for the country to have it cut up into 40 acres? Would not 40 acres do well?

Mr. **Stevenson**. Yes; 40 acres would make a good home if well cultivated. Now, on the Payette River the supply of water is abundant without storage, and will water all the land on it. There is a large amount of water there now. But on the Boisé River it would need storage. There is plenty of water here with proper storage facilities to cover the whole country. I am speaking of Lewiston. Around the city of Lewiston they could not raise fruit in the garden without irrigation. They irrigate there altogether. And on that table land around

Lewiston they could raise double as much in five years as they could without irrigation. There is an immense supply of water there.

The **CHAIRMAN**. Is that true of portions of Washington Territory where they do not irrigate now?

Mr. **STEVENSON**. Yes; it is true of those portions of Washington Territory about Walla Walla. Those crops suffer for want of water. There cereals and vegetables some years can not grow without irrigation. Frequently they can get along and get a good crop; but most frequently it suffers for want of water.

Senator **JONES**. How is it along that ditch which you and your partner constructed 22 miles in length?

Mr. **STEVENSON**. That takes water to perhaps 40,000 acres of land.

Senator **JONES**. There are 40,000 acres of land under it to which it could supply water?

Mr. **STEVENSON**. Yes.

Senator **JONES**. When did you cultivate the land tributary to that ditch?

Mr. **STEVENSON**. Six years ago.

Senator **JONES**. How much of it is under cultivation?

Mr. **STEVENSON**. I do not think there is more than 4,000 acres—there is not that much—3,000 acres.

Senator **JONES**. Have you any objection to stating the cost of that ditch?

Mr. **STEVENSON**. Twenty thousand dollars cash.

Senator **JONES**. How long is it?

Mr. **STEVENSON**. Twenty-two miles.

Senator **JONES**. What is the size of the ditch?

Mr. **STEVENSON**. Six feet on the bottom and 10 at the top.

Senator **JONES**. How much water does it carry?

Mr. **STEVENSON**. Two feet.

The **CHAIRMAN**. With what fall?

Mr. **STEVENSON**. An eighth of an inch to the rod. It has a large fall, but it does not cut the banks.

Senator **JONES**. What disposition do you make to the holders of adjacent lands? Do you sell the right to the water or do you give it to them?

Mr. **STEVENSON**. These men are all poor men, and have just commenced. We have never sold them any water if they wanted it. I have never established a right to the water, because I did not wish to get into the position of being compelled to give water when I did not wish to do so. Then, too, if I sell the water I have to pay taxes on the ditch, while I do not by not selling, and the rent which I would get for the water would not come up to the amount I would have to pay in taxes; so I do not sell it.

Senator **JONES**. What I wish to understand is your intention, whether you wish to part with the right to the water in that ditch to the owners of the adjacent lands, permitting them to have the water from year to year. I would like to know your intention if you have no objection.

Mr. **STEVENSON**. The Fayette River, out of which this ditch comes, has an immense amount of water in it. There is no monopoly of the water at all. But there were two or three of us who started in and took up some desert land down there, and we took a section apiece. After we got the ditch partly done, the other parties thought it would cost too much, and they sold out to us. So that we have the ditch and the land there. I did not make any arrangements about the selling of water.

Senator JONES. Your prime purpose was to reclaim this land?

Mr. STEVENSON. Yes; they require us to have about an inch to the acre, require us to provide that.

Senator JONES. But you have a little over 2,200 acres of land yourself?

Mr. STEVENSON. Yes.

Senator JONES. And you have water enough for 40,000 acres?

Mr. STEVENSON. The ditch would have to be enlarged to cover that amount of land. But if there were any monopoly of the water and no water there but this, then I would see the point in your question. But there is nothing to hinder anybody from getting the water out of the river.

Senator JONES. What I am trying to bring out is whether you are willing to sell the right to the water; whether, if I owned adjacent land to that ditch, you would sell me outright water enough to irrigate my land—make a contract, a final one, to furnish it to me from year to year? Under the water laws of the Territory you are under no obligation to supply water unless you wish to do so. I wanted to know what your purpose was. I will state freely that I think the right to the water ought to go with the land. I do not think one person should be permitted to prevent another getting the water, and my inquiry looks to the reason for constructing ditches in this country; not specially in your case, but the general drift of the whole business.

Mr. STEVENSON. In some localities they have built ditches and have been selling the water. So far as my experience goes the men who have built ditches have not found it profitable.

Senator JONES. Do they sell water?

Mr. STEVENSON. Over here on the river they charge so much per acre to irrigate the land.

Senator JONES. And that gives a man the right to have the water for a year?

Mr. STEVENSON. Yes.

The CHAIRMAN. Does he buy a perpetual right, or is it yearly?

Mr. STEVENSON. Yearly.

Senator JONES. Then the owner of the ditch can cut him off if he should choose to do so?

Mr. STEVENSON. Yes.

Senator JONES. Does the owner of the ditch fix the price for the water?

Mr. STEVENSON. No.

Senator JONES. But he has the right to close out the users?

Mr. STEVENSON. Yes, all of them.

Senator JONES. What is the yield per acre of grain-growing land in this country?

Mr. STEVENSON. I think 40 bushels to the acre is a good fair yield, and 50 bushels of oats on irrigated land.

Senator JONES. Is the expense of cultivating an irrigated crop greater than the expense where it is not irrigated?

Mr. STEVENSON. Yes.

Senator JONES. In what does that expense consist?

Mr. STEVENSON. In the irrigation. I suppose one man, if he had his land properly fixed and it was principally in grass, could irrigate 100 acres. If he had it in different kinds of crops he could not irrigate more than 40 acres.

Senator JONES. Is it irrigated by flooding?

Mr. STEVENSON. If it be in grass it is; but in vegetables it is in rows.

Senator **Jones**. Have you the water through the fields in a permainent way, or do you every year have to construct your apparatus for dstributing the water?

Mr. **Stevenson**. It is temporary.

Senator **Jones**. That is one of the expenses of cultivating crops?

Mr. **Stevenson**. Yes, one of the expenses.

Senator **Jones**. What kinds of crops are cultivated in this valley contiguous to this town?

Mr. **Stevenson**. Wheat, oats, barley, potatoes, some corn, and all kinds of vegetables and fruits.

Senator **Jones**. Of grass and hay crops what kinds?

Mr. **Stevenson**. Clover, timothy, orchard-grass, and alfalfa.

Senator **Jones**. I believe you said something of the yield of red clover on some of these fields. Can you make any statement about the yield of alfalfa and timothy?

Mr. **Stevenson**. Of alfalfa you can cut 2½ tons to the acre. But I have known two instances where they have cut 10 tons a year from an acre.

Senator **Jones**. That is an extraordinary yield, I suppose?

Mr. **Stevenson**. Yes, I think it is.

Senator **Jones**. What would you consider a fair average yield?

Mr. **Stevenson**. Six tons I would consider a fair yield.

The **Chairman**. Have you observed whether or not the cutting away of the timber on the hills has any effect upon the streams?

Mr. **Stevenson**. I presume it has, but I do not think it is perceptible to me.

The **Chairman**. It has not been perceptible in this Territory so far as your observation has gone?

Mr. **Stevenson**. No. On these streams up on the mountains, where they are very heavily timbered and not much population, the timber is set afire.

The **Chairman**. Are there forest fires raging in Idaho as well as in Montana?

Mr. **Stevenson**. Yes, and everywhere this year.

The **Chairman**. Have you any suggestion to make in regard to the management of this timber by the Government?

Mr. **Stevenson**. I think the Government should assume control of those lands and have agents to look after them, allowing the citizens to cut as much as they want to use. That, I think, would be better than the present system. These fires will destroy more timber in one year than all the settlers on the public lands in Idaho have taken. I suppose they will this year.

STATEMENT OF MILTON KELLY, OF BOISÉ CITY.

The **Chairman**. How long have you resided here?

Mr. **Kelly**. I have resided here since the fall of 1862, or at least in the Territory. I have resided here a portion of the time, and a portion in North Idaho. I am well acquainted with the character of this valley—Snake River Valley.

The **Chairman**. Go on and state such facts as you may think important relating to the subject of irrigation.

Mr. **Kelly**. I want to say this first: A large portion of this valley is a lava country. It is a desert country, and will be until it is covered over with 3 or 4 feet of good soil. But there are other portions that are fine agricultural lands. Considerable of it is hilly, and that probably will never be irrigated. The agricultural lands commence on this side of the Shoshone. The first important area of land is at Mountain Home here. No water can be brought onto that land except it be brought from the Boisé River, or be saved in lakes and ponds from Cañon Creek or Rattlesnake Creek. It would be a great object to save that water and distribute it over that area of land, which is fine agricultural land.

The **CHAIRMAN**. Do those lakes flow a large amount of water in flood time?

Mr. **KELLY**. Yes; but nearly dry up in the dry part of the season. I am talking of this side of Snake River; I will talk of the other side after awhile.

When we get below here on the south side of the Boisé River, until we get nearly opposite this point, we have this plain that is north or west of the railroad on which you entered the city. It extends down to the Snake River. That area of country is 12 or 15 miles wide and some 30 miles long. It is fine agricultural land if it were covered with water. The water to be put on that land must be taken from the Boisé River. I estimate that portion of the country to-day would employ, if it were improved as it may be, at least five thousand laborers more than are there. I do not mean children and families, I mean that many laborers, hard laborers, would be employed to cultivate the land. That is the portion of land that ought to receive your attention. It is in this county.

The next arable land that needs irrigation is the land on this side of the Boisé River, and from here down below Middleton, some 25 miles. It needs water on it. There has been some taken out by the farmers, but there has been no heavy ditch taken out. There is a large area of land lying there, and it is as good land as this in Boisé City, and it has never been watered. If that land were watered it would employ all of three thousand more laborers than we have.

Below this place, where I say the town of Middleton is, on the north side of the Boisé River, is another area of land. If we had a map of the county I could show it to you, so that you could understand it.

The **CHAIRMAN**. We understand it very well. We have already been over a considerable area of the Northwest.

Mr. **KELLY**. It needs water very much. They have taken out a ditch there to cover considerable of the land. But that will employ a good many laborers when it is cultivated. Then on the Payette River, of which Governor Stevenson was speaking, on the south side of that river eight of us tried to build a ditch, and we spent $20,000. Finding that it would take $50,000 the ditch lies in abeyance. We have given it to the settlers—a ditch we dug 30 miles long. There is a large area below this that we were not able to reach, or thought we were not. We did not abandon the enterprise, but we had to abandon the land and give up our money. There is a large area, fifty sections, of land there which is probably as fine land as is in this country, but it needs a ditch. And there is on the north side a large area of fine land that needs to be irrigated. I do not know how many sections there are—thirty or forty sections; probably fifty. I have been over it a number of times, but I do not want to make an estimate of the land. On those sections of land of which I speak we could employ in raising fruits, vegetables and grain, etc., at least, ten thousand laborers; and if we could get favorable rates with the railroad we could find a market for the products.

I would like to ask you what the Government intends to do for us. I want to know what is the object of this irrigation survey.

The **Chairman**. The object is to ascertain how much desert land there is, how important a question it is, what can be done in the way of getting information for the Government and for the people, so that the people may be able to utilize what they have, estimating the cost of constructing reservoirs and ditches, reservoir sites, etc. I do not know that the Government will continue to do that. It has commenced to do it, and we are investigating the matter to see whether it ought to be continued.

STATEMENT OF A. D. FOOTE, OF THE U. S. GEOLOGICAL SURVEY.

The **Chairman**. What is your occupation?

Mr. **Foote**. I am a civil engineer, in charge of the Idaho division of the Irrigation Survey.

The **Chairman**. You have been engaged in making some preliminary examinations of the Snake River and the lands that may be improved by it? State in your own way the result of your investigations in this portion of Idaho, or such portions as you have examined. State what you found, what land can be irrigated, what water is to be gotten, and how.

Mr. **Foote**. Taking the Snake River Valley and beginning at the lower portion. From my knowledge of the country, obtained before I was in the Government service and since, I should commence with the Weiser River Valley. The Weiser River will supply sufficient water with storage capacity, and I am confident the storage capacity can be found. Then the Payette River furnishes one of the best streams for water outside of the Snake, and the large lakes at its head make the storage of water there a matter of absolute certainty, and at very small cost.

The next is above the Boisé, which has some 400,000 acres of irrigable land and water supply sufficient for a full supply for about sixty days each year for irrigation, and from actual surveys is known to have ample storage room to furnish water for the balance of the year.

The **Chairman**. Are there good storage facilities on the Boisé?

Mr. **Foote**. Yes; the location found by actual surveys.

The **Chairman**. To supply all the land that can be covered by its flow?

Mr. **Foote**. Yes; to supply all the land that can be covered by its flow. I do not know how many acres are in Camas Prairie.

The **Chairman**. The stream goes down and empties into the Snake, does it not?

Mr. **Foote**. Yes; it is pretty high, and it is difficult to say how large an area can be irrigated there. I do not know, but I think there are 150,000 acres in Camas Prairie, of which a large portion, not to exceed 25,000 acres, can be irrigated by storage. There is a little natural supply, but the land lies in such a position that it gets very little irrigation.

The **Chairman**. Can it be reached by Snake River direct?

Mr. **Foote**. No; it is too high. There is not much drainage into it. The Boisé River furnishes water for about 75,000 acres without storage. That is, the land that lies immediately under it.

The **Chairman**. Do you meet with the basaltic rock on that side?

Mr. **Foote**. Yes. The extent of country between the Boisé Valley, running all the way up the Snake River to Eagle Rock, is covered more or less with lava. About two-thirds of it is most excellent land, and can be covered by a canal, probably, starting near Eagle Rock.

Senator JONES. Is that land which you call excellent covered with lava?

Mr. FOOTE. No; the lava is underneath that which is excellent.

Senator JONES. You mean it is underlaid with lava?

Mr. FOOTE. More or less of it is covered with lava.

Senator JONES. Where it underlies the ground it is worthless?

Mr. FOOTE. No; where it overlays it is worthless. It is very valuable land where it is underlaid; the richest that we have. I do not know how many acres we have in that strip. It could be supplied from the Snake; and northward from that, still further up the river, is a tract which can be supplied with storage to a great extent from Lost River, Camas Creek, Birch Creek, and upper waters of the Snake. Above Eagle Rock the land can be supplied by the Snake and other rivers. From canals actually constructed and actual surveys it is known that a district consisting of 500,000 acres, lying on the south side of the Snake and above the American Falls, can be covered. This estimate is based upon actual surveys and ditches constructed at the present time. That area can be covered by the waters from the Snake River and its tributaries. From actual surveys it is known that there is storage capacity on the Payette, Weiser, and Boisé Rivers. The lowest measurement of the Snake River at Eagle Rock, in this valley, is about 5,000 cubic feet per second, and from actual surveys we know at this time that there are reservoir facilities for 5,000,000 acre-feet.

The CHAIRMAN. That is a foot deep covering 5,000,000 acres each way?

Mr. FOOTE. Yes. And we have reason to believe that that quantity can be nearly or quite doubled. And there is a tract of land of 50,000 acres to be irrigated from the Owyhee River.

The CHAIRMAN. Where is that situated, in this Territory or in Oregon?

Mr. FOOTE. That is in Oregon.

The CHAIRMAN. It is in this great valley.

Mr. FOOTE. Yes. The Owyhee is a tributary of the Snake. And on the Malheur I do not know how many acres there are. That I shall have to find out, but as yet I have not been in that country.

The CHAIRMAN. How long have you been specially engaged in making these general examinations for the Government?

Mr. FOOTE. It is only three months.

The CHAIRMAN. Then your knowledge comes from your previous experience?

Mr. FOOTE. Most of my knowledge I had before I was employed by the Government.

The CHAIRMAN. Of course, you have not examined it critically, but what amount of land do you estimate can be irrigated from the Snake River and its tributaries?

Mr. FOOTE. I did not have the maps to make that estimate, and I will have to give you that later.

The CHAIRMAN. Can you state whether or not there could be sufficient water stored at a reasonable cost to irrigate the land of which you have spoken?

Mr. FOOTE. From my own knowledge and that obtained from others I am prepared to state that a sufficient amount of water can be stored to cover 5,000,000 acres of land in the Snake River Valley, at a storage cost of less than a half dollar an acre.

Senator JONES. That is the item of storage alone?

Mr. FOOTE. That is the item of storage alone.

The CHAIRMAN. In some places the construction of reservoirs would cost more and in some less?

Mr. FOOTE. Yes; but it would not average more than that sum.

Senator REAGAN. Do you mean general ditches or ditches for distribution?

Mr. FOOTE. The ditches in addition to that would be from $3 to $6.

The CHAIRMAN. Would it go higher than $5 or $6?

Mr. FOOTE. I would not look at any enterprise that would cost more than that.

The CHAIRMAN. What would you estimate to be the cost of irrigating these 5,000,000 acres?

Mr. FOOTE. From my experience I would estimate, and very closely too, that a million acres can be irrigated for $2 an acre.

The CHAIRMAN. Do you add a half-dollar to that for storage?

Mr. FOOTE. No; that is including the storage. But for the rest of the 5,000,000 acres I do not think we can do it for twice that.

The CHAIRMAN. Do you think you can do it for $5 an acre?

Mr. FOOTE. Yes; between $4 and $5 is the estimate.

The CHAIRMAN. Then 1,000,000 acres of the five can be irrigated at $2 an acre?

Mr. FOOTE. Yes.

The CHAIRMAN. And for the other 4,000,000 acres what?

Mr. FOOTE. I think it can be done for $5 an acre. Our water all comes in one big stream.

Senator JONES. Are there 5,000,000 acres of land to which water could be carried?

Mr. FOOTE. Yes; there are six.

The CHAIRMAN. You can not state whether you can reach six million acres?

Mr. FOOTE. I cannot state that positively.

The CHAIRMAN. What is your opinion?

Mr. FOOTE. It is my opinion that we can without any doubt.

The CHAIRMAN. Do you think you can reclaim 6,000,000 acres of this valley?

Mr. FOOTE. I think so. I think next year, if we have a chance, we can prove that.

Senator JONES. Will those 6,000,000 acres include all the irrigable land in the country?

Mr. FOOTE. Practically. The surveyor-general was just telling me that the northern counties would need irrigation. The Bear River is not included in this estimate at all.

Senator JONES. You have not estimated the amount of land in that valley?

Mr. FOOTE. No; we have nothing to do with that. That drains the other way, out of my basin.

Senator JONES. You have estimated what?

Mr. FOOTE. The drainage into the Snake River.

The CHAIRMAN. What proportion of the Territory does not drain into the Snake River?

Mr. FOOTE. I do not know how much irrigable land is in that Territory north; they say none. I do not know anything about it.

The CHAIRMAN. You have not examined that?

Mr. FOOTE. No. In the Bear Lake country I know there is a good deal of land to be irrigated.

The CHAIRMAN. You do not include Bear Lake in your estimates?

Mr. FOOTE. No; I include only the Snake River Valley.

The CHAIRMAN. Do you include in that estimate the small valleys back in the mountains that need irrigation?

Mr. FOOTE. If they flow into the Snake River.

The CHAIRMAN. In places, in carrying out your scheme to complete it, will there be small ditches and reservoirs necessary—ditches that would be independent of the large ones?

Mr. FOOTE. Yes; I should think it would encourage just those things.

The CHAIRMAN. From your examination of the country state whether all the enterprises are large, or some large and some small?

Mr. FOOTE. It includes all.

The CHAIRMAN. Are there many small enterprises?

Mr. FOOTE. I think a great many. There are too many altogether of the small ones for an economical use of water.

Senator JONES. What Senator Stewart wishes to know is, whether or not in this Snake River basin there are many localities where irrigation could be practiced, the water brought on to small tracts of land all along, before organizing big companies and having long and expensive ditches?

The CHAIRMAN. I do not want to have it stated that they go along the river; I wish you to state whether or not there are small places where water can be used instead of taking it out of the rivers and wasting it.

Mr. FOOTE. Yes; there are a great many small ditches taken out of the irrigating streams that irrigate all the land. It would not be taken out of the large streams. Every stream along the southern line of this Territory would carry a little water; but there might be a reservoir to store the water, and each one of them would irrigate a good deal of land in addition to what the large one would irrigate. They would run further up the stream than the large canal.

The CHAIRMAN. When this survey shall have been completed, tell whether or not there will be places outside of that big stream.

Mr. FOOTE. Yes; a good many of them, and we do not allow anything in these tributary streams except what I have named.

The CHAIRMAN. They can make their small storage reservoirs in the foothills above and cultivate the small patches of land without interfering with your scheme?

Mr. FOOTE. Yes.

Senator JONES. Those things could be done at a comparatively small expense, I presume?

Mr. FOOTE. Yes; in fact are all nearly done. Perhaps I had better explain our method of irrigation. Where the ground is not already known, where lines have not been already run, but where a tract of land can be covered, our general plan is to run lines for large canals around the valley and see just how much land can be covered and how much water will be required. But in places like the Boisé and Payette the surveys have been already made, and there we can tell almost how many acres of land and how much water will be needed to irrigate the land with the cost attached.

To the north of Eagle Rock, the South Fork, the canals have been already constructed to a large extent, and they can be enlarged. We know what has been done there, and how much water it will take. But there is a good opportunity to take water out of the Snake River. We put a line there and made our estimates as we went along. We run down 74 miles of line with the necessary drop into Blackfoot River, just as though we were going to construct a canal, and there 200,000 acres of land can be reclaimed for $230,000. That much is settled. Our plan is to go clear around the valley in that way, so that the Government may be able to show to anybody what can be done in the valley.

The CHAIRMAN. Have you any storage reservoirs at the headwaters of the Snake River, reservoirs which you can name?

Mr. FOOTE. I want to make a more thorough reconnaissance before I testify on that point.

The CHAIRMAN. We do not ask for detail?

Mr. FOOTE. I have been up there, and I can say that the opportunities for storing water are something enormous. The lakes there are so formed that there is a great drainage into them.

The CHAIRMAN. Is there a large number of lakes up there?

Mr. FOOTE. Yes.

The CHAIRMAN. Of much size?

Mr. FOOTE. Some of them 25 or 30 miles long.

The CHAIRMAN. About what altitude?

Mr. FOOTE. Six, seven, or eight thousand feet.

The CHAIRMAN. Where there is deep snow-fall and deep woods?

Mr. FOOTE. Yes.

The CHAIRMAN. Do those lakes drain down pretty low, or do they contain water through the whole season? How as to the rise and fall of those lakes?

Mr. FOOTE. They do not rise much, because the water runs out as fast as it gets in. But every basin of which I speak has a reservoir, and dams should be put in to make the water rise. I know of one place where there are meadows, basins of natural lakes scattered around, where 50 feet of water in depth could be stored at a cost not to exceed $100,000.

The CHAIRMAN. Are there any inhabitants around it?

Mr. FOOTE. Not at the present time. I know of other things better than that, larger than that.

The CHAIRMAN. Are many of them obstructed by claims at this time?

Mr. FOOTE. I think not any; very few. They are too high. The snow is too deep for the people to live there with their cattle. This year being a dry year they have gone in there and are feeding their cattle.

Senator JONES. These lakes of which you speak are all at the head of the Snake River?

Mr. FOOTE. Yes.

Senator REAGAN. I understood you to say that you had been engaged in this irrigation survey as a Government employé for three months.

Mr. FOOTE. Since the middle of May.

Senator REAGAN. Were you previously to that time surveying for canals in this country?

Mr. FOOTE. Yes.

Senator REAGAN. But not on Government account?

Mr. FOOTE. No, on private account.

Senator REAGAN. Do you find difficulty in separating your work done on private account from that done on Government account?

Mr. FOOTE. I am not doing any private work now. No one is allowed to do it when in Government employ.

Director POWELL. I know the survey is not yet completed, but give us an idea of Jackson Lake as a reservoir.

Mr. FOOTE. My notes give it as 30 miles long, from 5 to 8 miles wide, and by means of a dam the water can be made to rise 50 feet. That can be built for $250,000 or less, and it will give an area of 150 square miles and a capacity of 5,000,000 acre-feet. It is my intention to go and prove my work.

Senator **Jones**. That is one lake.

Mr. **Foote**. One lake.

The **Chairman**. Is the snow-fall sufficient there?

Mr. **Foote**. Yes, if it be half what they call it, 8 feet. If it be 4 feet it will fill the lake twice every year. You see the drainage is away up in the middle of the National Park.

The **Chairman**. Would it interfere with the National Park if it were dammed?

Mr. **Foote**. No; it is too far below.

Senator **Reagan**. State how many different plans of irrigation have been adopted along the valley of the Snake and Boisé Rivers and these other streams; how many different enterprises are now in operation.

Mr. **Foote**. There are a good many of them. They are building them everywhere.

STATEMENT OF L. F. CARTEE, OF BOISE CITY.

The **Chairman**. How long have you resided in Boisé?

Mr. **Cartee**. I came here in the spring of 1863 and have been in the Territory ever since.

The **Chairman**. Explain the results of irrigation in this vicinity.

Mr. **Cartee**. The best explanation that can be given is the fruit and vegetables which you see around you.

The **Chairman**. What do you see around us?

Mr. **Cartee**. This sage-brush land is capable of producing anything that can be raised in this latitude anywhere, not only all the varieties of fruits, but of all the cereals.

The **Chairman**. Describe the cereals and fruits that are raised here, giving the quantity, character, etc.

Mr. **Cartee**. I do not know how I can answer your question better than to say that we raise all kinds of fruits, nearly—apples, pears, peaches, and grapes. I have forty different varieties of grapes on my place, and they nearly all ripen, except the Catawba. That does not ripen because of the shortness of the season.

The **Chairman**. You say this land produces a grape of a good quality?

Mr. **Cartee**. A fair quality; better than any of the eastern grapes that we have. Of course, the quality is not equal to the California grape.

The **Chairman**. You have been surveyor-general of the Territory?

Mr. **Cartee**. Yes, for fourteen years.

The **Chairman**. And you have been farming yourself?

Mr. **Cartee**. Yes.

The **Chairman**. What is a fair crop of wheat here on irrigated land?

Mr. **Cartee**. From 25 to 50 bushels.

The **Chairman**. What is a fair crop of oats?

Mr. **Cartee**. From 30 to 60 bushels; occasionally 70 to 80 bushels, but that is exceptional.

The **Chairman**. How is barley?

Mr. **Cartee**. The same as wheat—25 to 50 bushels.

The **Chairman**. And timothy hay?

Mr. **Cartee**. On an average of about 2 tons to the acre.

The **Chairman**. And alfalfa?

Mr. **Cartee.** Six tons.

The **Chairman.** How about red clover?

Mr. **Cartee.** About the same as alfalfa, about 6 tons.

The **Chairman.** And your potatoes?

Mr. **Cartee.** Well, probably 600 bushels to the acre is a fair aggregate.

The **Chairman.** Is this land here good land for raising apples?

Mr. **Cartee.** It is first rate. It is the finest apple country in the world.

The **Chairman.** What varieties of apples do you raise?

Mr. **Cartee.** All apples do well here; you can hardly find an exception.

The **Chairman.** Do they grow to a large size?

Mr. **Cartee.** Very large.

The **Chairman.** Are the trees heavily loaded?

Mr. **Cartee.** Too heavily loaded.

The **Chairman.** Do you raise peaches?

Mr. **Cartee.** Yes.

The **Chairman.** How do they grow?

Mr. **Cartee.** They grow well.

The **Chairman.** How about prunes?

Mr. **Cartee.** Plums and prunes do remarkably well, better than in any country in which I have been.

The **Chairman.** And pears?

Mr. **Cartee.** Pears are very good.

The **Chairman.** Do you raise all varieties of pears?

Mr. **Cartee.** Yes, there is very little difference in the result. I have never made a failure of any variety that I have tried to cultivate, and I have made an effort with all varieties.

The **Chairman.** How are the small berries?

Mr. **Cartee.** They do finely.

The **Chairman.** And you raise all kinds?

Mr. **Cartee.** Yes.

The **Chairman.** What kind of land would be suitable for an ordinary farmer to cultivate in the highest style, irrigated, and how much would he need to support his family, well, as well as he could with a farm of 160 acres in the Mississippi valley?

Mr. **Cartee.** I would say from 25 to 40 acres.

The **Chairman.** Can a man make a living here on 25 acres of land if he cultivate it well?

Mr. **Cartee.** Yes. Our great drawback here is transportation. For instance, if we were to send a car-load of freight from here to Illinois, they will charge more than they would from San Francisco to Illinois, which is a great injustice.

Senator **Reagan.** Does the line from San Francisco to Illinois pass through this place?

Mr. **Cartee.** No.

The **Chairman.** Is this a good stock country?

Mr. **Cartee.** Very good.

The **Chairman.** What would be the condition of the farmers here if the land were under cultivation and they had the use of the hill lands for pasturage? Would they produce a large amount of meat for shipment?

Mr. **Cartee.** Yes.

The **Chairman.** If the farmers had the forage with which to fatten their cattle in the winter they could extend their meat production very largely, could they?

Mr. Cartee. Yes; and it would be really one of our best material interests.

The Chairman. It would be in a condensed form?

Mr. Cartee. Yes; and we could get it out of the country at less expense.

The Chairman. The cattle business has been the principal business here except farming?

Mr. Cartee. Yes.

The Chairman. Would that increase the reclamation of the valleys?

Mr. Cartee. Largely increase it.

The Chairman. How does the winter supply for cattle here compare with the summer supply?

Mr. Cartee. In the meat interest it has not been so good, because we have not had water range sufficient to keep up the pasturage. Our wild grasses do not stand that close feeding that they do in the east.

The Chairman. There is an abundance of summer supply?

Mr. Cartee. Yes.

The Chairman. If you had forage you think this would be a much better stock country than now?

Mr. Cartee. Of course it would be, in every sense of the word.

The Chairman. If your transportation were reasonable would you be able to ship your fruits to the Atlantic sea-board and the eastern cities?

Mr. Cartee. We could compete with our own growers; but whether we could do so with foreign growers is a question.

Senator Reagan. Where have you found a market for your fruits?

Mr. Cartee. Our large fruit market has been in the mines; but that has dropped off.

The Chairman. What character of shipment do you make to Chicago and New York?

Mr. Cartee. Probably pears of all varieties, and plums, and prunes.

The Chairman. Do you raise apricots and nectarines?

Mr. Cartee. No; apricots do not grow here.

The Chairman. Do you raise figs?

Mr. Cartee. I have raised a few—had a few trees—but the winter is too severe.

The Chairman. But pears and prunes, grapes and plums, you could ship?

Mr. Cartee. Yes. I sent up this morning some five or six different varieties of prunes.

The Chairman. You wish to say something further in regard to irrigation. Will you state any fact which may have occurred in your experience material to this subject?

Mr. Cartee. My idea of this subject of irrigation is that the waters of Snake River are not so available for any section west of Wood River or Bruneau, because the expense of taking it out would involve too large an expenditure, and we have ample small streams which could be utilized by building reservoirs, and from them we could irrigate the whole plain.

The Chairman. You think that by reservoirs there is a large amount of land that might be brought under cultivation by taking the water from the small streams, and that that could be done at no great expense?

Mr. Cartee. Yes.

The Chairman. Suppose that surveys were made and the information obtained, so that the people would know what they could do, would that enable settlers to reclaim a good deal of land before entering upon the large streams?

Mr. CARTEE. A good amount of land.

The CHAIRMAN. That is your experience?

Mr. CARTEE. Yes.

The CHAIRMAN. And in that light you think that the location of reservoirs and the lines of ditches would be undertaken by settlers before the large ditch would be constructed?

Mr. CARTEE. Yes.

The CHAIRMAN. Is that your knowledge, so far as the balance of the country is concerned?

Mr. CARTEE. Yes.

The CHAIRMAN. So that there would be important results from the surveys in the way of encouraging settlement?

Mr. CARTEE. Yes. Take Cañon Creek, which can not be forded in the spring. There is a lake there that would be 20 miles long.

The CHAIRMAN. Is there a large amount of land below it?

Mr. CARTEE. Yes, all the Rattlesnake country between here and what we call The Butte.

STATEMENT OF EPHRAIM SMITH, OF BOISÉ CITY.

Senator JONES (indicating a branch of a peach-tree in the display of fruit and vegetables that were gathered for the inspection of the committee). Have you measured that branch and counted the number of peaches on it?

Mr. SMITH. Yes.

Senator JONES. How many peaches are on it?

Mr. SMITH. The limb is 2 feet in length and it has on it twenty-nine peaches.

Senator JONES. This [exhibiting] is a peach off that limb?

Mr. SMITH. Yes.

Senator JONES. I find that it measures 8½ inches one way and 8¾ the other way. Do you know the name of this peach?

Mr. SMITH. I do not.

Senator JONES. Do you know its quality?

Mr. SMITH. It is a freestone, yellow peach, the yellow freestone.

Senator JONES. You measured at my request the branch of a plum tree containing some plums.

Mr. SMITH. Yes.

Senator JONES. With what result?

Mr. SMITH. There are twenty-seven plums on the branch and the branch is 14 inches long.

Senator JONES. This [exhibiting] is one of the plums from off that branch?

Mr. SMITH. Yes.

Senator JONES. It measures 6 inches one way and 7 inches the other?

Mr. SMITH. That is right.

Senator JONES. Here is another plum of the same variety. That measures 7¾ inches one way and 7¼ the other.

Mr. SMITH. That is right.

Senator JONES. How many varieties of plums have you on exhibition here?

Mr. SMITH. I think there are something like thirteen varieties. That is what I and another gentleman made them out to be.

Senator Jones. Here is a blue plum. Measure that branch and state its length and the approximate sizes of the plums.

Mr. Smith (after measuring). The branch is 11 inches long and has on it fifteen plums.

Senator Jones. And the plums are almost as large as these that have been measured?

Mr. Smith. Yes.

Senator Reagan. What is the name of that plum?

Mr. Smith. That is the blue-gage plum.

Senator Jones (exhibiting). Here are some of the same kind. I do not know whether they came off that limb or not; but they are larger than any we have measured except one. This is 6¾ inches one way and 6¼ inches the other.

Mr. Smith. Yes.

Senator Jones. This apple I have here is 15½ inches one way and about 14 inches the other?

Mr. Smith. Yes.

Senator Reagan. What variety of apple is that?

Mr. Smith. I do not know the name of that. General Cartee, do you know the name of this large apple?

General Cartee. That is the Gloria Munda.

Senator Jones. I have here a pear that measures one way 11½ inches and 10½ the other. Then there are a large number of varieties of peaches equal in size, color, and flavor to those already described, and also a number of varieties of apples of various sizes and of beautiful appearance, which are not to be surpassed anywhere. I have measured another plum. What is the length of that branch from which this plum was taken [exhibiting]?

Mr. Smith (after measuring). It is 1 foot in length.

Senator Jones. How many plums are on that branch?

Mr. Smith. Sixty-three plums.

Senator Jones. And they are more than an inch long by an inch in diameter, I should say.

Mr. Smith. Yes; the plum itself is.

Senator Jones. Of that variety one is 4 inches one way by 4 the other?

Mr. Smith. I want to make a statement here in regard to some corn that I raised in the corporation limits. I raised some corn the stalk of which was 22 feet in length and had on it six ears, and the lowest ear was about 6 feet from the ground. The stalk we had to chop down with an ax. That corn was taken to the fair at New Orleans and it was a pride to look at it.

Senator Reagan. Was that the Spanish seed?

Mr. Smith. I got it from Illinois. It is the horse-tooth gourd-seed. That is what they sent it to me for. I raised a squash (a pumpkin) in my garden that weighed 85 pounds; but there was one brought up from Dixie Valley that weighed 118 pounds. The winesap, and other apples keep here sixteen months.

The Chairman. What is the difference between the land here without water and land with it—what transformation takes place?

Mr. Smith. On land without water I have raised rye over half a crop. Some years I can raise a pretty good crop. I have been at it some time.

The Chairman. Can you raise other crops besides rye without irrigation?

Mr. Smith. I do not know that we can. I have tested other crops but have failed. But land that is cultivated and has plenty of water on it is worth from $100 to $125 down to $30 and $50, and so on.

The **CHAIRMAN.** How much land ought a farmer who works it himself have to support his wife and family, compared with farms in Illinois and other States?

Mr. **SMITH.** If a man has plenty of water he can support himself and family and make some money on 80 acres. A hundred acres would be abundant land for a large family. Our farmers here do not work their farms right; they let the brush grow up; they are cultivating brush and briars. We have a pretty good set of farmers, but I do not think they are up to the farmers of other countries.

The **CHAIRMAN.** Does a man need the same amount of land where it is irrigated that he would in a country where they do not irrigate?

Mr. **SMITH.** I think not, because on every inch of land you can grow something—wherever you put the water. You can grow vegetables where the roots go into the ground. I have seen them weighing from 40 to 50 pounds—a mangel-wurzel beet; carrots and parsnips grow here to an immense size, and the ruta-baga turnip would astonish you. I brought in some vegetables this morning that would astonish you, and it is right in the middle of the season.

Senator **JONES.** How do your potatoes compare with the potatoes grown in the East?

Mr. **SMITH.** It is said by the people from the East that we grow the best potatoes—better than anywhere else.

Senator **JONES.** Are you a practical fruit-grower?

Mr. **SMITH.** Well, I have been at it more or less.

Senator **JONES.** Is this exhibit which is here to-day a picked exhibit or is it a fair one?

Mr. **SMITH.** It is a fair example of what we can do. I have in my own neighborhood enough to show that it is not a picked exhibit. I had better peaches, but I did not bring them.

Senator **JONES.** I wish to ask you about your fruit crops.

Mr. **SMITH.** I have been here twenty-six years, and since I started—since the trees were three years old—I have always had enough for my own use and some to sell.

Senator **JONES.** How about your peach crop? Is it likely to be killed by frost?

Mr. **SMITH.** It never has been but once or twice since I have been here.

Senator **JONES.** Do you raise pears and apples easily?

Mr. **SMITH.** Yes, sir.

Senator **JONES.** Do these beautiful flowers which we see here grow in this neighborhood?

Mr. **SMITH.** Most of them grow in my garden, and I brought those you have before you. But they grow in all the private gardens here.

The **CHAIRMAN.** How does continuous cropping affect the land?

Mr. **SMITH.** I have been here some twenty-six years, and I have seen no difference. The farms grow as good crops as they ever did.

The **CHAIRMAN.** After continuous croping?

Mr. **SMITH.** Yes; and there is a place called Poverty Valley, below here, and you can go by there and you will see nothing but fences for miles, and all the land in grain, and as much will be cut off that land this year as was ever cut before.

The **CHAIRMAN.** Do you think irrigation tends to fertilize the land?

Mr. **SMITH.** It is my experience that it keeps the land in order. By irrigating it is almost like putting on dressing. The water coming from the mountains is filled with sediment that lodges on the ground.

The **CHAIRMAN**. Since this place was settled there has been no diminution in the crops?

Mr. **SMITH**. Not in consequence of the use of the ground.

STATEMENT OF T. A. STARRH, OF CASSIA COUNTY.

The **CHAIRMAN**. In what direction is Cassia County from here?

Mr. **STARRH**. South from here and about 60 miles east.

The **CHAIRMAN**. Is it on the waters flowing into the Snake River?

Mr. **STARRH**. Yes.

The **CHAIRMAN**. Is there any irrigation practiced in that county?

Mr. **STARRH**. Yes; we have between 35,000 and 40,000 acres now under irrigation.

The **CHAIRMAN**. With what success?

Mr. **STARRH**. Until this year with very good success.

The **CHAIRMAN**. This year there had been a deficiency of water.

Mr. **STARRH**. Yes.

The **CHAIRMAN**. How do the crops in Cassia County compare with those around Boisé?

Mr. **STARRH**. Very good.

The **CHAIRMAN**. Can you raise all sorts of fruit and grain as are raised here?

Mr. **STARRH**. Yes.

The **CHAIRMAN**. How about cattle?

Mr. **STARRH**. It is very good in that direction.

The **CHAIRMAN**. Do you irrigate from the Snake River or its tributaries?

Mr. **STARRH**. Its tributaries.

The **CHAIRMAN**. From what streams do you irrigate?

Mr. **STARRH**. Rock Creek, Dry Creek, Goose Creek, Marsh Creek, Cache Creek, and Raft River.

The **CHAIRMAN**. Are these large or small streams?

Mr. **STARRH**. Raft River, during the season, will carry 45,000 inches of water.

The **CHAIRMAN**. How about Cache Creek?

Mr. **STARRH**. Twenty-five thousand inches.

The **CHAIRMAN**. And Marsh Creek?

Mr. **STARRH**. Marsh Creek will carry 15,000 inches of water.

The **CHAIRMAN**. Does any of this water run to waste in flood-time?

Mr. **STARRH**. It all runs to waste from December until about the 1st of May.

The **CHAIRMAN**. If the water were stored so that you had the whole of it in the proper season, would you be deficient in water there at any time?

Mr. **STARRH**. I think we could increase the acreage 60,000 acres if we had a way of storing the water, and each one would have more water than he has now.

The **CHAIRMAN**. Would surveys showing where reservoirs could be made with estimates of cost of construction be of any use in enabling the people to increase their water supply?

Mr. **STARRH**. I think so.

The **CHAIRMAN**. Would it open a chance for settlement?

Mr. **STARRH**. It would increase the present settlement.

The **CHAIRMAN.** You say there would be a chance for new farms if these things were known?

Mr. STARRH. Yes. It is higher land than the canals would meet.

The **CHAIRMAN.** There are places for storing water—ravines along the water-courses?

Mr. STARRH. Yes, we have some natural lakes.

The **CHAIRMAN.** They could be dammed or cut down?

Mr. STARRH. Yes, so as to increase the storage.

The **CHAIRMAN.** Or the outlet might be lowered?

Mr. STARRH. It would not be best to do that. They are the sources of other streams, and it would be better to dam them.

The **CHAIRMAN.** Are there any other facts in regard to your section that you would like to state?

Mr. STARRH. I would like to say that we have four or five thousand acres of land in our county that could be redeemed by a canal in addition to Snake River.

The **CHAIRMAN.** That is irrigated from the other streams of which you spoke?

Mr. STARRH. Yes.

The **CHAIRMAN.** And that might be increased 60,000 acres more by storage reservoirs?

Mr. STARRH. Yes.

The **CHAIRMAN.** And even more than that?

Mr. STARRH. Yes, that is a small estimate.

STATEMENT OF DELEGATE FRED T. DUBOIS, OF BOISÉ CITY.

The **CHAIRMAN.** As you have been frequently over the Territory, you may make a statement in regard to the arable land that it contains, what amount there is of it, and the facilities there are for irrigating it.

Mr. DUBOIS. I am not prepared to make a detailed statement, but I will say this in a general way, that I have traveled on horseback and in wagon over the entire Territory. I have been in every county and in almost all parts of every county, and my general observation is that there are fair streams in almost all sections, and there are immense plains, all reasonably level, and it is sage brush land. There is only one section of the Territory, that which is in the south center, which is covered with outcroppings of lava rock, and that seems to me to be entirely useless. Of course, I am not speaking as an engineer, but it would strike me, having been through Utah and countries which have been irrigated, that with a proper outlay, and not a very large outlay either, one-quarter of the Territory could be made productive, could be brought under cultivation.

The **CHAIRMAN.** How many acres are there in the Territory?

Mr. DUBOIS. Between 54,000,000 and 55,000,000 acres in the Territory.

The **CHAIRMAN.** And you estimate that one-fourth of that could be brought under cultivation?

Mr. DUBOIS. I estimate that between 12,000,000 and 15,000,000 acres of land in this Territory, taking it all together, could be brought under cultivation.

The **CHAIRMAN.** In passing over these mountains and the foot-hills and valleys, have you had your mind upon the question of whether or not small farmers could store water in the lakes and marshy places, the coulées and ravines?

Mr. **Dubois**. Not since I made a speech in Congress on the subject. Since then I have not traveled over the country much. But I have tried to refresh my mind since then. When I traveled over the Territory I did not have that in mind, but I can think of numerous places—some places at any rate.

Let me say, in passing, that there is one portion of the Territory which has not been touched upon at all, and yet I am not prepared myself to enter upon a discussion of it in detail. That is the southeastern portion, where Beaver Lake is. There, I should think, would be a good place for a natural reservoir where an immense lot of water could be stored without trouble. And I will say this, that most of our valleys are surrounded by mountains, and pretty high mountains, too, where snow falls. So that when you get your reservoirs in these valleys you can run the water down.

The **Chairman**. Suppose an accurate survey, showing the places for reservoirs, with estimates of the cost of construction, were made, what would be the effect of that before taking out the Snake River? Is there a section of country that could be taken up by settlers without much outlay?

Mr. **Dubois**. I think so. I think there are natural places which, with a small outlay, could be brought to such a condition that people could go in and without being dependent on immense canals and an immense outlay of money.

The **Chairman**. How would the lands on which they could go compare with the other lands in the valley?

Mr. **Dubois**. I should think they would be just as good as the main valleys. But I am not speaking as an expert.

STATEMENT OF JOSEPH C. RICH, OF BEAR LAKE COUNTY.

The **Chairman**. Are you a farmer?

Mr. **Rich**. No, I am not a farmer.

The **Chairman**. Have you observed the effects of irrigation down in Bear Lake County?

Mr. **Rich**. I have.

The **Chairman**. And have you observed to some extent the means they have there of obtaining water for that purpose?

Mr. **Rich**. Yes.

The **Chairman**. And the extent of country that might be irrigated?

Mr. **Rich**. Yes.

The **Chairman**. Give a description of that country, stating what has been done there, and what might be done.

Mr. **Rich**. Bear Lake County is, I believe, the smallest county in the Territory. The valley is 70 miles long, by from 5 to 10 miles wide. The southern part of the valley is occupied entirely by the lake, with the exception of a few small settlements, I think four, on the margin of the lake. About one-half of the lake is in Utah Territory, the north half being in Idaho.

The **Chairman**. Where does that lake discharge, in Utah or in Idaho?

Mr. **Rich**. In Idaho. The lake is about 8 miles long, and from 5 to 8 miles wide, and from 40 to 200 feet deep. It is filled with fish of the best quality.

The **Chairman**. Are there lands below it which could be irrigated?

Mr. **Rich**. The lands north of the lake and adjacent to it are very nearly on the same level with the lake, although some of the lands that are now used, by the higher water rising in the mountains, could be watered by the lake, by damming the lake and increasing its volume.

The **Chairman**. Are there any valleys that would be benefited by an increase of the water in the streams?

Mr. **Rich**. Yes. Heretofore it has annually overflowed and made a good amount of hay land. But the lake for the last two or three years has been lower than it was ever known to be before, and the water in Bear River, which receives the water from the lake, has been taken out and this season it has been entirely dry.

The **Chairman**. Was it dry in the flood season? If you had a dam would it have saved any water for this season?

Mr. **Rich**. It would have held it in the lake.

The **Chairman**. Has the water run out in flood season to any considerable extent?

Mr. **Rich**. Yes. It could be increased in depth and could be controlled. The outlet is only about 40 feet wide.

The **Chairman**. What kind of crops do you raise in that valley?

Mr. **Rich**. That valley is high; the elevation is 6,000 feet.

The **Chairman**. And you raise what kind of crops there?

Mr. **Rich**. Small grain; wheat, oats, barley, some rye, and all kinds of hardy vegetables, and grass and hay.

The **Chairman**. Is there much ground that could be brought under irrigation in your county?

Mr. **Rich**. Yes; by a system of reservoirs outside of the lake there might be probably about 40,000 acres additional brought under cultivation in that county.

The **Chairman**. Could that be obtained by a combination of citizens and without great expense?

Mr. **Rich**. I think it is rather too much for the citizens. We need some help. I will state that heretofore, until the last two or three years, Bear River has been full. But as I stated, this season it has dried up in places. For a month or two there has been no water in it. Water has been taken out above. There are some fifteen or twenty dams in Wyoming. The water can be run into the river from Bear Lake, but on this side there is what is called the rim of the Salt Lake basin, and the waters of Bear Lake will never rise high enough to bring it over that rim. There is land in Gentile Valley and Bear River Valley that can be watered by that lake.

The **Chairman**. They need it in Utah.

Mr. **Rich**. Yes.

The **Chairman**. It runs down through Cache Valley?

Mr. **Rich**. Yes.

The **Chairman**. And by storing the water it would help them down there, would it not?

Mr. **Rich**. Yes.

STATEMENT OF E. S. WHITTIER, OF SODA SPRINGS, BINGHAM COUNTY.

The **Chairman**. Is irrigation practiced in Bingham County?

Mr. **Whittier**. Yes; I own a large extent of land on Snake River, of which you have been told. But the eastern part the surveyor's report does not touch. I live in Bear River Valley, which is distinct from Snake River Valley.

The **CHAIRMAN**. Is that to be watered by the Snake River?

Mr. **WHITTIER**. No; it runs into Salt Lake.

The **CHAIRMAN**. What are the opportunities for irrigating your valley?

Mr. **WHITTIER**. They come from Bear Lake, the same lake of which Mr. Rich has been speaking.

The **CHAIRMAN**. Do you concur in his opinion, that that could be improved by making the lake a reservoir?

Mr. **WHITTIER**. My residence is some 60 miles down, in the neighborhood of Gentile Valley.

The **CHAIRMAN**. Have you plenty of water there?

Mr. **WHITTIER**. No.

The **CHAIRMAN**. Is there sufficient to bring the land under cultivation?

Mr. **WHITTIER**. There is if there were reservoirs at the lake.

The **CHAIRMAN**. Would it be expensive to make reservoirs at the lake?

Mr. **WHITTIER**. Not there; and it could be easily controlled.

The **CHAIRMAN**. Have they been troubled in Cache Valley, down below you, in Utah?

Mr. **WHITTIER**. I have been told so; but I have not been down there.

The **CHAIRMAN**. The water that passes you was not as much as usual this year.

Mr. **WHITTIER**. The water has dried up to such an extent that it has not run in the river. Parties down there having a canal enterprise on hand have been up trying to locate our lakes, saying that they were short of water.

The **CHAIRMAN**. You raise all the hardy vegetables in your section?

Mr. **WHITTIER**. I am in the general merchandise business, but I handle vegetables. We ship potatoes, fruits, and vegetables, and all kinds of grain, all over the country. The land is not good except for small fruits, but grain we raise well. We had at the agricultural fair one squash that weighed 112 pounds; and the fruits and vegetables grow proportionately large.

The **CHAIRMAN**. And you say small grain does first class?

Mr. **WHITTIER**. Yes.

The **CHAIRMAN**. How much is a fair crop of wheat?

Mr. **WHITTIER**. 36 to 40 bushels.

The **CHAIRMAN**. And of barley?

Mr. **WHITTIER**. They raise about the same as wheat. They raise from 50 to 70 bushels of oats. I would like to make a statement in regard to a certain body of land that is right close to Soda Springs, containing about three and a half townships. That has been surveyed, and the ditches have been surveyed out on to it. But the expense is a little too much for our people there. There is a body of land, about eight townships, above there favorable for irrigation, and the water, I believe, could be put on to it for $100,000; that is, according to surveys made by private parties. That land covers about eleven and a half townships.

The **CHAIRMAN**. That would be 253,000 acres, and it could be irrigated for how much?

Mr. **WHITTIER**. From the surveys that have been made it could be done for $100,000.

The **CHAIRMAN**. What would the land be worth when irrigated?

Mr. **WHITTIER**. It is a distance from market; but every foot of it would be worth $10 an acre, and a good deal of it more. The climate there is not as severe as it is north and east.

The **CHAIRMAN**. How much alfalfa could you raise on that land?

Mr. WHITTIER. Five to seven tons, and we could raise wheat and everything of that kind. It has a high elevation.

The CHAIRMAN. Is it a good stock country.

Mr. WHITTIER. Yes. The average fall of snow is never over about 8 inches.

The CHAIRMAN. What experience have you as to the effect of cutting timber on the streams?

Mr. WHITTIER. I have been district attorney for that county, and there have been 250,000 to 300,000 acres of timber burned off in that county, and I have been unable to fasten it on to anybody. We have had more timber burned off than was cut in the last twenty years.

The CHAIRMAN. Have you any suggestion to make to the Government of a policy that it could pursue, and that would tend to save the forests. If the forests should be destroyed that would be a drawback to irrigation, because they keep the snow back.

Mr. WHITTIER. The General Land Office has been assisting me, and it has been attending to that business. But the laws seem to be deficient.

The CHAIRMAN. Instead of having special agents, suppose you had local timber agents with an office in their respective localities to look after the timber. Suppose with these local agents the Government should withdraw all the timber from the market and grant permits to anybody who might wish to cut the timber and clear away the brush; do you think anything could be done in that way?

Mr. WHITTIER. It would be an advantage in the eastern and northern parts of our county. We have large bodies of timber there.

The CHAIRMAN. Do the communities get prejudiced against these special agents, or do they vary?

Mr. WHITTIER. They vary. But the special permission to cut timber would do very well.

The CHAIRMAN. Do you think the people would co-operate if you had an officer in each district to watch over the timber?

Mr. WHITTIER. I think so, provided it were not arbitrary. If the agents would co-operate with the people in respect to cutting the timber, I think they would co-operate with him, and it would do much to save timber from destruction.

The CHAIRMAN. How does the amount of timber which is cut compare with that which is burned?

Mr. WHITTIER. There has not been as much cut off in our county for twenty years as there has been burned.

STATEMENT OF JAMES HAWLEY, OF BOISÉ CITY,

The CHAIRMAN. You have heard the testimony on the subject of forest fires, and you can give us your experience in that direction.

Mr. HAWLEY. I will say in regard to forest fires that they have been in certain years very destructive, especially dry seasons, such as the the present. These fires are caused by parties setting out fires in the mountains, for camping purposes, without taking care that they do not set fire to the dry timber and underbrush, and it is almost impossible to prevent them. So far as the destruction of timber is concerned, I agree with Mr. Whittier. I am familiar with all parts of Idaho, and I can say that there has been more timber destroyed by fire during the last twenty years than was cut. That is, in the timber sections of the Territory. My idea would be that the Government should take some measures to make an appropriation in the Territories for the purpose of preserving the timber, either do it by special agent, or I think it would be better to put the appropriation in the hands of the Interior Department, subject to the orders of the governor, to be called into play in a proper way by a board of commissioners. There are very few of these fires, and if they were taken at the start, they could be kept from spreading over any extent of country. For instance, if the county had the right to call on the governor for a certain amount of money, it would be easy to start a fire into a fire and thus prevent its spread.

The **CHAIRMAN.** Would it not be better to have a Government officer in a reasonably sized district whose duty it would be to attend to the matter?

Mr. **HAWLEY.** If you could get a Government officer who belonged in the Territory and understood the wants, that would be a good thing. But the Governor of the Territory is better conversant with it than the agents would be.

The **CHAIRMAN.** How would it be to substitute a local officer, a man who lived in the district? Would not that be more effective than the present system, where a stranger is called upon to watch?

Mr. **HAWLEY.** I think much more effective.

The **CHAIRMAN.** Is there a prejudice against strangers being brought into the Territory for that purpose?

Mr. **HAWLEY.** There has been considerable prejudice in the Territory against these special agents.

The **CHAIRMAN.** Would or not the people co-operate if one of their own citizens were appointed an officer to look after the timber, with power to grant permission to cut it?

Mr. **HAWLEY.** I think they would co-operate with any one appointed from their midst; but so far as permission is concerned, I do not think it is necessary.

The **CHAIRMAN.** In the mining regions they can cut timber for certain purposes; but the question is what is the purpose?

Mr. **HAWLEY.** Yes. The United States attorney for the last four years until the last two years had occasion to settle the laws in the courts—everything affecting timber.

The **CHAIRMAN.** Would you advise the withdrawal from sale of timber land not fit for agriculture?

Mr. **HAWLEY.** No; I would advise their withdrawal from sale in certain places, and in other localities open them to sale, allowing the parties to acquire title. I would allow certain portions to be purchased. I notice in my experience that where you denude a hill by a stream the stream decreases in volume.

The **CHAIRMAN.** It decreases in summer time.

Mr. **HAWLEY.** It goes with the flood. There is nothing to keep the snow back, and it goes down the valley.

The **CHAIRMAN.** With regard to the subject of irrigation, have you given any thought to that?

Mr. **HAWLEY.** I have given considerable thought to the matter.

The **CHAIRMAN.** To what extent could this country be irrigated?

Mr. **HAWLEY.** I would rather not address myself to figures; but I think the figures given by other gentlemen are correct. I think that between a third and a fourth of the land of the Territory could be irrigated.

The **CHAIRMAN.** The Government has commenced the work of making surveys for the purpose of ascertaining what amount of land can be irrigated and what can not be, designating reservoir sites, and estimating the cost of constructing hydraulic works, etc. We have had a pretty good general statement with regard to handling the larger streams, rivers, and creeks. Now, is it or not a fact that if these surveys were made they would show a large extent of country that could be entered upon immediately?

Mr. HAWLEY. There is a large section of country in the aggregate that could with a comparatively small expense be irrigated. Take the Lost River Valley. A reservoir system in that valley to hold back the water that otherwise goes to waste—and it could be done at a small expense—would be the means of reclaiming from twenty to one hundred thousand acres of land.

The CHAIRMAN. Are there places where a thousand or two or three hundred acres of land could be reclaimed from small streams?

Mr. HAWLEY. Yes; there are places of that kind. But take an enterprise like that of the Lost River. There is a section of country that has not been mentioned. It is in Custer County. It will average in arable land 5 miles in width. The Lost River sinks in a lava bed; but at the head there is a large body of water, and there are places where it could be collected in a reservoir to irrigate all that country. There they could raise vegetables and everything of that kind. But the men who desire to go in and make settlements are poor men, and although the expense seems small compared with the amount of land that could be irrigated, yet they are unable to enter upon the work.

The CHAIRMAN. Is it generally too expensive for them to obtain the information and make the preliminary surveys?

Mr. HAWLEY. It would be to make preliminary surveys, unless the Territory did it or the General Government. You could not depend upon those settlers doing that.

The CHAIRMAN. The settlers do not know what can be done, and they have no money to hire surveyors?

Mr. HAWLEY. No; when they see water running in a stream they know how to turn it on to their land; but when it comes to storing water for future use, that is another matter.

The CHAIRMAN. They are not competent to consider that?

Mr. HAWLEY. No.

The CHAIRMAN. So that you think surveys to determine those matters for them would encourage settlement?

Mr. HAWLEY. I think so.

The CHAIRMAN. Independently of the larger enterprises of taking out the great rivers?

Mr. HAWLEY. Yes; the great rivers like Henry Lake will make a reservoir that will cover a large amount of land that would be on the North Fork. I have an idea of irrigation that I would like to give to the committee. We would like to see the General Government take hold, and, if possible, construct our reservoirs and canals and sell the land with the water rights. But whether or not it is possible to carry on such a system of irrigation, as I understand it, is in doubt. But whatever aid the General Government can give, well and good. If they could not utilize all this water or find that the expense is too great, I would suggest to the committee that it might be wise for Congress to treat the arid lands of this country in the same manner that they did the swamp and overflowed lands. In other words, if they would give these arid lands to the State, and let the State work out its own salvation, it would be wise. But if Congress is unwilling to do that, instead of going on and making appropriations of a small amount of money and having the work of reclaiming this land delayed for many years, let it give to the State the right under proper regulations to put water on to the land and sell the land to actual settlers.

STATEMENT OF ALECK DANSTIN, OF BLACKFOOT.

The **CHAIRMAN.** Are there any artesian wells in your vicinity?

Mr. **DANSTIN.** There are right close by, a little south of Blackfoot, in the southern part of the county. I have never seen them.

The **CHAIRMAN.** Do you know how much water they flow?

Mr. **DANSTIN.** I am told it is a pretty large flow.

The **CHAIRMAN.** Do you know what depth they went in boring the well?

Mr. **DANSTIN.** No.

The **CHAIRMAN.** Do you know anything about the stratification through which they went?

Mr. **DANSTIN.** No.

The **CHAIRMAN.** Are they using the wells for farming purposes?

Mr. **DANSTIN.** In a small way; not a large piece.

STATEMENT OF C. J. BASSETT.

The **CHAIRMAN.** Have you any information which you desire to give with regard to artesian wells in Bingham County?

Mr. **BASSETT.** I have seen the artesian wells of which Mr. Danstin spoke, at Oxford, Bingham County.

The **CHAIRMAN.** What is the extent of the wells?

Mr. **BASSETT.** Mr. Harkness has on his land four, and has the water running over about 20 acres of land. There is about 20 inches per second of flow, and he irrigates 20 acres of land. He sunk the wells for the purpose of watering his stock, he having a large stock ranch there.

The **CHAIRMAN.** To what depth did he go for water?

Mr. **BASSETT.** Only about 80 feet.

The **CHAIRMAN.** They flow out to the surface?

Mr. **BASSETT.** Yes; they went through dry land; some clay and sand and gravel.

FURTHER STATEMENT OF T. A. STARRH.

Mr. **STARRH.** The leading people of Cassia County have for a long time recognized the necessity of reservoirs. They would be of great use to the entire community. The few who were able, however, to put up money to make surveys did not feel that it was their duty to do so for the general public. The county is a pretty fair sized county and the different locations cover a number of places. In fact the head of each stream has places where reservoirs could be built and some of them two or three locations along the stream. The general business of the country has been at a stand-still on account of the water question. Even if a large canal were made down Snake River, after it was commenced it would take some three or four years to complete.

The **CHAIRMAN.** You recognize the right, if you store water and turn it into a stream, to take out an amount below?

Mr. **STARRH.** That seems to be the opinion of the people in our country. In fact we have two reservoirs in our county, but each one of them was made by individuals and they recognize that right—the right to draw as much from the reservoirs as they thought they had stored.

The **CHAIRMAN**. There will probably have to be some sort of local government about it.

Mr. **STARRH**. I think so; but it will be a nice question to settle, for I don't think it is a question that you can leave to every one to settle for himself.

The **CHAIRMAN**. You would have to have some form of local government about it. For example, you would need to have a water master to divide the water up among the people in proper proportions and at the proper time so as to secure an economy in the use of the water.

Mr. **STARRH**. Yes. Of course we have not enough water in our county to enable us to irrigate all our land. But no railroad company has had sufficient inducement to come in there to cheapen transportation, and that has been a great disadvantage.

The **CHAIRMAN**. What scheme for a railroad has been projected there?

Mr. **STARRH**. There was one that was projected from Salt Lake City by some eastern firm I believe in connection with a Montana firm. There was an original survey made by the Union Pacific Railroad Company across Snake River somewhere near the Park; also the Denver and Rio Grande Railroad intended coming through there, but was prevented by some money troubles.

STATEMENT OF J. C. FOX, OF CUSTER COUNTY.

The **CHAIRMAN**. What is your occupation?

Mr. **FOX**. I have been in a saw-mill. I am now in a mining company.

The **CHAIRMAN**. In what part of the Territory is Custer County?

Mr. **FOX**. A little over 200 miles northeast from here.

The **CHAIRMAN**. Is it on the water-shed of Snake River?

Mr. **FOX**. No; on that of the Salmon River.

The **CHAIRMAN**. Is irrigation required in that county?

Mr. **FOX**. Altogether.

The **CHAIRMAN**. Will you state how that county is situated; about how much land and how much water it has?

Mr. **FOX**. Custer County is a new county. It has but very little irrigation, and, comparatively speaking, not a great deal of farming is done compared with older counties; not, for instance, compared with this county. About probably one-fourth of the county is capable of growing all agricultural products that are raised here.

The **CHAIRMAN**. About what area of land would that be; about how many acres?

Mr. **FOX**. I should think there are probably 40 or 50 miles in length by perhaps 5 miles wide. There is not water enough there to irrigate all that land unless it is reservoired. Of course there could be reservoirs made there, but to irrigate the whole of it would be expensive. I do not know whether there would be water enough to irrigate the whole of it even if it were stored. There is water enough of course if it could be all retained, but it could not be. The Salmon River is quite a large stream and affords all the water probably that is necessary to irrigate both Custer and Lembi Counties. It runs through both of them and enters into the Snake River at Lewiston.

The **CHAIRMAN**. Is there much land that can be cultivated in Lembi?

Mr. FOX. Yes, a great deal. I am not so familiar with it as Governor Shoup. Probably he can state it better than I can. Perhaps the report however covers it.

The CHAIRMAN. I think the report is pretty full on each county.

Mr. FOX. It is not very full on our county. There is probably seven or eight times more land there that can be cultivated than our report speaks of. The gentleman who made the report is well qualified to make it but has not traveled over the county very much, and did not know how much there was. There are 50,000 or 60,000 acres of land there that would make good arable land. We are somewhat higher there than this place. Corn is not raised there to any extent. They sow nothing there except what grows quickly. The greatest portion of our county is mountainous, and the principal products there are silver and lead.

The CHAIRMAN. You raise good crops there when you do irrigate, do you?

Mr. FOX. Excellent.

The CHAIRMAN. The same kinds that are raised here?

Mr. FOX. Yes.

The CHAIRMAN. Is the soil good?

Mr. FOX. The soil is very good. Probably the soil is quite as good as the soil here. I think they use the same crop and the same ground for three or four or five years. After that I think it would not raise as good a crop as it would have formerly.

The CHAIRMAN. Have you seen that tried?

Mr. FOX. Yes; I have a ranch there and have raised 50 or 60 bushels to the acre of oats. It has been in oats for four or five years now, and it does not raise quite so much to the acre as when we first took it up. Of 120 acres, 20 acres of it was wheat, and it averaged 60 bushels to the acre all around.

Senator JONES. Was that on the first crop?

Mr. FOX. Yes.

Senator JONES. Have you produced other wheat crops afterward from it?

Mr. FOX. Yes; this was an average of wheat and oats together. The wheat of course was not as good as the oats. The wheat was 38 bushels, I think, the first year, and the oats were over 60. The frost came the first year about the 20th of August. We had not got the water on the crop early enough, and so it did not get quite ripe.

Senator JONES. What have you made in wheat the other years?

Mr. FOX. About 40 bushels.

Senator JONES. There is no decrease in the crop, then, since the first year?

Mr. FOX. Not generally. They do not generally sow wheat so much in succession to itself as they do oats. I want to state here that not an acre of land in Custer County has been surveyed, and many are holding more land there than they would hold if it were surveyed.

The CHAIRMAN. Do you think a survey which would direct the settlers where to find water, etc., would be of use?

Mr. FOX. Yes; it certainly would be of great benefit. But unless the land is surveyed so that it can be taken up in smaller quantities, men will hardly know what is there. Of course, at present the right is but a squatter's right, but some have taken up land under the desert-land act.

STATEMENT OF FRANK RIBLETT, OF ALBION.

The CHAIRMAN. In what part of the Territory do you reside?

Mr. RIBLETT. The south-central part; Cassia County.

The CHAIRMAN. Near the Nevada line?

Mr. RIBLETT. Yes; Nevada and Utah bound us on the south.

The CHAIRMAN. What is your occupation?

Mr. RIBLETT. I am a civil engineer.

The CHAIRMAN. Have you been engaged in the business of surveying lands and water-ditches in your county?

Mr. RIBLETT. Yes.

The CHAIRMAN. For how long?

Mr. RIBLETT. A little over ten years.

The CHAIRMAN. Will you describe the character of the country in Cassia County?

Mr. RIBLETT. We have a very large area of valley lands. The principal valleys are those of the Raft River, the Goose Creek, and the Salmon River.

The CHAIRMAN. Then you have a Salmon River there?

Mr. RIBLETT. It is called sometimes Salmon River and sometimes Salmon Creek. It enters into the neighborhood of the Salmon Falls.

The CHAIRMAN. Do any of those streams rise over in Nevada or Utah?

Mr. RIBLETT. Yes, some of the heads of them are in Nevada and some in Utah.

The CHAIRMAN. Is there much average land in your county?

Mr. RIBLETT. I should judge that in these large valleys there would be found over a million acres in that county, and probably 500,000 acres more on the higher lands.

The CHAIRMAN. How much of it can be irrigated?

Mr. RIBLETT. At least 1,000,000 acres.

The CHAIRMAN. Explain how you would irrigate a million acres there.

Mr. RIBLETT. The flood volume of the streams of Cassia County would furnish water, if properly reservoired, for the irrigation of probably 500,000 acres. A canal from Snake River would cover 700,000 acres, and 200,000 acres covering these reservoirs would be under the horizon of the canal from Snake River.

The CHAIRMAN. To what extent could settlers go upon it and by uniting bring in their own ditches, providing the surveys were made to give them information?

Mr. RIBLETT. I think only to a very limited extent. They would have to have assistance either from capital or from some other source.

The CHAIRMAN. Are the enterprises already there expensive, or are they some cheap enterprises?

Mr. RIBLETT. They are cheap compared with the land they would cover, but of great magnitude after all.

The CHAIRMAN. You mean they are cheap per acre?

Mr. RIBLETT. Yes; they are cheap per acre.

The CHAIRMAN. Have you ever estimated how much it would cost to irrigate the million acres you spoke of?

Mr. RIBLETT. I should judge $5,000,000.

The CHAIRMAN. How much would it be worth after it was irrigated?

Mr. RIBLETT. About $30 an acre.

The CHAIRMAN. Is it good land?

Mr. RIBLETT. The best of land.

The **Chairman**. Does it raise fruit also?

Mr. **Riblett**. Yes; I have seen some fine peaches raised in that county. All the hardy fruits can be raised in that county.

The **Chairman**. How is it in the southern part, where Utah and Nevada join?

Mr. **Riblett**. It is more mountainous there.

The **Chairman**. Have you been much into Utah and Nevada opposite Cassia County?

Mr. **Riblett**. Yes.

The **Chairman**. What kind of country have they there?

Mr. **Riblett**. I have never been in the valleys much, but I have been in the mountains on the borders of Cassia County.

The **Chairman**. Are the mountains high there?

Mr. **Riblett**. They vary. Some of the streams are on the low tablelands and some are in the mountains. Goose Creek, for instance, has a very extensive water-shed of about 1,000 square miles.

The **Chairman**. Is that in Nevada?

Mr. **Riblett**. Partially in Nevada and partially in Utah. The depth of snow on this water-shed is estimated by trappers, hunters, and stock men at from 3 to 4 feet.

The **Chairman**. I have heard of a white sage-brush plain in that region where people winter stock. Is that in your county?

Mr. **Riblett**. We have several sage plains.

The **Chairman**. The one I refer to is that to which a good deal of stock has been sent from Elko, and further I was told it was in Idaho or Utah.

Mr. **Riblett**. I do not know of any.

The **Chairman**. Does it destroy sage-brush to feed it off?

Mr. **Riblett**. It has done so in our county. Sheep will destroy it.

The **Chairman**. This enterprise involving $5,000,000 is not all one enterprise, I presume, but would involve a good many enterprises?

Mr. **Riblett**. I am speaking of a grand system of reservoirs and canals taking in the volume of the small streams, and a canal from Snake River.

The **Chairman**. Could you divide it up so as to let us see what would be the least expensive scheme?

Mr. **Riblett**. Some would cost only $2 or $3 an acre.

The **Chairman**. How much would it cost in the aggregate for some of your easy schemes?

Mr. **Riblett**. I will mention one—Goose Creek. There is a basin there that is 900 acres in extent; that can be covered with about 100 feet of water by a dam 100 feet wide at the bottom and 200 feet at the top and 140 feet high.

The **Chairman**. What would be the expense of that?

Mr. **Riblett**. Not to exceed $100,000.

The **Chairman**. How much land would it cover?

Mr. **Riblett**. At least 40,000 acres.

The **Chairman**. That would be about $2.50 an acre.

Mr. **Riblett**. Yes.

The **Chairman**. Is the land in your county mostly public land?

Mr. **Riblett**. Yes.

The **Chairman**. There are no railroad grants in it, are there?

Mr. **Riblett**. I think there is a very little in the southeast corner—Central Pacific lands.

The **Chairman**. You may state to the committee any other facts that occur to you, that will be useful in their inquiry.

Mr. Riblett. I might say that the flood volume of Cassia County would not be less than four or five thousand million cubic feet, if properly stored. I am not stating these figures at random. I have been a witness in water suits, and have had occasion to measure this sort of thing.

The Chairman. Have you heard of any efforts, by suits, to measure water, to see whether the parties had enough?

Mr. Riblett. Not yet. The matter to some extent may be litigated at the next term of court.

The Chairman. Colorado passed a law requiring the district attorney to bring suits on each stream and make all parties parties to the record who claim water, so as to make them prove up the date of location and the quantity appropriated. Then a schedule was made and those making new appropriations were required to make a record of it, and then a water-master was appointed to distribute it according to priority. You have not yet anything of that kind in Idaho, have you?

Mr. Riblett. No. I would like to say that for about nine years an association of citizens of Cassia and Logan Counties has been investigating the project of turning the waters of Snake River at Story's Ferry for the irrigation of lands in Logan and Cassia counties. This scheme, if carried out, will irrigate at least 85,000 acres in Logan County and 15,000 acres in Cassia County. The 85,000 acres in Logan County are unsurveyed, and in order to procure capital in furtherance of this project and for the benefit of Logan County, it would be necessary for this land to be surveyed by the Government, and in connection with other lands, in case it can be found that the canals can be extended farther, to see if more land can not be covered in both counties.

The Chairman. I presume if the Government goes on with this policy of ascertaining what lands can be irrigated and what not, it will have the irrigable lands all surveyed. The settlers can not do that very well.

Mr. Riblett. There are a great many other lands in Cassia County which should be surveyed. The appropriations seem to have been insufficient. In regard to the exhaustion of Snake River, it has been shown practically in the experience of Cassia County that water can be used for irrigation and it will rise again farther down the stream by percolation, and can be so used several times in succession. I do not think that if the entire water of the Snake River were turned into Bingham County it would make any difference in the volume in Cassia County.

The Chairman. If there was not, the storage system would make it all right, at any rate, would it not?

Mr. Riblett. Yes; because I think that during high water there are not less than 50,000 second-feet in Snake River. We measured it on the 22d of July at Storey's Ferry; as near as we could estimate it there were about 5,500 second-feet at extreme low water. The river is lower than it has been for twenty-five years, and was at least 14 feet below ordinary high-water mark and nearly 17 feet below the maximum high-water mark. So there would probably be at least 50,000 second-feet. In regard to the arable land of Cassia County at least one-half ranges from 4,000 to 4,500 feet. Some will be more and some less. To more fully show the character of Goose Creek Valley I will state, and without, I think, danger of contradiction, that at least 160,000 acres in the valley can be selected in which there would not be 160 acres of waste land.

The Chairman. The land is fertile?

Mr. **RIBLETT.** Extremely so. Let me make one other statement. I was in a field of volunteer wheat, wheat that ran over from the previous year, wheat that sowed itself so to speak; of that there were about 8 acres, and that will average when it is thrashed at least 100 bushels to the acre, as estimated by careful farmers. The field has been cropped for six or eight years.

The **CHAIRMAN.** Does it produce good crops every year?

Mr. **RIBLETT.** I will not say that that is an average, but it shows what is done sometimes.

The **CHAIRMAN.** The land is irrigated, is it?

Mr. **RIBLETT.** Yes.

STATEMENT OF JOSEPH A. CLARK, OF EAGLE ROCK.

The **CHAIRMAN.** Eagle Rock is on the Snake River?

Mr. **CLARK.** Yes.

The **CHAIRMAN.** Have you given any attention to irrigation?

Mr. **CLARK.** Yes.

The **CHAIRMAN.** Have you been engaged as an engineer in making surveys for irrigation?

Mr. **CLARK.** Yes.

The **CHAIRMAN.** What do you say as to the facilities for irrigation and what as to the land needing irrigation in your county?

Mr. **CLARK.** The facilities are first class and the land is also first class.

The **CHAIRMAN.** How much land have you in your county that is susceptible of irrigation?

Mr. **CLARK.** I understand it is reported here to-day as something over 2,000,000 acres. I am not so well acquainted with the county as with my own neighborhood.

The **CHAIRMAN.** In the neighborhood of Eagle Rock how much land is there that can be irrigated by one system?

Mr. **CLARK.** We have now about five townships under one irrigating system.

The **CHAIRMAN.** That is a little over 100,000 acres?

Mr. **CLARK.** Yes.

The **CHAIRMAN.** What stream do you irrigate from?

Mr. **CLARK.** From Snake River.

The **CHAIRMAN.** What will be the expense per acre to irrigate five townships?

Mr. **CLARK.** We estimate it from $3 to $5, but that is probably a little over the real cost.

The **CHAIRMAN.** It will cost then some $300,000 or $400,000 to construct the ditch?

Mr. **CLARK.** Yes; to irrigate that land.

The **CHAIRMAN.** What would be your plan? Would you ditch from Snake River?

Mr. **CLARK.** We have head-gates directly in the river, and take the water out in canals that are about 30 feet wide at the bottom.

The **CHAIRMAN.** You do not find it necessary to build any dams in the river. You put your head-gates in and take it out at the level of the flow?

Mr. **CLARK.** This is the first year we have had to do that. Heretofore the water has been sufficient to take it out without a dam.

The **CHAIRMAN.** You have had to dam it this year?

Mr. **CLARK.** Yes.

The CHAIRMAN. Is there a rock bottom, so that you have no difficulty in making dams?

Mr. CLARK. We make them without much trouble, but the probability is that if these dry years continue very long, it will be necessary to make permanent dams, unless we go higher up or lower our works.

The CHAIRMAN. Is it productive land—the land in these five townships.

Mr. CLARK. Yes.

The CHAIRMAN. What is its character?

Mr. CLARK. It is clay loam, sandy somewhat, and bears sage-brush.

The CHAIRMAN. Is it strong land?

Mr. CLARK. Strong land? Yes.

The CHAIRMAN. Is there basaltic or lava rock below?

Mr. CLARK. A portion of it is lava, so that we can not get good wells. Then another portion of it is not, and there we get very good water.

The CHAIRMAN. How do you find the soil? Do you find it equally irrigable where the lava rock is near the surface?

Mr. CLARK. I think so.

The CHAIRMAN. The water wastes on account of its fractured condition, does it?

Mr. CLARK. Yes.

The CHAIRMAN. Is it fractured very much, so that the water percolates down through it?

Mr. CLARK. I do not think there is a great deal of loss in that way.

The CHAIRMAN. You have heard the testimony here. State any facts that you wish the committee to know.

Mr. CLARK. I have been an interested listener. I think it likely that we shall have to have reservoirs on the river in order to keep the supply. The canals under construction, if they were all fixed up at present, would take pretty nearly all of the water out of the river, and it would be consumed in that valley and farther down. I think it likely in an ordinary year the canals now constructed would exhaust Snake River through the ordinary irrigating season, but if reservoirs could be made on the upper waters that difficulty would be avoided.

The CHAIRMAN. Are you familiar with the headwaters?

Mr. CLARK. I have been 50 or 60 miles above the head-gate. I have not been to the lake spoken of, but I am satisfied that the opportunities for storage are there.

The CHAIRMAN. Can you tell us anything more in regard to your country?

Mr. CLARK. No; I think not. It is a new country, and we have no fruit-bearing trees there yet. I think it is about 1,500 feet higher, perhaps, than this place. But the smallest trees are not yet a success.

The CHAIRMAN. As far as vegetables are concerned, are they a success?

Mr. CLARK. Yes; our county fairs have been a great success, and the vegetables there are very good.

The CHAIRMAN. Are there many places where the settlers could irrigate by themselves by a combination of a few farmers?

Mr. CLARK. That is the irrigation that is being done mainly in our Territory. There is no foreign capital doing it.

The CHAIRMAN. There is no water taken out to be sold?

Mr. CLARK. No. Opportunities are offered for a ranchman to go and take as much water as his land will need.

The CHAIRMAN. Do you say you are irrigating now 100,000 acres there?

Mr. **Clark.** There are 100,000 acres under the canal, but it has not all produced yet.

The **Chairman.** You mean the water is so arranged that it can be put on all that acreage?

Mr. **Clark.** Yes, and counting a miner's inch for two acres the company is stocked for about 40,000 acres, but we are enlarging these canals every year, and expect to reach 100,000 acres.

The **Chairman.** But you have not got water yet for 100,000?

Mr. **Clark.** No. There are close on to 40,000 in cultivation in that valley.

The **Chairman.** They are using, then, about all the water that the ditch will afford?

Mr. **Clark.** Yes.

The **Chairman.** How much per acre has it cost to construct these works up to this time?

Mr. **Clark.** It has cost altogether about $100,000.

The **Chairman.** That will be about $2.50 an acre?

Mr. **Clark.** Yes.

The **Chairman.** Does that mean the main ditches alone, or does it include the side ditches?

Mr. **Clark.** The main ditches.

STATEMENT OF E. C. HELFRICH, OF LAMAR COUNTY.

The **Chairman.** What is your occupation?

Mr. **Helfrich.** General merchandise.

The **Chairman.** On the water-shed of the Snake River?

Mr. **Helfrich.** Yes.

The **Chairman.** What rivers have you running through it?

Mr. **Helfrich.** The Snake River and the South Boisé. Water is taken from the South Boisé.

The **Chairman.** Has there been any water taken out from the Snake River?

Mr. **Helfrich.** No.

The **Chairman.** Is there any irrigation in the county?

Mr. **Helfrich.** There is not an irrigating ditch in the county.

The **Chairman.** What do the people do?

Mr. **Helfrich.** Up to this season they have depended upon the little creeks that come in the little breaks of the mountains. They are all hay ranchers. There is not a farmer among them. No farming is done there.

The **Chairman.** Do the sheep or cattle men own the lands?

Mr. **Helfrich.** No; it is public land.

The **Chairman.** Is it well adapted for farming?

Mr. **Helfrich.** Yes.

The **Chairman.** Could water be got on the land by reservoirs?

Mr. **Helfrich.** To a limited extent.

The **Chairman.** If that could be done it would make some good farms, would it not?

Mr. **Helfrich.** Yes.

The **Chairman.** That would be higher up, or around the foot-hills, I suppose?

Mr. **Helfrich.** Yes.

The **Chairman.** As to the rest, how is it?

Mr. **Helfrich.** There would not be enough coming from the Snake

River to cover the tributaries to it. The South Boisé drains away the whole mountain system, and the creeks are just this side of South Boisé River, so that they have to take the leavings.

The **Chairman.** What amount of arable land have you in the county?

Mr. **Helfrich.** About 220,000 acres.

The **Chairman.** Have you ever had an estimate made as to what it would cost to bring water on it?

Mr. **Helfrich.** We made an estimate for a storage reservoir two years ago. That was supposed to cost about $6,000.

The **Chairman.** That would be a good enterprise, would it not, for the farmers?

Mr. **Helfrich.** Yes; but it would be of no use this season.

The **Chairman.** Was the water a total failure this year?

Mr. **Helfrich.** Yes.

The **Chairman.** How long have you been in this valley?

Mr. **Helfrich.** About seven years.

The **Chairman.** And is that the first failure you have seen?

Mr. **Helfrich.** Yes, the first complete failure. There are two ranches in the county that have natural wells or springs. Their owners have succeeded in raising regular crops this year just as if there was no trouble. They will make 4 tons of alfalfa, 2 tons to each cutting. I do not think the county this year will turn out more than 8,000 tons of hay, when we ought to turn out 12,000 or 15,000. We have a fine orchard on one of the ranches, but we have not water to irrigate it with.

The **Chairman.** Until Snake River is turned?

Mr. **Helfrich.** Until Snake River is turned.

The **Chairman.** Did you say you had an estimate made to see what it would cost to take Snake River out there?

Mr. **Helfrich.** No; but we had an estimate made on the South Boisé, to take that out; and it would have to be by tunnel. That would cost about $120,000.

The **Chairman.** Is there enough water there for irrigation purposes?

Mr. **Helfrich.** Not unless we stored it. If we took it out, there would be none for down here.

STATEMENT OF M. H. ADAMS, OF CAMAS.

The **Chairman.** What is your occupation?

Mr. **Adams.** Raising cayuses and calves, cattle and hay.

The **Chairman.** Is there any irrigation in your county?

Mr. **Adams.** Yes, when we have water.

The **Chairman.** What stream do you irrigate from?

Mr. **Adams.** Camas Creek, Bingham County.

The **Chairman.** Of what is that a tributary?

Mr. **Adams.** It loses itself in the desert, and rises in the range of lakes between the Idaho line and Montana.

The **Chairman.** Could it be increased by reservoirs?

Mr. **Adams.** Yes; that is all we need in our country. We have a natural fall, and plenty of ditches. I have ditches to-day, but no water to put in them.

The **Chairman.** Have you examined the country above to see what chances there are to save the water?

Mr. **Adams.** Yes.

The **Chairman.** What are the chances generally?

Mr. **Adams.** Forty miles above me is what is called the Camas Meadows; next to the base of the mountains it is level, and when it breaks through there it comes through the cañon and runs about 40 miles before it comes to the town of Camas.

The **CHAIRMAN**. Is that valley level enough so that a dam could be made so as to cover a large portion of it?

Mr. **ADAMS**. Half a township, very conveniently. The situation of our country is this: We have two rivers there, the Big Lost River and the Little Lost River, Birch Creek, Medicine Lodge, and the Camas. All those streams have their rise of water from the mountains along the line. They all sink in the desert. None of them come forth in the Snake River at all.

The **CHAIRMAN**. Are there opportunities on all of them for storage?

Mr. **ADAMS**. On every one of them; plenty of opportunities. The altitude of those mountains is from 7,000 to 8,000 feet, and that altitude is not high enough to hold snow. In the season of the year when we are in need of water it is gone. The Lost River will flow a good deal of water in the spring, but by July it is gone.

The **CHAIRMAN**. Is that land good land?

Mr. **ADAMS**. Very good land. I have ranched a little there for the last five or six years. My vegetables and oats are equal to any I have ever seen here. We are 4,800 feet in altitude. It is not so good for fruit, but all cereals and vegetables grow as well as they do here.

The **CHAIRMAN**. How much land could be brought under cultivation in that valley if you had a proper storage system?

Mr. **ADAMS**. Along the Camas and the Lost River it is from one to the other a distance of 50 miles across. There is plenty of land, and it is all productive if it had water.

Senator **JONES**. How does the water disappear from these rivers that you call the Lost Rivers?

Mr. **ADAMS**. It runs right into the lavas, and keeps sinking. In the Big Lost River it runs down on the cañons and after a while it is all exhausted. It seems as though this water in the Lost River lost itself in these lavas and breaks out again somewhere else. Undoubtedly the lava is above the sand and lime. That whole country is one system of storage, and has no connection with any other part of the country.

STATEMENT OF W. B. ALLEN, OF SHOSHONE.

The **CHAIRMAN**. How long have you resided at Shoshone?

Mr. **ALLEN**. About five or six years. It is in the heart of a desert, if there is a desert. This is in the very central portion of the lava beds, yet in our county we have over 1,000,000 acres of good arable land.

Senator **JONES**. How large is Logan County?

Mr. **ALLEN**. There are about one hundred and fifty townships, which would be 3,750,000 acres of land.

The **CHAIRMAN**. In the portion of the lava beds that you do not cultivate, the lava is on top?

Mr. **ALLEN**. Yes; and there it is broken in such a way that a canal could not be cut through to any great distance. Following the general course of the Snake River in the northeastern section of Idaho Territory, where it rises in Yellowstone Park, there is a great deal of fall. Lying on the north side of Snake River are the lava beds. The Oregon Short Line enters the county at the American Falls and comes due west. The land is largely devoted to grazing at the present time.

The **CHAIRMAN**. Have you irrigated some in your county?

Mr. **ALLEN**. We have. About 2 per cent. of our available agricultural lands are under cultivation. Camas Prairie is a level stretch of valley or meadow land about 12 or 15 miles in width and from 45 to 55 miles long; that is on the northern side of the county. That is fed by a number of little streams going from Camas Range or Wood River Range, and feeds that valley, which does not require so much irrigation.

The **CHAIRMAN**. Are these streams exhausted so far as irrigation is concerned?

Mr. **ALLEN**. Yes; they are.

The **CHAIRMAN**. Could you increase the irrigation by storage reservoirs.

Mr. **ALLEN**. Yes. Our theory has been that we were unable to get further in the way of irrigation except by aid from the Government or from large capital. I have been working to secure the unity of the whole people of the Territory for that purpose. We hope to convince your committee that Idaho has capacity of soil and climate and production to become a great State. The proposition is that we are almost helpless without other aid.

The **CHAIRMAN**. So far as the State question is concerned, it depends more on what you all want than on what we want.

Mr. **ALLEN**. We will be able to convince you all in regard to that by next winter.

Senator **JONES**. What benefit would statehood confer on you in regard to irrigation?

Mr. **ALLEN**. As a Territory we have not the means to issue bonds, whether for the State or the county, to support a system of irrigation.

Senator **JONES**. Do you think the State would do it if it were a State?

Mr. **ALLEN**. I have visited every section of the Territory and have made a careful study of this question, and was one of the first to agitate it and to endeavor to get this work of our local committee done. I am fully convinced that if it is given into the charge of the State it will be carried out faithfully and systematically. Otherwise we should have to depend on the General Government to cultivate and irrigate this whole agricultural region.

The **CHAIRMAN**. Have you ever had an estimate as to the cost of irrigating this body of land that you speak of?

Mr. **ALLEN**. The estimates run different in different localities.

The **CHAIRMAN**. Take your locality for example.

Mr. **ALLEN**. It will run from $2.50 to $7 an acre.

The **CHAIRMAN**. How many acres?

Mr. **ALLEN**. Perhaps three quarters of a million out of the million acres that it is possible to reclaim.

The **CHAIRMAN**. Suppose it costs $7 per acre; if the State should construct the work—if it should cause a corporation to be organized, and have some shares of stock for each acre or each 10 acres, do you think the settlers would buy the water right for their land and pay for the land more than $7 an acre?

Mr. **ALLEN**. They would willingly pay $10 to $25 an acre wherever the water is placed with the land.

The **CHAIRMAN**. Then what is the difficulty in the State taking it and selling it as fast as it may be constructed?

Senator **JONES**. The difficulty is, that there is no State?

The **CHAIRMAN**. Is that the point?

Mr. ALLEN. Yes. I think the land and water should be sold to each settler, not to exceed 160 acres. If Congress will grant to the State a sufficient quantity of this land, I should think, speaking for myself, that we could afford to pay the General Government back very liberally. If Congress is not liberal enough to grant to Idaho what it has granted to other States as swamp land, we can afford to pay $1.25 per acre, as an estimate of its actual value.

The CHAIRMAN. What is the necessity of a grant of land to the State? Can not individuals take a grant of the land from the Government?

Mr. ALLEN. But there is no individual that will take 160 acres who can afford to expend $10,000,000.

The CHAIRMAN. But if the State constructs the ditch the State will have the water?

Mr. ALLEN. Yes.

The CHAIRMAN. Then why can not the State sell the water and let the people get the land from the General Government under the homestead law?

Mr. ALLEN. It will be on the principle of some man building a dam for another party who owns the land.

Senator JONES. But when the other party proposes to give the land away, how is it then?

Mr. ALLEN. Well, that would be a little circuitous.

The CHAIRMAN. Would it not be better to have the homestead law apply and give a man 80 acres? If a man wanted 20 acres you could sell him water enough to water 20 acres. You fix your price so that it pays the cost of construction and a little interest, and then when it is all sold out the people would have it and there would be assessments enough to keep it in order. Is it not, therefore, better to leave it so, with the laws as they are regarding homesteads, and let the State build the ditches and deliver the water to sell.

Mr. ALLEN. But how can the State issue bonds to build the ditches?

The CHAIRMAN. It does not need to issue bonds. It can take $100,000 and build a ditch.

Mr. ALLEN. That would build one ditch, perhaps.

The CHAIRMAN. But you don't want to build ditches any faster than the settlers want them. Here are 100,000 acres of land which perhaps can be irrigated for $200,000. The State starts in with an appropriation of $100,000 for that. That $100,000 will irrigate some of the land. You then commence to sell the water rights. If no settlers come you do not need to dig any more. After settlers have come you can build more. The General Government will let them have the land; whereas if the State had the land would it not be likely to sell it in too large quantities?

Mr. ALLEN. The theory we have been following out is that the State should have the power to dig these canals.

The CHAIRMAN. It has.

Mr. ALLEN. And that it should also have the supervision over the rates to be charged.

The CHAIRMAN. You do not suppose it would have "rates?"

Mr. ALLEN. Well, it would have a charge.

The CHAIRMAN. Would it not be better to have the individual owners of the land become the stockholders in the water company?

Mr. ALLEN. The majority would consolidate.

The CHAIRMAN. How could they consolidate if you kept the water and the land together? Or if they wanted to consolidate the State could pass laws against it.

Senator JONES. Senator Stewart's idea is that the ownership of the water should be inalienable from the land, and that men could not sell or alienate the water right except by selling the land, and that when they did the man who had the land should have the water right.

Mr. ALLEN. It seems to us that it would take a great many years to carry that out, but that with the land a necessary amount of money could be raised sooner.

The CHAIRMAN. The land is only the instrument. The Government is willing to give them that. The Government is anxious that people should come and settle on the land; that does not cost anything.

Senator JONES. His idea is that if the Government should convey it to the State, the State could raise the money to construct these ditches more readily than could otherwise be done.

The CHAIRMAN. The State does not want security.

Senator JONES. The people who furnish the money would want some security.

The CHAIRMAN. I would not advise a State to have a scheme for getting into debt. If a State can raise $100,000 or $200,000, as this State can, I believe that $200,000 would be all that you would want to reclaim these deserts—I would start with that capital. I would take an easy place and irrigate 50 or 60 acres of land, and commence the construction of a ditch, and to every one that went on that land I would sell a water right. I would do it gradually so as to get the State a fair return. At some places they could charge $10 an acre, and at some places $6 or $7 an acre. When you sold to a man water with which to irrigate 40 or 50 acres of land, you would get your money. Then if the people came to buy it, you could extend it 3 or 4 miles, and then get your money. I don't think you should dig a ditch any faster than you could get the people to come and take it. You need not irrigate all the land before the people come.

Senator JONES. But every poor fellow who comes up for a homestead would not have the $10 cash with which to get the water, whereas if they had time to pay—three or four years—they might do it. In the mean time the State's capital would be used up, and they would have to wait. Men who want homesteads have not many times $10 an acre to spend that way.

The CHAIRMAN. The Government of the United States could allow a man to mortgage his property to the State, though I would never countenance a mortgage to individuals, because they might be unjust and exacting. I see no objection to the Government having a mortgage on it, however. If it is mortgaged to individuals who would not construct the ditch, it would be better not to have it mortgaged at all.

Mr. ALLEN. In our constitution we have provided that all the waters of the State are subject to public use, and we have provided that when, with the permission of Congress, this Territory becomes a State, it shall not go into debt.

The CHAIRMAN. That is very good.

Mr. ALLEN. But your proposition to build these canals would get us into debt more than our constitution allows.

The CHAIRMAN. How much can you go into debt under the constitution?

Mr. ALLEN. Not more than 1½ per cent., including our present debt. There are many details of this plan I spoke of that are not entirely clear. But it seems to me that the General Government might divide, say, one-half of the lands with the State.

The CHAIRMAN. The Government does not want to make anything out of the lands.

Mr. **ALLEN**. It might allow the State to make something out of them.

The **CHAIRMAN**. The Government does not want anybody but the settler to make anything out of them. If you could get a system started, you do not want much money to start with. My observation has shown that States have been ruined by taking their lands outside the protection of the land laws of the United States.

Mr. **ALLEN**. We have also provided that the public lands of the State granted by Congress heretofore, or hereafter, shall not be sold at a price less than $10 per acre, nor more than 25 sections in any one year, nor in tracts exceeding 160 acres to any one settler. They may lease, if the State so chooses, in order to obtain a rental. I think Congress should give us a portion of those lands.

The **CHAIRMAN**. Whenever Congress wants to give you land do not ask it to put you in a position to sell the land to monopolists.

Mr. **ALLEN**. We have already arranged it so that that could not be done. We will go and see you next winter about it.

The **CHAIRMAN**. Most of your land is public land and you can fill this Territory up if you do not make any mistakes.

Mr. **ALLEN**. We have about 84,500 square miles in Idaho, equal to nearly 55,000,000 acres. We have 15,000,000 acres of agricultural land. Running underneath the lava beds is an immense volume of water coming from seepage. In these lava beds there are localities where the water comes to the surface from Lost River, and I think you can trace that water from Lost River into the Shoshone Falls.

The **CHAIRMAN**. When you store the water in the mountains, will you not cut that off a good deal?

Mr. **ALLEN**. It would be impossible to cut off all of it. I estimate that there is not 1 per cent. of the water in the Territory that is used. For 700 miles Snake River flows around and through Idaho Territory, and it has along its extent a great many tributaries.

STATEMENT OF C. H. BASSETT, OF BINGHAM COUNTY.

The **CHAIRMAN**. Where do you reside?

Mr. **BASSETT**. In the southeastern part of Bingham County, on the Bear River.

The **CHAIRMAN**. Do the waters from your county flow into Bear River and down to Salt Lake?

Mr. **BASSETT**. Yes.

The **CHAIRMAN**. What is your occupation?

Mr. **BASSETT**. I am a farmer and rancher.

The **CHAIRMAN**. You cultivate land by means of irrigation, do you?

Mr. **BASSETT**. Yes.

The **CHAIRMAN**. What kind of crops do you raise on that farm?

Mr. **BASSETT**. We do not raise much but grain, vegetables, and some small fruits.

The **CHAIRMAN**. Do you raise those successfully?

Mr. **BASSETT**. Yes.

The **CHAIRMAN**. What amount of grain do you raise to the acre?

Mr. **BASSETT**. That part that is irrigated thoroughly and is given good care will average about 50 bushels of oats, 40 bushels of wheat, and 60 bushels of barley.

The **CHAIRMAN**. Do you raise vegetables in abundance in this Territory?

Mr. **BASSETT**. Yes; very fine vegetables.

The **Chairman**. Do you raise apples?

Mr. **Bassett**. We raise some apples there, but I don't think any peaches are raised.

The **Chairman**. State whether the supply of what you grow is abundant?

Mr. **Bassett**. It has always been so until this summer. The river has been very low this year, and if the company had not appropriated Bear Lake as a reservoir there would have been half a dozen canals.

The **Chairman**. Did some company appropriate Bear Lake?

Mr. **Bassett**. Yes; the papers report that an irrigating company has appropriated Bear Lake, and have scared many people away from it.

The **Chairman**. Under what law was it appropriated? It was reserved two years ago.

Mr. **Bassett**. I do not know as to the law. They are appropriating under a law of the Territory, they claim.

The **Chairman**. It is public land, is it not, and belongs to the United States?

Mr. **Bassett**. Yes; I presume so.

The **Chairman**. The United States said two years ago that no private individual could appropriate it.

Mr. **Bassett**. Then I hope that the United States will stick to its word. I know to my certain knowledge of three companies that would have taken out canals had if it not been for that.

The **Chairman**. Bear Lake is now a reservation and has been so for two years.

Mr. **Bassett**. If the Government would make a reservoir of Bear Lake, the people out there would take out the canals themselves.

The **Chairman**. Suppose the Government should make the reservoir and do nothing more; all could participate in it then. Could the people not combine and make a reservoir themselves?

Mr. **Bassett**. No; I do not think they would; not now at any rate. It would take probably two or three hundred thousand dollars.

The **Chairman**. To build a dam?

Mr. **Bassett**. To build the right kind of dam, probably. And the water has been so low in the river this year that it discouraged the people. There have, however, been several canals taken out.

The **Chairman**. With Bear Lake used as a reservoir, irrigation could be pretty extensively practiced, could it not, in the county?

Mr. **Bassett**. Yes; I made several surveys myself, and took up some of the land down there, but there was no water and I got scared out.

The **Chairman**. If that country is to be developed prosperously the storage system is a necessity, is it?

Mr. **Bassett**. Yes; an actual necessity.

FURTHER STATEMENT OF ALECK DANSTIN.

The **Chairman**. Bingham County is largely irrigated, is it not?

Mr. **Danstin**. Considerably; but there is only a small portion of it that can be irrigated.

The **Chairman**. About what extent of land can be irrigated in that county?

Mr. **Danstin**. I think Mr. Foote's estimate was about something like 300 or 400 acres.

The **Chairman**. Is it good land?

Mr. DANSTIN. Yes.

The CHAIRMAN. By what process would you irrigate it?

Mr. DANSTIN. By taking the water from Snake River principally. There are other small streams there that ditches are taken from, but it is principally from Snake River that they have to be irrigated.

The CHAIRMAN. Have they increased the volume of those by reservoirs at all?

Mr. DANSTIN. Not at all.

The CHAIRMAN. Is there any opportunity to do it?

Mr. DANSTIN. Yes; there is a very good chance to do it.

The CHAIRMAN. Is the scheme of taking it out of the Snake River very expensive?

Mr. DANSTIN. Not in proportion to the amount of land that could be irrigated.

The CHAIRMAN. About how much would it cost per acre?

Mr. DANSTIN. About from $2 to $5 an acre.

The CHAIRMAN. Suppose it would cost $5 an acre, would homestead settlers on the land buy a right in it for $5 an acre?

Mr. DANSTIN. Yes; I think so.

The CHAIRMAN. Do you think that place would be settled up rapidly if that were done?

Mr. DANSTIN. Very quickly.

The CHAIRMAN. If any person would construct a ditch and reservoir you think the water would sell readily for $5 an acre?

Mr. DANSTIN. I think it would.

The CHAIRMAN. And $5 an acre would certainly do it?

Mr. DANSTIN. My opinion is that it could be done for that very easily, taking it on a large scale.

The CHAIRMAN. What is the character of the land? Is it productive?

Mr. DANSTIN. It is. It is very much such land as you see this fruit growing on [referring to fruit on table].

The CHAIRMAN. Do you raise fruit there the same as they do here?

Mr. DANSTIN. Pretty much the same, although the country there is younger.

The CHAIRMAN. It is a little cooler there than it is here?

Mr. DANSTIN. A little bit; but I think you can raise there everything that can be raised here.

The CHAIRMAN. It is equally fertile with this land?

Mr. DANSTIN. I think it is.

The CHAIRMAN. What is a fair crop of wheat to the acre?

Mr. DANSTIN. About 40 bushels.

The CHAIRMAN. And of barley and oats?

Mr. DANSTIN. Barley about 60, and oats probably 75 bushels.

The CHAIRMAN. What is a fair average crop of potatoes?

Mr. DANSTIN. About 300 bushels to the acre would be a fair crop, although there has been twice that much raised on an acre. Taking, however, a good, fair average crop, about 300 bushels per acre would be right.

The CHAIRMAN. How much irrigated land do you think a family ought to have to make a good living, if they cultivated it well?

Mr. DANSTIN. It would vary a good deal, but on that kind of land I think they could make a good living on 40 acres.

The CHAIRMAN. Would 40 acres there be as good as 160 acres in Kansas or Nebraska?

Mr. DANSTIN. I think it would be better. From what I have heard I think 40 acres there with water on it would be as good as 160 acres in Kansas, and would produce more in fact.

The CHAIRMAN. Have you been a farmer?

Mr. DANSTIN. Yes; though I do not farm at the present time.

The CHAIRMAN. What did you raise on your farm?

Mr. DANSTIN. It is a number of years since I farmed. I have been engaged lately in ditching in Blackfoot and in surveying and work of that kind. I have been working on ditches for the past three years.

The CHAIRMAN. Do you think there is an abundance of water by storage and ditches together in Snake river to irrigate a large section of the country?

Mr. DANSTIN. I think there is, providing it is stored. There is going to be a scarcity there in a few years if it is not stored. At the present time there is a great scarcity.

The CHAIRMAN. They do not store so much as they litigate now?

Mr. DANSTIN. That is what they are doing now. Their idea for the remedy for the scarcity of water is to sue one another. I am now engaged in distributing water on a small stream between parties who have been in litigation for a year. If this storage system were carried out there would be no occasion for litigation. I think there is water enough there to be used.

The CHAIRMAN. If they do not let it run away in the flood time you think there is enough?

Mr. DANSTIN. There is enough to irrigate three times the amount of acres that it can be utilized for as it is.

The CHAIRMAN. You think the storage system would not only supply these farmers, but three times more?

Mr. DANSTIN. Yes.

The CHAIRMAN. Without going to Snake River at all?

Mr. DANSTIN. On those small streams; and then also the Snake River. It will be an actual necessity in a few years to have storage on that river. There is an abundance of water there now, but if it keeps going it will be quite small after awhile.

STATEMENT OF JOHN ANDREW O'FARRELL.

The CHAIRMAN. You are a miner and prospector?

Mr. O'FARRELL. Yes.

The CHAIRMAN. And have traveled pretty much all over this Territory?

Mr. O'FARRELL. Yes.

The CHAIRMAN. And have lived here for a good many years?

Mr. O'FARRELL. Since 1863.

The CHAIRMAN. What was the condition of this valley where these orchards and vineyards now are, at the time you first saw it?

Mr. O'FARRELL. It was a dry sand-bar, like a wash-out. Nothing could make a living on it hardly, except that a toad would be sometimes found near one of the little springs.

The CHAIRMAN. What has produced the change that we see?

Mr. O'FARRELL. The use of water.

The CHAIRMAN. Do you find similar changes in other parts of the Territory? Where you put water on the land does it become fertile as it has become here?

Mr. O'FARRELL. Everywhere.

The CHAIRMAN. Have they been able to produce trees and orchards and all sorts of crops all over the Territory?

Mr. O'Farrell. Everywhere where the water is used for irrigation and properly attended to, the product is the same. It is really marvelous.

The Chairman. Of course there are some places that are a little more fertile than others and easier to irrigate?

Mr. O'Farrell. Yes.

The Chairman. Have you traveled over the mountains generally, and observed their conformation with regard to the storage of water in Idaho?

Mr. O'Farrell. Yes; I have given that subject particular attention within the last six years.

The Chairman. What have been the general opportunities for storage that you have observed?

Mr. O'Farrell. Just north and east of where we now are surpasses any part of the State of Colorado, and I have traveled that whole State as a miner and farmer. I was for two seasons there.

The Chairman. Describe the condition of the mountains at the headwaters, and those streams as a general rule; what are the general features of the country?

Mr. O'Farrell. The country is a rolling, mountainous country, heavily clothed with timber. The cañon of the South Branch of the Payette and the Boisé meet on the same dividing ridge; the ridge is very abrupt and the distance from the head of one stream to the other is very short. The Salmon River empties itself on the eastern side of the range and along the Bitter-root Valley. The Salmon, Boisé, and Payette come into the same valley.

The Chairman. Are these mountains high, so that they gather a good deal of moisture?

Mr. O'Farrell. Yes.

The Chairman. Are high mountains and plenty of snow characteristics of this Territory?

Mr. O'Farrell. They are in the portion of the Territory to which you refer. I would say that at these particular places there are quite a number of lakes, and those lakes look as though they now occupied the places of extinct volcanoes. They are elevated high up in the mountains. The lakes could by a rampart or dam be made to hold a vast quantity of water.

The Chairman. You found lakes at the headwaters of what streams?

Mr. O'Farrell. Of all the streams; the Payette, the Boisé, and the Salmon.

The Chairman. Are those lakes numerous?

Mr. O'Farrell. On the South Boisé, in one of the Table Mountains, there are, I think, seven lakes. One is quite large, standing on an elevated plateau of land, and by very little work all the water could be taken from those lakes on to the Salmon River; but its natural flow is to the South Boisé stream.

The Chairman. The South Boisé covers a good deal of land if it can give sufficient water?

Mr. O'Farrell. Yes.

The Chairman. Is the land valuable?

Mr. O'Farrell. Yes; but by storage there could be much more made valuable.

The Chairman. Have you been up to the head of the Snake?

Mr. O'Farrell. Yes; and all through the National Park.

The Chairman. What is the opportunity up there for lakes for storage?

Mr. O'FARRELL. If dams were constructed on Lake Jackson and other places, it would be one of the mammoth storing places for water on the Rocky Mountain range.

The CHAIRMAN. By "mammoth" you mean very large?

Mr. O'FARRELL. Immense.

The CHAIRMAN. Are the mountains high, so as to gather very much snow?

Mr. O'FARRELL. Very high. The shed of the Tetons empties all its water into the lake.

The CHAIRMAN. Have you been into the southern part of the Territory and south of the Snake and towards the Utah and Nevada line?

Mr. O'FARRELL. Yes.

The CHAIRMAN. How is that watered?

Mr. O'FARRELL. At the head of the Owyhee River the country is very level, and forms a basis similar to the Boisé basin here, but the mountains in the vicinity are not so high.

The CHAIRMAN. They do not collect so much snow.

Mr. O'FARRELL. They do not collect so much snow, or at any rate so much snow does not lie there. But the water that comes from the channel of the Owyhee, if stored, would cover the whole valley of the Humboldt.

The CHAIRMAN. They could go into Nevada State?

Mr. O'FARRELL. Yes, the "Bull's Run trail," as they call it, is the lowest pass, and when you form a dam right down there at those several little branches of the Owyhee, you will throw the whole of the water into the Nevada valley, and I believe it would not require twenty feet.

The CHAIRMAN. What are the characteristics of the Payette River?

Mr. O'FARRELL. From what I have seen in the Territory of Idaho, I have been on no stream that has the same natural advantages for easy work and cheap irrigation as the Payette has. The country of itself and the surroundings are generally better, and the stock range, above the line of any canal that could be constructed there, is more extensive than anywhere that I know of for any of the projected canals.

The CHAIRMAN. Have you any other suggestions to make about irrigation?

Mr. O'FARRELL. As you have asked me about the Payette, I may say that I have been down there, and those who go down there can not ordinarily see one-fourth of the area that the water will cover, because on the north side when you run to Willow Creek there is a rough, irregular ditch there, and you can go through that and get into a table land between the Weser Valley and Payette Valley.

The CHAIRMAN. How much of that table land?

Mr. O'FARRELL. A friend of mine and myself estimated 150,000 acres as the extent of ground upon which that water could be utilized. The lower part of the Payette, however, he estimated at 200,000 acres.

The CHAIRMAN. You have 350,000 acres then, altogether?

Mr. O'FARRELL. That was Mr. Kinney's estimate.

The CHAIRMAN. Have you estimated how much it would cost per acre to irrigate that?

Mr. O'FARRELL. Yes; for the lower lands on the south side of the river it would cost $1.60 per acre, and for the higher lands on the north side of the river, including the difficulty of getting through this pass, it would cost about $3.30 per acre. I had the thing reduced to figures by Mr. Kinney, who was a very practical man.

The CHAIRMAN. If the whole 350,000 acres can be reclaimed for $5 per acre, would there be any difficulty in selling the water rights at $5 per acre?

Mr. O'FARRELL. Not in that locality. As fast as you can get the water in the country you can get it settled up.

STATEMENT OF W. A. RANKIN, OF BOISÉ CITY.

The CHAIRMAN. What is your occupation?

Mr. RANKIN. I was brought up a tiller of the soil.

The CHAIRMAN. Have you traveled through this region of country here where the timber grows?

Mr. RANKIN. I have, through Nevada, California, and Idaho.

The CHAIRMAN. Have you seen forest fires in Idaho, Montana, Washington Territory, and Oregon, and have they been very destructive?

Mr. RANKIN. Yes; they have been very destructive this season; more so than usual. I have just returned from a 150-mile trip north of this Territory and found that the fires are very destructive.

The CHAIRMAN. How does the amount of timber destroyed by fire compare with the amount used by the people?

Mr. RANKIN. I think there will be more timber consumed by fire during 1889 than all that has been consumed by the inhabitants of Idaho Territory from its organization.

The CHAIRMAN. Can you suggest any way by which the General Government can assist in protecting the forest?

Mr. RANKIN. I can suggest a plan, I think.

The CHAIRMAN. Tell us what your plan is?

Mr. RANKIN. It is that there should be something like local commissioners; that is, a commissioner to be chosen from among the citizens in the different localities or timber districts, and that they should have some appropriation, either from the General Government or from some other source, so that they could pay men for labor performed to prevent fires. These fires come from carelessness of parties who go into the mountains to hunt, fish, prospect, etc.; whereas if there was some one to follow tourists up immediately, these fires could be checked.

The CHAIRMAN. How would you do it?

Mr. RANKIN. It could be done in many places by a few buckets of water, sometimes by doing a little shoveling around a big pine tree.

The CHAIRMAN. Over so large an area, would not that method require a large number of persons as guards?

Mr. RANKIN. Not a great many. One man could follow along a mountain range where this is occurring, and could put out a great many fires in a day's walk.

The CHAIRMAN. After the fires got started to some extent he could not accomplish much?

Mr. RANKIN. No; he could not.

The CHAIRMAN. In what portions of the year do fires occur?

Mr. RANKIN. There are only about ninety days in the year when these fires are dangerous and destructive. If kept subdued for that dry period (during the months we will say of July and August and part of September), fires would not trouble the forests of the country at other seasons, because there is more or less rain-fall. High in the mountains in September there is often considerable snow that will put out fires.

The CHAIRMAN. Then your idea is to have local commissioners or officers in convenient districts with power to employ persons during the fire season?

Mr. **Rankin**. Yes; to employ help when it became necessary.

The **Chairman**. Would it be agreeable to the people if all the timber lands were withdrawn from sale, and every man was allowed to cut timber, provided he would comply with the regulation, and leave the undergrowth untouched?

Mr. **Rankin**. I think it would meet with the full approbation of the pioneers of the West.

The **Chairman**. If people were allowed to cut what they wanted for their own use, or for any use, would they be willing to pay sufficient stumpage to re-imburse the Government for the expense of guarding the forests?

Mr. **Rankin**. Yes; I believe they would be all willing to do it.

FURTHER STATEMENT OF ALANSON SMITH.

The **Chairman**. I understand you wish to add something to the testimony you have given. I see there is quite a difference of opinion in regard to the number of acres of arable land. By arable land I understand that which can be made to subserve the plow, and does not consist entirely of sage-brush land. Land that can be made to produce crops by irrigation is arable land.

Mr. **Smith**. I include in the arable land of Idaho a very large surface, although small in comparison with the whole. There is a large surface of land covered to some extent with timber, perhaps small timber. I refer to the lands from which you can cut down the timber and have part of the land for grass. I have been making estimates since 1875, when I first attempted to make an estimate in regard to the capacity and resources of this country. My estimate of the arable land of Idaho would be larger than that made by Mr. Dubois and others, because I include in arable land all land that is capable of cultivation by any ordinary means.

The Valley, as it is termed, is reported here to be from 60 to 80 miles long and 10 miles wide. That makes about 600 or 800 square miles. I have traveled all over that country—all the river and its tributaries (and there are some large streams running into the main Payette River), and I believe that in extent it is at least equal to the State of Delaware, and that is about 2,000 square miles. The arable portion of it is about equal to the State of Rhode Island. In that I include not only the grass land which I rode through for miles, but I have also included the lands along the tributary streams, which include land, a good deal of land, covered with small timber; but if the timber were cut off and the land cultivated, it would produce the best kind of crops.

I place the arable land of Idaho as high as at least 20,000,000 acres. That is about one-third of the whole Territory. I am fortified in this estimate by the land that I have seen in the Walla Walla region and in northern Idaho. I took a great deal of pains, in northern Idaho, to ascertain the facts regarding the amount of cultivable land. I set down the area of northern Idaho as equal to all the arable land of New England. I place the arable land of the whole Territory, including the lands easily cleared of timber, as equal to the whole of the arable lands of New York and Pennsylvania put together. I believe that is how the Census Reports of 1870 placed it. My object has been not to enhance the value of the Territory beyond what it deserved, and I make this statement in order that I might be right upon the record with regard to this point, as I have investigated the subject for the last fourteen years.

STATEMENT OF FRANK GREENE, SECOND LIEUTENANT, SIGNAL CORPS, U. S. ARMY.

My views upon the subject of irrigation are based upon an experience of several years' duty in the Northwest and some personal investigation of the question of wheat growing without irrigation.

When the annual precipitation falls to or below 12 inches, irrigation will be found necessary, although, as shown in Senate Ex. Doc. No. 229, Fiftieth Congress, first session, the mean annual precipitation at Walla Walla, Wash., in the heart of the Columbia River wheat basin, is but 17 inches.

That the dry sage-brush land of the west will, when watered, produce an ample crop, is shown in the same document, page 16, the bunch-grass land averaging 25.3 bushels of wheat per acre, and the mixed bunch-grass and sage-brush land 25.7 bushels per acre.

For the growth of cereals irrigation will be found necessary principally in the months of March, April, and May, and to a more limited extent in June. After this time, for the remainder of the year, it would, for this purpose, be unnecessary, although, to render a region habitable, it must be continued the year round. It would seem, then, that the most important problem would be the securing of ample water supply in the first half of the year.

Where a large river with considerable fall passes through a region such as the Snake River in southern Idaho and eastern Oregon, it appears practicable to supply large tracts of land on each side with water for irrigation by a system of tapping the river at well-selected points above, to water the lands lying below. If a low-lying dam, of only sufficient height to direct the water into the acequia during the low-water stage, from November to the last of May, can be protected against the first few feet of rise over its top in the June rises, the matter of protecting the mouth of the acequia against high water will not be difficult and a means of obtaining a constant water supply will be found.

When no supply from a stream is available, the question of a water-supply may yet be solved in some of the interior basins by the artesian well.

To a limited extent, water can be elevated above the level of the acequia to a distance equal to the radius of the wheel that the current in the acequia will revolve, by means of the well-known irrigating water-wheel, such as is used so successfully in Boisé City, Idaho.

It may not be amiss even to speak of the clearing of the sage-brush land, always a task involving much labor. I have seen such land rapidly cleared by dragging over it the bight of a stout iron chain, to each end of which oxen are hitched, the smaller sage-brush being torn out at once by the roots, while a man following in the rear, with the tap of an ax to the top roots, readily releases the hold of the larger brush.

STATEMENT OF JAMES M. COOK, SECRETARY OF THE REXBURG AGRICULTURAL AND HORTICULTURAL ASSOCIATION, REXBURG, BINGHAM COUNTY.

All lands in our section require irrigation to produce crops. There is yet considerable land without water, but in most instances where it is convenient to get water the land is under claim.

Six years ago, February, 1883, this district, which lies between the forks of the north and south forks of the Snake River (it is 22 miles east from Market-Lake Depot to Rexburg), first began to settle up, and a large quantity of land has been taken up by settlers. They continue to do so where an opening occurs and there is any prospect of getting out ditches. I am unable to give the extent of land yet without water, but can say our country is large, extending some 30 to 40 miles, perhaps 50 miles by 20 to 25 miles, more or less under water or now in contemplation of such advantage.

The average rain-fall is very light, especially in the earlier parts of the year. Some winters we have considerable snow. The last two winters have been exceptions and we have had doubts of our streams holding out for irrigation.

In Rexburg we have two canals, each recorded to be 20 feet wide in the bottom, and each able to carry 8,000 inches of water. Rexburg contains about two hundred lots of 2½ acres each. The estimated water-right required per lot is $20. The estimate for farm lands is $2 per acre.

The upper canal is taken out of the Geton River (south fork) 3 miles above Rexburg, and is some 7 feet higher than the lower one, which is taken out opposite Rexburg and is used mostly for the farm lands, which it strikes about 1 mile from the river.

Dams of rock are required in the river by both canals so as to continue the supply to the end of irrigation time. The upper canal has a head-gate 10 feet wide; the lower one a head-gate 20 feet wide.

By March, 1888, these two canals had cost $15,400, which was mostly credited to labor for those who wanted water. Our canals are made by those who want water. Some little delay is caused on account of the scarcity of capital, in thefinal completion of ditches. On March 26, 1888, it was decided to cancel half the amount of the cost of Rexburg canals, which has reduced the cost to $7,700.

Our canals to date having cost by amount after cancelled $8,000.

The water estimate at the recording of our canals was 1 inch per acre under 4-inch pressure. We estimated to take under them some 16,000 acres.

The estimate of $20 per lot and to $2 per acre is raised on the amount now recognized, viz, $8,000 as cost of canals, assessments for cleaning out and repairing for 1889 was one day's work with team for 10 acres of land, and the same for one city lot. There is also a cash tax for water master's fees of 10 cents per acre cultivated land and of $1 per city lot.

We have always had a good supply of water. This is distributed by the water master, who is allowed his own discretion and judgment in all cases. In no case have we had to measure out our water. Two waterings, or at most three, is sufficient for grain crops. The manner of holding water property here in Rexburg as been up to the present by book account, which was transferable at the will of the owner, the secretary being appointed at the same time as the water master, the third Monday in March. I have been secretary of the Rexburg Irrigation Company since the date of its commencement in spring of 1883. There is somewhere about 5,000 acres at present under our canals. We have other canals around here; two near Rexburg, two or three at Lyman, 8 miles south. There are two or three or more at Teton, 8 miles east; the same at Salem, 3 miles north; Welford, and at other places about 11 miles northeast. All the supply of water is mostly taken from the Teton River, whose source is at the Teton Peaks, or a little south of that ridge of mountains. The stream forks some 9 miles east of Rexburg, one fork going a little south and the other a little north, both forks entering the Snake

River north of where the north and south forks of the great Snake River meet. On the Teton Island, as between the forks of the Teton River is called, there is quite a number of canals; some two or three are interested together, and in other instances five or six, and so on till we get to our larger ditches. The greatest fear we have is as to the extent of the Teton River. There is no doubt that more water is recorded and claimed than it holds, especially after it has lowered considerably, which it does do in June.

It would be good if something could be done to insure the supply. It has been contemplated to connect Fall River with the Teton, which would take some 6 miles of rather heavy canal, after which a natural swale or channel would form a good canal. Fall River lies some 20 or 30 miles east of Rexburg, is a faster stream and carries more water than the Teton. It could be relieved of half its contents and leave enough to irrigate the level lands that it passes through.

Teton, 8 miles east of Rexburg, has been trying to get a canal out of Cañon Creek, some 12 or 14 miles, for five years past. Cañon Creek is a stream that lies very low, its channel being cut in lava rock. This canal would cover some of the prettiest land around here, some 2,000 or 3,000 acres. It is rather expensive to make canals through rock on the side of cliffs. Assistance would be near to charity in this instance.

All vegetables and grain crops are grown with irrigation. Nothing would mature without it, only where the rivers overflow at high-water time, which produces hay, some trees and willows, which are mostly on the river bottoms.

Out of the valley rolling hills are found, and after average winters of snow we have a fair pasture of bunch grass. In the last six years there has been a large quantity of land brought under cultivation by means of water. Every year brings to light some new enterprise or some large canal enterprise. All the canals have been built by those who are making homes for themselves. We have a net-work of ditches all through the country, or, as it is termed, between the forks of the Snake River on the south side of the river and on to Eagle Rock. On the south side of the Snake they have had more speculative companies than we have had around Rexburg. All the cry is for water, water. Every one wants water; nothing can grow without it.

STATEMENT OF, FRANK B. ANDREWS, SECOND LIEUTENANT FOURTH INFANTRY, U. S. ARMY, BOISE BARRACKS.

Reservoirs, of necessary size, to be constructed and filled from the large streams through ditches. If constructed by erecting a dam across any of the streams, a sudden rise in the water might cause the dam to give way and loss of property result. Size and direction of ditches leading from reservoirs would of course depend upon conditions obtaining in particular locality. If Congressional action could be had with a view to transferring to a State or Territory all public lands which should be certified by a surveyor (under employ of the General Government) as having been actually reclaimed by the State, authority granted for the issue of bonds to defray expense of such reclamation, bonds to be redeemed by proceeds of sale of land granted as above, it would seem as though the work would be thoroughly done. Each State would hasten the reclamation of all lands within its borders in order to secure the earliest settling. If, then, each State should adopt laws similar to those of Colorado, dividing the State into districts, each one under charge of a water commissioner, who should be under orders of and report to the State engineer, the amount of arid land in the country would in the shortest practicable time be reduced to a minimum.

Adjourned.

WATER RIGHTS UNDER PROPOSED STATE CONSTITUTION.

The following provisions of the constitution adopted by the people for the proposed State of Idaho were filed with the committee by the secretary of the constitutional convention:

ARTICLE I.—*Bill of rights.*

SEC. 14. The necessary use of lands for the construction of reservoirs, or storage basins, for the purposes of irrigation, or for rights of way for the construction of canals, ditches, flumes, or pipes, to convey water to the place of use, for any useful, beneficial, or necessary purpose, or for drainage, or for the drainage of mines, or the working thereof, by means of roads, railroads, tramways, cuts, tunnels, shafts, hoisting works, dumps, or other necessary means to their complete development, or any other use necessary to the complete development of the material resources of the State, or the preservation of the health of its inhabitants, is hereby declared to be a public use, and subject to the regulation and control of the State.

Private property may be taken for a public use, but not until a just compensation, to be ascertained in a manner prescribed by law, shall be paid therefor.

ARTICLE XV.—*Water rights.*

SEC. 1. The use of all waters now appropriated, or that may hereafter be appropriated, for sale, rental, or distribution; also of all water originally appropriated for private use, but which after such appropriation has heretofore been or may hereafter be sold, rented, or distributed, is hereby declared to be a public use, and subject to the regulation and control of the State in the manner prescribed by law.

SEC. 2. The right to collect rates or compensation for the use of water supplied to any county, city, or town, or water district, or the inhabitants thereof, is a franchise, and cannot be exercised except by authority of and in the manner prescribed by law.

SEC. 3. The right to divert and appropriate the unappropriated waters of any natural stream to beneficial uses shall never be denied. Priority of appropriation shall give the better right as between those using the water; but when the waters of any natural stream are not sufficient for the service of all those desiring the use of the same, those using the water for domestic purposes shall (subject to such limitations as may be prescribed by law) have the preference over those claiming for any other purpose, and those using the water for agricultural purposes shall have preference over those using the same for manufacturing purposes. And in any organized mining district, those using the water for mining purposes or milling purposes connected with mining shall have preference over those using the same for manufacturing or agricultural purposes. But the usage by such subsequent appropriators shall be subject to such provisions of law regulating the taking of private property for public and private use as referred to in section 14 of article 1 of this constitution.

SEC. 4. Whenever any waters have been or shall be appropriated, or used, for agricultural purposes, under a sale, rental, or distribution thereof, such sale, rental, or distribution shall be deemed an exclusive dedication to such use; and whenever such waters so dedicated shall have once been sold, rented, or distributed to any person who has settled upon or improved land for agricultural purposes with the view of receiving the benefit of such water under such dedication, such person, his heirs, executors, administrators, successors or assigns, shall not thereafter, without his consent, be deprived of the annual use of the same, when needed for domestic purposes, or to irrigate the land so settled upon or improved, upon payment therefor, and compliance with such equitable terms and conditions as to the quantity used and times of use as may be prescribed by law.

SEC. 5. Whenever more than one person has settled upon or improved land with the view of receiving water for agricultural purposes, under a sale, rental, or distribution thereof, as in the last preceding section of this article provided, as among such persons priority in time shall give superiority of right to the use of such water in the numerical order of such settlements or improvements; but whenever the supply of such water shall not be sufficient to meet the demands of all those desiring to use the same, such priority of right shall be subject to such reasonable limitations as to the quantity of water used, and times of use, as the legislature, having due regard both to such priority of right and the necessities of those subsequent in time of settlement or improvement, may by law prescribe.

SEC. 6. The legislature shall provide by law the manner in which reasonable maximum rates may be established to be charged for the use of water sold, rented, or distributed for any useful or beneficial purpose.

TERRITORIAL LAWS OF DAKOTA IN RELATION TO WATER AND WELLS.

[In force in both States—South and North Dakota.*]

POLITICAL CODE—TERRITORY OF DAKOTA, 1887.—*Article* 4. *Water rights.*

Sec.
2029. Person holding land has right to water.
2030. Right of way for conducting water.
2031. Right of way limited.
2032. Controversies, how determined.
2033. Deterioration or diminution of waters not to be considered.

Sec.
2034. Damaging lands—penalty for.
2035. Abandoned water-right; bridging ditches.
2036. Failure to comply with provisions of last section.
2037. Manner of locating water-rights.
2038. When abandoned.

SEC. 2029. Any person or persons, corporation or company, who may have or hold a title or possessory right or title to any mineral or agricultural lands within the limits of this Territory shall be entitled to the usual enjoyment of the waters of the streams or creeks in said Territory for mining, milling, agricultural, or domestic purposes: *Provided*, That the right to such use shall not interfere with any prior right or claim to such waters when the law has been complied with in doing the necessary work.

SEC. 2030. When any persons, corporation, or company owning or holding land, as provided in section 2029, shall have no available water facilities upon the same, or whenever such lands are too far removed from any stream or creek to so use the waters thereof as aforesaid, such person or persons, corporation or company shall have the right of way through and over any tract or piece of land for the purpose of conducting and conveying said water by means of ditches, dykes, flumes, or canals, for the purpose aforesaid.

SEC. 2031. Such right to dig and construct such ditches, dykes, flumes, and canals over and across the lands of another shall only extend to so much digging, cutting, or excavation as may be necessary for the purposes required.

SEC. 2032. In all controversies respecting rights to water under the provisions of this act the same shall be determined by the date of appropriation as respectively made by the parties, whether for mining, milling, agricultural, or domestic purposes.

SEC. 2033. The waters of the streams or creeks of the Territory may be made available to the full extent of the capacity thereof for mining, milling, agricultural, or domestic purposes, without regard to deterioration in quality or diminution in quantity, so that the same do not materially affect or impair the rights of the prior appropriator.

SEC. 2034. Any person or persons, corporation or company, damaging or injuring the lands or possessions of another by reason of cutting or digging ditches or canals or erecting flumes as provided by section 2030, the party so committing such injury or damage shall be liable to the party so injured for the actual damage occasioned thereby.

SEC. 2035. This act shall not be so construed as to impair or in any way or manner interfere with the rights of parties to the use of the waters of such streams or creeks acquired before the passage of this act: *Provided*, That all water rights or ditches that have not been used or worked upon for one year next prior to the passage of this act shall be deemed abandoned and forfeited and subject to appropriation anew. Any person or persons, corporation or company who may dig any ditch or canal, dyke, or flume over or across any public road, trail, or highway, or who use the waters of such ditch, dyke, flume, or canal shall be required to bridge the same and keep the same in good repair at such crossing or other places where the water from any such ditch, dykes, flumes, or canals may flow over or in anywise injure any road, trail, or highway, either by bridges or otherwise.

SEC. 2036. Any person or persons, corporation or company offending against section 2035, on conviction thereof shall forfeit and pay for every such offense a penalty of not less than twenty-five dollars nor more than one hundred dollars, to be recovered with costs of suit in civil action in the name of the Territory of Dakota, before any court having jurisdiction. One-half of the fine so collected shall be paid into the county treasury of the county in which the offense was committed, and the other half shall be paid to the person or persons informing the nearest magistrate that such offense has been committed. All such fines and costs shall be collected without stay of execution, and such defendant or defendants may by order of the court be confined in the county jail until such fine and costs have been paid.

---

* Copies of statutes received too late for insertion in Dakota division.

SEC. 2037. Any person or persons, corporation or company appropriating the waters of any streams or creeks in this Territory, shall turn the water from the channel of such creek or stream, and construct at least twenty feet of ditch or flume, within thirty days from the date of appropriation, and turn the water therein; and construct at least twenty rods of said ditch or flume, if needed, within six months from the date of such appropriation, and turn the water therein; and within twenty days from the date of location, the locator or locators of such water right shall file a location certificate thereof with the register of deeds in the proper county within which such water right is situated; a copy of such certificate shall be posted at or near the head of such ditch, flume, or canal, and shall contain the name or names of the locators, the date of location, number of inches of water claimed or appropriated, and the purpose of the appropriation; and in no case shall the number of inches of water claimed exceed the conveying capacity of the first twenty feet of the flume or ditch, nor shall said ditch or flume be enlarged to the prejudice or injury of a subsequent appropriator before such enlargement.

SEC. 2038. On failure to commence the construction of such ditch or flume for sixty days after location, and prosecute such ditch, canal, or flume to final completion without unnecessary delay, such appropriation shall be deemed abandoned.

CIVIL CODE—CHAPTER 3.—1887.—*Servitudes.*

SEC. 2760. The following land burdens or servitudes upon land may be attached to other land as incidents or appurtenances, and are then called easements:

* * * * * * *

4. The right of way.
5. The right of taking water, etc.

* * * * * * *

9. The right of receiving water from or discharging the same upon land.
10. The right of flooding land.
11. The right of having water flow without diminution or disturbance of any kind.

ARTICLE I, TITLE 3.—*Rights and obligation of owners.*

SEC. 2771. The owner of land owns water standing thereon or flowing over or under its surface, but not forming a definite stream. Water running in a definite stream, formed by nature over or under the surface, may be used by him as long as it remains there; but he may not prevent the natural flow of the stream, or of the natural spring from which it commences its course, nor pursue nor pollute the same.

ARTESIAN WELLS.

[Chapter 14. Acts of eighteenth session, 1889.]

AN ACT to provide for the sinking of artesian wells and construction of water-courses therefrom.

Be it enacted by the legislative assembly of the Territory of Dakota:

SECTION 1. [*Commissioner created.*] That for the purpose of carrying into effect the provisions of this act, the judge of probate of each county shall be *ex officio* county artesian well commissioner, which office is hereby created.

SEC. 2. [*Application by ten resident freeholders.*] Before the artesian well commissioner shall take any action toward creating or establishing any artesian well, there shall be filed with him an application, signed by not less than ten resident freeholders of any township or townships in which such artesian well and the lands to be benefited thereby and to be assessed therefor may be situated, giving a description of the place where said well is proposed to be located, and also a definite description of the beginning, the route, and the terminus of the water-way through which it is proposed that the water from such well shall flow when the same is completed and in operation, and offering the right of way for said well and such water-way through their said land, and who shall be subject to direct assessment therefor.

SEC. 3. [*Appointment of viewers—duties.*] At the expiration of twenty days after the filing of such application the said commissioners shall appoint three disinterested persons as viewers who shall without unnecessary delay proceed to personally examine the place where said well is to be located and the course, route, and terminus of said proposed water-way, and shall ascertain whether said location of such well and establishment of said water-way is practicable and necessary and beneficial to the public welfare of the district in which the same is proposed to be located, and shall report the result of such investigations in writing to said well commissioner, having first been duly sworn to faithfully and impartially discharge their duties as such viewers. If any person upon whose land the proposed well is located or through whose land any water-way therefrom may pass, shall have filed any protest against the location of said proposed well and water-way, prior to the appointment of said viewers, they shall assess the damages, if any, which such person may sustain from the location of such well or said water-ways through his land, and shall report said damages with the report of their proceedings made as heretofore provided.

SEC. 4. [*Report when damages assessed.*] If a majority of the viewers assess and report damages in favor of any person protesting against the location of such well or its water-ways, their report shall be presented to the board of county commissioners of said county, and if said board shall consider the proposed well of sufficient importance to the public they shall order the costs and damages to be paid out of the county treasury; but if a majority report against the claims for damages of such person he shall be liable for the costs of such appraisement.

SEC. 5. [*Power of county commissioners.*] If it shall be made to appear to the board of county commissioners that the damages assessed are unreasonable they may set aside such assessment, and in such case the artesian-well commissioner may order another appraisement by different persons, under the same regulations as provided in the first appraisement.

SEC. 6. [*Appeal to district court.*] Any person aggrieved by any decision of any board of commissioners had under this chapter may appeal therefrom to the district court, the same as provided relating to highways, bridges, and ferries. (Section 29, chapter 29, Political Code, 1217 General Laws.)

SEC. 7. [*Fee of viewers.*] The viewers appointed under the provisions of section 3 of this act shall receive the sum of two dollars per day for their services as described in said section, to be paid by the persons who signed the application for said well, who shall be severally liable to pay the same.

SEC. 8. [*Survey after favorable report—plat filed.*] If the viewers make and file a written report with said commissioners recommending said location and route as practicable, necessary, and beneficial the commissioners shall cause a survey and measurement of the location of said well and the line of the proposed water-way to be made by the county surveyor, and a plat thereof shall be filed in the office of the register of deeds of said county, and be subject to public inspection, and shall show the location of the well and the lines and route of the water-way therefrom.

SEC. 9. [*Order of location by commissioner—damages.*] Upon the filing of the plat and the minutes of said survey as provided in said section 5, the said commissioner shall make an order in writing in which he shall declare said well and said water-ways therefrom to be located in accordance with said plat and survey: *Provided*, That in cases where damages have been appraised and assessed, the same shall first be paid to the person entitled thereto, or paid into the county treasury for their use, before such lands shall be actually taken.

SEC. 10. [*Railway's contribution to water-way—penalty—collection.*] Whenever it is necessary to construct a water-way from any artesian well across the right of way or road-bed of any railroad company it shall be the duty of the railroad, when notified by the commissioners so to do, to make and maintain the necessary opening through said road-bed, and to build and maintain a suitable culvert. Notice in writing to make such opening and to construct such culvert may be served on such company as provided in the service of summons, at least thirty days before such railroad company shall become liable.

In case such railroad company shall refuse or neglect to comply with the provisions of this section, it shall be liable to a penalty of ten dollars for each day's refusal or neglect to make such opening and construct such culvert. The district attorney of the county in which such railroad company shall have refused or neglected to comply with the provisions of this section, shall upon complaint being made by the artesian-well commissioner bring suit to collect such penalty or fines, and it shall be his duty to prosecute the same to a final determination in any court having competent jurisdiction.

SEC. 11. [*Duty of road overseers, etc.*] All that part of such artesian well or artesian-well water course, which is laid and constructed within the limits of or across any public highway shall be under the jurisdiction of the overseer of public highways or road supervisors, and it shall be his duty to keep the same open and free from all obstructions, and when any highway is subsequently constructed along or across such artesian-well water-way then so much thereof as shall come within the limits of such highway shall also be kept open and free from obstructions as above provided.

SEC. 12. [*Name of well.*] In his order locating any well under the provisions of this act the artesian-well commissioner shall give the same a name by which it shall be known and recorded.

SEC. 13. [*Advertise for bids for construction—contract—security.*] After making said order locating said well and the water-ways thereof, the artesian-well commissioner shall proceed to advertise for bids for contracts for sinking or making such well, and consructing said water-ways. He shall give not less than sixty days' notice of the time and place where such bids may be offered and opened, by causing a notice thereof to be published, not less than eight weekly insertions, in the official paper of said county, such bids shall be filed with the county clerk of said county by the parties making the same, and shall be taken subject to the approval of the board of county commissioners of said county. No contract made by the artesian well commissioner shall be valid unless approved by the board of county commissioners of such county, and their approval indorsed thereon by the chairman of said board.

The artesian well commissioner shall contract with the lowest responsible bidder giving adequate security for the performance of the work.

Such security shall cover the completion of the job in the manner and within the time fixed in the contract, and the amount thereof shall be fixed by said artesian well commissioner. Said commissioner shall reserve the right to reject any and all bids, and may adjourn the time for receiving such bids from time to time by publishing a notice of such adjournment, but not in all more than sixty days from and after the time named in the first advertisement, for receiving such bids. The contract for sinking the well may be separate from the contract for constructing the waterways, and may be let to different persons. Whenever any such artesian well shall have been fully completed and final report thereof made by the well commissioner, to the board of county commissioners, the said board shall turn over the control and management of said well and appurtenances to the board of supervisors of the township wherein said well is situated.

SEC. 14. [*Board of assessment—Meetings.*]—Immediately after making his order locating said well, the artesian well commissioner shall notify the chairman of the board of county commissioners and the county treasurer of said county, who shall, together with said well commissioner, constitute a board of assessment herein. The county clerk of said county shall be the clerk of said board of assessment. The members of said board shall meet within twenty days after receiving said notice, and may adjourn from day to day until their duties are performed as hereinafter set forth.

SEC. 15. [*Mode of assessment and apportionment—Tax collection.*]—The said board of assessment shall make an estimate of the costs of constructing said artesian well and the said water-ways, for the purpose of raising the funds necessary for the construction of said well. They shall have power to apportion the costs thereof as follows:

(1) They shall create a county fund to be known as the Artesian Well Fund, and may levy an assessment upon all taxable property in said county, not exceeding two mills on the dollar, and the basis of value upon which the annual levy of the current or preceding year was made: *Provided*, That not more than one-tenth of the cost of any artesian well, or waterways therefrom, shall be paid out of said fund, and the amount so paid shall be applied to the payment of the expenses and per diem of the well commissioners, the viewers, surveyors, members of the board of assessment, damages for right of way, and other like incidental expenses.

(2) They shall determine what portion of the costs of said well and its waterways shall be paid by each of the townships in which said well or said water courses therefrom are situated: *Provided*, That in no case shall the amount apportioned to any one township exceed one-fourth of the estimated cost of such well and waterways, and the county clerk shall present a statement of such amount to the respective clerks of such townships if organized; and said board of assessment shall establish and determine the rate of assessment necessary in such townships to raise the amount so apportioned to such townships. It shall then be the duty of the officers of such townships, who have similar duties to perform in other matters of township revenue, to levy, and they are hereby empowered to levy, an assessment upon the taxable property of said township, not exceeding the rate fixed by the board of assessment for such township, which shall be placed upon the tax-list under the head of "General Township Tax for Artesian Well Purposes," and collected as other township taxes are collected, and shall be held by the county treasurer when collected as a distinct fund to be disbursed, as hereinafter provided, to pay for constructing such well.

(3) In addition to the foregoing general township and county assessments, the said board of assessment shall also make a special assessment against each piece and parcel of land directly benefitted by said well and said water courses, carefully adjusting the per cent. and amount of such assessments with reference to the relative distance of such lands from the well itself, and the water-courses, and the amounts so

apportioned shall be levied as a special tax upon said land, and shall be placed upon the tax list by the county clerk or auditor under the head of "Direct tax for artesian well," and shall be paid into the county treasury as other taxes, and kept by said treasurer in a special fund to pay for the cost of constructing said well and said water-ways; said assessment shall be for a sufficient amount with the general county and township tax aforesaid to pay for said well and water-ways.

SEC. 16. [*Annual installments.*]—Said board of assessment may provide that the entire amount necessary to pay for the construction of said well and water-courses, be levied and collected as above in one year, or they may divide the same into two, three, four, or five equal installments, one of which shall be collected the first year, and one installment each year following, provided that the portion designated as county and township tax shall all be collected the first year.

SEC. 17. [*Review of assessment—Appeal.*]—The owner of any lands directly assessed for the construction of any artesian well under the provisions of this act, who may feel aggrieved by such assessment, may at any time before such tax becomes delinquent, appear before the board of county commissioners of the county in which such assessment was made and ask to have said assessment, as to his property, reviewed, and said board shall have the right to raise or lower his assessment, so as to make it just and reasonable, and an appeal may be taken from the action of said board as in other cases.

SEC. 18. [*Disqualification by interest—vacancy—how filled.*] No member of any county board, and no county officer, whose lands have been directly assessed under this act, shall act on the board of assessment. In case any member of such board is so disqualified, his place shall be filled by calling in the sheriff of said county, or, if said sheriff is so disqualified, the county coroner may act on said board.

SEC. 19. [*Benefits—principle of assessment.*] All assessments of benefits under the provisions of this act shall be upon the principle of benefits derived. All descriptions of land under the provisions of this act shall be made by giving the legal subdivision thereof whenever practicable, and when the tract of land which is to be benefited or affected by such well is less than such legal subdivision it may be described by designation of the lot or other boundaries, or in some way by which it may be known.

SEC. 20. [*Additional assessment.*] Whenever the amount assessed for the construction of any well shall not be sufficient to complete the same, and to pay all the costs and incidental expenses, a further assessment shall be made to meet the deficit or additional expense. Such further assessment shall be apportioned, assessed, levied, and collected as provided in the first instance, and on the same percentage, and shall be collected in one year.

SEC. 21. [*Enrollment of tax by clerk.*] It shall be the duty of the county clerk to spread on his roll the total amount of all the well taxes determined upon by the board of assessment, to be assessed upon any township at large, as a part of the township tax for the year, and he shall also spread upon said roll separately, and immediately following the other descriptions, all tracts or parcels of land specially assessed for benefits, and shall place opposite each description the amount of taxes apportioned thereon for such benefits. All wells shall be entered separately, naming each well.

SEC. 22. [*Collection—mode of.*] All taxes assessed under the provisions of this act shall be collected in the same manner as territorial and other general taxes are collected, and collecting officers are hereby vested with the same power and authority in the collection of such taxes as are or may be conferred by law for collecting general taxes. All taxes levied under the provisions of this act, with all lawful costs, interests, and charges, shall be and remain a perpetual lien upon the lands upon which they are assessed, and a personal claim against the owner or owners of such lands until they are paid.

SEC. 23. [*Sale for delinquency.*] If the taxes levied for the construction of any well are not paid to the county treasurer as provided herein, he shall proceed to sell the said lands for such taxes, at the same time and in the same manner in every respect, as in the case of any other tax and with like effect.

SEC. 24. [*Compensation of officers.*] The artesian well commissioner and the members of the board of assessment herein provided for, shall receive for their services a sum not to exceed three dollars per day for each day actually and necessarily spent by them in the discharge of their respective duties as hereinbefore described. All expenses, except on contract for constructing said well or such water-courses, shall be paid out of the general fund of the county on the order of the board of county commissioners, as other claims against the county are paid; said fund to be re-imbursed, out of the first money collected under the provisions of subdivision 1 of section 15 of this act.

SEC. 25. [*Blanks drawn by attorney-general.*] It shall be the duty of the attorney-general to draft a complete set of all the blank forms that may be required under this act, and county clerks are authorized, and it shall be their duty, to procure at the expense of their respective counties the necessary books and blanks to carry out the provisions of this act.

SEC. 26. [*Mode of payment to contractor.*] No payment shall be made to any person contracting to construct or sink an artesian well or any water-course therefrom under the provisions of this act except as follows: One-third of the amount to be paid for the entire performance of the contract may be paid when one-third of said work is done; one-third of said amount may be paid when two-thirds of said work is completed; but the balance of said amount shall not be paid until said contract has been fully completed and the work accepted and approved by the artesian well commissioner. The said payments shall be made in the following manner: The contractor shall make a statement of the amount claimed by him to be due under his contract, and if the same is correct it shall be approved by the artesian well commissioner, whose duty it shall be to carefully examine the work done under said contract; said claim so approved shall be presented to the board of county commissioners, and if correct they shall issue county orders or warrants upon the well funds of each particular well, naming it: *Provided*, That if the assessment of taxes for such well has been divided into installments, as provided in this act, said board shall not issue orders payable in any one year for a larger amount than the said installment for that year, but shall draw as near as may be to the exact amount of such installment. When such orders or warrants are presented to the county treasurer for payment, if he has not yet received sufficient funds to pay the same, then such orders may be indorsed and registered as other county warrants under the general law, and shall bear the same rate of interest as other warrants.

SEC. 27. [*Description of assessed lands filed with register—lien.*] The clerk of the board of assessment provided for in this act shall make a statement of the direct assessment for benefits made against the several pieces and parcels of lands, giving a description of such lands, the amount of the direct assessment against each piece or parcel, the name of the well for which the assessment was made, and shall file the same with the register of deeds of said county, and the same shall thereafter be a lien upon said lands to secure the payment of any orders or warrants issued as herein provided; which lien may be foreclosed by the holder of such warrants or orders, and shall be prior to all other liens except for taxes.

SEC. 28. [*Water-course unobstructed, duty of overseer of highways.*] It is hereby made the duty of every person through whose land any water-course constructed under this act may pass to keep the same open and unobstructed. On failure so to do, any person aggrieved may complain to the overseer of highways in the district where such water-course is situated, and such overseer shall have the authority, and it is hereby made his duty, to call out the persons residing in said district who are liable for road tax, and open said water-way, and the expense thereof shall be entered by the county clerk as a tax against said land.

SEC. 29. [*Repeal.*] All laws heretofore enacted on the subject of artesian wells are hereby repealed: *Provided*, That all proceedings heretofore had and all contracts made under the provisions of existing laws on the subject of artesian wells are hereby declared to be valid and may be continued and completed under the provisions of this act.

SEC. 30. [*Effect when.*] This act shall take effect on the 1st day of July, 1889.

Approved March 8, 1889.

WATER RIGHTS UNDER THE CONSTITUTION OF THE STATE OF MONTANA.*

SECTION 1 The use of all waters now appropriated, or that may hereafter be appropriated, for sale, rental, or distribution; also, of all water originally appropriated for private use, but which, after such appropriation has heretofore been, or may hereafter be, sold, rented, or distributed, is hereby declared to be a public use, and subject to the regulation and control of the State in the manner prescribed by law.

SEC. 2. The right to collect rates or compensation for the use of water supplied to any county, city, or town, or water district, or the inhabitants thereof, is a franchise, and can not be exercised except by authority of and in the manner prescribed by law.

SEC. 3. The right to divert and appropriate the unappropriated waters of any natural stream to beneficial uses shall never be denied. Priority of appropriation shall give the better right as between those using the water for the same purpose; but when the waters of any natural stream are not sufficient for the service of all those desiring the use of the same those using the water for domestic purposes shall (subject to such limitations as may be prescribed by law) have the preference over those claiming for any other purpose, and those using the water for agricultural purposes shall have preference over those using the same for manufacturing purposes.

---

* Delayed in transmission and inserted here in place of Montana division.

SEC. 4. All persons and corporations shall have the right of way across public, private, and corporate lands for the construction and maintenance of canals, ditches, flumes or pipes for the purpose of conveying water to the place of use, for any useful or beneficial purpose, and for drainage, upon paying therefor a just compensation in the manner prescribed by law.

SEC. 5. Whenever any waters have been, or shall be, appropriated or used for agricultural purposes under a sale, rental, or distribution thereof, such sale, rental, or distribution shall be deemed an exclusive dedication to such use; and whenever such waters so dedicated shall have ever been sold, rented, or distributed to any person who has settled upon or improved land for agricultural purposes with a view of receiving the benefit of such water under such dedication, such person, his heirs, executors, administrators, successors, or assigns shall not thereafter without his consent be deprived of the annual use of the same when needed for domestic purposes, or to irrigate the land so settled upon or improved, upon payment therefor and compliance with such equitable terms and conditions as to the quantity used and times of use as may be prescribed by law.

SEC. 6. Whenever more than one person has settled upon or improved land with the view of receiving water for agricultural purposes under a sale, rental, or distribution thereof, as in the last preceding section of this article provided, as among such persons priority in time shall give superiority of right to the use of such water in the numerical order of such settlements or improvements; but whenever the supply of such water shall not be sufficient to meet the demands of all those desiring to use the same, such priority of right shall be subject to such reasonable limitations as to the quantity of water used and times of use as the legislative assembly, having due regard both to such priority of right and the necessities of those subsequent in time of settlement or improvement, may by law prescribe.

SEC. 7. The legislative assembly shall provide by law the manner in which reasonable maximum rates may be established to be charged for the use of water sold, rented, or distributed for any useful or beneficial purpose.

SESSIONS OF THE COMMITTEE.

Page.

Washington, D. C., April 8, 1889 5
St. Paul, Minn., August 1, 1889.......... 7-53
Sioux Falls, S. Dak., August 2, 1889 53-68
Sioux Falls, S. Dak., August 2, 1889.......... 68-74
On train, near Huron, August 3, 1889.......... 74-77
Huron, S. Dak., August 3, 1889.......... 77-92
On the train, Jamestown, N. Dak., August 4, 1889.......... 92-100
Bismarck, N. Dak., August 5, 1889.......... 100-114
Resumed session.......... 114-124
Glendive, Mont., August 6, 1889.......... 124-132
Miles City, Mont., August 7, 1889 132-149
Billings, Mont., August 7, 1889 149-166
On train, near Billings, Mont., August 8, 1889 166-171
Bozeman, Mont., August 8, 1889.......... 171-185
Helena, Mont., August 9, 1889.......... 185-250
Butte City, Mont., August 10, 1889 250-254
Missoula, Mont., August 11, 1889.......... 254-266
Moxie Company's Ranch, Yakima, Wash., August 13, 1889..........
Yakima, Wash., August 13, 1889.......... 266-276
North Yakima, Wash., August 13, 1889 276-285
Ellensburgh, Wash., August 13, 1889.......... 284-285
Walla Walla, Wash., August 15 285-299-306
The Dalles, on train, Oregon, August 15.......... 306-308
Baker City, on train, Oregon, August 16.......... 308
Palmer, Idaho, August 16, 1889.......... 317
Boisé City, Idaho, August 17, 1889.......... 319

INDEX.

A.

Page.

- Absorption of water 247,248
- Altitudes:
  - Almo Creek 339
  - Alturas County, Idaho 331
  - Bismark, N. Dak 31
  - Fargo, N. Dak 31
  - Jamestown, S. Dak 31, 116, 128, 133
  - Lakes, in North Dakota 95, 96
  - Malta, Idaho 339
  - Mountains in Idaho 399
  - Mountains, of the Blue 294, 296
  - Rivers, in North Dakota 95, 96
  - Salmon River Valley, of 344
  - Stahrr's Ferry, of 340
  - Tables of 331
  - Timbered valleys 193
  - Tracks and railway stations, of, in North Dakota 96
- Areas irrigated:
  - Idaho, in 352, 353, 354, 400
  - Montana, tables of, in 195
  - Reference to 137, 413
- Artesian wells, locations of:
  - Ada, Minn 94
  - Aberdeen, S. Dak 11, 12, 17, 26, 63, 86, 96
  - Andover, S. Dak 33
  - Ashton, S. Dak 22, 45
  - Blackfoot, Idaho 391
  - Billings, Mont 163
  - Bismarck, N. Dak 31
  - Black Hills, in 20
  - Bozeman, Mont 163
  - Brookings, S. Dak 70
  - Brown County, S. Dak 55, 87
  - Burn, Idaho 349
  - Cass County, N. Dak 11, 26
  - Campbell, S. Dak 34, 60
  - Columbia, S. Dak 33, 82, 86
  - Devil's Lake, N. Dak., at 27, 96, 07
  - Douglas County, S. Dak 56
  - Ellendale, N. Dak 27, 31, 112
  - Fargo, N. Dak 26, 31, 106
  - Frankfort, S. Dak 22, 45
  - Frederick, S. Dak 31
  - Fulman, Wash 301
  - Grandin, N. Dak 93
  - Grafton, N. Dak 28, 96, 97, 105
  - Groton, S. Dak 9, 19, 26, 86, 90
  - Highmore, S. Dak 11, 12, 24
  - Hillsboro, S. Dak 93
  - Hitchcock, S. Dak 9, 10, 83
  - Huron, S. Dak 9, 10, 11, 12, 22, 24, 26, 60, 63
  - Hoffman's Dell, Mont 135
  - Ipswich, S. Dak 39, 86
  - James River Valley, in the Dakotas 13, 23
  - Jamestown, N. Dak 24, 26, 27, 28, 31, 79, 81, 82, 96, 97

Page.

Artesian wells, locations of—Continued.
  Lake County, S. Dak ... 71
  Letcher, S. Dak ... 64, 65
  Madison, S. Dak ... 72, 73
  Mandan, N. Dak ... 115, 118, 119, 120
  Marshall County, S. Dak ... 54
  Mayville, S. Dak ... 105, 112
  Miller, S. Dak ... 9, 10, 11, 24, 25
  Miner, S. Dak ... 60, 81
  Miles City, Mont ... 135, 142
  Mitchell, S. Dak ... 60
  Morehead, Minn ... 28, 106
  Montana, number of, in ... 142, 224
  Montana, character of, in ... 157, 245
  Oakes, S. Dak ... 31
  Oxford, Idaho ... 390
  Pasco, Wash ... 300
  Pierre City, S. Dak ... 101
  Plankington, S. Dak ... 34, 60
  Ramsey County, S. Dak ... 113
  Redfield, S. Dak ... 22, 45, 63
  Red River Valley, N. Dak ... 26
  Roslyn, Wash ... 301
  Salem, S. Dak ... 69
  Sandborn, S. Dak ... 60, 81
  Spink County, S. Dak ... 43
  Sahara Desert, in ... 49
  Tower City, S. Dak ... 96, 105, 106
  Tyndall, S. Dak ... 34
  Warm Springs, Oregon ... 306
  Webster, S. Dak ... 33
  Yankton, S. Dak ... 24, 35, 65, 79, 81
  Yellowstone Valley, Mont., in ... 303
Artesian wells, remarks on:
  Analysis of waters ... 8, 83, 97, 110
  Belt in Dakotas ... 11, 67, 68, 97
  Boring for ... 12, 60, 62, 69, 225
  Capacity of ... 81, 88, 93, 95, 97
  Character of water ... 10, 27
  Congress, action asked from ... 51, 76, 351
  Dakota, laws of, on ... 22, 418
  Depth of ... 11, 225
  Flow of ... 51, 89, 92, 93, 105, 163, 225, 365
  Hitchcock, pressure of, at ... 10
  Inches of flow ... 310
  Interior, basins of ... 412
  Irrigation by ... 342, 350, 390
  Miller, double flow ... 10
  Missouri, towards the ... 11
  Practicability of, in Idaho ... 362
  Volume of water, in ... 12

B.

Barbed-wire fences ... 237
Bluffs, location of ... 128, 137, 160
  Guy's, Montana ... 137
  High, Montana ... 157
  Idaho, in ... 338
Buttes, references to ... 128, 129

C.

Canal, incorporations ... 121, 122, 235, 236, 304, 305
Canals, names of, companies in Dakota:
  Bay State, The ... 122
  Bear, Butte, and Elk Creek, The ... 121
  Bear Butte, Strawberry and Ruby Gulch ... 121
  Bismarck Works, The ... 121
  Black Hills Company's, The ... 121, 122

Page.

Canals, names of, companies in Dakota—Continued.
  Box Elder, The 122
  Boston and Little Rapids, The 122
  Brown's Irrigating, The 121
  Butte County, The 121
  Butte Irrigating, The 122
  Central City, The 121
  Deadwood Water, The 121
  Elm Grove, The 121
  Fargo Water, The 121
  Guyville, The 121
  Lone Tree, The 121
  Lower Rapids, The 121
  Mutual Water, The 121
  Rapid City, The 121, 122
  Rapid River 122
  Rapid Valley, The 121, 122
  Rockville Tepee, The 122
  Wacum, The 122
  Western Improvement, The 121
Canals, summary and tables of, in Idaho:
  Ada County 326, 329
  Alturas County 331
  Bear Lake County 331, 332
  Bingham County 333, 334
  Boisé County 335, 336
  Cassia County 343
  Elmer County 346
  Logan County 352
  Onieda County 358
  Owyhee County 359, 360
  Washington County 362
Canals, names of, companies in Montana:
  Beaver Creek Company 236
  Belt Creek 236
  Big Spring Company 235
  Boulder Valley 235
  Canon Ditch Company 235
  Desert Company 235
  Eldorado Company 235
  Italian Company 236
  Miller Creek Company 236
  Miles City Company 235
  Moreland Company 235
  Republican Company 236
  Ryan Company 236
  Surprise Company 236
  Tongue River Company 236
  Union Company 236
  Ward Company 236
Canals, names of, companies in Washington:
  Ahtanum and Wide Hollow, The 305
  Atalman, The 304
  Broad Gauge, The 305
  Brock Creek, The 305
  Coleman Creek, The 305
  Eureka, The 305
  Fowler, The 305
  Iowa Flat, The 305
  Last Chance, The 305
  Manastask, The 305
  Moxsee, The 305
  Natchez and Cowiche, The (2) 305
  Old Union, The 305
  Oriental, The 305
  Schanno, The 305
  Settlers, The 305
  Tenaway, The 305
  Tenemas, The 305

Page.
Canals, names of, companies in Washington—Continued.
  Union, The 305
  Valley, The 305
  Wanatchee, The 305
  Wenas, The 305
  West Side, The (2) 305
  Yakima Valley, The 305
  Yakima Farm and Water, The 305
  Yakima Irrigating and Improvement, The 305
Canals, reference to:
  Bear River, Idaho and Utah 357
  Beaver Head, Mont 187, 235, 236
  Benton Lake, Mont 239
  Black Cañon, Idaho 329
  Black Hills, in 18
  Bitter Root Valley, in 254
  Boisé City, Idaho 325, 326, 329
  Boisé River, in 327
  Cañons, in 321
  Clark's Fort, Mont 238
  Dearborn, Mont 238
  Deer Flat, Idaho 329
  Dry Creek, in 326
  Duplex plans 321
  Eagle Island, Idaho 329
  Eagle Rock, Idaho 376
  Flat Creek, in 192, 238
  Florence, at 192, 239
  Fresno, Cal 20
  Gallatin, Mont 192
  Meagher County, Mont., sites for 192
  Miles City, at, Mont 137
  Moxie Ranch, at 267
  Fayette River, Idaho 326
  Phyllis, Idaho 327, 328
  Proposed, in Idaho 329
  Rexburg, Idaho 412, 413
  Ridenbaugh, Idaho 326
  Rock Creek, at 305
  Sebree, at, Idaho 326
  Snake River Valley, in, Idaho 342, 343, 346, 393
  Teton River Valley, Mont 413
  Welford, Wash 413
  Weiser River, in 363
  Wisdom River, in 194
  Yellowstone Valley, Muselshell, and Flat Willow 215, 238
Canals, Capitalists engaged in 239
  Colorado, water laws of 394, 413
  Co-operative effort in 20
  Cost and construction of 152, 239, 322, 325, 414, 415
  Headgates of 413
  Indian Reservation, Flathead 241
  Irrigating by reference to 137,
      163, 187, 188, 190, 192, 194, 204, 211, 213, 235, 236, 237, 238, 239, 242, 243,
      247, 251, 253, 254, 256, 267, 268, 272, 331, 332, 344, 361, 363, 376, 383, 405
  Routes by 358
Cañons, mountain and river 206, 208, 213, 243, 251, 252, 253, 254, 258, 263, 270, 339
  Clear Creek, on 339
  Discharge at Boisé River 346
  Foote's, in Idaho 341, 344, 347
  Green, in Idaho 338
  Payette, at 407
  South Branch Boisé River, at 399, 400, 407
  The Narrows, Idaho 357
Cigars, made from irrigated tobacco 275
Coal, references to 12, 109, 115
Columbia, Department of 143, 157, 236, 237
Committee members, special references to Senators:
  Allison, William B 5

Page.
Committee members, special references to Senators—Continued.
  Gorman, Arthur P 5
  Hiscock, Frank 5
  Jones, Alexander R 5, 250, 254, 266, 284, 285, 306, 308, 317
  Plumb, Preston B 5, 185
  Reagan, J. H 5, 7, 53, 68, 74, 77, 92, 100
  114, 124, 132, 149, 166, 171, 185, 250, 254, 266, 276, 284, 285, 306, 308, 317.
  Stewart, William M. (chairman) 5, 7, 53, 68, 74, 77, 92, 100, 114
  124, 132, 149, 166, 171, 185, 250, 254, 266, 276, 284, 285, 306, 308, 317.
Constitutional conventions, memorials:
  Of North Dakota 122, 123
  Of South Dakota 67
Counties, names of, and reference to:
  Ada 324, 325, 328, 346, 347, 365
  Alturas 329, 331, 350, 351
  Barnes 102
  Beadle 8, 83, 85, 91
  Bear Lake 331, 375, 384, 385, 390, 391
  Beaverhead 187
  Bingham 333, 334, 359, 363, 384, 385, 390, 391, 395, 399, 404, 405
  Boisé 335
  Bottineau 111
  Brown 61, 86, 87
  Burleigh 104, 108, 109, 114, 116, 117
  Butte 16, 63
  Cascade 186, 187, 191
  Cass 26, 105
  Cassia 321, 322, 336, 340, 341, 342, 343, 350, 383, 393, 395
  Choteau 188
  Codington 56
  Custer 5, 15,
  132, 133, 134, 135, 136, 137, 140, 144, 7145, 146, 151, 189, 220, 330, 344, 346, 392.
  Dawson 140, 151, 189
  Deer Lodge 189, 212, 257
  Dickey 16, 30, 112
  Deuel 53
  Douglas 34, 55, 300
  Edmunds 38
  Elmore 321, 322, 344, 346
  Fall River 63
  Faulk 61
  Fergus 166, 189
  Franklin 299, 300
  Gallatin 161, 187, 178, 189
  Gillman 307
  Grant 60
  Harney 312
  Haud 51
  Hamlin 56
  Jefferson 191
  Kern 132
  Kingsbury 58, 74, 75
  Kootenai 320, 362, 365
  Lake 68, 69, 71, 72, 73
  La Moure 25, 40
  Latah 320, 365, 366
  Lawrence 16
  Lemhi 323, 353, 354, 391, 395, 399, 404
  Logan 319, 322, 329, 340, 341, 342, 343, 348, 351, 452, 353, 392, 394, 395, 400
  Madison 186, 192
  Malheur 312
  Marshall 54
  Meade 64
  Meagher 140, 192
  McCook 59
  McLean 104
  Minnehaha 35
  Miner 59
  Missouri 191

Page.

- Counties, names of, and reference to—Continued.
  - Missoula 192
  - Morton 104, 114
  - Nez Perces 320, 357, 365, 366
  - Oneida 356, 357, 358
  - Owyhee 321, 322, 359, 360, 361
  - Park 166, 194, 229
  - Pennington 63
  - Ransom 100
  - Rattlesnake 380
  - Richland 106, 107
  - Sanborn 59, 65
  - Shoshone 320, 352, 353
  - Silver Bow 105, 112
  - Spink 22, 43
  - Stark 104, 105, 109
  - Sully 57
  - Traill 105, 112
  - Umatilla 307
  - Washington 323, 363, 364
  - Whitman 301
  - Yakima 305
  - Yellowstone 140, 151, 164, 168, 194
- Countries, reference to:
  - British America 319
  - British Columbia 338
  - England, farming in 142, 220
  - Europe, common law in 210
  - Scotland, law in 209
  - Mexico, irrigation in 243
  - Nova Scotia, crops in 154
- Couleés in Northwest 33, 101, 102, 103, 111, 164, 188, 384
- Creeks, names of, and references to:
  - Almo 339, 341
  - Amell 189
  - American Fork, on 192
  - Arrow 187, 188, 190
  - Alkali, in 189
  - Auchard 239
  - Basin 338
  - Baison 350
  - Battle 63
  - Bannack 358
  - Beaver 136, 191
  - Bear 364
  - Belt 188
  - Big Elk 192
  - Big Blackfoot 189, 190
  - Big 335, 336
  - Big Dry Creek 189
  - Big Malaca 358
  - Big Porcupine 189
  - Big Spring 167, 187, 188, 190
  - Big Timber 194
  - Big Willow 325
  - Birch 338, 358, 359, 361, 373
  - Bitter Root Valley, small, in 193, 257
  - Black Tail Deer 192
  - Boulder [illegible]
  - Box Elder 63, 188
  - Brown's 361
  - Burnt Forks 193
  - Cabin 189
  - Cache 383
  - Camas 349, 323, 399, 400
  - Camp 350
  - Cañon 413
  - Cannon 371, 380
  - Carman 354

Page.

Creeks, names of, and references to—Continued.
- Cassia 338, 339, 342
- Castle 361
- Catherine 361
- Cedar 342
- Cherry 359, 361
- Choteau 55
- Clark's Fork 189
- Clear 127, 130, 189, 335, 336, 337, 343
- Clear Water 365, 366
- Clifton 359
- Clover 351, 352
- Corral 349, 350
- Cottonwood 335, 338, 342
- Cow 361
- Cowlitz 269
- Crane 189
- Crow 191
- Dead Wood 361
- Dearborn 192
- Deer 350
- Deer 329, 331
- Deer Lodge 189
- Deep 188, 359, 361
- Devil 358, 359
- Duck 194
- Dry 324, 325, 338, 340, 341, 343, 352, 383
- East Rock 336, 340, 341, 343, 338, 349, 350
- Elk
- Elk 63, 212
- Fall 328, 339
- Fifteen Mile 324
- Fish 192, 351, 352
- Five Mile 359, 324
- Flats, in 188, 192, 239, 244, 253, 256, 257
- Flint 189, 190
- French 63
- Fox 189
- Goose 338, 341, 383, 393, 394
- Grant 193
- Horn Fork 364
- Haylen 340, 343
- Hazard 335, 336
- Head, in 209, 243
- Henderson 359
- Highwood 188
- Hot 191
- Jump 360, 361
- Kinney 354
- Lake Fork 335, 336
- Land 338
- Little Big Horn 189
- Little Blackfoot 189, 190
- Little Malad 359
- Little Muddy 239
- Little Porcupine 189
- Little Prickly Bear 191
- Little Willow 325
- Logan 331
- Lone Tree 361
- Malad 350
- Mann's 363
- March 338, 342, 356, 358, 383
- McClellan 191
- Medicine Lodge 399, 400
- Medicine 194
- Middle 190, 191
- Mill 358, 359
- Mining and Milling 361

Page.

Creeks, names of, and references to—Continued.
- **Mink** 359
- **Mizpah** 189
- **Muddy** 188
- **Musselshell** 188, 189
- **Narrows, The** 330
- **Nevada** 189, 190
- **O'Fallon** 189
- **Pass** 331
- **Pease** 189
- **Potlatch** 366
- **Prickly Bear** 191
- **Pryor** 189
- **Pickett** 361
- **Race Track** 209
- **Rapid** 63
- **Rattlesnake** 257, 371
- **Reynolds** 361
- **Rock** 337, 338, 340, 349, 383
- **Rock Red** 192, 193
- **Rocky Fork** 189
- **Rocky Gap** 188
- **Rosebud** 137, 189
- **Salmon** 342
- **Seven Mile** 191, 192
- **Shield's** 194
- **Shoo Fly** 361
- **Shoukin** 188
- **Silver Bow Valley** 194
- **Silver** 348, 349, 352
- **Sinker** 361
- **Sim's** 239
- **Sixteen Mile** 192
- **Skallkaho** 193
- **Smith** 328
- **Soldier** 349, 350
- **South Mountain** 361
- **Spring** 189, 349, 350
- **Squaw Creek Flat** 335, 361
- **Story** 189
- **Sublette** 336, 339, 340, 343
- **Sunday** 357
- **Sweetwater, South Fork of** 357
- **Ten Mile** 324
- **Three Mile** 350, 361
- **Trail** 329, 331
- **Trapper** 343
- **Trout** 190, 361
- **Two Mile** 359
- **Upper Flint** 190
- **Warm** 359
- **Warm Spring** 190, 209
- **Weeping Child** 193
- **Weston** 357, 359
- **West Rock** 336, 338
- **White Beaver** 194
- **Williams** 361
- **Willows** 324, 225, 349, 409

Crops, general reference to 62, 74, 77, 88, 90, 99, 100, 101, 104, 107, 108, 112, 114, 117, 126, 127, 130, 133, 137, 139, 142, 144, 146, 147, 150, 153, 154, 155, 159, 165, 191, 216, 218, 219, 220, 224, 231, 233, 241, 250, 256, 257, 260, 262, 263, 265, 267, 268, 272, 274, 326, 368, 395
- **Alfalfa** 124, 130, 132, 134, 150, 155, 156, 159, 165, 168, 214, 215, 227, 231, 233, 250, 267, 268, 271, 272, 274, 275, 317, 318, 337, 338, 339, 344, 358, 370, 386, 399
- **Barley** 200, 208, 218, 219, 231, 257, 260, 263, 268, 272, 274, 318, 337, 338, 339, 344, 385, 386, 404
- **Beets** 224
- **Blue joint grass** 202, 203, 215, 227, 231, 233
- **Clover** 231, 233, 268

Page.

- Crops, general reference to—Continued.
  - Corn 200, 218, 222, 268, 271, 272, 274, 344
  - Grains, small 339, 358, 366, 385, 386, 404
  - Grasses 129, 130, 221, 227, 231, 233, 354, 362
  - Hay . 114, 144, 150, 153, 165, 215, 219, 222, 231, 250, 272, 274, 325, 337, 339, 357, 362, 385, 399
  - Hops 272, 274
  - Oats 114, 152, 165, 192, 218, 219, 257, 260, 263, 268, 271, 272, 274, 337, 338, 339, 344, 385, 386, 392, 404
  - Onions, flavorless 225
  - Potatoes, their size and weight . 165, 224, 218, 226, 231, 260, 263, 272, 318, 337, 338, 344
  - Roots 77, 263
  - Rye 133, 220, 222, 231, 367, 372, 385
  - Timothy 125, 227, 271, 337, 338, 344
  - Tobacco 272, 274
  - Vegetables, garden 144, 155, 293, 337, 339, 386, 397, 404
  - Wheat 64, 107, 114, 115, 122, 125, 129, 132, 133, 145, 152, 153, 157, 159, 165, 208, 215, 219, 221, 222, 231, 250, 257, 260, 263, 267, 268, 271, 272, 274, 318, 325, 337, 338, 339, 344, 386, 392, 404
- Crops, reference to location:
  - Cassia County, in 336
  - Comparative production 208
  - Continual cropping, effects of 215
  - Crow Indians, by 242
  - Dakota, raised in 9
  - Dry grass 221
  - Flathead Indians, by 241, 242
  - Helena, prize grain from 220
  - Idaho, in 326, 352, 377, 338
  - Latah County, in 382
  - Lemhi County, in 354, 366
  - Logan County, in 353
  - Manuring, raised by 215
  - Maximum, average 218
  - Minimum, average 218
  - Montana, by irrigation 173, 180, 217
  - Nez Perces County, in 357
  - On irrigated lands 378
  - Prize grain, World's Fair, London 220
  - Prize grain, Centennial, Philadelphia 220
  - Roots, Yellowstone Valley, in 303
  - Shipped to Chicago 379
  - Walla Walla, grown at 291, 292, 293, 295, 297
  - Washington, eastern, in 288
  - Yield per acre, with irrigation 173, 180, 202, 217, 218, 358, 370, 414
  - Yield per acre, without irrigation 224, 332

D.

- Dakota, laws of:
  - Act for artesian wells 418, 422
  - Additional assessments 421
  - Advertise for bids 420
  - Appeals to district court 419
  - Application by freeholders 418
  - Appointment of viewers 418, 419
  - Appointment, mode of 420
  - Assessed lands, description of 422
  - Assessment, board of 420
    - meetings of 420
    - modes of 420
    - principles of 421
    - reviews of 421
  - Attorney-general, duty of 421
  - Blanks, attorney-general's office 421
  - Board assessment, meeting of 420
  - Clerk county, duty of 421
  - Collection of tax 420, 421
  - Commissioners created 418
  - Compensation of officers 421
  - Construction, bids for 420

Page.

- Dakota, laws of—Continued.
  - Contract, security of 420
  - Contractors, mode of payment 422
  - Delinquency, sale for 421
  - Description assessed lands 422
  - Disqualification of officers 421
  - Disqualification by interest 421
  - Duty of overseers 419, 420, 422
  - Enrollment of tax 421
  - Code, civil 418
  - Code, political 417
  - Fee of viewers 419
  - Fund, artesian well 420
  - Location, order for 419
  - Model for assessment 420
  - Model for appointment 420
  - Model for collection 420
  - Model for railway collection 419
  - Overseers of highways 422
  - Penalty for non-payment 419, 422
  - Plat, filing of 419
  - Repeal of law 422
  - Report on damages 419
  - Sale of land for delinquency 421
  - Tax, general township 420
  - Tax, railway share of 419
  - Water-courses unobstructed 422
  - Wells, references to 419, 422
- Dakota, investments in 43
  - Land office, receipts in 43
  - Memorials to Congress 67, 122, 123
  - Necessity for irrigation in 21
  - North Dakota, constitutional convention of 122
  - South Dakota, constitutional convention of 67
- Dakota, servitudes of water in:
  - Abandoned, right of way, when 417
  - Bridging ditches 417
  - Damaging lands, penalty for 417
  - Deterioration of lands 4 7
  - Diminution of water 417
  - Failure of, compliance with law 417
  - Land-owner's rights 417
  - Locating right of way 418
  - Right of way 418
  - Water rights, under 417, 418
- Dams for irrigation purposes... 53, 57, 61, 63, 70, 71, 112, 116, 118, 130, 137, 189, 192, 206, 207, 213, 216, 244, 245, 249, 252, 255, 270, 350, 365, 367, 383, 408.
  - Brush wing, A 245
  - Cost of 206, 256. 405
  - Construction, masonry 252, 253
  - Core of clay in 252, 253
  - Earth, of 354
  - Holland, devices in 245
  - Low, lying 412
  - Mexican, experience 247
  - Mills, for 363
  - Pence, at 363
  - Piles for 245
  - Rock of 351, 413
  - Rock bottom, a 396
  - Spain, in 244
  - Storage, for 331
  - Story's Ferry, at 351
  - Teton River, on 280
  - Wyoming, in 385
- Debt, defined by State constitution 403
- Deep Wells:
  - Bisuka, Idaho 363, 364
  - Bliss 363, 364

Page.

- Deep wells—Continued.
  - Idaho, in 349, 350, 364
  - Mindoka 363, 364
  - Mora 363, 364
  - Napi 363, 364
  - On Oregon Short-Line Railroad 363, 364
- Ditches for irrigation:
  - Ahtanum, Yakima County 305
  - Atalman, Yakima County 304
  - Alturas County, in tables of 329, 330
  - Belle Fourche, cost of 18, 19
  - Big Creek, on 335, 336
  - Big Horn, on 339
  - Billings, at 149, 154, 156, 155
  - Blackfoot, on 406
  - Broadgauge, on 395
  - Brown's, at 188
  - Caldwell, at 327
  - Camas, prairie, on 350
  - Cañon, at 150, 235
  - Capital needed for 178
  - Clark Fork, on 165
  - Clear Creek, on 335, 336
  - Coleman Creek, on 305
  - Cost of 232, 239, 269, 272, 273, 274, 275, 397
  - Costin, at 329
  - Custer Station, at 227
  - Crayon Creek, at 165
  - Dry Creek, on 329
  - Ellis, at 326
  - Expensive nature of 375
  - Flathead, Indian Agency 422
  - Gold Fork 335, 336
  - Harlan & Humble 193
  - Horseshoe Bend, at 336
  - Iowa Flat, at 305
  - Irrigating, references to 51, 53, 57, 121, 130, 137, 141, 157, 161, 164, 165, 188, 190, 191, 192, 194, 195, 211 249, 254, 261, 262, 267, 268, 269, 329, 339, 357, 359–363, 372, 373, 398, 412
  - Italian Company, the 165, 230
  - Jacobs & Co., the 326, 329
  - Kelly and Bush, the 329
  - Kimball's, at 335, 336
  - Kipp, the 188
  - Lake Fork, the 335
  - Last Chance, the 305
  - Latah County, in 367, 369
  - Laterals 152, 235, 267, 268, 272, 329
  - Lemhi County 254
  - Lone Horse Prairie, at 127
  - Main works, Moxie Ranch 275
  - Manastask Water 305
  - McAdow, the 165
  - McCarthy, the 193
  - Mill, the 165, 363
  - Mining, in Yellowstone County 194, 238
  - Mining, in Deer Lodge County 257
  - Moxie Ranch 260, 261, 266, 305
  - Needed in eastern Oregon 309
  - North Yakima 284
  - Old Union, the 305
  - Oriental, the 305
  - Parallel, the 150
  - Payette County, in 329
  - Payne's 329
  - Pence, the 363
  - Phyllis, the 329
  - Private, reference to 21, 365
  - Red Water, at 18

Page.

Ditches for irrigation—Continued.
  Republican, on 193, 236
  Ridenbaugh, at 327, 329
  Scharmo, the 305
  Settlers, the 305, 327, 329
  Shepherd, the 193
  Short ditches 251, 329, 375
  Stevenson's, at 326, 329
  Squaw Creek Valley, in 336
  Surprise, the 193, 238
  Tables of 187, 329
  Tamarak Falls, at 335
  Tenemas, the 305
  Teneway, the 305
  Union, the 305
  Valley Land, the 305
  Walling, the 326, 329
  Wanatchee, the 305
  Warm Springs Agency, at 305
  Watt, the 305
  Wenas, the 305
  West Side, the 177
  West Gallatin, the 177
  Yakima, at 305
  Yellowstone Valley 227
Drainage basins 64, 86, 102, 148, 151, 167, 252, 253, 255, 270, 304, 375, 376
  Judith Mountains, the 161, 169, 190, 232, 233
  Lakes in 151, 157
  Mountains, from 341
  Silver Bow, at 194, 244
  Snake River, on 376

E.

Engineers, references to:
  Bradford, Daniel 238
  Civil, Montana, Society of 185
  Clark, Joseph A 396
  De Lacey, Walter W 185, 201, 202, 203, 205, 208
  Foote, A. D., irrigation survey 322, 346, 372, 377
  Foster, C. M 310
  Greene, B. H 185, 195, 196
  Hall, James M 366, 372
  Hinton, Richard J 64, 70, 82, 136, 319
  Lombard, Arthur 238
  McIntyre, J. D 240
  McIntyre, H. L 245
  Mexican 245
  Moore, Professor 87, 89
  Riblett, Frank 341, 342, 394, 397
  Scheetze, George 132
  Tompkins, C. H., jr 328, 329
Evaporation of water 205, 248, 257, 258, 326, 341

F.

Falls, water:
  American, the 321, 322, 357, 364, 373, 400
  Great Shoshone 321
  Minidaka, the 351
  Salmon River 352
  Shoshone River 337, 351, 404
  Tamarak 335
  Twin 321
Ferries at:
  Bonner's 362
  Glen's 321
  Storey's 394, 395
  Starrh's 337
  Payne's 337
  Cow Gulch 338

Page.
Flour, Colorado, made in 220
  Kansas, made in 220
  Minnesota, made in 220
  Nebraska, made in 220
  Wisconsin, made in 220
Flour mills 326, 327
Flumes 120, 126, 137, 205, 211, 241, 352
Foot-hills, reference to 128, 157, 213, 219, 349, 351, 366, 383, 398, 375
Forest fires:
  Bozeman, near 135, 136, 170, 179, 185
  Causes of 197, 198, 410
  Destructive, this year 139, 237
  Grass burning 228
  Railroads, cause of 228
  Idaho, local officers in 371, 410
  Prairie fires 136
  National Park, at 180
  Local laws, on 237
Forts, United States:
  Adams 281
  Assinniboine 242, 246, 248
  Benton 65, 75, 239
  Buford 65, 186, 189
  Burton 161
  Keogh 249
  McGinniss 246
  Meade 49
  Owen 192
  Pierre 96
  Shaw 187, 243
  Simcoe 301, 302, 318
  Smith 189
  Snelling 52
  Sully 103
Fruits, small, references to 150, 155, 193, 234, 291, 318, 325, 340, 353, 380, 400, 401, 402, 406, 407
  Blackberries 291, 325
  Grapes 291, 325
  Melons 130, 289, 291
  Raspberries 289, 291, 325
  Strawberries 289, 291, 295, 325
Fruit-trees, references to 290, 295, 340, 344, 353, 355, 370, 377, 380, 382, 387, 400, 407
  Apples 193, 260, 290, 295, 325, 404
  Idaho, in 397
  Orchards, Dakota, in 158, 190, 260
  Orchards, Idaho, in 407
  Orchards, eastern Oregon, in 311
  Orchards, eastern Washington, in 209, 291, 295, 297, 301
  Peach 290, 290–5, 393
  Pear 193, 260, 905, 325
  Plum 193, 260, 325
  Plum, wild 158

G.

Government aid, references to:
  Asked for, irrigation 41, 52, 61, 319, 345, 346, 400
  Canal construction, for 327
  Dakota, from 23, 27
  Jetties, to build 227
  Reservoir sites, for 148
  Rivers, navigation of 227
  Storage, water of 227
  Survey, irrigation, for 261, 349, 395
Grasshoppers, ravages of 130, 264

I.

Page.
Immigration, increase of 207
Indian reservations, irrigation on:
  Black Hills 13, 66, 188
  Cheyenne, Northern 240, 241
  Crow 138, 151, 156, 159, 189, 192, 242
  Flathead 192, 263
  Fort Hall 356
  Sioux 66, 67, 103
  Idaho, in 365, 366
  Nez Percés 355
Irrigation, general references to 10, 49, 51, 54, 57, 58, 60, 61, 62, 63, 64, 68, 69, 70, 71, 73, 94, 99, 100, 102, 105, 109, 110, 116, 118, 119, 125, 126, 127, 130, 131, 132, 133, 134, 135, 136, 138, 139, 140, 141, 144, 145, 146, 147, 148, 152, 153, 154, 155, 162, 163, 164, 165, 166, 167, 168, 187, 189, 190, 193, 194, 199, 200, 201, 202, 203, 204, 208, 210, 213, 215, 217, 219, 221, 224, 226, 228, 229, 230, 231, 234, 240, 242, 243, 245, 246, 247, 248, 249, 251, 253, 254, 257, 259, 263, 264, 265, 267, 269, 277, 319, 331, 341, 347, 350, 352, 376, 377, 391
Irrigation, special remarks on:
  Acres irrigated 322, 336
  Artesian wells, by 77, 83, 84, 85, 86, 87, 88, 97
  Arid lands, on 348
  Bear Lake County, in 384
  Belle Fourche Valley, in 15
  Billings, in 150
  Bingham County, in 365, 399
  Boisé River, by 325
  Boisé Valley, in 303
  By farmers 317, 397
  By checks, cost of 72, 273
  Colville Valley, in 303
  Camparison of crops 216
  Cost of flooding 272, 273
  Cost of, by furrows 272, 273
  Cost of, generally 270, 279, 370, 374, 393, 394, 396, 397, 401, 409
  Country irrigated 368
  Crops, best way to irrigate 267
  Decreasing knowledge of 228
  District for 364
  Doubling crops 182
  Eastern Oregon, in 297, 307
  Effects on soil 310
  Egyptian Desert, on 228
  Electrical power for 342
  Expensive 172, 263, 264
  Egyptian knowledge of 228
  Extent of 360
  Facility for 383, 396
  Flooding, by 174
  Fort Shaw, at 301, 302
  General Government, system, by 389
  Home companies, by 321, 322
  How to irrigate 393
  Idaho, in 371
  James River Valley, in 37
  Kittitas Valley, in 281, 285
  Klamath Valley, in 303, 320, 321
  Kootenai County 362, 363
  Land at Boisé City, changed by 325
  Latah County, in 366
  Land that could be improved by 357, 372, 375
  Linkville, at 318
  Maximum values of land 221
  Milk River Valley, possibilities in 182
  Mormons, by 243
  Needed, where 182, 367, 278, 385
  No large enterprises 365
  Oneida County, in 358
  Owyhee River, from 373

	Page.
Irrigation, special remarks,on—Continued.	
Potatoes on land	278
Powder River Valley, in	309, 310, 311, 313
Practicable, where	357
Prairies, on the	244
Private capital, by	255, 257, 270, 271
Production, increased by	311; 312, 314
Raising water for	247, 248
Relative cost of	21
Report on, in Montana	233, 235, 238
Reports on, in Idaho	320
Rogue River Valley, in	303
Seasons for irrigating	9, 183, 186, 340, 360, 361, 412
Sections irrigated	266
Secret of good crops	296
Seepage by	256, 292
Snake River, used for	303, 380
Statistics of	325
Streams, used for	215, 356, 357, 375
Storage of water for	373
Subirrigation by	23, 73
Subsoil, the	23
Surface soil, the	23
Surveys, for	60, 94, 139, 183, 277, 281, 283, 284, 288, 309, 319, 372
Systems of	50, 61, 62, 63, 64, 68, 71, 72, 76, 77, 107, 242, 246, 249, 266, 267, 271
Tapping rivers for	412
Times of	274
Town lots for	283
Townships under	396
Valley of Yakima, in	277
Walla Walla, at	292
Way to irrigate	370
Water-wheel, by	412
Wheat-growing, with and without	411
Works, cost of, too large for farmers	183, 304
Yakima Indians, by	320

L.

Labor:	
Amount, needed, with irrigation	224
Cost of, east and west	224, 234
Lakes, names of:	
Alpowa	291
Bear	375, 384, 386, 404
Benton	239, 252, 253
Big Stone	60, 61
Brant	36
Cleveland	338
Clear Lake	130
Cœur d'Alene	362
Cottonwood	25, 31
Devil's, the	27, 31, 97, 100, 110, 111
Deer Lodge	255
Flathead	186
Fish	362
Grand Creek	258, 259
Great Falls	252
Hayden	362
Herman	70
Henry	59, 329
Jackson	377, 408
John Day's	335
Klamath	307
Kampeska	54, 56, 57
Market	412
Middle	320
Moses	300
Mystic	177
National Park	200

Page.

Lakes, names of—Continued.
- North Fork 389
- Park 205
- Pend d'Oreille 362
- Pumice Stone 33
- Preston 58, 59
- Red Rock 186
- Reyburg 412
- Rock Creek 209
- Salt Lake 404
- St. Mary's 243
- Stump 97
- Spirit 59, 75, 76
- Summit 238, 239
- Thompson 59, 75
- Webster 22, 44
- Whitewood 59, 75
- Yellow Hawk 291

Lakes:
- In extinct volcanoes 408
- Large, in Idaho 372
- Natural 325
- Near mountain summits 206
- Nearly dry 32

Land, references to:
- Action of Congress on 394, 413
- Base of mountains, at 231
- Bunch-grass lands 412
- Carnas meadows 399
- Carnas prairies 347, 348, 349, 350, 400
- Cassia County, in 395
- Columbia River, reclaimable on 300
- Cost of irrigating 342
- Custer Flats, at 117, 118
- Dakota, agricultural, in 146, 164, 201, 225, 234, 235
  - areas of 51, 52, 66, 80, 188, 231
  - bench land in 134, 135, 188, 190, 192, 194, 202, 219
  - cultivated area of 183, 272, 273
  - grazing lands of 135, 143, 165
  - irrigable, in .. 99, 109, 110, 111, 113, 118, 126, 127, 129, 134, 136, 156, 157, 158, 159, 189, 190, 191, 192, 193, 194, 200, 201, 208, 213, 215, 217, 221, 231
  - irrigated, in 127, 160, 191, 192, 264, 265
  - lowlands in 131, 256
  - meadows in 187
  - prairies, in 112, 128, 136, 159
  - public, in 85, 140, 145
  - railroad, in 118
  - rolling lands in 152
  - without irrigation in 131, 153
- Desert, Great American 242, 342
- Desert lands 141, 357
- Farm lands 351
- Fertilizing the 147
- Forty acres of 406
- Government lands 216, 218, 322, 357, 358, 359
- Great Plains, the 246, 247, 248, 253
- Hail belt of Dakota 147
- High Idaho 367, 379, 383
- Homestead and pre-emption 318
- Idaho, agricultural, in 325, 341, 342, 351, 365, 366, 371, 388, 398, 400, 409, 411, 414
  - arid, in 320, 350, 351, 389, 413
  - cultivated, in 352, 366, 367, 368, 404
  - desert, in 320
  - grazing, in 400
  - irrigable, in 322, 335, 341, 345, 346, 349, 351, 353, 354, 356, 357, 366, 371, 373 375, 386, 394, 404, 114
  - acres of 396, 405. 409
  - amount of, irrigated in 317, 344, 352, 364, 365
  - meadow, in 341

Page.

Land, references to—Continued.
  Idaho—Continued.
    mineral, in 344
    mountainous, in 407
    plains, land in 358
    public land in 357, 371, 394, 398, 403
    sage brush, in 377, 383, 394, 411, 412
    State of, grant to 401
    Indian reservation in 281
    irrigated, Blue Mountain, at 286
    irrigated, Ellensburgh, at 284
  Irrigation, land requiring 412
  Irrigation, reclaimed by 401
  Malad Valley, in 359
  manuring, needed 204
  market, proximity to 225
  Montana, in 154, 231, 233, 234, 235, 243, 244, 246, 247, 251, 252, 253, 254, 256, 257, 263, 265, 269, 273, 276, 389, 413
    Irrigated areas, in 191, 192, 194, 272, 273
    Pasture, in 234, 235
    School lands, value per acre, in 273
  Oregon, in 311
  Owyhee County, in 361, 363
  Pacific Central Railroad 394
  Pasture, lands on 192, 220, 231, 235, 250, 350
  Payette County, in 326
  Railroad grants of 394
  Sage Brush Plains 273
  Snake River, on 280, 358
  Table lands, on 121, 151, 156, 168, 188, 194, 201, 214, 231, 235, 255, 256, 354, 366, 368, 409
    Irrigation on 354
    Nez Perces County, in 357
  Value of, increased by irrigation 90, 99, 118, 131, 132, 214, 290, 298, 310, 312, 313, 345, 363, 382, 393
  Washington, State of, in 256, 267, 276, 277
Legal provisions on water right, Idaho (proposed State constitution):
  City or town, for 413
  Compensation therefor 413, 414
  Development of water supply 412
  Domestic purposes, for 413
  Manufacturing, for 413
  Mining, for 413
  Priority of application, for 413, 414
  Public use, defined 412
  Rental or distribution not alienable 413
  Rental controlled by legislation 414
  Right to appropriate, The 413
  Right to divert, the 413
  Purchaser or renter, rights of 414
  Supply, settlement, insufficiency of 414
Laws on timber:
  Burning of 212
  Common control of 211
  Cutting of 212
  Forest protection, for 410
  Homestead on 140, 195, 401
  Idaho, in 198, 199
  Necessary changes in 195
  proposed regulations under 171
  Sanders, W. H., views on 196
  State, laws, in 229
  Yellowstone Park, in 195, 196
Lumber, piles from 237
  Railroad ties, for 237
  Shingles, for 237
  Trestles, for 237
  Use of 241

M.

Page.

- Maps, referred to 100, 149, 270
- Miner, the 407
- Mines 327, 351
  - Placer 327
  - Reports of census, 1870 411
  - Speculative companies in 414
  - Syndicate, Eastern, on Bear River 359
  - Tables of 322, 334
- Moisture from gulf and lakes 66
- Mountains, names of ranges:
  - Adams 281
  - Bannock 340
  - Bear Tooth Range 194
  - Bear Paw 243
  - Berch Creek 354
  - Belt 188
  - Black Hills, the 13, 67, 87, 103
  - Blue, the 281, 285, 294, 296, 297
  - Big Horn, the 200
  - Big Snowy 190
  - Bird Tail Rock 187
  - Bridger 194
  - Bull's Run Trail 409
  - Bitter Root Valley, in 202, 257, 321
  - Cariboo 335
  - Cascade 320
  - Cassia 394
  - Clear Creek 339
  - Couteaux du Missouri, the 22, 32, 38, 53, 60, 75
  - Crazy 194
  - Deer Lodge 189
  - Gallatin Range 194
  - Goose Creek, on 337, 338, 339
  - Harrison, Mount 338
  - Horse Shoe Bend, the 335
  - Idaho, in 325, 383, 407
  - Independence, Mount 338
  - Judith Gap, at 190, 230
  - Little Belt 190
  - Montana, in 135
  - National Park, in 322
  - Powell, Mount 209
  - Preuss Range 335
  - Raft River, on 339
  - Rocky, the 87, 88, 89, 115, 116, 118, 119, 148, 191, 197, 231, 232, 236, 242, 243, 246, 250, 251, 323, 354, 408
  - Salmon Range 354
  - Salt Lake, at 358, 360
  - Saw Tooth Range 320, 321, 323, 354
  - Seven Lakes 408
  - Sublette 339
  - Teton Peaks 413
  - Turtle, the 104, 111
  - Utah, in 322
- Mountains, references to:
  - Low ranges of 205, 233, 364
  - Snow on 194
  - Strata of 209
  - Table 408
  - Water from 252

N.

- Names of witnesses:
  - Adams, M. H 399
  - Ake, Frank 345
  - Alderson 175
  - Allen, Joseph W 130
  - Allen, W. B. 400

Page.

Names of witnesses—Continued.
  Allen, W. C 348
  Ambrose, Charles J 85
  Andrews, F. B 414
  Ashley, William, jr 320, 363
  Baker, S. W 284
  Bancroft, L. L 74
  Bassett, C. J 390
  Bassett, C. H 404
  Blandfort, H. S 293
  Bell, W. P 320, 357
  Bellows, James 117
  Bennett, Morris S 129
  Bentzoin, Charles 249
  Berry, E. W 263
  Berry, George T 296
  Birdseye, J. W 353
  Bonney, Ed. R 39
  Bradford, Donald 238
  Branch, T. F 97
  Bryant, E 260, 261
  Burkhardt 329
  Burleigh, W. A 226
  Burns, T. C 181
  Burt, W. A 8, 9
  Butler, D. W 317
  Campbell, Frank 357, 358
  Cary, Lyman 120
  Carpenter, Capt. S. J., U. S. Army 320
  Cartee, L. F 324, 377, 381
  Carter, Hon. T. H 185
  Casey, L. R 27, 30
  Chapin, Charles 340
  Childs, W. C 215
  Childs, E. R 362
  Choteau, A. A 16
  Clark, J. B 116
  Clark, Joseph A 396
  Coburn, C. B 365
  Coburn, C. P 320, 357
  Cock, H. D 283
  Cook, James M 412
  Cook, William 54
  Collins, Timothy 213
  Conrad, J. H 158
  Courtney, William 141
  Crow, W. H. B 333
  Cunningham, B. A 272
  Cunningham, ——— 268
  Cushing, John J 22, 24
  Cushing, J. J 44
  Cushman, S 13, 14
  Cuskelly, Timothy 39
  Daustin, Aleck 390, 406
  De Lacy, W 2, 3, 4, 201, 205
  Dickinson, H. L 39
  Doan, Charles S 353
  Drake, E. D 37
  Dubois, Fred T 383
  Eddy, H. W 59
  Egbert, Marion G 301
  Elmer, C. A 290
  Evans, H. R 356, 357
  Fassett, Charles L 83
  Foote, A. D., U. S. Geological Survey 322, 328, 346
  Frazier, A 274, 153
  Force, Charles M 357
  Foster, James W 291

Names of witnesses—Continued.	Page.
Fox, J. C	391
Gibson, John, U. S. Army	301
Galloway, Thomas C	363
Gray, W. P	299
Greene, Benjamin	185, 195
Greene, Frank, U. S. Army	411
Grimm, C. E	33
Gordon, Mr	145
Hailey, John	348, 349, 350
Haines, L. D	312
Hall, C. W	30
Hall, David	57
Hall, James M	266
Harrison, E. P. H	136
Harvey, P. F., U. S. Army	249
Hastings, John B	329
Havard, V., U. S. Army	45, 49
Hayden, Professor	319
Hawley, James	387
Henry, Charles	298
Hesse, E. H	325, 328
Hilliard, A	39
Hilliard, Smith	39
Hill, John M	287
Hindman, C	310
Hobson, Simeon S	232
Hodson, Enoch	184
Hapson, L. D., U. S. Geological Survey	348
Houlton, C. A	55
Howe, W. E	73
Howeth, Charles	345
Howlett, Luther S	279
Huffman, L. A	144
Hulett, Franklin W	360
Hull, Abram	140
Humphrey, W. A	61
Jacobs, S. W	69
Jacobs, E. H	72
Johnstown, L. H	344
Jones, A. L	38
Kelley, Milton	371
Kingsbury, John T	276
Klinefelter, C. H	39
Knowles, Hiram	208
Koch, P. W	182
Labrie, J. E	43
Lang, T. S	306
Lilienthal, ——	220
Lewis, J. R	281
Luce, T. L	174
Luck, J. J	114
Lowthian, W. J	32
Macdonald, J. B	76
McDonald	74
McGregor, J. A	39
Manning, George A	320, 362, 364
Martin & Mason, bankers	16
Meade, J. R	124
McPherson, Mr	138
McGillicuddy, Dr	66
Millburn, George R	138
Mullen, Captain, U. S. Army	193
Mund, H. H	153, 163
Morrison, Eager	24
Neill, Henry	60
Noble, V. B	111
Noble, William B	326
Ordway, N. G	103

Page.

Names of witnesses—Continued.
O'Farrell, John A 407
Otis, C. A., U. S. Army 242
Parker, A. F 346
Parley, G. E 35
Patton, S 40
Patterson, H. J 68
Patterson, J. H., U. S. Army 246
Patterson, F 357
Paulson, E. M 112
Peck, S. S 56
Peirson, J. D 75
Perkins, W. Z 350
Perry, G. S 34
Peoples, George 109
Pierce, D. C 38
Potter, W. M 25, 40
Priestly, Thomas, Indian agent 320
Pritchard, L. J 360
Purcell, W. E 106
Ramsay, James S 126
Rankin, W. A 409
Ray, J. H 127
Red Wolf, Indian chief, reference to 291
Reed, W. H 285
Reininger, Henry 362
Renan, Peter, U. S. Indian agent 241, 422
Riblett, Frank, C. E 340, 341, 392
Ritz, Philip 291
Rich, J. C 331, 384
Roberts, A. B 291
Roberts, A. B 341
Robinson, J. C 211
Rockaffow, I 38
Roeder, V. C 364
Rogers, B. A 38
Rowe, W. H 112
Rowley, H. W 149
Sanders, W. F 197
Sebree, Howard 317
Scheetz, George 132
Scott, Jos. T 39
Shoup, G. L 330, 341, 350, 357
Skillman, Philip 86
Sisk, S. M 335
Smalley, E. V 7
Smith, Alanson 319, 411
Smith, W. F 68
Smith, Benjamin J 335
Smith, Ephraim 380
Snyder, Andrew H 16
Sodenberg, C. A 38
Spaulding, Rev. Mr 291
Spaulding, B. F 105
Spedden, E. C 347
Spooner, I. K 58
Standrod, D. W ....
Starrh, T. A 336, 340, 383, 390
Sterling, Edward 91
Stevenson, Hon. E. A 324, 328, 367
Stevens, R. M 100
Straughan, Jos. C 319, 324, 326, 335, 346, 351, 357, 364, 365
Stoddard, William 61
Stough, W. H., U. S. Army 52
Stribell, J. W 146
Sturgill, J. W 313
Sunsmer, N. C 39
Swallow, G. C 229

Page.

- Names of witnesses—Continued.
  - Tompkins, C. H., jr 328
  - Towne, Elmer 345, 346
  - True, E. B 342
  - Tucker, R. S 353
  - Turner, John M 114
  - Turner, R. J 39
  - Underhill, T. S 109
  - Upham, Warren 92
  - Upshaw, R. L 240
  - Van Tassel 65
  - Westcott, C. E 53
  - Wheeler, William F 236
  - Whelpley, James D 166
  - Whittier, E. S 385
  - Whitney, L 155
  - Whipple, A. S 38
  - Williams, Arthur, U. S. Army 49, 52
  - Williams, John 171
  - Williams, Frank H 254
  - Winter, Charles 258
  - Wilson, John R 13, 22
  - Wilson, H. M., U. S. Geological Survey 250
  - Wood, C. L 63
  - Wyman, M. P., U. S. Indian agent 242
  - Young, L. G 71
- Newspapers, references to:
  - Artesian wells, on 17, 19, 77
  - Dispatch, Redfield, Dak 17
  - Ditches, expense of construction 19
  - Forum, The, Senator Stewart in 216
  - Times, The, Cassia County 343
  - Walla Walla, at 292
- New York, reference to, Mining Company 322. 325, 326, 327

O.

- Ocean currents, Japan and Pacific 133

P.

- Passes, mountain 133
- Plateaus, mountain 116, 117, 128, 231, 241, 319, 325, 327, 408
- Population of Gallatin County 178
- Powell, John W., Director U. S. Geological Survey 100, 102, 104, 109, 114, 124, 132, 135, 145, 147, 149, 125, 271, 276, 284, 285, 306, 308. 317
- Pumps for irrigation 115, 247, 248, 342

R.

- Railroads, references to, Central Pacific in Idaho 394
  - Denver and Rio Grande, the 391
  - Inducements to irrigate 181
  - Manitoba road, the 105, 181
  - Missouri to Yellowstone River 117
  - Northern Pacific, the 103, 105, 120, 137
  - Oregon Short Line, the 326, 350, 351, 364, 365, 400
  - Rights of 211
  - Salt Lake City, at 391
  - St. Paul and Minneapolis, the 181
  - Union Pacific, the 364
- Rain-fall, statements relating thereto—
  - Altitudes, at high 289, 293
  - Dakota, general reference to 29, 32, 35, 36, 39, 41, 74
  - Forts, U. S. Army, Assinniboine, at 242, 243
    - Maginnis 246
    - Meade 49
  - Idaho, in 347, 354, 366, 412
  - Montana, in 154, 217, 224, 256

Page.

Rain-fall, statements relating thereto—Continued.
- North Dakota, Bismarck 103
  - Fargo 106
  - Jamestown 97, 100
  - Madison 71, 73
  - Manchester 74
  - Rapid City 66
- Percolation of 85
- Precipitation of 40, 44, 49, 50, 51, 85, 217, 225, 248, 251, 256, 296
  - tables of 85
- South Dakota, in Alexandria 44
  - Ashton 29
  - De Smett 75
  - Huron 44, 77, 82, 85
  - Sioux Falls 53
- Washington, in State of, Dayton 293, 294, 295
  - Lewiston 294

Ranches, stock:
- Brown's, at 337, 345
- Moxie, North Yakima, at 266
- Natural wells on 399
- Range for stock 409
- Stock growing 342, 378
- Springs on 399

Rapids in rivers and streams:
- Aprees, the Columbia, on 299
- Buffalo, the 137
- Half Breed Island, at 240
- Snake River, on 364, 373, 400

Ravines, references to 75, 120, 213, 217, 225, 229, 230, 253, 257, 258, 384

Rattlesnakes 117

Reports, counties in Idaho, on 333, 334, 336, 346, 352

Reservoirs, evidence as to 51, 56, 57, 61, 63, 70, 76, 101, 107, 109, 110, 111, 113, 115, 116, 130, 134, 135, 144, 145, 147, 148, 151, 157, 161, 187, 188, 189, 190, 191, 192, 194, 199, 204, 205, 207, 208, 209, 213, 215, 216, 227, 229, 231, 232, 233, 234, 237, 238, 240, 247, 249, 251, 252, 253, 255, 256, 257, 258, 262, 271, 328, 331, 332, 352, 354, 365, 374, 375, 383

Reservoirs, references to:
- Aid for construction 385
- Appropriations for 341
- Artificial storage, in 321
- Basin, fit for 341
- Baker City, Oregon, at 309, 311, 312, 313
- Bear Lake, Idaho, at 404
- Bear River, Idaho, at 385
- Boisé City, Idaho, at 408
- Building of 380
- Cache, on the 386
- Camas County, needed in 399
- Cañon, fit for 337
- Cassia County, sites for 341
- Cedar Creek, at 341
- Cleveland Lake, at 343
- Conant's store, near 377
- Considerations for construction 414
- Cost of construction 205, 230, 252, 342, 344
- Co-operation, popular, needed 322
- Cow gulches at 343
- Facilities for 373
- Forks, the, at 343
- Foot-hills, sites in 321, 350
- Gentile Valley, in 385, 386
- Goose Creek, on 337, 338, 341, 342
- Goose Creek Basin, at 485, 394
- Government, construction by 405
- Government survey for 388
- Hagler Cañon, in 340
- Jackson Lake, as a site 377
- Lake beds for 352

Page.

Reservoirs, references to—Continued.
    Lakes of Idaho for 371
    Lava walls for 346
    Liberty, at 332
    Lost River Valley, system of 389
    Lower Blind Creek, at 346
    Lower Fall Creek, at 346
    Mark Green, site for 343
    Malta, site at 339
    McFarland's Gulch, at 326
    Mountain basins for 341
    National Park, water-storage in 321
    Natural lakes for 376
    Natural sites 346, 384
    Necessity of 390
    Raft River Valley, in 339
    Rock River, on 341
    Rocky Bar, at 346
    Sites mentioned for 270, 279, 322, 323, 324, 337, 339, 341, 343, 349, 351, 354, 357, 358, 359, 361, 364
    Size of, the 252
    Smith Creek, at 346
    Snake River, on 375, 385, 386, 397
    Storage in 321, 331, 336, 338, 341, 345, 349, 351, 353, 375, 376, 393, 398, 400, 412
    Survey showing sites for 384
    Sublette Forks, at 341
    System of 342, 389
    Trapper Creek, at 338
    Typical, site 342
    Underground, site 225
    Upper Blind Creek, at 346
    Upper Fall, at 346
    Volume of, the 405
    Water saved by 398
    Weston Creek, at 357, 359
    Yakima, site for 270
Resolution of United States Senate authorizing committee 5
Rivers, names and references to:
    Arkansas, the 14, 246, 247, 248
    Bear, the 335, 337, 359, 375, 385, 404
    Beaverhead, the 263
    Belle Fourche, the 16, 18, 19, 63
    Big Blackfoot, the 193, 335
    Big Heart, the 108, 116, 117, 120
    Big Hole, the 192, 194
    Big Horn, the 135, 137, 152, 158, 186, 189, 215, 243
    Big Lost, the 399
    Big Prickly Pear, the 192
    Big Sioux, the 35
    Big Smoky, the 344
    Big Wood, the 348, 349, 351, 352
    Bitter Root, the 192, 193, 186, 254, 258, 260
    Blackfoot, the 186, 335, 376
    Boisé, the 317, 322, 324, 325, 328, 345, 346, 368, 371, 372, 373, 377, 398, 399
    Bowlder, the 191
    Box Elder, the 134, 190
    Bruneau, the 360
    Canadian, the 245, 246, 247, 248
    Cannon Ball, the 109, 117
    Cheyenne, the 13, 14, 28, 63, 101, 102
    Clark's Fork, the 186, 192
    Clear Water, the 347, 348, 357
    Columbia, the 44, 186, 192, 280, 299, 306, 352
    Cowlitz, the 270
    Cub, the 357
    Dearborn, the 186, 187, 191. 192, 238, 250, 253
    Deer Lodge, the 186, 189. 191, 194
    Devil, the 249
    Des Chutes, the 306, 319, 321

Page.

Rivers, names and references to—Continued.
  Elm Branch, of 112
  Falt, the 413
  Flat Head, the 192, 193
  Flat Willow, the 190, 215
  Fork, the 262
  Fork, North of 239
  Fork, South of 240, 252
  Gallatin, the 186, 190, 191, 240
  Grande Ronde, the 297
  Great Falls, the 186, 187, 188
  Greene, the 121
  Heart, the 117, 118, 120
  Hell Gate, the 199, 192, 262
  Idaho, the 373
  James, the 11, 12, 24, 25, 27, 28, 33, 37, 44, 58, 60, 61, 68, 69, 74, 77, 79, 82, 87, 104, 112, 114, 115
  Jefferson, the 186, 191, 192
  Judith, the 166, 167, 186
  Jocko, the 241, 423
  John Day's, the 297, 306
  Kansas, the 245
  Klamath, the 318
  Knife, the 109
  Kootenai, the 192, 362
  Lemhi, the 353, 354
  Little Blackfoot, the 191
  Little Heart, the 108
  Little James, the 79
  Little Lost, the 399
  Little Wood, the 348, 349, 351, 352
  Little Missouri, the 39, 134, 136, 137, 138, 189
  Little Prickly Pear, the 192
  Little Powder, the 137
  Lost, the 263, 331, 373, 389, 399
  Lower Platte, the 245
  Madison, the 186, 191, 192
  Malad, the 351
  Malheur 373
  Maple, branch of 112
  Maria's, the 188, 243
  McClellan, the 225
  Milk, the 181, 186, 188, 243
  Mississippi, the 228, 242, 304
  Missoula, the 192, 193
  Missouri, the 11, 12, 20, 22, 24, 25, 30, 31, 34, 35, 39, 44, 55, 58, 60, 61, 65, 66, 75, 81, 89, 99, 103, 104, 116, 117, 119, 121, 124, 125, 136, 150, 158, 161, 186, 187, 188, 189, 191, 192, 199, 228, 238, 240, 243, 245, 246, 247, 248, 250, 282
  Moxie, the 282
  Musselshell, the 157, 186, 189, 190, 192, 215
  Owyhee, the 313, 321, 373, 408, 409
  Pack, the 363
  Park, the 104
  Payette 322, 324, 325, 326, 335, 363, 367, 368, 369, 372, 373, 409, 411
  Pecos, the 249
  Pend d'Oreille, the 363, 364
  Pipestone, the 191
  Platte, the 246, 247, 248
  Pocatello, the 335
  Port Neuf, the 335, 358
  Powder, the 128, 137, 186, 243, 308, 311
  Raft, the 337, 345, 383, 393
  Rattlesnake, the 258
  Rapid, the 64
  Red, the 25, 28, 92, 102, 106, 107, 110, 245
  Red Rock, the 187
  Red Water, the 15, 18, 19
  Rosebud, the 134, 138, 186, 189, 240
  Rio Grande, the 242, 245, 246, 249

Rivers, names and references to—Continued. Page.
  Ruby, the ....
  Salmon, the 192
  Sheds of Teton, the 336, 347, 353, 354, 391, 393, 408
  Shields, the 408
  Shoshone, the 194
  Sioux, the 371
  Sioux Falls, the 32, 35, 44, 53, 54, 56, 57, 70, 77, 81
  Skunk, the 70
  Smith River, the 78
  Snake, the 186, 188, 192
  .... 200, 285, 300, 304, 311, 317, 319, 322, 326, 335, 336, 337,
  339, 340, 341, 345. 347, 348, 350, 351, 352, 353, 357, 358, 359, 363, 364, 365, 371, 372,
  373, 374, 375, 376, 377, 379, 384, 385, 390, 394, 395, 396, 397, 398, 399, 400, 404, 408
  Snake, North and South Forks of ....
  Spear Fish, the 412
  Spokane, the 21, 63, 64
  Square Buttes, the 362
  Sun, the 108, 187
  .... 186, 187, 188, 191, 192, 239, 240, 243, 250, 251, 252, 253, 302
  Souris, the ....
  Sweet Grass, the 104
  Swimming Woman, the 157, 194
  Teton, the 190
  Terkamon, the 186, 188, 239
  Tietan 287, 250, 253
  Touchet, the 280
  Tongue, the 290
  Trail, the 128, 137, 138, 144, 186, 200, 215, 240, 243
  Two Woods, the 329
  Umatilla, the 348
  Upper Marion, the 307
  Upper Sun, the 243
  Vermillion, the 250
  Walla Walla, the 58, 59
  White Tail Deer, the 285, 286, 290, 296, 297
  Weiser, the 191
  Wild Rice, the 321, 363, 364, 372
  Wood, the 107
  Yakima, the 327, 329, 349, 379, 400
  .... 266, 269, 280, 284
  Yellowstone, the 125, 126, 128, 130, 131. 132, 134, 135,
  136, 137, 143, 150, 152, 154, 158, 165, 186, 189, 194, 199, 240, 246, 247, 248, 167
  Yellowbanks, the ....
Rocks, mention of: 32
  Basaltic ....
  Cambrian 352, 373, 396
  Chalk Stone 95, 96
  Cretaceous 65
  Clay slate 95
  Granite 105
  Lava beds 95
  .... 349, 350, 364, 371, 373, 400, 404
  Lava rock ....
  Porous 364, 383, 396, 413
  Sand rock 105, 112, 113, 119
  Sandstone 87, 89, 97, 105, 112
  Shale 142
  Slate 157
  Silt 157
  Strata 118, 131, 132
  .... 51, 71, 81, 83, 86, 88, 92, 93
  Rocks, Montana in 131, 241, 207

S.

Sage-brush lands:
  Gumbo land ....
  In Idaho 164
  Irrigation with 318, 322, 349, 356, 364, 367, 394
Saw-mills, reference to 66, 126, 157, 272, 303
Seasons, the, and irrigation: 327
  Climate of Dakota ....
  Climate of Idaho 133
  Dry winds, effects of 400, 401
  272

Page.

- Seasons, the, and irrigation—Continued.
  - Drought, 1889, in ... 182
  - Drought in Idaho ... 345, 363
  - Effects of dry season ... 348, 361
  - Frost ... 132, 202
  - Irrigation on ... 140, 191, 192, 193, 200, 208
  - On floods, effects of ... 384
  - On plowing ... 209, 224
  - Rainy, the ... 204
  - Walla Walla, at ... 294, 295
- Seepage, conditions and effects of ... 205, 251, 256, 258, 292, 326, 341, 404
- Small farms, desirability of ... 299
- Snow-fall, reference to:
  - Dakota, Central and South, in .. 8, 23, 27, 33, 35, 36, 73, 82, 91, 111, 112, 154, 191, 246, 258
  - Idaho, in ... 333, 351, 376, 377
    - in cañons of ... 339
    - in Cassia County ... 339
    - in Lemhi County ... 356
    - on mountains of ... 252, 384, 408, 409
    - Rexburg, at ... 412
    - water-shed, on ... 393
    - Washington County, in ... 363
    - Wood River Mountains, on ... 349
  - Marsh Valley, in ... 338
  - Melting of ... 256
  - Montana, depth in ... 186
  - Pockets of ... 320
- Springs, references to ... 348, 361, 364, 365
- Soils, in reference to irrigation. 61, 64, 65, 69, 72, 73, 75, 77, 81, 83, 89, 92, 93, 95, 97, 103, 122, 126, 133, 136, 153, 157, 159, 164, 218, 219, 227, 228, 234, 241, 242, 249, 250, 258, 268, 328
  - Alkali, the ... 103, 115
  - Ashy loam, of ... 266
  - Black land, of ... 351
  - Clay of ... 390, 396
  - Deep, rich ... 364
  - Gravel, with ... 266, 267, 269
  - Productiveness of ... 207, 225, 362, 390
  - Sandy ... 219, 266, 267, 356, 390, 396
  - Sub-soil, the ... 234, 250, 266, 267, 268
- St. Paul, trade relations and arid west ... 7
- States, reference to:
  - California, of ... 134, 209, 220, 251, 266, 269, 307, 319, 409
  - Colorado, of ... 133, 147, 149, 153, 167, 210, 220, 268, 276, 318, 394, 407
  - Dakota, North and South ... 43, 53, 105, 226, 227, 242
  - Delaware, of ... 411
  - Foreign, British-American possessions ... 265
  - Illinois, of ... 147, 149, 155, 160, 232, 378, 382
  - Iowa, of ... 144, 208, 232
  - Kansas, of ... 155, 220, 246, 276
  - Maryland, of ... 139
  - Middle, the ... 232
  - Minnesota, of ... 145, 146, 152, 242
  - Missouri, of ... 232, 187
  - Montana, of ... 124, 126, 140, 146, 160, 161, 166, 167, 168, 187, 208, 227, 246, 250, 251, 253, 338, 371, 409.
  - New England, the ... 411
  - New York ... 411
  - Nevada, of ... 134, 160, 208, 210, 276, 319, 320, 337, 392, 408, 409
  - New York, of ... 141, 145, 147, 168, 240, 411
  - Nebraska, of ... 220
  - Oregon, of ... 306, 319, 373, 409, 412
  - Pennsylvania, of ... 411
  - Texas, of ... 163, 242, 243, 246, 247, 276
  - Virginia, of ... 139, 159
- Statehood for Territories, references to:
  - Arizona ... 147, 212, 276
  - Idaho ... 133
- Stock raising, reference to ... 243, 319, 320, 352, 356, 362, 365, 371, 383, 401, 403, 404, 409, 410, 412, 413, 414
  - Belle Fourche, at ... 14

Stock raising, reference to—Continued. Page.
  Cattle, food for
  Gallatin Valley, in 202, 231, 333
  Helena, at 178
  Horses, raising 143, 234
  Pastures, for 333
  Sheep, raising 143
Streams, characteristics of: 333
  Fall of
  High banks on 186
  In couleés 365
  Intersecting 160, 164
  Irrigation, use in 335
  Laterals, as 356, 360, 365
  Large ones 200
  Lemhi County, in 374
  Milling, for 353
  Mountain ones 357
  Port Neuf, at 209, 225, 366, 371
  Small ones 364
  Springs, from 352, 367, 377, 380
  Valleys, in 166, 351
  System of, for irrigation 188, 262
Surveys: 240, 242
  Systems of
  Cost of 148
  Custer County, in 207
  Duty of Government, on 392
  Finding water, for 358
  For reservoir sites 209, 389
  Government, by 234
  Irrigation, for 214, 234, 358, 389
  Preliminary to 161, 216, 227, 234
  Rights of way, for 389
Surveyor, land 234
  Surveyors-general 325
Tables of: 319, 320, 335, 341, 348, 352
  Estimates of water needed
  Lands under irrigation 138
Territories, the, references to: 195
  Idaho
  Indian, the 8, 133, 243, 319, 383, 384
  New Mexico 242, 246
  Utah 276
  Washington 133, 243, 276, 339, 342, 355, 383, 384, 393, 394, 408
  Wyoming 266, 362, 367, 368
  Wyoming, boundary of 143, 276
Timber, growth, use, destruction of 137
  Belts of 66, 67, 135, 136, 139, 211, 212
  Bodies of 242
  Burned in Idaho 236
  Co-operation of the people needed 386, 410
  Cutting, in Idaho 197
  Cutting, effect on water-courses 410
  Culture of 179, 228
  Denuding of 318
  Forests, best way to preserve 195, 196, 387
  Grown in Idaho 237
  Government selling 367, 370
  Government control of 198
  Land in Montona 180, 229
  Land in Idaho 228
  Mount Independence, at 411
  National Park, in 339
  New growth, of 232
  Regions, where found 237
  Reserves for 327, 342, 409
  Scanty brush, in 342
  Sections of, Idaho 242
  Territory, useless for 388, 411
  201

Page.
Timber agents, United States:
  Prejudice against strangers as........ 388
  Pinkerton detectives objected to as........ 229
  Secret, opposition to........139, 170, 179, 184, 196, 228
Towns, names of:
  Aberdeen........ 86
  Albion........338, 342, 343
  Alexandria........ 44
  Anaconda........ 190
  Ashton........ 44
  Augusta........ 192
  Baker City........ 310
  Basin City........341, 348, 349, 350
  Bellevue........ 348, 352
  Bennington........ 331
  Black Cañon........ 326
  Blackfoot........ 390
  Blalocks........ 306
  Bloomington........ 332
  Billings........ 149, 150, 153, 155, 158, 160, 162, 164, 165, 166, 167, 168, 223
  Bismarck........ 102, 103, 109, 122
  Boisé City........ 320, 228, 336, 341, 351, 367, 371, 405, 409, 412
  Bonanza Bar........ 339, 340, 343
  Bozeman........ 161, 163, 175
  Buford........ 134, 223, 240
  Butte........ 194
  Caldwell........ 317, 326, 364
  Camas........ 399
  Canova........ 59
  Challis........ 344
  Chicago........ 113, 235, 375
  Cornwallis........ 193
  Clark's Fork........ 193
  Dayton........ 293
  Deer Flat........ 326
  Deer Lodge........ 190, 209
  Devil's Lake........ 7, 110
  Digle........ 331
  Dillon........ 187
  Duluth........ 242
  Eagle Rock........ 322, 373, 376, 396
  East Fork........ 329, 331
  Eldorado........ 188
  Emmetsville........ 325, 326
  Fairy Point........ 131
  Faulkton........ 61
  Fargo........ 102, 103, 104, 105, 110
  Ferry Point........ 126, 127, 128
  Fish Haven........ 332
  Freiburg........ 116
  Forsyth........ 137
  Georgetown........ 331
  Glendive........ 126, 127, 128, 129, 130, 131, 134, 160
  Gold Fork........ 335, 336
  Grand Forks........ 104, 105
  Grangeville........ 342, 347
  Great Falls........ 240, 253
  Hailing........ 329
  Helena........ 148, 167, 208, 211, 221
  Huron........ 59
  Howard........ 137
  Individual........ 332
  Jamestown........ 59, 68, 77, 97, 103
  Ketcham........ 329
  Kootenai........ 362
  Kuna........ 326
  Lavina........ 165
  La Moure........ 40
  Lewiston........ 204

Page.

Towns, names of—Continued.
- Lewiston, Mont 190, 294
- Lewiston, Idaho 357, 365, 368, 391
- Liberty 332
- Lisbon 100
- Livingston 125, 253
- Madison, Wis 129
- Madison, S. Dak 69, 71, 72, 73
- Malad City 356, 359
- Malta 339
- Manchester 74
- Mandan 108, 109, 115, 116, 131
- Mankato 242
- Mayville 112
- Middle Fork 335
- Middleton 371
- Miles City 132, 136, 137, 138, 140, 141, 144, 145, 150, 240
- Millbank 60
- Milwaukee 220
- Missoula 223, 254
- Mount Chute 306
- Mount Jefferson 306
- Mount Hood 306
- Mountain Home 345, 371
- Myers 137
- Nampa 326
- New Chicago 190
- New Orleans 381
- New Salem 114
- Niles City 240
- Nounan 332
- Oakly 341
- Ogden City 357
- Omaha 242. 364
- Obide 332
- Paris 332
- Pembina 104
- Phœnix 132
- Pocatello 364
- Rapid City 63, 66
- Red Lodge 163
- Rocky Bar 344
- Salmon City 353, 354
- Sanders 137
- San Francisco 378
- Saw Tooth 329
- Silver City 360
- Sioux Falls 53
- Shoshone 342, 349, 350, 352
- Smith's River 188, 400
- Soldier 350
- Spring Forks 335
- St. Charles 332
- Stanton 348
- Teton 413
- Teton Island 413
- The Dalles 306
- Thomas Fork 332
- Tikura 351, 352
- Topeka 242
- Totten 103
- Tower City 105
- Van Wyck 335
- Virginia City 221
- Wahpeton 106
- Walla Walla 285, 301, 367, 368, 411
- Wallula 293, 296
- Washington, D. C 336
- Webster 44

Page.

- **Towns, names of—Continued.**
  - **Weiser** 362, 363
  - **Wolf Point** 138
  - **Yakima** 279, 281, 283
  - **Yankton** 44, 77, 103
- **Topography, references to** 120, 144, 146, 147, 163, 166, 167, 200, 213, 216, 393
- **Townships of land, Montana, in** 140, 187, 188
- **Tunnels, references to** 259, 345
- **Trading posts, Major Owen's** 193
- **Trees, in arid region:**
  - **Alder** 51, 78, 236
  - **Cottonwood** 236
  - **Decay of, on mountains** 198
  - **Growth of** 198
  - **In Montana** 236
  - **Kind of, the** 197
  - **Lodge-pole pine** 197
  - **Mining purposes, for** 198 237
  - **Pine, the** 197

V.

- **Valleys, for irrigation, names of:**
  - **Atanah** 281
  - **Antelope** 344
  - **Bar Butte** 49
  - **Bear Creek** 358
  - **Bellevue** 348
  - **Big Horn** 131, 242
  - **Billings, at** 99, 125, 131, 149, 153, 154, 156
  - **Bitter Root, the** 192, 193, 194, 201, 254, 262, 269, 277
  - **Boisé** 325, 373
  - **Bruneau** 336, 358
  - **Clark's Fork** 165
  - **Crow Creek** 191
  - **Custer County** 137, 148
  - **Deer Lodge** 189
  - **Divie** 381
  - **Dry** 326
  - **Frenchtown** 193
  - **Gallatin** 119, 131, 133, 137, 191
  - **Garden** 335
  - **Gila River** 147
  - **Grass** 193
  - **Heart River** 108
  - **Hellgate Ronde** 193
  - **Hose Plain** 193
  - **James, the** 32, 61, 62, 65, 74, 79, 83, 88, 89, 104
  - **Jefferson** 137
  - **Judith Basin** 161
  - **Junction** 339
  - **Little Horn** 242
  - **Lone Horse Prairie** 126
  - **Long, O** 322, 323, 335, 337, 352
  - **Lost River** 344
  - **Madison** 137
  - **Malad** 357, 359
  - **Marsh** 338, 343
  - **Middle** 363
  - **Mississippi** 147, 232, 378
  - **Missoula** 192
  - **Missouri** 101, 104, 246
  - **Nachetz River** 281
  - **Nevada** 409
  - **Paksimer** 354
  - **Payette** 409
  - **Pashamaroi** 344
  - **Pease Bottom** 137. 148
  - **Pierre** 89
  - **Poverty** 383

Page.

Valleys, for irrigation, names of—Continued.
- Pryor Cheek 242
- Raft 339
- Rapid 63
- Red River, the 26, 77, 92, 93, 95, 96, 101, 103, 104, 105
- Rock Creek 358
- Rosebud 134
- Round 335, 344
- Salt River 147
- Smith River 192
- Spear Fish 63
- Snake 321, 322, 345, 348, 364, 371, 372, 374, 375
- Squaw 335
- Thompson's Prairie 193
- Tongue River 137, 149
- Weiser 372, 409
- Yakima 269, 277
- Whetstone 32
- Yellowstone 99, 125, 126, 131, 134, 137, 144, 149, 151, 158, 161, 165, 226, 227, 234

Valleys, agricultural land in 325
- cultivated lands in 202, 207
- low, for use 134
- of the Nile 118, 132, 147
- water in 207

W.

Water for irrigation, references to:
- Acequia, above level of 412
- Alfalfa, for 271, 272
- Amount needed for first year 251
- Amount, per acre 319
- Appropriated, amounts 255, 256, 363, 394
- Bear Lake, in 385
- Bench lands, on 224
- Bottom lands, on 224
- Camas Prairie, at 349
- Cash tax, for 413
- Cassia County, in 336
- Cheyenne River, character of 28
- Commissioner of 413
- Constitution, State, on use 403
- Corn, used for raising 271, 272
- Cost of, per acre 194, 247, 248, 249, 255, 337
- Cost per acre 262, 271, 272
- Cost when stored 363
- Croton Acqueduct, reference to 247
- Cubic feet of 15, 322, 346
- Disappears through lava beds 400
- Disputes over rights of 206
- Distributing of, the 363, 406
- Duty of 271, 272, 327, 340, 342, 285
- Economy in use of 282
- Elevation of 269, 412
- Failure of, the 398
- Fertilizer, as a 215
- Floods of 217, 342, 359, 393
- Flow of 271, 272, 337, 338, 343, 348, 356, 383, 390, 394
- Flowing under surface 225
- Found easily, where 362
- Grasses, growth under water 271, 272
- Head of 397
- High 327, 395
- How sold 397
- Inches of, required per acre 340, 413
- Irrigation for 229, 348, 349
- Lack of 351
- Laws of 148, 412
- Legislation on 209
- Lent to the people 318

Page.

- Water for irrigation, references to—Continued.
  - Litigation on 184, 394, 406
  - Local government, and 390
  - Low-water mark 269, 395
  - Mammoth storage of 408
  - Master, water 391
  - Minimum of 341
  - Miner's, inches of 259, 260, 326, 358, 363
  - Mining for 207, 230, 354
  - Ownership, of 402
  - Ponds, in 161
  - Power, for log floating, as 327
  - Price of, for irrigation 211, 316, 346, 403, 406
  - Percolates, how it 257, 267, 268, 395
  - Percentage of waste 186, 197, 404
  - Quantity, per acre, required 204
  - Riparian rights, in 209, 363
  - Rights, of and in 166, 167, 210, 211, 238, 312, 340, 390, 409, 412, 413
  - Rent per acre 403
  - Rent, cost of, in United States, Italy, and France 20
  - Rights, power to sell 403
  - Scarcity of 407
  - Seasons of increase and decrease 349
  - Sheds, water 116, 363, 366
  - Spring, in 363
  - States, to sell by 401, 402
  - Storage of, references to 30, 103, 118, 135, 147, 157, 214, 216, 217, 218, 227, 228, 229, 230, 231, 232, 233, 234, 235, 237, 244, 246, 252, 253, 255, 256, 257, 258, 261, 265, 269, 270, 276, 281, 313, 314, 335, 339, 334, 350, 353, 363, 364, 365, 372, 373, 374, 383, 385, 395, 399, 400, 404, 405, 406, 407, 408.
  - Storm waters, the 116, 145, 147
  - Subterranean supply, a 350
  - Supply, Artic currents, by 319
  - Supply of, where from 160, 183, 205, 207, 223, 224, 242, 264, 265, 294, 308, 317, 338, 351, 356, 359, 364, 412, 413
  - Supreme court, decisions of, on 210
  - Surface, on 165, 214, 247
  - Veins of 108
  - Windmills, raised by 362
  - Weirs in irrigating works 252, 321, 341, 346
  - Waste of water, natural 252
  - Winds, the Chinook 114, 115, 223

Y.

- Yellowstone, National Park, the 151, 186, 200, 377, 400, 408

REPORT

OF THE

SPECIAL COMMITTEE

OF THE

UNITED STATES SENATE

ON THE

IRRIGATION AND RECLAMATION OF ARID LANDS.

VOL. II.—THE GREAT BASIN REGION AND CALIFORNIA.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1890.

VOL. II.

THE GREAT BASIN REGION AND CALIFORNIA.

UTAH.
NEVADA.
CALIFORNIA.
ARIZONA.

IRRIGATION AND RECLAMATION OF ARID LANDS.

UTAH DIVISION.

Salt Lake City, Utah, *August* 19, 1889.

The committee met pursuant to the call of the chairman.

Present: Messrs. Stewart (chairman), Plumb, Jones, and Reagan; also Director Powell.

STATEMENT OF A. L. THOMAS, GOVERNOR OF UTAH.

Mr. Chairman and Gentlemen: I have here some laws on the subject of irrigation in this Territory. The first is that contained in the compiled laws in regard to the organization of irrigation companies. Then there is a law in the session laws of 1878, amending that to some extent. Then we have a law passed in 1880, providing for the recording of vested rights and the use of water. To-morrow I shall file a statement respecting this latter law. And I would say that the courts have adjudged some of them unconstitutional.

The laws referred to are as follows:

WATER RIGHTS.

Sec. 422. Whenever, by priority of possession, rights to the use of water for mining, agricultural, manufacturing, or other purposes, have vested and accrued, and the same are recognized and acknowledged by the local customs, laws, and the decisions of courts, the possessors and owners of such vested rights shall be maintained and protected in the same; and the right of way for the construction of ditches and canals for the purposes herein specified is acknowledged and confirmed; but whenever any person, in the construction of any ditch or canal, injures or damages the possession of any settler on the public domain, the party committing such injury or damage shall be liable to the party injured for such injury or damage.

Sec. 423. All patents granted, or pre-emption or homesteads allowed, shall be subject to any vested and accrued water right, or rights to ditches and reservoirs used in connection with such water rights, as may have been acquired under or recognized by the preceding section.

Sec. 424. The right to the use of water for the reclamation of desert lands, in accordance with the provisions of an act approved March third, eighteen hundred and seventy-seven, shall depend upon bona fide prior appropriation; and such right shall not exceed the amount of water actually appropriated, and necessarily used for the purpose of irrigation and reclamation; and all surplus water over and above such actual appropriation and use, together with the water of lakes, rivers, and other sources of water supply upon the public lands and not navigable, shall remain and be held free for the appropriation and use of the public for irrigation, mining, and manufacturing purposes, subject to existing rights.

Sec. 425. All navigable rivers, within the Territory occupied by the public lands, shall remain and be deemed public highways; and in all cases where the opposite banks of any streams not navigable belong to different persons, the stream and the bed *thereof* shall become common to both.

SEC. 2775. s 1. The selectmen of the several counties of this Territory are hereby created ex-officio water commissioners for their respective counties, whose powers and duties shall be to make, or cause to be made and recorded, such observations, from time to time, as they may deem necessary, of the quantity and flow of water in the natural sources of supply, and to determine, as near as may be, the average flow thereof at any season of the year, and to receive, hear, and determine all claims to the use of water, and on the receipt of satisfactory proof of any right to the use of water having vested, to issue to the person owning such right a certificate therefor for recording, and to generally oversee, in person, or by agents appointed by them, the distribution of water within their respective counties, from natural sources of supply, to all the corporations or persons having joint rights in and to any natural source of supply, and to fairly distribute, according to the nature and extent of recorded rights, and according to law, to each of said corporations or persons their several portions of such water; and in case of dispute between any of such persons or corporations as to the nature or extent of their rights to the use of water or right of way, or damages therefor, of any one or more of such persons or corporations, to hear and decide upon all such disputed rights, and to file a copy of their findings and decisions as to such rights with the county recorder, and to distribute the water according to such findings or decision, unless otherwise ordered by a court of competent jurisdiction.

SEC. 2776. s 2. In cases where persons, or corporations, use water in different counties from the same natural source of supply, the water commissioners of each of said counties shall unite in appointing, either from among their number or otherwise, as they may determine, a board of reference of not less than three competent persons, to hear and decide all disputes in regard to water rights in and to such natural source of supply, and they shall file a copy of their decision with the county recorders of each of said counties; said water commissioners and members of the board of reference shall each, respectively, have power to administer oaths, and if any person who may be duly sworn in any matter in relation to the nature, extent, or exercise of any right or duty under any of the provisions of this act, shall falsely swear, such person shall be deemed guilty of perjury.

SEC. 2777. s 3. The certificate of the water commissioners shall state generally the nature and extent of the right to use water of the person, or corporation, to whom it is issued, and must be filed with the county recorder for recording.

SEC. 2778. s 4. It shall be the duty of the county recorder of each county, upon any certificate of water commissioners being filed in his office, as prescribed by this act, and upon any findings or decisions of any commissioners, or board of reference, as to the extent of any such rights, and upon payment of the fees allowed by law for such service, to record, in a book, or books, to be kept by him for such purposes, all such certificates, findings, and decisions, which said record shall be deemed to impart notice to all persons whomsoever of the contents thereof, and shall be prima facie evidence of the existence and verity of the facts therein recited.

SEC. 2779. s 5. No person, or corporation, shall maintain any suit, at law or in equity, for the determination of the existence or extent of any right, or rights, to the use of water in this Territory, until after the decision of the proper county commissioners, or of the proper board of reference, as the case may be, unless said commissioners, or board, shall fail and neglect to hear and decide such person's claim of right to use of water for more than three months after such person may have presented, in writing, his claim, or claims, and evidence in support thereof, for adjudication: *Provided*, This section shall not be construed to affect or impair the authority or jurisdiction of any court in the issuance of a temporary injunction or restraining order in such cases, or to abridge the right of any person aggrieved by any such decision to maintain any lawful suit, or appeal, after such decision may have been made.

SEC. 2780. s 6. A right to the use of water for any useful purposes, such as for domestic purposes, irrigating lands, propelling machinery, washing and sluicing ores, and other like purposes, is hereby recognized and acknowledged to have vested and accrued, as a primary right, to the extent of, and reasonable necessity for such use thereof, under any of the following circumstances:

1. Whenever any person or persons shall have taken, diverted and used any of the unappropriated water of any natural stream, water-course, lake, or spring, or other natural source of supply.

2. Whenever any person or persons shall have had the open, peaceable, uninterrupted, and continuous use of water for a period of seven years.

SEC. 2781. s 7. A secondary right to the use of water for any of said purposes is hereby recognized and acknowledged to have vested and accrued (subject to the perfect and complete use of all preliminary rights) to the extent of and reasonable necessity for such use thereof, under any of the following circumstances:

1. Whenever the whole of the waters of any natural stream, water-course, lake, spring, or other natural source of supply has been taken, diverted, and used by prior

appropriators for a part, or parts, of each year only; and other persons have subsequently appropriated any part, or the whole, of such water during any other part of such year, such person shall be deemed to have acquired a secondary right.

2. Whenever, at the time of an unusual increase of water exceeding seven years average flow of such water, at the same season of each year, all the water of such average flow then being used by prior appropriators, and other persons appropriate and use such increase of water, such persons shall be deemed to have acquired a secondary right.

SEC. 2782. s 8. A right to the use of water may be measured by fractional parts of the whole source of supply, or by such fractional parts, with a limitation as to periods of time when used, or intended to be used; or it may be measured by cubic inches with a limitation as to periods of time when used or intended to be used; or it may be measured by cubic inches with a limitation specifying the depth, width and declination of the water at point of measurement, and, if necessary, with a further limitation as to periods of time when used, or intended to be used, and such right may be appurtenant to the land upon which such water is used, or it may be personal property, at the option of the rightful owner of such right, and a change of the place of use of water shall in no manner affect the validity of any person's right to use water, but no person shall change the place of use of water, to the damage of his co-owners in such right, without just compensation.

SEC. 2783. s 9. A continuous neglect to keep in repair any means of diverting or conveying water, or a continuous failure to use any right to water, for a period of seven years at any time after the passage of this act, shall be held to be abandonment and forfeiture of such right, and whenever hereafter a conveyance of any parcel of land is executed, and a right to the use of water has been continuously exercised from the time of its first appropriation, in irrigating such land, such right shall pass to the grantee of such conveyance; and in cases where such right has been exercised in irrigating different parcels of land at different times, such right shall pass to the grantee of any parcel of land on which such right was exercised next preceding the time of the execution of any conveyance thereof; subject, however, in all cases, to payment by the grantee of any such conveyance, of all amounts unpaid on any assessment then due upon any such right: *Provided*, That in any of the cases mentioned in this section, any such right to the use of water, or any part thereof, may be reserved by the grantor of any such conveyance, by making such reservation in express terms inserted in such conveyance.

SEC. 2784. s 10. All rights to the use of water, and means of diverting water, shall be exempt from taxation, except for the purpose of regulating the use of the exercise of such right in all cases where the land or other property upon which the pertaining to such rights is assessable for taxation, but in making the assessment the assessor shall estimate the increased value of such land or other property, caused by the use of such water.

SEC. 2785. s 11. It shall be the duty of all persons using water from any natural source of supply to provide suitable ditches for conveying surplus water again into the natural channel, or other places of use, to the satisfaction or approval of the water commissioners; and if, through neglect so to provide such ditches, water is allowed to form pools or marshes, or otherwise run to waste, and if any person shall turn or use any water in a manner that damages the property of another, except when such turning or using in the prudent, careful exercise of such person's lawful right to so turn or use, such person or persons so offending shall be liable for damages to any aggrieved person entitled to the use of water from the same source of supply, and the water commissioners may, on application, or of their own motion, cause the water supply to be diverted from such offending party until such waste ditches are provided.

SEC. 2786. s 12. Whenever the terms mentioned in this section are employed in this act, they are employed in the sense hereinafter affixed to them, except when a different sense plainly appears;

1. The term "person," when applicable, includes "firm," "partnership," "joint-stock company," "association" and "corporation."

2. Words in the singular number may include the plural, and words in the masculine may include the feminine.

3. The term "continuous use" includes use for that part of each year necessary for the purpose used for.

SEC. 2787. s 14. Whenever the waters of any natural source of supply are not sufficient for the service of all those having primary rights to the use of the same, such water shall be distributed to each owner of such right in proportion to its extent, but those using the water for domestic purposes shall have the preference over those claiming for any other purpose, and those using the water for irrigating lands shall have preference over those using the same for any other purpose, except domestic purposes: *Provided*, such preference shall not be exercised to the injury of any vested right, without just compensation for such injury.

SEC. 2788. s 15. All persons shall have the right of way across and upon public, private, and corporate lands, or other right of way, for the construction and repair of all necessary reservoirs, dams, water-gates, canals, ditches, or flumes, other means of securing and conveying water for any necessary public use, or for drainage, upon payment of just compensation therefor, but such right of way shall in all cases be exercised in a manner not to unnecessarily impair the practical use of any other right of way, highway, or public or private road, nor to unnecessarily injure any public or private property.

SEC. 2789. s 16. Whenever a majority of individuals owning several rights to the use of water, and a joint interest in the means of diverting or conveying such water, or who may desire to divert and use any unappropriated water, desire to organize themselves into an association for the purposes of regulating the diversion and distribution of such water, they may organize into a corporation in the manner provided in "An Act providing for incorporating associations for mining, manufacturing, commercial, and other industrial pursuits," approved February 18, 1870, and all amendments thereto, with power to levy and collect all necessary assessments, and the distribution of water to each stockholder may be regarded as the payment of dividends, and such corporation shall have perpetual succession, unless dissolved by three years' nonuse of its rights, or by a two-thirds majority vote of its members, at a meeting called for that purpose; in all cases of dissolution, the property held by the corporation, shall revert to the members, in proportion to their rights therein, or they may organize into an irrigation district, under "An Act to incorporate Irrigation Companies," approved January 20, 1856, as they may elect.

AN ACT Compiling the Laws Relating to the Incorporation of Irrigation Companies.

SEC. 2403. s 1. *Be it enacted, etc.:* That upon the majority of the citizens of any county or part thereof, representing to the county court that more water is necessary, and that there are streams or part of streams unclaimed or unused, which, if brought out of their natural channels and thrown upon tracts of land under cultivation, or to be put under cultivation, can be of value to the interests of agriculture, the county court having jurisdiction may proceed to organize the county, or part thereof, into an irrigation district; and thereafter the landholders of such district shall be equally entitled to the use of the water in, or to be brought into such district, according to their acknowledged rights; *Provided*, Such landholders pay their proportion of the expense incurred in the construction and keeping in repair of the necessary canals, flumes, dams or ditches.

SEC. 2404. s 2. The citizens of an irrigation district, when so organized for the purposes provided in the preceding section, may, in mass meeting, proceed to the formation of a company, by electing, *viva voce*, not less than three nor more than thirteen trustees, a secretary and a treasurer. Notice of the time, place and object of said mass meeting shall be given by the clerk of the county court, at least ten days previous, by advertising three times in some newspaper having general circulation in the county, and by posting up notices in three public places in the district.

SEC. 2405. s 3. It shall be the duty of the trustees so elected to locate the proposed canal or ditch, determine the amount and quality of the land to be benefited thereby, to estimate the cost, including dams, flumes, locks, waste weirs and all the appurtenances belonging thereto, the amount per acre of the percentage on taxable property which will be necessary to construct the same.

SEC. 2406. s 4. It shall then be the duty of the trustees to make a report to the county court of the location and estimate provided for in section 3 of this act; also to call a meeting of the holders of the lands to be benefited by the proposed canal or ditch, at which a copy of said report shall be presented, and the said landholders shall vote "yes" or "no" upon the following questions:

1. Do you mutually agree to pay —— per acre, land tax, to construct the proposed canal or ditch?
2. Do you approve the action of the mass meeting in the election of officers?

Notice shall be given by the trustees at least ten days previous to the time appointed for such meeting, by advertising at least three times in some newspaper having general circulation in the county, and by posting up notices in three public places in the district. Said advertisement and notice shall state distinctly the time and place and object of such meeting, and be signed by a majority of the trustees and the secretary. The voting at said meeting shall be by ballot, and the chairman and secretary of said meeting shall be the judge and clerk of the election. A ballot-box shall be provided by the trustees, and each voter shall present his ballot to the judge of election, who shall deposit it in the box, and the clerk shall write the name of the voter in a poll-list or book, which shall also be provided by the trustees. No person shall be entitled to vote at said meeting or election unless he is a landholder in the district. Immediately after the close of the election the ballots shall be openly counted by the judge and clerk, assisted by two persons chosen by the voters present. A certificate of the results of the election, signed by the persons who counted the votes, shall be forwarded at once to the clerk of the county court by the judge of said election.

SEC. 2407. s 5. If upon counting the votes it shall appear that two-thirds of the votes polled have been answered in the affirmative, then the tax so agreed upon shall be a law in the said irrigation district; and the tax when collected shall be paid over to the treasurer of said company on his order; *Provided*, That not exceeding one-half of the tax so agreed upon shall be collected at one time, and the residue to be collected as the work progresses; *Provided further*, That if the first estimate prove insufficient for the construction of the canal or ditch with its appurtenances, then additional taxes may be assessed in the same manner as hereinbefore provided until the said canal or ditch is completed.

SEC. 2408. s 6. If less than two-thirds of the votes polled are answered in the affirmative, then all proceedings under this act shall be null and of no effect; *Provided*, That if there are objections to the officers so elected by the mass meetings, the electors may write other names on their tickets; the persons having the most votes to be declared elected, and it shall be the duty of the county clerk to notify such officers forthwith of their election.

SEC. 2409. s 7. Within twenty days after receiving such notice, the officers so elected shall file bonds in the office of the clerk of the county court, conditioned for the faithful performance of their several duties; the amount of such bonds to be declared by the county court having jurisdiction.

SEC. 2410. s 8. The term of office of the first trustees, secretary and treasurer, shall be till the next general election; and thereafter for two years, and until their successors are elected and file bonds.

SEC. 2411. s 9. All subsequent elections for determining the rate of tax shall be held annually on the first Monday in December, and for the election of company officers, biennially, on the same day, at such time and place within the district as shall be designated by the trustees, at which time the number of trustees may be changed by a two-thirds vote to not less than three nor more than thirteen. Notice of said election shall be given and the election conducted and certificates thereof returned, as provided in section 4 of this act, and the officers elected shall give bonds as provided in section 7 of this act. The rate of tax determined at said election by a majority vote shall be a law in said irrigation district, and shall constitute a permanent lien on the interest of the tax-payer in said canal or ditch and his right to the use of the water therein flowing from the day of assessment: *Provided*, That no tax created or payable by this act shall be or create a lien upon the land.

SEC. 2412. s 10. The trustees at their first meeting shall elect one of their number president, and it shall be their duty and they shall have power to fill any vacancy which may occur in the board by death, change of residence, or otherwise; and the persons chosen for this purpose shall hold office until the next annual election. The trustees shall also have power to meet at such times and places as they may deem expedient to make by-laws, rules, and regulations necessary to carry into effect the objects of the people; to appoint agents, subordinates, and officers, and employ such workmen as may be requisite; to appoint assessors and collectors, or make agreement with the county assessors to assess and collect the tax, and notify collectors when additional installments of the tax will be needed; to construct and complete said canals or ditches, with all necessary appurtenances thereto; to cause to be kept an account of all receipts and disbursements, and to complete said canals and ditches, and settle all accounts of the same. Said trustees shall make an annual report of their proceedings under this act to the county court on or before the first day of February, and shall file with the clerk of the county court a map of said irrigation district, showing the location and subdivision of land therein, and of the company's canals and ditches.

SEC. 2413. s 11. The trustees shall have power to sue and be sued, plead and be impleaded, to have and to hold all such real estate and personal property as may be necessary to construct the contemplated ditch or canal, including all appurtenances belonging thereto.

SEC. 2414. s 12. If any part of the lands to be benefited by the proposed ditch or canal are not legally claimed, then such lands may be appraised by the trustees and shall be held and the possession of them sold by the trustees, as opportunity may offer, and the estimated amount of the funds necessary to complete such canal or ditch shall be decreased by the estimated value of such lands, previous to the levy and assessment of any tax.

SEC. 2415. s 13. Where the streams to be taken out for irrigation purposes come from counties other than the one in which the district is situated, but where there are no existing claims to the water and where no individual or settlement will be injured thereby, then the power of said irrigation district is hereby extended to said other county, insomuch as said extension may be necessary for the construction of dams to turn the waters, and ditches or canals with all necessary appurtenances as may be necessary to convey the same to where it is to be used.

Sec. 2416. s 14. Where lakes or ponds in natural basins have outlets, or where such can be made by dams across hollows, such lakes or ponds may be used as reservoirs, to store water for lands lying on lower levels; and the people of any irrigation district may, under the provisions of this act, construct such artificial or use such natural basins for irrigation purposes: *Provided*, The waters of such lakes or ponds are in no case to be raised, by dams or otherwise, so as to interfere with or damage settlers upon the margin thereof.

Sec. 2417. s 15. Upon the construction or partial construction of any canal, ditch, or reservoir contemplated in this act, they shall become the property of the irrigation district; and thereafter all funds necessary for repairs upon said canal, ditch, or reservoir, and for keeping the same in order, or for altering or enlarging the same may be levied by a tax upon the lands benefited, the landholders in the district to vote upon the same in the manner heretofore provided for in this act. And in case of any sudden emergency, caused by inundation or otherwise, said trustees are hereby authorized and empowered to make such repairs, or take such measures as they may deem necessary to preserve the canals, or ditches, or other works of said company or district, and for payment of the expenses so increased the trustees are hereby authorized and empowered to levy a tax for the necessary amount upon all the lands of said district benefited by such canals or ditches, and said tax may be collected in the same manner and at the same time, if necessary, as provided for the collection of other taxes in said district.

Sec. 2418. s 16. All property or money belonging to any irrigation district, in the hands of the trustees to be expended by them under the provisions of this act, is hereby exempted from all city, county, and Territorial taxes.

Sec. 2419. s 17. After any canal or ditch shall have been laid out under this act, or under any special charter where other provision has not been made, the trustees or company may agree with the owners of land through which it will pass for the purchase of so much thereof as may be necessary for the making of the canal or ditch and the appurtenances thereto belonging.

Sec. 2420. s 18. In every case where the owner of the land so required shall absent himself from the country, or shall not, from any cause, be capable in law so to agree, or shall refuse to agree, or ask an exorbitant price, the value of such land and the damages to the owner thereof shall be ascertained in the following manner:

1. The owner of or claimant to such land and the trustees may each select a referee, and in case of disagreement the two may select a third, and these referees shall proceed to determine the value of the land under controversy, and assess the amount of damages, if any, which each owner of lands or improvements has sustained, or will sustain, in consequence of the canal or ditch.

2. The appraisal, with a description of the land so appraised, shall be acknowledged by the referees signing it, before the clerk of the county court of the county in which the lands are situated, and when so acknowledged it shall be filed in the said clerk's office within ten days after it shall have been made. In case the occupant or claimant shall refuse or neglect to select a referee as herein provided, the trustee may petition the district court of the district in which the land is situated for the appointment of three or more commissioners to condemn the land and fix and determine the damages; said commissioners to be appointed upon such notice to the complainant or occupant as said court shall direct. Said commissioners shall report to said court their award and determination for approval or disapproval. The motion for approval of said award shall be heard on such notice as the court shall direct.

Sec. 2421. s 19. The trustees, upon payment to the rightful claimant of the several sums assessed in the appraisal so made, or upon making a tender thereof when the same shall be refused, shall be entitled to enter upon the lands described in the appraisal, and have and hold the same for the use and benefit of such irrigation district forever.

Sec. 2422. s 20. If on any parcel of the lands so described there shall be no person then living authorized to receive payment for the damages assessed for such parcel, and such damages shall not have been lawfully demanded within ten days after the filing of such appraisal, the board of trustees may enter thereon without payment or tender of such damages, but subject to such payment whenever the same shall be thereafter lawfully required.

Sec. 2423. s 21. Any person, who, in violation of any right of any other person, or of said corporation, wilfully turns or uses the water, or any portion thereof, of said canal, ditch, or reservoir, except at a time or times when the use of such water has been duly distributed to such person, or wilfully uses any greater quantity of such water than has been duly distributed to him, or in any way changes the flow of water when lawfully distributed for irrigation or other useful purposes, except when duly authorized to make such change, or wilfully or maliciously breaks or injures any dam, canal, water-gate, ditch, or other means of diverting or conveying water for irrigation or other useful purpose, is guilty of a misdemeanor.

SEC. 2424. s 22. All companies or districts organized under the provisions of this act shall be liable for any damage which may occur by the breakage of any canal or ditch. When any land in an irrigation district is benefited or damaged by the company's canals or ditches, from soakage or other incidential cause, and the owner of said land and the company can not agree as to the amount of the benefit or damage, the matter in dispute, as well as the question of damage through breakage, may be referred and decided as provided in the preceding section of this act. No irrigation company organized under the laws of this Territory shall be entitled to divert the waters of any stream to the injury of any irrigation company or person holding a prior right to the use of said waters, and all cases of dispute arising from such unlawful diversion may also be referred and decided as provided in section 18 of this act.

SEC. 2425. s 23. Nothing in this act shall be so construed as to interfere with the right of the legislative assembly to repeal, alter, or amend the same at pleasure.

SEC. 2426. s 24. That persons who have constructed canals, ditches, or dams, and taken out water for irrigation purposes before the passage of this act to which this act is amendatory, are hereby authorized to organize under the provisions of said act, and to enjoy all the rights, powers, and privileges guaranteed therein: *Provided*, They shall proceed in the same manner as is provided for the organization of new companies.

SEC. 2427. s 25. Nothing in this act shall be so construed as to prevent any association of persons incorporating under the laws of this Territory relating to private corporations for general purposes.

STATEMENT OF ELIAS A. SMITH, OF SALT LAKE CITY.

The CHAIRMAN. I believe you are one of the commissioners of the Territory?

Mr. SMITH. I am one of the commissioners of this county.

The CHAIRMAN. You have been probate judge of the county?

Mr. SMITH. Yes; I was probate judge of this county for five years.

The CHAIRMAN. How long have you resided in Salt Lake?

Mr. SMITH. I was born here, and I am now thirty-one years old.

The CHAIRMAN. Are you familiar with the regulations made here governing the distribution of water among those who irrigate?

Mr. SMITH. Yes, some of them.

The CHAIRMAN. Will you state generally how you manage to distribute the water to the consumers?

Mr. SMITH. There are two or three systems. We have, first, the incorporators on the streams, controlling it themselves—they agree how it shall be manipulated; second, the county courts that matured and organized irrigating companies; and, third, private corporations, taking out charters the same as any other corporation would, as, for instance, a person or a company of men settle upon a stream and appropriate the water in it. In early times they had sufficient to irrigate what land they would break up. Those we will term the primary owners of the water. Afterward others would come who, finding a surplus of water in the stream, would appropriate still further water, and so on until all the water of that stream would be taken out. They dug their ditch, gave it some name, and took what water they could through their land. In establishing some streams there would be what is known as the first, second, and third right. The third right, when there is a scarcity of water, shuts off the entire stream, and the second and first rights take the entire stream. The owners of each of those ditches meet and appoint what is called a "water-divider" or "water-master," who has control of the ditch for that year, and whose duty it is to divide the water of the streams into ditches, as, for instance, if there were four streams drawing water, they would appoint a divider to turn the water of those streams into the ditches, and the water-master would take the water as it would get into the ditch and give it to the owners as their rights might appear. I do not think there is an irrigating ditch in the

Territory under the irrigation law; they have all taken out private charters.

The **CHAIRMAN**. Explain how that is operated.

Mr. **SMITH**. It is an incorporation where certificates of stock are issued under the general laws of the Territory. They elect their board of truestees and manage the affairs of the company. Those trustees appoint a water-master, who takes the number of shares each owner of it has and divides to each his proportion of the water that comes through a certain ditch from the stream. Those streams are mostly artificial streams, having been taken out from some large body of water. That system prevails more on the west side than on the east side, though there are some on the east.

The **CHAIRMAN**. Then the stockholders in the corporation have the land?

Mr. **SMITH**. Yes. But the water right can be transferred without transferring the land. It is a water right independently of the land.

The **CHAIRMAN**. Can a man sell his water right and keep his land?

Mr. **SMITH**. Yes; sell it the same as he could the stock in any corporation.

The **CHAIRMAN**. How does that work? What do they do with the water if they have not the land?

Mr. **SMITH**. I am one of those parties. I own stock in one of those corporations, yet I own no land. I rent my water by the year to owners of land.

The **CHAIRMAN**. Is there any law by which the price of water is regulated?

Mr. **SMITH**. No.

The **CHAIRMAN**. You can charge all you can get?

Mr. **SMITH** All I can get, and the parties get it for as little as they can.

The **CHAIRMAN**. Then you take the water from one land owner and give it to another?

Mr. **SMITH**. Yes. But there is hardly a land owner but who has some water right.

Senator **JONES**. Does the corporation as a body rent this water?

Mr. **SMITH**. Each individual.

Senator **JONES**. The several members of the corporation dispose of the water to the farmers?

Mr. **SMITH**. The corporation has no water to dispose of. There is no corporate power to dispose of the water.

The **CHAIRMAN**. Does that lead to a monopoly?

Mr. **SMITH**. Not so far. There is one company, of which I am the secretary, that has issued 10,000 shares, and there are a little over four hundred owners of that stock. The largest owner holds 209 shares.

The **CHAIRMAN**. Do you regulate the amount of shares with reference to the amount of land to be irrigated?

Mr. **SMITH**. We count that one share of water will irrigate 1 acre of land. If a man have 80 acres of land he must provide himself with 80 shares of stock. The ditch is some 30 miles long. They take out of that what they call a weir ditch, and the owners of the land under that weir ditch appoint a water-master to divide the water out by the hour.

Senator **REAGAN**. Do you find complaint on the part of the land owners that there is a monopoly of the water?

Mr. **SMITH**. I have never heard it.

Senator **REAGAN**. Do you find complaint of excessive charges for water?

Mr. SMITH. I have never heard it.

The CHAIRMAN. There you have two of the systems; what is the third?

Mr. SMITH. The other is virtually the same, only the county court granted them a charter to take out and control a certain stream. They found that that stream did not work. I think in every instance in this county they have abandoned it.

The CHAIRMAN. They had that system in vogue in Carson when I went there. They had a county judge dealing out the water. There the county court assumed jurisdiction. But that has been abandoned here, you say?

Mr. SMITH. We found that it did not work. When there have been companies organized they have taken out what is called private incorporation charters under the laws of the Territory.

The CHAIRMAN. You have no corporation that sells water exclusively?

Mr. SMITH. I do not think there is a corporation in Utah Territory that rents water exclusively.

The CHAIRMAN. Then the only renters of water are the stockholders in these corporations who have a surplus, who have more stock than land, and they sell their surplus water to their neighbors?

Mr. SMITH. Yes, that is the only system in vogue in this Territory to-day. The legislature of Utah in 1880 passed a law leaving the entire water rights claim to be adjusted by the county commissioners, and afterward their judicial powers were annulled by decree of the court.

The CHAIRMAN. You recognize in the acquisition of the use of water priority of appropriation?

Mr. SMITH. Yes.

The CHAIRMAN. How do you limit the appropriation? If a man should take more water than he could use economically, would that be an appropriation in excess of what he ought to have?

Mr. SMITH. We have had but one suit of that kind, and that was this year—a suit where the party owning the primary right was using more water than was necessary to irrigate his land. The suit was brought to curtail him in the use of that water, and the court decided that he could only use enough to irrigate his land; that he should cause no waste of water. Now, we had a case where one person in what we call the primary class claimed that he had a better right than others in the same class, and the court decided that whenever there was a scarcity of water they should all share equally.

The CHAIRMAN. In this arrangement have you any supervision of the amount of water that should be used?

Mr. SMITH. None other than that the water master apportions to each person so many hours for the use of the water, and it is his business to see that he does not infringe upon the time of his neighbors, but if he should have more water than he needs in those hours, he could waste it if he should please to do so.

The CHAIRMAN. This is to say that if he did not see fit to ditch his soil he could allow the water to run to waste?

Mr. SMITH. Yes.

The CHAIRMAN. In some of these new constitutions the water is the property of the State.

Mr. SMITH. We have never considered it the property of the State, but of the individual.

The CHAIRMAN. But there is a pretty strong public opinion against wasting water, is there not?

Mr. SMITH. Yes; a pretty strong one. Judge Goodwin calls my attention to the fact that we had a good deal of alkali land on which we turned water in abundance to wash the alkali out. In some places it would be called a waste; here we call it redeeming the land.

The **Chairman**. Do you not find it necessary to drain it off? If you turn water onto the land and allow it to soak away it will increase the alkali.

Mr. **Smith**. Yes; but if we turn it on and permit it to stand for a little while it will raise the alkali and then we can wash it off.

The **Chairman**. But you must have drainage?

Mr. **Smith**. Yes.

The **Chairman**. By putting on fresh-water after the alkali is taken off you can reclaim the land?

Mr. **Smith**. Yes.

The **Chairman**. Where you have irrigated here and allowed the water to stand in low places has it not created alkali patches?

Mr. **Smith**. Yes. If we turn water onto a place without providing a way of draining it we make alkali land.

The **Chairman**. Then drainage is as important where you have alkali to deal with as is the putting of water on to the land?

Mr. **Smith**. Yes; in fact we have had to dig ditches to take water off that class of land. Of course, where we have the water measured and each person takes his own we have very little waste water.

The **Chairman**. Would irrigating properly and with proper drainage reclaim the land from alkali instead of putting more alkali on it?

Mr. **Smith**. Yes; and then we can put on California clover.

The **Chairman**. Alfalfa is California clover?

Mr. **Smith**. No; we have two classes. What we here term the California clover is larger and grows much longer.

Colonel Hollister asks me to explain the connection of the original water rights, through these certificates that in all instances relate to artificial streams.

Senator **Reagan**. That is a fresh-water lake?

Mr. **Smith**. Yes; it is 8 miles between the lake and the point of the mountains here. At the point of the mountains there is a dam placed in there, ostensibly for the purpose of storing water in Utah Lake. From the Jordan River there are five large canals taken out, two at the dam and three below it. But they are all taken from the waters of the Jordan. There are three on one side and two on the other. One goes to Salt Lake City, one to farms on the east side, and three to the others. Salt Lake County put in the dam out of the funds of the county.

The **Chairman**. To store more water?

Mr. **Smith**. To store more water, and with a view to bringing under cultivation a greater area, and in each of these canals on the west side expended means toward helping the incorporators take out water. The companies were incorporated the same as most any other company, except that the capital stock was to be paid off in the excavation of the canal.

The **Chairman**. That is to say, they worked it out?

Mr. **Smith**. Yes. There had to be some cash assessments, for supplies; but the most of it was done through the work of individuals. The greatest number of shares that any one person was permitted to have in any one of these canals was 300.

The **Chairman**. That was giving the person holding that number of shares 300 acres of land?

Mr. **Smith**. The water for 300 acres of land. My father was the largest owner, and his stock will be divided so soon as his estate is divided. He held 209 shares.

The **Chairman**. Then, as I understand you, Salt Lake County organized corporations?

Mr. **Smith**. They organized no corporations; they aided those corporations.

The **Chairman**. The corporations organized to construct these canals were composed of persons who were allowed to put in their labor and obtain stock, and the county furnished a little money.

Mr. **Smith**. No; the county put in the dam and built, I think, the first 3 miles of the canal. That was the hardest canal to build. It was on a side hill all the way around there for 8 or 10 miles.

The **Chairman**. And the county made no charge against the corporation for that?

Mr. **Smith**. We did make a charge against the canal company. But it was afterward settled. When I went in as probate judge I found that against the canal company on the books of the county, and we made an arbitration in which we received a small amount and canceled the obligation. In another case we had the canal take stock in the corporation, and when I went in there we still had that stock in the county treasury. But we improved the road and allowed those who worked on the road to receive stock to get rid of it.

The **Chairman**. That was a combination of individuals by putting in their own work to construct a ditch, and no money was necessary except for obtaining supplies and tools?

Mr. **Smith**. Yes, and powder for blasting purposes. On the west side of this river there are 20,000 acres that receive water from these ditches. This lake is exclusive to Salt Lake City.

The **Chairman**. Those corporations of which you spoke are simply corporations of individuals to bring in water to put on the land?

Mr. **Smith**. Yes.

The **Chairman**. Did they put in the money?

Mr. **Smith**. Mostly labor. Of course, where a man did not wish to work it out he paid some one to do it for him.

The **Chairman**. It does not require much capital to do this?

Mr. **Smith**. No; if it did the canals would not have been built.

The **Chairman**. Then you have built most of them by men putting in their labor?

Mr. **Smith**. Yes. I do not know of a canal that was constructed in any other way. I think this one on the west side of the river has cost in the neighborhood of $200,000 or $250,000.

The **Chairman**. And that was put in by labor?

Mr. **Smith**. Yes.

Senator **Jones**. That canal will irrigate how much land?

Mr. **Smith**. From 5,000 to 10,000 acres.

Director **Powell**. Be good enough to explain that a little further. They went in and labored on these canals as men go on our roads and labor, and their wages were computed at so much, so that the cost of those canals was increased in that way?

Mr. **Smith**. In going on the dams the men were allowed so much per day, while if they had actual cash, the price would have been reduced.

The **Chairman**. They allowed the men all the same wages?

Mr. **Smith**. Yes.

The **Chairman**. What were the wages?

Mr. **Smith**. Four dollars a day, man and team. There are 10,000 shares in the company, which to-day can be bought at $12 per share, and that would be $120,000 for the canal.

Senator **Plumb**. Would that represent about the actual cash cost?

Mr. SMITH. No, I think not. There has been a scarcity of water, and that has decreased the value of the stock.

Senator PLUMB. What was the cash value?

Mr. SMITH. I think $150,000 would have constructed the ditch.

Senator PLUMB. And the company is capitalized at $250,000?

Mr. SMITH. Yes.

Senator PLUMB. And the owners of the ditch would sell it?

Mr. SMITH. The owners of the stock.

Senator PLUMB. Do these persons own the land under the ditch?

Mr. SMITH. Yes.

Senator PLUMB. What would a man do for water on his land if he sold his stock?

Mr. SMITH. Either let the land lie idle or buy the water back from the owner. Each person would have some little of this stock to sell.

The CHAIRMAN. They would not sell it to destroy their farms, would they?

Mr. SMITH. No; some have a surplus.

The CHAIRMAN. Would it not have been more economical to have taken the water out of the upper ditch?

Mr. SMITH. No. The lower ditches were constructed first. This ditch did not require a dam to take it out; it takes the water out from what is really the mountain source.

The CHAIRMAN. The upper ditch is the most expensive ditch. If the upper ditch had been constructed first it would have irrigated how much land? You were calculating how much was between the two ditches.

Mr. SMITH. I was counting what was between the 5,000 and 10,000 acres. If it were all one it would have irrigated 20,000 acres.

The CHAIRMAN. What would have been the construction of the upper ditch to irrigate 20,000 acres?

Mr. SMITH. I believe $250,000 would have done it, to take the whole supply of water that the three canals use.

The CHAIRMAN. Would it not be a more economical use of the water to have it all in one ditch?

Mr. SMITH. It would in these two upper ones; but I do not think it would in this lower one. This upper one here is merely a conjecture.

The CHAIRMAN. Then there can be one brought still higher?

Mr. SMITH. It would have to be by hydraulic pressure, pumping the water 115 feet in the air. A few of us were going to undertake it. The ditch on the east side comes exclusively to the city and is not used for irrigation, except right by the city.

The CHAIRMAN. How long has that been in use?

Mr. SMITH. Some six or seven years.

The CHAIRMAN. What is the length of the ditch?

Mr. SMITH. Something like 25 miles, I think. That is next to the longest canal.

The CHAIRMAN. What is the value of the average farming land under this ditch?

Mr. SMITH. On the west side it is from $25 to $40 an acre.

Senator PLUMB. How far from the city?

Mr. SMITH. That would be 15 miles from the city.

Senator PLUMB. Is it all under fence?

Mr. SMITH. No; very little fenced; it is open land.

The CHAIRMAN. And it is all under irrigation?

Mr. SMITH. All under irrigation. But that does not include the water right. You would have to add $25 or $30 for that. Where it obtains this water from the mountain stream it differs. South here, at Draper, it would average about the same as on the west side. On the east side, 18 miles south of the city, is worth $40 or $50 an acre. Then they have the mountain stream where the land would come higher, from $50 to $75; and the further up the land would average $100 an acre; that is, where they have the mountain streams.

Senator **JONES**. Why is that?

Mr. **SMITH**. They have always considered the mountain streams a better source of supply. There is a débris that comes down with the mountain streams which increases the fertility of the land. Then, when you get right south of the city, up to about two years ago the land was rated at $300 an acre. That was farming land. In the last year or two it has increased in value. But that is due to the fact that it is looked after for residences. Within a radius of six miles from the city you can hardly get farming land for less than $300 an acre.

Senator **REAGAN**. What is the height and length of the dam?

Mr. **SMITH**. The length of the dam is about 120 feet, and I think it was put in something like 4 feet high. They have boards to put in to raise it 9 feet higher.

Senator **REAGAN**. Does that overflow the plains?

Mr. **SMITH**. It does not; but it will overflow the border of Utah Lake. It would not overflow below the lake and the dam, but it would overflow the lake and the land adjacent to it. We finally entered into an arbitration and agreed to what height we could raise the water.

The **CHAIRMAN**. Would it fill if you raised the dam higher?

Mr. **SMITH**. It could fill. Utah Lake has been known to be some 6 or 7 feet higher than it is to-day.

The **CHAIRMAN**. Could you have it higher and cover more land?

Mr. **SMITH**. Yes; I think we could.

The **CHAIRMAN**. There is a good deal of water runs to waste?

Mr. **SMITH**. There has not been for the last two or three years; but it has been so that it did run to waste.

The **CHAIRMAN**. Could the water be saved over or would it evaporate?

Mr. **SMITH**. We could save it over. There is some land unsurveyed adjacent to it, but it is occupied by what we call squatters, and their rights we have to respect. It it were not for them we could raise the water in Utah Lake, and it could be used to an advantage below. There is not sufficient water in all these ditches to irrigate all the land under them.

Senator **REAGAN**. Would it be too expensive to levee it?

Mr. **SMITH**. Yes. On the west side it is a natural reservoir, and on the east it is of a sloping character, and can not be leveed.

The **CHAIRMAN**. Are you familiar with the crops they produce, so as to be able to say what character of crops they raise there? How much of wheat do they produce?

Mr. **SMITH**. On $300 an acre land, within 6 miles of the city, from 40 to 50 bushels to the acre. That is on the east side.

The **CHAIRMAN**. And of oats?

Mr. **SMITH**. In the neighborhood of 90 bushels to the acre.

The **CHAIRMAN**. And barley?

Mr. **SMITH**. I could not say as to barley.

The **CHAIRMAN**. Do you raise alfalfa?

Mr. **SMITH**. Yes.

The **CHAIRMAN**. What kind of crops?

Mr. **SMITH**. They will raise in the neighborhood of 4 or 5 tons per year. You can extend that all over the Territory. In the southern part they can raise more on account of cutting one more crop.

The **CHAIRMAN**. There would be then probably 6 or 8 tons per year?

Mr. **SMITH**. They can raise one more crop than we can.

The **CHAIRMAN**. Do you raise a good quality of potatoes?

Mr. **SMITH**. Good quality; and the land will produce in some places one quality and in others another quality.

The **CHAIRMAN**. What would be the production on this rich land?

Mr. **SMITH**. Five hundred bushels to the acre.

The **CHAIRMAN**. And of other vegetables in like proportion?

Mr. **SMITH**. Yes. It is very productive land.

The **CHAIRMAN**. How does fruit grow here?

Mr. **SMITH**. It grows very well. But the last few years we have been troubled with a moth, which has made our fruit crop a failure. It has been to a certain extent abandoned—the apple, for instance. What we do raise is very choice fruit. Peaches do not thrive, except in certain localities.

Senator **REAGAN**. What is the nature of this moth?

Mr. **SMITH**. It is in the shape of a worm that enters the apple.

Senator **JONES**. What is the irrigating season here?

Mr. **SMITH**. In May, and it runs to October. Alfalfa is the last we irrigate.

Senator **JONES**. What do they do with the water in the winter?

Mr. **SMITH**. In Utah Lake we put in the boards at the dam and hold it back, and of the mountain streams coming west we retain what goes into the lake. When the height of the water in the lake is not beyond the point we have agreed upon, we can hold it.

Senator **REAGAN**. But some seasons it gets above that?

Mr. **SMITH**. Yes.

The **CHAIRMAN**. If you could save it at that time do you think it would help you enough?

Mr. **SMITH**. Unquestionably so.

Senator **JONES**. You have not found it economical to store water from other sources of supply?

Mr. **SMITH**. We have not. But from now on we will. We in the city will have to find a place to store water for use in the winter season. In the winter and spring seasons the streams become torrents.

The **CHAIRMAN**. Are you familiar with the summits of the mountains, to be able to say whether there are flats up on them?

Mr. **SMITH**. Yes; there are cañons that have flats.

The **CHAIRMAN**. With a narrow gorge and a valley between them?

Mr. **SMITH**. Yes. But there are others who are better acquainted with that matter than I am.

Senator **PLUMB**. What arrangement is being made for a canal from Bear River?

Mr. **SMITH**. There is what we call the Boutwell system that is started there.

Senator **PLUMB**. Is that a corporation?

Mr. **SMITH**. It is a corporation, and for the same purpose as ours of letting water to land-owners. It is separate from the land, however.

Senator **PLUMB**. They have an incorporation to get their water right and get their contract?

Mr. **SMITH**. They have their contract, but there will be a question as to the water-right.

Senator **PLUMB**. Between them and the prior appropriators?

Mr. **SMITH**. Yes.

Senator PLUMB. That will go to the extent of the appropriated water?

Mr. SMITH. All the appropriated water.

Senator PLUMB. You understand this company will have the right to take the water not already appropriated?

Mr. SMITH. Yes.

Senator PLUMB. Where will they use this water?

Mr. SMITH. In the territory known as Box Elder and Weber Counties, in the vicinity of Corinne; northwest from Corinne.

Senator PLUMB. Do you know what quantity of land they expect to irrigate?

Mr. SMITH. Thirty thousand acres.

Senator PLUMB. Do they own the land themselves?

Mr. SMITH. There are some large cattle companies who own the land with them. But there is some land there that has not been taken.

Senator PLUMB. That will wholly discharge the water into Utah Lake?

Mr. SMITH. Yes; if they dig the ditch the size they are contemplating it will take every drop of water that flows into Utah Lake by Bear River.

Senator PLUMB. What would be the result?

Mr. SMITH. It would run it down.

Senator PLUMB. Will the lake practically disappear?

Mr. SMITH. Not disappear. This year there is practically no water running into the lake.

Senator PLUMB. Has the lake other sources of supply besides Bear River?

Mr. SMITH. I do not think there are other waters that are not appropriated.

Senator PLUMB. What do you people get for staple products—wheat, oats, etc.?

Mr. SMITH. Of course, of corn we have a limited supply.

Senator PLUMB. For wheat?

Mr. SMITH. It is 80 cents a bushel. It is more than it has been. It runs along from 60 to 80 cents a bushel.

Senator PLUMB. What has it been doing for a series of years?

Mr. SMITH. In the vicinity of 60 and 65 cents a bushel.

Senator PLUMB. And oats?

Mr. SMITH. At thrashing time, from $1.16 to $1.60 a hundred pounds. I think our oats are a little heavier than the eastern oats. We have some oats in the Territory that will go 50 pounds to the bushel.

Senator PLUMB. Where are these products marketed?

Mr. SMITH. Mostly marketed at home. We have some wheat that goes to Colorado; but most of the product is marketed in the Territory.

Senator PLUMB. You are speaking of the product of the Territory?

Mr. SMITH. Yes.

Senator PLUMB. You mean that which comes from Cache Valley?

Mr. SMITH. We call the Cache and San Pete Valleys the Territory. There is wheat in large quantities that goes to Colorado from those valleys; but I do not think we ship any oats from the Territory. What goes to Colorado is in the shape of flour. We have a number of mills in the Territory.

Senator PLUMB. When you speak of the price of these articles do you mean the market at Salt Lake?

Mr. SMITH. Yes. In Weber County we have two or three mills, and in Salt Lake the same, and those mills pay the universal price for wheat.

Senator Plumb. In Weber they pay the same price as here?

Mr. Smith. Yes. They are all competing for the trade.

Senator Plumb. Is the land the same price up there as it is here?

Mr. Smith. No. I was the chairman of the board of equalization of taxes, and passing through the Territory to assess the land in Cache Valley I saw the best farming land, and it averages about $45 an acre, and will produce as much per acre as land in this county.

Senator Plumb. What is the best character of land? What makes the distinction between the best, the next best, and the poorest?

Mr. Smith. Productiveness and fertility of the soil.

Senator Plumb. Is it bench land or bottom land, or a combination of both?

Mr. Smith. Combination of both. The mountain streams run down and bring a good deal of débris. That débris goes on the soil and fertilizes it. It makes the land very rich and productive.

Senator Plumb. Is distance from the main ditch any element in the cost of land?

Mr. Smith. No; whether it is at the head or tail of the ditch the land is the same price.

Senator Plumb. Do all these farmers who own and occupy this land understand the process of irrigating—do they all do it alike?

Mr. Smith. Yes; I think they all use the same system.

Senator Plumb. Do they all understand it alike?

Mr. Smith. Yes; of course, you will find land in this Territory where the fertility is different from the land adjacent to it; one is good and the other has mineral in it.

Senator Plumb. All these farmers understand how to make the best use of the water?

Mr. Smith. Yes. Most of the farmers in this county are old residents, and know from experience how to irrigate the land.

Senator Plumb. How much water is deemed necessary to irrigate the land?

Mr. Smith. There is no measurement. They run it off into an irrigating stream for so many hours, the amount a man can use to the best advantage.

Senator Plumb. What is the largest farm in the Territory that you know of, that is to say, land that is actually farmed?

Mr. Smith. By any one person?

Senator Plumb. Yes.

Mr. Smith. I will state that the largest farm that I found that was all irrigated was one of 210 acres. That was in the Cache Valley, in a compact body, owned and farmed by one man. There are some parties that of course own a considerable quantity of land that they do not irrigate.

Senator Plumb. And they are holding it for speculation?

Mr. Smith. Holding it for speculation. For instance, under the new canal that is started, there is one company that bought from the railroad something like 10,000 to 15,000 acres.

Senator Plumb. Take the actual farmer in the Territory, a man who occupies the land he expects to make use of himself, for pasturage and all?

Mr. Smith. I think you could put it at a thousand acres.

Senator Plumb. What is the average?

Mr. Smith. I do not think it would be over 25 to 40 acres. I do not think in this county it will average 15.

Senator Plumb. These holdings must have been diminished in quantity lately?

Mr. **SMITH.** No. In the first place, in settling this Territory they surveyed first into 5-acre tracts, and each person drew lots for his land, and each got a lot. Then south of that were 10-acre lots; and to-day you will find some of the original owners holding that land, 10 and 5 acre tracts.

Senator **PLUMB.** And who never owned more?

Mr. **SMITH.** Yes.

Senator **PLUMB.** And they are making a living on it?

Mr. **SMITH.** Yes. Most of our farmers own stock in the way of sheep, and for pasturage they run in the mountains. Of course, our mountains are full of grass and will sustain the stock.

Senator **PLUMB.** When your people came to take land under the laws of the United States they took 160 acres?

Mr. **SMITH.** Yes.

Senator **PLUMB.** Have they held on to that?

Mr. **SMITH.** No. In this locality you will find one man would recognize the right of a neighbor and would deed to him for the expense of entering the land.

The **CHAIRMAN.** So that they entered for their neighbors?

Mr. **SMITH.** Yes. They had a mutual understanding. A man would enter upon a quarter section, and after he got his patent he would deed to his neighbor the actual amount of land on which he entered.

Senator **PLUMB.** Has there been any subdivision of the land?

Mr. **SMITH.** Yes, in most every instance.

Senator **PLUMB.** So that the tendency has been to diminish the area of holdings?

Mr. **SMITH.** Yes. In many instances they were poor men who could not hold the 160 acres.

The **CHAIRMAN.** Not able to irrigate it?

Mr. Smith. Yes.

The **CHAIRMAN.** How much should one man have?

Mr. **SMITH.** From these canals on the west side of the river he could own 40 acres; but on the east side he could not give good attention to 20. It is better, more productive, and needs a good deal of care; that is, to farm it well. A great many farm more; but I do not think they ever farm to advantage.

The **CHAIRMAN.** Do those who have more land usually do better?

Mr. **SMITH.** They do better, but they have to hire help. I am speaking of farmers, not men owning land and employing persons to till it.

Senator **PLUMB.** Does this land change hands?

Mr. **SMITH.** Very seldom. In the last year there has been more than for ten years previously.

Senator **PLUMB.** Does the annual production vary much?

Mr. **SMITH.** No; I think it was less this year than before. But you can count on so much.

Senator **PLUMB.** You say there was very little shifting in the agricultural districts?

Mr. **SMITH.** Very little.

Senator **PLUMB.** Does it diminish any?

Mr. **SMITH.** I think not.

Senator **PLUMB.** Generally increases?

Mr. **SMITH.** Generally increases; I do not think it diminishes.

Senator **PLUMB.** Take the land in the Cache Valley which yields so much; why is it not worth as much as that in Salt Lake Valley?

Mr. **SMITH.** I have told my friends that Cache Valley was the place for men to go and settle.

Senator PLUMB. If you get land in this valley does it increase in value because of its proximity to a large city?

Mr. SMITH. I think so.

Senator PLUMB. But outside of this valley the value of the products should settle the value of the land.

Mr. SMITH. Not to my understanding. But still the people place a fictitious value on the land.

Senator PLUMB. What relation does that land in taxation bear to the actual value of the land?

Mr. SMITH. This year, on the 1st of January, it was about 45 per cent. of its actual value.

Senator PLUMB. When you say its actual value, do you mean this price of which you have spoken—$300 an acre?

Mr. SMITH. Some of that $300 an acre land changed hands at $800 and $1,000 an acre. That was assessed at $200 an acre.

Senator PLUMB. That was two-thirds of its actual value.

Mr. SMITH. That piece of land in this county we threw out, because it was a fluctuating price.

Senator PLUMB. I am speaking of that which is used for agricultural purposes, 6 miles out from the city.

Mr. SMITH. Forty-five per cent. of its actual value; it would average all the way from $150 down to $20 an acre.

Senator PLUMB. What is the rate of taxation?

Mr. SMITH. Three mills on the dollar for Territorial purposes. The tax for school purposes is 3 mills on the dollar.

Senator PLUMB. How are the districts created?

Mr. SMITH. The county court divided the county into school districts, and upon the second Monday in June the resident tax-payers meet to elect trustees, who are the trustees of the district. For school purposes each district can levy a tax not to exceed 2 per cent. in every year, and the trustees themselves can levy a tax not to exceed one-quarter of 1 per cent. without a vote of the tax-payers.

Senator PLUMB. Then the people themselves can levy more?

Mr. SMITH. Two per cent. But it requires a two-thirds vote to levy that tax.

Senator PLUMB. How is the Territorial tax distributed?

Mr. SMITH. It is a 3-mills tax, and distributed to the various districts in the Territory not confined to any one county. It is a Territorial tax. In the county of San Pete they draw from the Territorial treasury for school purposes $12,200 more than they pay into the treasury, on account of the land being low and the per capita of the children being high.

Senator PLUMB. What is the school age?

Mr. SMITH. Between eight and sixteen. The school tax for last year was $2 per capita.

Senator PLUMB. To what extent do you think the area of this Territory could be increased?

SMITH. It could be increased, I think, if we had the water, to a third more of agricultural land than we are to-day tilling.

Senator PLUMB. Do you think water is within reach under this process of storing which you have suggested?

Mr. SMITH. I think we could add a third. There is plenty of water in the flood seasons of the year to irrigate all the land necessary. This, of course, does not count such large tracts as this canal contemplates, the Bear River Canal. It has been considered heretofore as being in such a position as not possible of being irrigated, on account of the expense.

The **CHAIRMAN**. Is there much of that water that runs to waste?

Mr. **SMITH**. Yes, in the Bear River.

The **CHAIRMAN**. Can they not increase the water a great deal by making a reservoir of Bear Lake?

Mr. **SMITH**. I question the advisability of storing water in Bear Lake. I own a ranch on Bear Lake, and there is no large stream of water that flows into the lake. The lake is supplied principally from the springs. They are contemplating raising the lake some 5 feet, but I do not think there is sufficient water goes into it to raise it that high. I think evaporation would take it off.

Senator **JONES**. There is a continual outflow from the lake?

Mr. **SMITH**. Yes.

Senator **JONES**. In certain seasons there would be no objection to saving that outflow?

Mr. **SMITH**. I think evaporation would keep it down.

Senator **JONES**. Would it increase the evaporation to decrease the outflow?

Mr. **SMITH**. I do not think it would, but it would be necessary to draw it off. It has not such a great flow as people imagine. I will say here that storing for twelve months the water that is now drained out would raise the lake a foot.

The **CHAIRMAN**. Whatever it did raise it would be so much gained?

Mr. **SMITH**. Yes.

Senator **JONES**. That which passes off in the flood season would be of some value?

Mr. **SMITH**. Yes.

Senator **JONES**. Does not Bear River get a considerable supply from Bear Lake?

Mr. **SMITH**. That I can not speak of.

Senator **JONES**. Is there not considerable land irrigated from Bear River?

Mr. **SMITH**. Yes; there are several mountain streams that furnish the water for Bear River. I think a small portion of it comes out of Bear Lake.

Senator **PLUMB**. What is the agricultural area of Utah at the present time?

Mr. **SMITH**. I do not know.

Senator **PLUMB**. You think the total area of cultivated land could be increased about a third?

Mr. **SMITH**. Yes.

The **CHAIRMAN**. Exclusive of the Bear River scheme?

Mr. **SMITH**. Yes. Of course we have land in the proximity of Bear River that could not be reclaimed. There is a good deal of waste land there.

Senator **JONES**. How much waste land is there under irrigation?

Mr. **SMITH**. I think the biggest tract that we had they had a canal coming to it. You can say that but a small percentage of the land of the Territory is what we call dry farming.

Senator **JONES**. In Idaho, in some localities under the foot-hills, they raise wheat without irrigation. Is there none of that kind of land here?

Mr. **SMITH**. There is, but it is a very small percentage. There is some in this vicinity; but I do not think it is 1 per cent. of the tilled land of the Territory.

Senator **JONES**. Do you think that is the rule?

Mr. **SMITH**. In some places it is. I think in Davis County they till some. There they would go higher—4 or 5 per cent. But I do not think it would go above that.

Senator **PLUMB**. Is that successful generally—profitable farming?

Mr. **SMITH**. Some have thought so. But Davis County is the only place that I know of its being done with success. There they get from 15 to 20 bushels of wheat to the acre.

Senator **PLUMB**. Has there been any effort made to test food-plants raised in arid regions, that is, in Arabia, and so on?

Mr. **SMITH**. No.

Senator **PLUMB**. Only fruits?

Mr. **SMITH**. Last session the legislature made a provision for an agricultural college in Bear Valley.

Senator **PLUMB**. Nothing of that kind had been done before?

Mr. **SMITH**. No.

Senator **PLUMB**. Have the farmers of this country accumulated property? Do their material possessions increase from year to year?

Mr. **SMITH**. Yes. In this Territory, until late years, very few farmers owed for their farms. That is to say, they had no mortgages on them, and they accumulated year by year.

Senator **JONES**. You say until the last few years?

Mr. **SMITH**. Of course, some of them have made ventures in other directions.

Senator **PLUMB**. The mortgage crop is increasing?

Mr. **SMITH**. I am sorry to say it is increasing.

STATEMENT OF JESSE W. FOX, OF SALT LAKE CITY.

The **CHAIRMAN**. How long have you resided here?

Mr. **FOX**. On the 21st of September next, forty years.

The **CHAIRMAN**. Were you among the first settlers?

Mr. **FOX**. I came here in 1849. The pioneers were here two years before I came.

The **CHAIRMAN**. Had much progress been made in the way of cultivating the soil before you arrived?

Mr. **FOX**. Not a great deal. It was quite limited.

The **CHAIRMAN**. Were any of the settlers from countries where they had irrigated before coming here?

Mr. **FOX**. No, not any.

The **CHAIRMAN**. You came without experience in that direction?

Mr. **FOX**. I came without experience.

The **CHAIRMAN**. Did you meet with any difficulties in your first experiments with irrigation?

Mr. **FOX**. We at first did not know the amount of water that was necessary. The water was used liberally at first, until we became acquainted with the amount of water necessary to mature crops.

The **CHAIRMAN**. You knew when you first came here that this country would not produce crops without irrigation?

Mr. **FOX**. It was so announced by the pioneers on their return.

The **CHAIRMAN**. You came to the country with the full knowledge that you would have to put water on the land, and without ever having had any experience in that direction?

Mr. **FOX**. Yes. We were from Illinois, most of us, where we had plenty of rain.

The **CHAIRMAN**. Immediately after coming here you commenced to turn the water on to the land to irrigate it?

Mr. FOX. Yes; we turned the water from the mountain streams. This bench land to the east was the first cultivated.

The CHAIRMAN. Have the methods of using the water constantly improved since that time?

Mr. FOX. Yes.

The CHAIRMAN. You can irrigate a great deal more land now with the same amount of water than you could when you commenced?

Mr. FOX. We do.

The CHAIRMAN. You have been surveyor-general of the Territory?

Mr. FOX. Yes.

The CHAIRMAN. And you are familiar with the Territory?

Mr. FOX. Yes.

The CHAIRMAN. What amount of land in the Territory is now under cultivation?

Mr. FOX. I can not say the exact amount. We are extending our farming interests in different directions. There are new settlements forming in new localities.

The CHAIRMAN. You are constantly extending your farming; are new settlers coming in and occupying the land?

Mr. FOX. Yes.

The CHAIRMAN. How is that done?

Mr. FOX. Through entries, through the land office.

The CHAIRMAN. By taking out new streams of water?

Mr. FOX. By appropriating the water of what is called the basin, a deposit of Salt Lake, the great Salt Lake Basin. And, for instance, the water of the Weber River and the Provo and those larger streams we are taking out and applying to new localities through artificial canals.

The CHAIRMAN. The supply, then, is not exhausted?

Mr. FOX. This season it is more than exhausted.

The CHAIRMAN. With the exception of the dam at Utah Lake have any means been adopted of storing water in high latitudes?

Mr. FOX. We are now locating reservoirs, not very large ones, but temporary reservoirs.

The CHAIRMAN. Are you familiar with the mountain ranges and the topography of the country generally?

Mr. FOX. I am.

The CHAIRMAN. You are an engineer?

Mr. FOX. Yes.

The CHAIRMAN. Then you know pretty well about the snow-fall. You have kept a note of it?

Mr. FOX. I have kept no note of it

The CHAIRMAN. I mean from observation.

Mr. FOX. Yes.

The CHAIRMAN. Is there considerable opportunity for increasing the water supply by these reservoirs?

Mr. FOX. Yes.

The CHAIRMAN. Do you think it can be largely increased?

Mr. FOX. Very largely increased.

The CHAIRMAN. What proportion of the arable land in the Territory is now cultivated by means of irrigation? Of course, I ask for rough estimates; you are not expected to be accurate. Of course, occasionally there may be a dry spell?

Mr. FOX. I think we have exhausted the amount of water unless we resort to reservoirs.

The CHAIRMAN. By means of storage reservoirs how much can your agricultural area be increased?

Mr. FOX. Two hundred per cent., I think.

Senator JONES. Do you mean by that that it is the limit of the land or the limit of the water that may be obtained?

Mr. FOX. I think there is water that can be stored in artificial reservoirs to increase our irrigation at least 200 per cent.

Senator JONES. Is there a larger amount of land if you had water to irrigate than 200 per cent. increase would cover?

Mr. FOX. I think not.

Senator JONES. You think the capacity of the land and the water would be increased 200 per cent.?

Mr. FOX. Yes.

The CHAIRMAN. Through the Territory what is the average size of the irrigated farms?

Mr. FOX. Originally in locating the farming land throughout the country I had the oversight of it as Territorial surveyor-general, and every person who came had what they could cultivate judiciously. If he was a lone man or had a small family we gave him about 10 or 20 acres; if he was a man with four or five or six boys, we gave him more—from 40 to 60 acres. That was our standard in dealing out the country until the land came into the market.

The CHAIRMAN. After it came into the market those holdings were recognized and you distributed the land accordingly. But since the land has come into the market, do the holders have larger farms or do they enter and subdivide?

Mr. FOX. Sometimes they subdivide; but generally they retain their entry.

The CHAIRMAN. With these small farms have families been able to support themselves and get along very well?

Mr. FOX. Yes.

The CHAIRMAN. Have they grown more profitable in time?

Mr. FOX. Yes; if closely cultivated they are more profitable than a large farm.

The CHAIRMAN. That is, a man can make more money and support his family better on 40 acres well cultivated than he could were he to attempt to extend the area of his farm to 160 acres and cultivate it himself?

Mr. FOX. That has been our experience.

The CHAIRMAN. To cultivate a farm of 160 acres a man would have to employ help, would he not?

Mr. FOX. Yes; and the prices of products at the present time do not justify a man in hiring help.

The CHAIRMAN. What are farm wages here?

Mr. FOX. From $25 to $40 a month, including board.

The CHAIRMAN. What is the average crop of wheat in this Territory?

Mr. FOX. From 25 to 30 bushels to the acre.

The CHAIRMAN. What is the average crop of oats?

Mr. FOX. About 40 bushels.

The CHAIRMAN. Of barley?

Mr. FOX. Sixty bushels.

The CHAIRMAN. As I understand it, you raise larger crops in certain localities; but that is the average crop for the Territory?

Mr. FOX. Yes; 50 bushels of wheat have been raised; 80 bushels of barley, and about the same of oats.

The CHAIRMAN. What is the crop of potatoes where the land is well cultivated?

Mr. FOX. Three hundred bushels to the acre.

The CHAIRMAN. Do you raise as high as 500 or 600?

Mr. FOX. It has been reported that 600 bushels have been raised.

The CHAIRMAN. What has been the system of constructing your canals? Have they been constructed by individuals or by association in some form?

Mr. FOX. By association.

The CHAIRMAN. Do you form an association to build a canal?

Mr. FOX. We organize under the general irrigation act of the Territory. The organization is called a stock company, the same as a railroad company, or any other corporation that issues stock.

The CHAIRMAN. How is that stock paid for? How does a man get his stock from the corporation?

Mr. FOX. Either by a payment of cash or by furnishing labor to construct the ditch.

The CHAIRMAN. The money paid in is used in the construction of the canal?

Mr. FOX. Yes.

The CHAIRMAN. Is the stock issued to anybody except the land owners below the ditch?

Mr. FOX. The stock is an article to be purchased the same as railroad stock or any other stock.

The CHAIRMAN. To what does the stock entitle you?

Mr. FOX. To water from the ditch. The dividend is water.

The CHAIRMAN. And the dividend cannot be distributed except below the line of the ditch?

Mr. FOX. Yes.

The CHAIRMAN. Do you limit the amount of stock that each man may take?

Mr. FOX. No.

The CHAIRMAN. Suppose a man would have more stock than he would need for his land, thus getting more water than he has land, what would he do with the water?

Mr. FOX. Either rent it or sell it.

The CHAIRMAN. The company does not either rent or sell the water?

Mr. FOX. No, the individuals.

The CHAIRMAN. When you rent water here what rent do you generally receive?

Mr. FOX. About 10 per cent. of the cost.

Senator JONES. Is there anything to prohibit the holders of stock to authorize the company to act for them—having the company rent or sell the water without their control?

Mr. FOX. No.

Senator JONES. They can do that if they choose?

Mr. FOX. Yes.

The CHAIRMAN. Previous to the passage of your incorporation act, under which you have been operating recently, how did you do?

Mr. FOX. We would go to work and get the ditch out voluntarily.

The CHAIRMAN. And then divide the water among yourselves?

Mr. FOX. Yes.

The CHAIRMAN. You would have an understanding among yourselves, and each man would turn in and work?

Mr. FOX. Yes.

The CHAIRMAN. It was labor which the people put together in the beginning to do these things?

Mr. FOX. Not under any law of the Territory.

The CHAIRMAN. Not any law; but it was a voluntary arrangement among yourselves? As a rule settlers going into a region like this, unless they have capital, must associate their efforts to cultivate the land?

Mr. FOX. Yes. That was the method of getting out our water-ditches in early times.

The CHAIRMAN. Then you had the probate court to regulate matters between you, did you not?

Mr. FOX. Yes.

The CHAIRMAN. And now you have abandoned the regulation by the probate court?

Mr. FOX, Yes, I think so,

STATEMENT OF CHARLES HENRY WILCKEN, OF SALT LAKE CITY.

The CHAIRMAN. How long have you resided in Salt Lake City?

Mr. WILCKEN. Thirty years.

The CHAIRMAN. You are water-master here, I believe.

Mr. WILCKEN. Yes.

The CHAIRMAN. State the system you have of distributing water.

Mr. WILCKEN. We have a Territoriol ordinance that requires property-owners to file an application. In that they are required to state how many rods of land they are in possession of. When I get those applications, I divide the city into five districts. The ditches run that way, and it is convenient to divide into five districts. I then sum up the number of rights applied for, and I arrange it so that each man will get so many minutes to the rod, or so many hours each week. We get around generally once a week, except this year.

The CHAIRMAN. Are you familiar with the distribution of water outside the city—in the country?

Mr. WILCKEN. Some of it in the country. We have been short this whole summer in the county. We arrange it so as to have the water once a week, or once every ten days.

The CHAIRMAN. You have a water-master in the county?

Mr. WILCKEN. We have a water-master to divide the water into the large ditches. Then we have water-masters on every water ditch. They divide the time on the same principle that I do, except that they divide by the acre and not by the rod. But water comes around once in ten days, at any rate.

Senator JONES. In these districts here, after you have supplied the first, do you give to the others the full amount of water under the division?

Mr. WILCKEN. Yes.

Senator JONES. Suppose, after number one has been supplied, the water runs down; how much does the next one get?

Mr. WILCKEN. That much less water; but they get the quantity that the first district gets. We turn the water into the five districts at once.

Senator JONES. So that the falling off of the supply is all over the city?

Mr. WILCKEN. Yes. Of course, the person who lives at the head of the ditch has a little advantage of the one living at the end. There is evaporation and seepage going on, especially in the dry seasons.

Senator JONES. But practically it is uniform?

Mr. WILCKEN. Practically it is uniform.

The CHAIRMAN. That is what you aim at making it?

Mr. WILCKEN. Yes.

The CHAIRMAN. Are you familiar with the other portions of the Territory?

Mr. WILCKEN. Yes; I have traveled some in the Territory.

The CHAIRMAN. This system of having a water-master prevails generally throughout the Territory?

Mr. WILCKEN. Generally prevails. There is no contention; a person knows when his time comes for irrigating, and when he gets through with the water, the next one gets it.

The CHAIRMAN. Have you given any attention to the subject of storing water in the wet seasons, in the winter-time, with the view of meeting the requirements of a dry season like this.

Mr. WILCKEN. Yes. I believe it could be done for this county and city. I have studied a good deal on the subject of this water supply for Salt Lake, and I find that Utah Lake has the only storage capacity for irrigating purposes. It takes a great amount of water for irrigating purposes, and reservoirs could not be constructed in the cañons, because it takes too large an area to store the necessary water. But I have always felt that Utah Lake is the only place where we could get water for irrigating purposes. In the winter-time there are several rivers running into it, and we could store water there.

The CHAIRMAN. That absorbs a great portion of Utah County?

Mr. WILCKEN. Yes. Drains the water-shed from the east. There are several rivers, which, as a general rule, get up high in the spring and fill the lake. Then they have a dam at the lake to store water. There has been a little contention with the people in Utah County. The lake has been going down rapidly since 1884; people have crowded upon the land, and the moment we commenced to store water, thereby causing the lake to rise, there was a cry.

The CHAIRMAN. Within the last year there has been a reservation of any land needed for that purpose, and the Government will survey such land and set it apart; otherwise will there not be a disposition to crowd upon it and settle it up?

Mr. WILCKEN. Of course, some of the land has been entered; but whether they have perfected their titles or not I do not know. The water in Utah Lake for culinary purposes is not good; it is fishy. But for cultivating purposes it is better than the mountain streams.

Senator REAGAN. Where do you get your water for culinary purposes?

Mr. WILCKEN. Out of the mountain streams. We have a superintendent of water-works there, and for domestic purposes we would be obliged to have water out of those mountain streams. But of course some reservoirs might be built and exchanges made—bring the water for agricultural purposes from Utah Lake and give to the farmers in exchange.

Senator REAGAN. What kind of water is that which comes from Utah Lake?

Mr. WILCKEN. It is a little brackish, and tastes milky. It has a sediment in it, and does not chill the crop when you put it on. But the mountain streams chill the ground and set the crops back a year or two.

Senator JONES. Have you had any experience with flowing wells?

Mr. WILCKEN. I am driving some at present in Utah County. I have about sixty in operation there, throwing out about 6,000,000 gallons.

Senator JONES. How long have they been in use?

Mr. Wilcken. I am driving wells that were started in Utah County a month ago.

Senator Jones. You have about sixty, and you began about a month ago?

Mr. Wilcken. The city has eight or ten flowing wells.

Senator Jones. Has there been any benefit derived from the use of the water?

Mr. Wilcken. In some localities there has been a great deal of benefit, where they get from 75 to 100 gallons per minute from an inch-and-a-half or two-inch pipe. Of course, several wells like that will irrigate a good deal of land. But in other localities we can only get from 4 to 10 gallons per minute. Where I am driving at the present time there seems to be a good water-shed. We are meeting with good success and getting good water.

Senator Jones. Are you using that water for irrigating purposes?

Mr. Wilcken. Supply for the city—merely experiments to see what can be done.

Senator Plumb. The water in the ditch flows into the city?

Mr. Wilcken. It flows from there into the Jordan River, and then into our canal. In early years we took the first water that came up; but that is a failure. In driving down to the second and third streams you will find that that holds the better—seems to be more permanent and better water.

Senator Plumb. What are the various depths of these wells?

Mr. Wilcken. They vary. Where I am driving now it is 80 to 115 feet, with a 2-inch drill. I get some of them through that flow from 75 to 100 gallons per minute.

STATEMENT OF JAMES L. LITTLE, OF KANAB.

The Chairman. How far is Kanab south of Salt Lake?

Mr. Little. Estimated at 330 miles, usually, by the wagon road and railroad.

The Chairman. How far from the Arizona line?

Mr. Little. About 3 miles.

The Chairman. On what stream is your town situated?

Mr. Little. It is called Kanab Creek.

The Chairman. How much of a stream is that?

Mr. Little. I do not know what comparison I could give you. It would afford this season of the year about two heavy irrigating streams for a farmer, perhaps three.

The Chairman. How much land that is fit for irrigation is on the stream?

Mr. Little. About 1,000 acres.

The Chairman. Are their other streams in that vicinity?

Mr. Little. No; none to amount to anything for irrigation purposes.

The Chairman. Is there much irrigable land in the southern part of the Territory?

Mr. Little. Yes; from the rim of the basin it is practically unlimited. When considered without connection with the supply of water the land is without limit.

The Chairman. Water, then, is the principal thing needed?

Mr. Little. Yes.

The Chairman. Is the land good?

Mr. Little. Yes.

The **CHAIRMAN**. What water supply have you?

Mr. **LITTLE**. Are you speaking of Kanab?

The **CHAIRMAN**. Yes.

Mr. **LITTLE**. Kanab Creek is the only stream in that country that amounts to anything for irrigation purposes until you get over to the head of the Sevier.

The **CHAIRMAN**. What streams are there in the southern part of the Territory? Over the rim, either in Utah or Colorado, how much country is there which could be irrigated?

Mr. **LITTLE**. It is a big country.

The **CHAIRMAN**. The water is limited?

Mr. **LITTLE**. Extremely limited.

The **CHAIRMAN**. And the land good?

Mr. **LITTLE**. A great deal of good land, yes; but there is a good deal of barren land there, some mineral land, etc. There is a good deal of land there that will not be irrigated for a generation or two at least.

The **CHAIRMAN**. The mountains are not high?

Mr. **LITTLE**. Pretty rugged—6,000 or 7,000 feet.

The **CHAIRMAN**. Is there any snow on the tops of the mountains?

Mr. **LITTLE**. Very little in the summer, but they're covered from autumn until May, in some places.

The **CHAIRMAN**. And there is enough water falls there so that you could store it?

Mr. **LITTLE**. The facilities for reservoirs are very abundant.

The **CHAIRMAN**. Would there be sufficient water supply?

Mr. **LITTLE**. A good deal of the water supply goes to waste.

Senator **REAGAN**. You have very heavy snows?

Mr. **LITTLE**. Yes; and there are also summer showers. There is considerable rain around the hills in July and August, when water goes to waste.

The **CHAIRMAN**. Explain that.

Mr. **LITTLE**. We can not utilize it at the time.

The **CHAIRMAN**. Does it come in the crop season?

Mr. **LITTLE**. Yes; but it comes in a torrent, a flood.

Senator **REAGAN**. And you have no dams to hold it?

Mr. **LITTLE**. No, but we are glad to shut up the heads of our ditches to hold it.

The **CHAIRMAN**. It is like a cloud-burst when it comes?

Mr. **LITTLE**. Yes.

The **CHAIRMAN**. And that is true of Arizona?

Mr. **LITTLE**. I understand so. All below the rim of the basin in Arizona the country is very similar in character.

The **CHAIRMAN**. But do you think it practical at the time those storms occur, if you had the reservoir, to retain the water?

Mr. **LITTLE**. Yes; more or less, if the reservoir were well constructed. But the soil of that country is loose. It is not the character of soil that is in the great Salt Lake Valley, and the water easily washes the soil away, thereby increasing our difficulties.

The **CHAIRMAN**. When we get to Arizona we will find the people familiar with the subject?

Mr. **LITTLE**. Yes; but the country changes.

The **CHAIRMAN**. When you get outside the rim of the water-shed where does the water discharge?

Mr. **LITTLE**. Into Salt Lake, into the valley. Salt Lake is the principal reservoir of Utah Lake.

The **Chairman**. How far south does the water flow toward Salt Lake, until you get to the rim?

Mr. **Little**. To my knowledge it does not flow to Salt Lake.

The **Chairman**. How far is the water-shed?

Mr. **Little**. Seventy-five miles below the county.

The **Chairman**. How much population, all together, have you in Utah on the south side where the water-shed goes into the Colorado River?

Mr. **Little**. Say, perhaps, 15,000.

The **Chairman**. On what streams do they live principally?

Mr. **Little**. On the Rio Virgin and the Santa Clara Rivers, and Kanab Creek. And there is a little water 12 miles east of the Kanab, which in the wet season of the year runs down into the country; but it is not fit for irrigation purposes. It has been stored a little.

The **Chairman**. Are you familiar with that country extending over to Muddy, and through there?

Mr. **Little**. No.

The **Chairman**. You think by a system of reservoirs down there you could increase your population very much?

Mr. **Little**. Yes; there is no doubt about that.

The **Chairman**. Have you been looking over the country with that view, having your attention called to the subject?

Mr. **Little**. No; it is not in my line. But there is a report by the county surveyor which was printed in the papers.

The **Chairman**. What kinds of crops do you raise here?

Mr. **Little**. All kinds that are raised in a temperate climate.

The **Chairman**. Do you raise any fruits?

Mr. **Little**. Yes.

The **Chairman**. What kind of fruits?

Mr. **Little**. Apples, peaches, plums.

The **Chairman**. And the small fruits?

Mr. **Little**. Yes; gooseberries, grapes, etc.

The **Chairman**. There was an experiment tried down there some years ago in the direction of raising cotton. Did that succeed?

Mr. **Little**. Not practically. I think it was a failure.

Director **Powell**. Mr. Little could give you his experience in the development of irrigation in Kanab Creek and Sevier River. The Kanab would be a good illustration of the manner in which they have worked, and it would be instructive to the committee were it explained.

The **Chairman**. State what you have done on any one stream in Utah.

Mr. **Little**. We first settled on Kanab Creek in 1870. We had at that time but a few settlers. At that time the water ran near the surface, with a wide sandy bottom, which made the evaporation so heavy in July that we could scarcely get the stream on to our gardens through the heat of the day.

Director **Powell**. But go back of that and let us know about Upper Kanab.

Mr. **Little**. I was not a settler there. I commenced right there in the sand.

The **Chairman**. Go on and give your experience.

Mr. **Little**. We struggled until the water got to increasing to some extent. We reservoired a little in some places and helped ourselves. In the spring we had plenty of water to mature small grain, and perhaps we raised some corn, potatoes, etc. It ran along that way until the latter part of 1884. That was a stock country, and the people turned their attention to raising stock. They cultivated the soil only to a limited extent, on account of the scanty supply of water. In the latter part of July, 1884, we had a tremendous flood. It tore what water ditches we had to pieces, and our dams disappeared, and the gulch went down in five or six hours in places 30 to 40 feet. Take the side of a house, and it will give you some idea of the flood. Of course it was muddy and piles of rocks and chunks of dirt were scattered along. The chunks of clay left on the surface of the ground as they came out of the creek into the valley are there to-day. We had to make a flume, and it was very hard on us as a settlement. Then we carried our ditch a mile further up the cañon toward this gulch. We had hardly got that done and some water on to our crops when there came another flood that tore that out. I think we made the third effort that season, if I remember aright, and then there came another flood and tore us up until we could do nothing. We were almost lost in the contemplation of our calamity for several days before we could settle upon the means of doing anything. Finally we had to build one or two dams—expensive ones.

The CHAIRMAN. How much water runs in an irrigating stream?

Mr. LITTLE. One hundred inches on the surface would make a good irrigating stream for a farmer.

The CHAIRMAN. How much land will a good irrigating stream irrigate in a season?

Mr. LITTLE. I think that the irrigating stream of to-day all runs in one ditch and will cover 800 or 1,000 acres.

Senator REAGAN. How do you utilize the water now that the gulch has been eroded so deep down?

Mr. LITTLE. That has been the difficulty. We struggled along and lived, got in a ditch when we could, perhaps not until the next season, and finally we got our city dam, which was built in the first place by that ridge by the rocks in the gulch. But our field dam has stood for three or four years. In flood time the water comes with such a character and such force on account of its density as to sweep everything before it.

The CHAIRMAN. Is not that a characteristic that must be met with in that country and in Arizona?

Mr. LITTLE. Yes. On the Rio Virgin our work is not yet a success. The last dam they put in on the Rio Virgin cost $10,000.

The CHAIRMAN. How would you construct reservoirs to avoid the destruction caused by these floods?

Mr. LITTLE. By pile-drivers, as we are now preparing to do in Kanab. I presume we will keep water pretty generally on our land now. But to-day the tax on our city lots is $16 a lot. Last year it was $30, and it has been $40 or $50 on our town lots. It has been expensive, without any result to amount to anything.

Senator PLUMB. The name of your place is Kanab. How far from the mouth of the stream are you?

Mr. LITTLE. It is right at the mouth of the gulch.

Senator PLUMB. Near the Colorado River?

Mr. LITTLE. It is about 63 miles from the Colorado?

Senator PLUMB. And Kanab Creek flows into the Colorado?

Mr. LITTLE. Yes.

Senator PLUMB. And your stream emerges from the hills?

Mr. LITTLE. From the divide.

Senator PLUMB. How much of a town have you there?

Mr. LITTLE. Ninety families.

Senator PLUMB. Does that number embrace the country population?

Mr. LITTLE. Those are all who are in that immediate vicinity.

Senator **PLUMB.** You have a town, and you each have holdings in the fields?

Mr. **LITTLE.** Yes.

Senator **PLUMB.** This thousand acres of land is divided among you?

Mr. **LITTLE.** Yes.

Senator **PLUMB.** Nearly equally?

Mr. **LITTLE.** No. There are some stock men who do not farm—make no business of farming. There are comparatively few farmers.

Senator **PLUMB.** Where is your railroad station?

Mr. **LITTLE.** Milford is the nearest station. But we generally do our freighting from Juab, on account of the road, and it is less railroad freight.

Senator **JONES.** How long have you lived in that place?

Mr. **LITTLE.** I think I went there in 1870—nineteen years.

Senator **PLUMB.** You have been in this country a long time?

Mr. **LITTLE.** I came here in 1849.

Director **POWELL.** I think it would be well to have it mentioned somewhere in the record that this was the second experiment on the same stream; that the first attempt was 40 miles higher up the stream, and that it was abandoned because it was too cold.

The **CHAIRMAN.** Is that the case?

Mr. **LITTLE.** Yes. Sometimes they would plant the settlement too far up in the mountains and sometimes too far down. They have changed the canals over and over again. This is but one illustration of it. St. George would be a much more striking illustration. We have had to change our fields because of the floods of sand. They had one crop nearly destroyed by the sand coming down over our corn when it was in the shock, and also before it was cut.

STATEMENT OF G. M. OTTINGER, OF SALT LAKE CITY.

The **CHAIRMAN.** Are you familiar with the water supply in this locality and the modes of obtaining it?

Mr. **OTTINGER.** Yes. Salt Lake is supplied from City Creek for culinary purposes and lawn sprinkling. The area of the water-shed of City Creek is a little short of 13,000 acres. The average flow of the creek in ordinary times, when you have a good snow-fall, is about 10,000,000 gallons in twenty-four hours. For the last three years it has been flowing only about 8,000,000 gallons. Last year, owing to the three years of dry seasons, it has been flowing much less—5,000,000 gallons. Yesterday it was a little over 4,000,000 gallons. The creek has been lower this year than it has been since 1880.

The **CHAIRMAN.** What means have you taken to increase the water supply?

Mr. **OTTINGER.** We have increased the capacity of the creek this year 2,000,000 gallons.

Senator **JONES.** Yet it is below the average?

Mr. **OTTINGER.** Our sources of supply depend on the snow and rain fall in the mountains. When we have little snow we have a scarcity of water.

The **CHAIRMAN.** Are there any basins high up in the mountains in which to store water?

Mr. **OTTINGER.** We could make storage reservoirs, but it is hardly practicable. The only way to build reservoirs is to build large ones. We are building a reservoir, and it is to be so constructed that we can run the entire contents of the creek into it. The consumption here is 4,000,000 gallons daily. We have only 3,000 inhabitants, but they use a great deal of water for sprinkling. All our lawns and streets are sprinkled.

The CHAIRMAN. You use the water of Utah Lake. How much does that cover?

Mr. OTTINGER. That would cover in the neighborhood of 3,000 acres; all this lower portion, say about two-thirds of the city. We are unable to bring the water on the high lands. We are using the creek to bring the water to the city. For culinary purposes all we have had is City Creek

The CHAIRMAN. Can you help City Creek by using Utah Lake?

Mr. OTTINGER. That is our main hold. Utah Lake is the proper reservoir for Salt Lake City. It has an area of from 10 to 20 miles, with an average depth of 8 to 9 feet. The rain-fall from June to the 1st of September is about 3½ inches. The average rain-fall is not over 17 or 18 inches during the year.

The CHAIRMAN. How much water do you put on the land for irrigating purposes?

Mr. OTTINGER. It requires a cubic inch.

The CHAIRMAN. How many irrigations do you give it?

Mr. OTTINGER. About twenty.

The CHAIRMAN. An inch deep all over?

Mr. OTTINGER. Yes.

The CHAIRMAN About 20 inches in depth.

Mr. OTTINGER. Yes. It would require a tremendously big reservoir to impound water enough to irrigate a large area of land.

The CHAIRMAN. In irrigating in this city—of course that would not be for ordinary agricultural purposes—but in irrigating in this city, have they tried sub-irrigation?

Mr. OTTINGER. No, I do not believe they have tried that, except in one or two cases. Generally they pour the water over the land and it soaks it up like a sponge. We have about 96 miles of streets. We have about 25.3 miles of water-mains, which, taking in the business portion of the town, supplies water to about one half the town. But we are very short of water in parts of the town. It can be supplied. We can impound water for culinary purposes by a reservoir; but I do not think it would be practicable to impound water for agricultural purposes. It would be as expensive as impounding water by machinery; it would take so much. One hundred and thirteen tons of water would irrigate one acre of land. To impound water enough to irrigate a large area of land would take a big reservoir.

Senator REAGAN. One hundred and thirteen tons of water to one acre?

Mr. OTTINGER. Yes. It is hard to tell how much water is used per capita, because we are using so much for irrigating lawns. But we have 2,018 water taps. The city is using those taps and 4,000,000 gallons of water a day. Fifteen thousand persons are not drinking that water; it is used on the lawns. This year we have restricted them in the use of the water, by fixing a time for sprinkling the lawns. We are compelled to do that.

The committee took a recess until 8 o'clock.

EVENING SESSION.

STATEMENT OF JOSEPH R. WALKER, OF SALT LAKE CITY.

The **CHAIRMAN**. How long have you resided in Salt Lake City?

Mr. **WALKER**. About thirty-seven years.

The **CHAIRMAN**. You are a merchant, I believe?

Mr. **WALKER**. Yes.

The **CHAIRMAN**. You desire to make a statement in regard to some lakes or places for reservoirs for storing water for the use of this city?

Mr. **WALKER**. Yes.

The **CHAIRMAN**. I will state to you the condition of the law at the present time. The Government has reserved the reservoir sites and rights of way; and this reservation, as I understand the law, is for the benefit of those who shall use the water. It was made for the purpose of preventing persons occupying those sites to the exclusion of those who might wish to store and use the water. That reservation was made nearly two years ago, and rights acquired since that time are subject to the right of the Government to make these selections. If anything can be done for you by way of having the places designated as reservoir sites, Major Powell, who has authority to do that, will direct it to be done.

Mr. **WALKER**. There is a chain of lakes at the head of the Big Cottonwood, some sixty-eight in number, that can be made to store a great deal of water. That is the only permanent source from which Salt Lake can get water in the future. I am pleading the cause of the city; personally, I want nothing to do with it. There are four or six of these lakes, about 18 or 20 miles from the mouth of the Big Cottonwood.

The **CHAIRMAN**. Can you describe those lakes?

Mr. **WALKER**. You first commence with Silver Lake. As you go up the cañon you find Lakes Mary, Martha, and Catharine, and also Dog Lake, on the east side of Lake Mary.

Senator **REAGAN**. How far are those lakes from the city?

Mr. **WALKER**. Twenty-eight to 30 miles. There are also two other lakes called the Twin Lakes.

Senator **REAGAN**. Are they south from the city?

Mr. **WALKER**. Yes, in a southerly direction, going toward Alta, at the head of the Little Cottonwood. There are also two other lakes which lie midway between the mouth of the cañon and Silver Lake, which is 18 miles distant. These two lakes lie easterly or southeasterly from the Twin Peaks, from the range of Little and Big Cottonwood.

Senator **REAGAN**. You had commenced making a statement as to two other lakes. What was their direction and course?

Mr. **WALKER**. They went about one-half way up the cañon.

Senator **REAGAN**. The same cañon?

Mr. **WALKER**. The same cañon—say 9 miles—and they lay on the south side of the cañon under the Twin Peaks and on the range between Big and Little Cottonwood.

Senator **REAGAN**. What is the size of those lakes?

Mr. **WALKER**. The size of Silver Lake is possibly 400 acres. The size of the Twin Lakes is perhaps three-quarters of a mile in length, if you consider the two lakes as one, which they would be by putting up an embankment. They are possibly from one-half to five-eighths of a mile in width. Lake Mary, by making it a storage reservoir, could be made to cover possibly 100 acres. Lake Martha could possibly be made to cover 100 or 120 acres. These figures, of course, are guesses, but I think they will approximate the proper figures. Lake Catharine would cover perhaps 60 or 75 acres.

Senator **Reagan**. Are those lakes situated so that they could be connected one with another?

Mr. **Walker**. They would have to be made into separate reservoirs, except as to Twin Lakes. The Twin Lakes could be made into one large reservoir.

Senator **Reagan**. The nearest of them is about how many miles from the city?

Mr. **Walker**. The nearest are the two lakes which lie under the Twin Peaks, distant about 17 miles from this city. The other lakes will be an average of from 28 to 30 miles distant.

Senator **Reagan**. What is the character of the country over which a ditch would have to be made?

Mr. **Walker**. There would be no ditch required because it has a natural outlet, which is Big Cottonwood Creek or Cañon. The country in which they lie is a granite country; some of the basins you may see here in a granite formation. The water would flow down the cañon right to the mouth of it, which is, say, 13 miles of transit; there the water would flow down naturally.

Senator **Reagan**. So that you would have to provide artificial conveyance only from the mouth of the cañon to the city?

Mr. **Walker**. That is all. The lakes are used for irrigation on the Big Cottonwood from 7 to 12 miles distant. That whole country is watered by a natural flow of water. What I have in contemplation is the raising of the dam; that is to say, putting a dam in front of each of them to get a surplus of water.

Senator **Reagan**. What water-shed is there to supply water to those lakes?

Mr. **Walker**. The water-shed is the entire basin of the Big Cottonwood to the backbone of the Wasatch, and the spurs that enter into the Big Cottonwood cañon.

Senator **Reagan**. Would they furnish water for the country that is now in the neighborhood, and then for the city?

Mr. **Walker**. I have no doubt of it. There is a large watershed there. It is the region of perpetual snow. The altitude of Silver Lake is 8,600 feet, and the other lakes I have mentioned are 10,600 feet.

Senator **Reagan**. Your idea is to increase the capacity by dams?

Mr. **Walker**. Yes; so as to have the lake take the surplus water.

Senator **Plumb**. Would your plan be to have Congress make the expenditure?

Mr. **Walker**. Yes; that is my view of it.

The **Chairman**. Has not the city of Salt Lake the power to make the expenditure without special act of Congress?

Mr. **Walker**. I think so, although the debt of the city is climbing up pretty well. It is now something like $400,000, and the next $50,000 will make it $500,000.

The **Chairman**. Is there a large amount of water from the Cottonwood that runs to waste in flood time?

Mr. **Walker**. Yes; there is a vast amount. Much more runs to waste than is utilized.

The **Chairman**. Your idea is to save that surplus in those lakes?

Mr. **Walker**. Yes; by storage. The material of the very best class is right there—granite blocks of any size you want.

STATEMENT OF JOSEPH D. JONES, OF PROVO CITY.

The CHAIRMAN. What is your occupation?

Mr. JONES. I am probate judge of Utah county.

The CHAIRMAN. Do you live near Utah Lake?

Mr. JONES. Yes; on the east side of it.

The CHAIRMAN. Have you given your attention to irrigation in t Territory?

Mr. JONES. Yes.

The CHAIRMAN. Have you made any investigation of the subject?

Mr. JONES. I have, by looking through the county.

The CHAIRMAN. State to the committee the results of your inves gation.

Mr. JONES. I have here a map of the entire county, showing the ir gation system and the natural springs.

The CHAIRMAN. What county?

Mr. JONES. The county of Utah.

The CHAIRMAN. Does it adjoin Salt Lake County?

Mr. JONES. It joins Salt Lake on the south. This map is drawn a scale of 1 inch to the mile, and shows the land that is irrigated.

Senator REAGAN. Can you designate where those lakes are that M Walker spoke of?

Mr. JONES. These lakes are south of those that Mr. Walker spo of. This section of country lies south of that about which he spol This map shows the summit of the mountain range, which is also t boundary of the counties of Wasatch and Utah. It shows the wat shed that supplies Utah County with water down through these natu streams. It also shows where natural reservoirs exist; that is to sa the places where reservoirs may be constructed. The section of count on the east side of Utah Lake is pretty much all cultivated in ordina seasons, when there is an ordinary supply of water. The blue lines the map represent the artificial canals. This district of country on t east side of the lake is pretty well watered and the majority of it is n under cultivation; but there are a number of acres there of good aral land that could be brought under cultivation with an increase of wat supply. The committee on compilation has found there is sufficie water going to waste during the winter and spring months, if proper taken care of, to water all the arable land in the county, with the e ception of that district on the west side of the lake. There are no mour ain ranges there that furnish sufficient water. The only way to g water there would be to provide artesian wells. I have a table of st tistics here that the committee has prepared.

Senator PLUMB. What proportion of land is not irrigated that c be irrigated?

Mr. JONES. There are 69,166 acres that are under cultivation in t county. There are 225,540 acres that are accessible for cultivation a could be cultivated if there was sufficient water. There are 308 cul feet of water per minute in all the natural springs in Utah County low-water season. There have been 28,985 acres of crops lost this se son for want of water—it being an unusually dry season.

Senator PLUMB. Nearly one-half of the entire acreage under cultiv tion?

Mr. JONES. Yes; there are 662 miles of main artificial canals in t county leading from these natural springs, as represented here up this map. We find in pretty much all these cañons shown here th here are reservoir sites, in which water can be stored, and that there is vater that goes to waste during certain seasons, all of which could be tored. There are a number in Provo Cañon in particular. I will menion the largest one. It would be at the head of the cañon, and at the ower end of what is known as Provo Valley. There can be a reservoir uilt there 4 miles long by a mile or a half wide, with a depth of erhaps 30 feet. As to the depth, of course a great deal would depend n the height of the dam.

Senator Plumb. Is any of this land irrigable that is marked above hese valleys?

Mr. Jones. No; that is a very rugged country. Here [indicating] is he Provo country, and there are the reservoir sites designated on the map, in green. There is very little fall in the upper end of the cañon. That Provo River drains a country about 60 miles by 30.

Senator Reagan. Are the Cottonwood streams drained into this lake?

Mr. Jones. No; they come into Salt Lake County. This district of ountry, shown on this map, lies south of that. These two large plains hat you see in the western side of the county are good arable land, but here is no water.

Senator Reagan. The portion of the land intended to be irrigated by the Bear River Canal is not shown on this map?

Mr. Jones. No.

The Chairman. As to the White Lake, to what extent could it be used for a reservoir?

Mr. Jones. It will do for 130 square miles.

The Chairman. Can the water supply be increased by damming that; by making a reservoir of it?

Mr. Jones. Yes.

Senator Jones. Where is the Jordan River on that map?

Mr. Jones. On the north [indicating the river].

The Chairman. What are the difficulties about raising the Utah Lake?

Mr. Jones. There is no difficulty except that if it were raised 6 or 7 feet it would overflow a good deal of very valuable land, on the east and south particularly. If it were raised to any great extent it would flow over those lands unless it were diked.

The Chairman. When designating the land that could be brought under cultivation, you included the making of Utah Lake into a reservoir, did you?

Mr. Jones. No, not for that purpose. Utah Lake is too low to be utilized by Utah County.

The Chairman. That is then for Salt Lake County?

Mr. Jones. Yes, it can be utilized for Salt Lake County.

The Chairman. Then what you have been speaking of is Utah County entirely—beyond Utah Lake?

Mr. Jones. Yes. Up at the head of the Provo River there are a number of natural reservoirs 60 miles from Provo City and in a northeasterly direction, at an elevation of eight or nine thousand feet. There are natural lakes there that are all the way from half a mile to a mile and a half in area.

Senator Plumb. What is your suggestion as to how this additional land should be put under irrigation; that is, as to who should do it?

Mr. Jones. My idea would be for the Government to furnish sufficient lands to enable the citizens to some extent to build these reservoirs.

Senator Plumb. Are they not able to do it themselves?

Mr. Jones. No; the land is owned as a rule by poor people, in five, ten, and twenty acre lots, and they are cultivating what they can get water for easily and cheaply. In order to get any extensive improvements in the way of reservoirs it would be necessary to get all those people to go into a corporate organization or company and use labor. They have not the means.

Senator PLUMB. As to all this 235,000 acres that is not under water, can you say whether that is in private ownership now?

Mr. JONES. No, the principal part of that is Government land. That lies in the south end of the valley.

Senator PLUMB. Then your suggestion is that the Government should first help these people who own land to irrigate their land, and then to irrigate the other body of land also?

Mr. JONES. There is no way to irrigate that land on the west side except by driving wells.

Senator PLUMB. Where is this area of 235,000 acres that you say can be irrigated?

Mr. JONES. That is the land on the east side that is not cultivated, and also in part those plains on the west.

Senator PLUMB. How much on the east side?

Mr. JONES. About 75,000 acres on the east side; and it is good arable land, but it is not cultivated.

Senator PLUMB. Is that in private ownership?

Mr. JONES. Yes.

The CHAIRMAN. How do you expect the Government to get its money back if it does this for private parties, where the Government itself does not own the land?

Mr. JONES. I had not considered that feature of the case.

Senator PLUMB. That is the Government side of the case, I suppose?

Mr. JONES. Yes.

Senator REAGAN. Is this body of land on the Spanish Fork River irrigable?

Mr. JONES. Yes, that is good land. There is a good deal of land on the east side of Utah Lake that could be farmed profitably now if Utah Lake was kept down to where it is at this time. It is much lower than usual now.

Senator REAGAN. But you do not wish it kept down to where it is now?

Mr. JONES. Yes. Utah County does wish it kept down to where it is now, for the reason that it would make hundreds of acres more valuable.

Senator PLUMB. How can that be done—by diking?

Mr. JONES. By diking or by lowering the outlet of the Jordan so that the water can go off.

The CHAIRMAN. If you lowered the outlet it would get below the ditches, would it not?

Mr. JONES. I understand so, but I am not familiar, however, with the Jordan River.

Senator PLUMB. How much money would it take to enable these people to irrigate their land?

Mr. JONES. I have not made any estimate of it.

Senator PLUMB. Would they be willing to borrow the money from the Government and apply it in that way?

Mr. JONES. I think so.

The CHAIRMAN. If the Government should make these surveys and should show what could be done and give estimates of the cost, would not that enable private parties to combine and bring the water through this Government land and occupy it; would that be of any assistance?

Mr. JONES. Yes, I think it would. I think there would be a good many companies go ahead and construct reservoirs.

The CHAIRMAN. Without Government aid?

Mr. JONES Yes, I think they would.

The CHAIRMAN. You think it would be of some service to have the reservoir site shown, and you think that that would induce settlement on the Government land which you have mentioned, or the taking up of that land to some extent?

Mr. JONES. The Government land which could be irrigated from these reservoirs is now owned by individuals.

The CHAIRMAN. Then you mean there is no Government land there at all?

Mr. JONES. Only on the west side of the lake—about 150,000 acres.

Senator JONES. That is land that you say is not irrigable?

Mr. JONES. Only by artesian water.

Senator JONES. There is no Government land that can be irrigated there?

Mr. JONES. No, I think not.

STATEMENT OF O. J. HOLLISTER, OF SALT LAKE CITY.

The CHAIRMAN. What is your occupation?

Mr. HOLLISTER. I am secretary of the chamber of commerce of Salt Lake City.

The CHAIRMAN. The committee will be glad to have such information as you can give regarding irrigation in this Territory.

Mr. HOLLISTER. The drainage basins of Utah are three, Great Salt Lake, Sevier Lake, and the Colorado River. The principal streams of the first are the Bear, in the north, the Weber, in the east, and the Jordan, in the south.

There are in this valley between the Wasatch and the lake in round numbers 1,000,000 acres of land; more than half of all the land in Utah that can be irrigated.

The streams named, with those coming in from the Wasatch, have a mean volume of about 10,000 cubic feet per second. At a duty of 100 acres to each cubic foot, it will be seen that there is water enough to irrigate the land.

Bear Lake, in the north, and Utah Lake, in the south (with Weber River in the center), are natural reservoirs, which may be so used for storage as to assure the needed quantity in the irrigating season. The towns cut no figure in the calculation, because they are included in the acreage, and their wants are not materially in excess, in proportion to their acreage, of the wants of the farming lands. The waters from the two ends can be carried to the delta plain of the Weber if that river should prove insufficient.

Utah Valley is included in the above statement. Without storage on the heads of the streams which feed Utah Lake, about 50,000 acres on those streams can not be served. Explorations made within a few weeks developed that there are several lakes at the head of the Provo, some of them covering a thousand acres. Ten of them were recently located by people living on the Provo River. Utilizing these, there is no land in the Utah Basin but that can be watered.

As to drying up Great Salt Lake by irrigating these lands; when the pioneers came here the area of the lake was about one-sixth less than it was twenty years later. If all the land that can be watered were watered, it would take about one-sixth of the average inflow for the year. Were the lake then to recede to its area in 1850, one-sixth less surface would be exposed to evaporation. Diversion of the water would be offset by decrease of surface exposed to evaporation. And if this is not quite fair, much of the water used in irrigation finds its way back into the streams and the lake by percolation, and the increase of plants and foliage tends to increase the rainfall. There is no danger, probably, of the lake ever receding below its stage in 1850.

About 400 square miles of this land was under cultivation in 1877, and perhaps 600 square miles of it are now under cultivation. What is now cultivated can at least be doubled in area. The 1,500 square miles includes 40 square miles in Tooele Valley.

The diversion of Bear River will reclaim at least 300 square miles in this valley, and by storage in Bear Lake there will be rendered possible the reclamation of 500 square miles in Idaho.

The western part of Salt Lake drainage basin is not worth talking about. There are sixty tracts susceptible of cultivation, but they average less than 1 square mile each. East of the lake the rivers carry the melting snows of the Wasatch to the valleys, and fertility is the result. West and northwest of the lake, the mountains are too light in mass to store up snow, the streams are spent before summer comes, a few springs only are perennial, and the result is a general desert, dotted with a few little oases.

The principal stream of the Sevier Lake drainage basin is the Sevier River. It rises on the high plateaus 200 to 300 miles south, flows northward a long distance, then bends westward and plunges through the Pavant range, goes out on the desert, and sinks in Sevier Lake.

Captain Dutton says in Major Powell's work on the arid region, published in 1879, that the region where this river heads affords extraordinary facilities for storage of water. The top of the high mesas have numbers of large basins drained by narrow gorges cut through volcanic sheets. There is Panquitch Lake, 8,200 feet above the sea, completely surrounded by barriers, nowhere less than 100 feet high, having its outlet through a narrow cleft. By throwing a dam 30 feet high and 60 feet long in the trachyte throat of this outlet a lake would be formed with an area of 6 or 7 square miles. Thirty or 40 square miles of lake surface, averaging 20 feet in depth, might be created at slight expense upon the Panquitch mesa alone. A dam across the upper part of East Fork Canyon would create a lake of 12 to 15 square miles. Numerous reservoirs may be made at small expense in Grass Valley, upon the Fish Lake plateau and upon the Sevier plateau, and in the valley drained by Salina Creek and its tributaries. The Sevier River itself can be cheaply dammed, and several gorges can be made to overflow swampy flats above, notably at the head of Marysvale Canyon, and again just north of Van Buren's ranch.

Whatever the facilities for storage are in this high country, the land on the course of the Sevier needs them all. Between Joseph City and Juab there are 300 square miles of good land, with water; in Juab, Goshen, and Cedar Valleys there are 300 more, and west of the Pavant, on what is now "the desert," probably 20 townships, 720 square miles.

The San Pitch is the most considerable tributary of the Sevier. There are 55,000 acres of good land upon its course, and no doubt it could all be watered by use of such storage facilities as there are. They cultivate somewhat more than one-half of it.

The remainder of the Sevier Lake basin contains fifteen or twenty small creeks, upon which there are 50 square miles of arable irrigable land. What the facilities for storage are in these cases I do not know.

The Colorado River drainage extends from the southwest corner of the Territory to the northeast corner on the southern and eastern slope of the mountains.

The streams beginning at the southwest are the Virgin, Kanab Creek, the Paria, the Escalante, the Fremont, the San Rafael, the Price, the Minnie Maud, the Uintah, Ashley Fork, Henry's Fork, White River, Green River and Grand River.

There are 800 to 1,000 square miles of irrigable arable land on these streams, about one-third of which is on the Uintah and Uncompahgre Indian Reservations. The arable lands are generally largely in excess of the water supply. There are 30 square miles on the Virgin, 38 on the Fremont, 175 on the San Rafael, 25 on Ashley's Fork, 75 on the White, 85 on the Green, and 40 on the Grand. The others range from 11 square miles down to 3.

Little is known about the facilities for storage on these streams. They flow the cañon lands, the lands available for agriculture are necessarily above the cañons, consequently pretty high; it is a region of cloud-bursts, making bad work of dams and canals, yet no doubt they are worthy of examination.

The engineers of the Geological Survey made a cursory examination of all the streams of Utah in 1877; their reports are published in Major Powell's Arid Region, to which I am indebted for much of my information on this subject.

They made the total arable-irrigable land of Utah, taking into the account, roughly, the facilities for storage, 2,262.4 square miles. It is a good deal for me to say, under such circumstances, that I believe it will ultimately be found to be more by 50 per cent., but it will do no harm to say it.

They returned 494.7 square miles as under cultivation in 1877. It is not likely that this has increased more than 50 per cent., or to 750 square miles. If, then, there are 3,000 square miles of irrigable arable land in Utah, from which I believe there is no doubt the land now under cultivation in Utah may be increased by fourfold.

The CHAIRMAN. Is there anything you wish to say regarding the project of Mr. Bothwell to use the Bear Lake and River for irrigation?

Mr. HOLLISTER. Yes; Mr. John R. Bothwell, promoter of the Bear River Canal project, and now president of the Bear Lake and River Water Works and Irrigation Company, was suddenly called east last week on personal matters of great urgency, and upon leaving he requested me to appear for him before you.

I met Mr. Bothwell for a moment in New York, where he resides, a a few years ago, but never had much acquaintance with him until he came here last winter and engaged in this undertaking. He called at my office and inquired as to what kind of a field Utah is for loaning money on farms. I believe that was last autumn, and in prosecuting this inquiry he learned of the opportunity offered by Bear River and its delta plain.

This plain was surveyed in 1856, but from the impossibility of getting water upon it without great expense it was almost entirely unoccupied in 1869, when the first Pacific railroad was completed, and the right of the railroad company to the alternate sections attached. The 20-mile limit passes very near the cañon at the head of the plain. Much of the reserved land was pre-empted in that year and later. I think there is but little public land in the plain now.

The town of Corinne was founded in March, 1869, where the railroad crosses Bear River, and the same year, procuring the needed assistance, mostly volunteer, I ran a level from the head of Bear River Cañon to the surface of the plain near Hampton's Bridge, and in connection with others endeavored to raise the money to divert the water. We sent an agent to Washington to secure from Congress, if possible, a grant of 50,000 acres of the reserved land. If we had obtained that it was our intention to try and arrange with the railroad company to give us a part of their land, in consideration of putting it all under water. With these lands we would have had a basis upon which to raise the money required. Ex-Governor Stone, of Iowa, now Commissioner of the General Land Office, was interested in that undertaking. Public opinion was growing more and more unfavorable to the land-grant policy of the preceding twenty years, however, and our application failed, or else the magnificent delta plain of Bear River would now be one of the most beautiful and fruitful places in the world.

Since those times the railroad company has sold its lands in the plain to individuals in large tracts; Mr. John W. Kerr of this city was and is the largest owner of these lands, and during the last few years he has made several ineffectual attempts to interest capital in diverting Bear River upon them. Five or six years ago I presented them upon Mr. Kerr's terms to an Amsterdam banker, who was on a visit to New York, but the enterprise failed to interest him. I have always had a disinterested interest in seeing the river diverted, because it means the increase by about one-third of the cultivatable land of this valley, which is one of the choice spots of the earth.

Mr. Bothwell was here about the 1st of last March to make a proposition to the citizens respecting the promotion of a railroad between this city and Los Angeles, and at that time informed me that he had undertaken to divert Bear River and would assuredly do it. The 4th of March last suggested to me the 4th of March, 1869, when President Grant was first inaugurated, and when the founders of Corinne, together with sundry of the leading men of this city, who drove their four-horse rigs up there and took up land about the embryo town, duly celebrated the occasion in tents on the bank of the river below Corinne. I wrote an article for the Salt Lake Tribune recalling those old times, and suggested the carrying of the water down along the base of the mountains, as well as around the plain on the right bank of the river, thus doubling the area of land to be served, or nearly so. The article closed as follows:

> North of the lands watered by the Weber there are 250,000 acres of good land, which we doubt not will average $50 per acre in value before another twenty years have passed away. This means $12,000,000 worth of land and improvements to be created on the northeastern border of Great Salt Lake. Suppose each 40 acres of it to sustain five souls, it would mean a new agricultural population of thirty thousand, and this would mean the addition of an equal or greater number to the towns in that region.

I have reason to believe that Mr. Bothwell's original scheme contemplated only the diversion of the water upon the right bank of the river below the cañon. This he had been advised would not cost more than a quarter of a million at the outside.

But after thorough examination competent engineers estimated the cost at a round million dollars. The first step towards success was the inducing of Mr. Kerr to enter into a contract which gave Mr. Bothwell, in consideration of the diversion of the water, a large contingent interest in 35,000 acres of land; similar arrangements were made with Dr. Roche, another large land owner. The Walker ranch was bought outright at a fair price for the land minus water. The Danish settlement, between the Bear and the Malad, the town of Corinne, and most of the scattered settlers and owners, were induced to enter into contracts, either agreeing to pay a stipulated sum per acre for diverting the water, and the same for its use annually thereafter, or to sell part of their land at a fair figure minus the water. Without these concessions upon the part of the land owners it is safe to say that the money required could not have been raised. The water passing the cañon was roughly measured early in the season, and it was appropriated by Mr. Bothwell for the purpose of diversion, under existing laws and customs, still earlier.

The next time I saw Mr. Bothwell he had enlarged his scheme so as to water both banks of the river and run it down under the mountains as far as Odgen, supplying the towns, and swapping it with the farmers under the canal for the streams coming out of the Wasatch, which were to be diverted latterly, so as to cover the lands above the canal to the base range. The project now involved the taking out of 2,000 second cubic feet of water at the head of the cañon, crossing a moiety to the right bank at some suitable point, and carrying it southwestward along the upper edge of the plain as far as Blue Creek, 45 miles, and the remainder down along the base of the mountains as far as Odgen, 55 miles; and this raised the estimate of cost to a million and a half.

Four months passed in working up the matter to this stage; $20,000 had been expended. About the middle of June, Bear River being at a very unusually low stage, Mr. Bothwell became alarmed lest in seasons of extraordinary drouth, when water would be most indispensable, there should not be enough passing through the cañon to supply the proposed canal—a weakness, since the strength of a chain is measured by its weakest link, which would be fatal to the entire enterprise. It is clear that if a man induces the settlement of a tract of land upon the assurance that he will supply the land with a given amount of water, and then neglects any precaution to enable him to fulfill his contract, such a man is a scoundrel.

A little previously the Malad, Idaho, correspondent of the Salt Lake Tribune, called attention to Bear Lake as a natural reservoir, already provided by nature, high up in the mountains, lying off from but near the river, and having connection with the river. I have resided in Utah twenty years, and have kept a pretty bright lookout, but this was the first mention of Bear Lake as a reservoir I had ever seen or heard. Whether this correspondence suggested the idea I know not. In any event, deeming its appropriation absolutely essential to success, Mr. Bothwell visited Bear Lake with his chief engineer, and finding it admirably adapted to the purpose, appropriated it for storage purposes, and commenced building a dam across the outlet. I do not think he was aware of the law of October 2, 1888. I believe that it has never been published until Secretary Noble sent out a copy in response to Governor Shoup's telegram.

Some farmed lands on the shore, which would be covered by damming the outlet, Mr. Bothwell made arrangements to purchase outright. With farmed lands on Deep Creek, the main feeder of the lake, or on Bear River above the lake, storage would not interfere. With lands on the river below the lake it would interfere by furnishing them with a flow of about 6,000 cubic feet per second during the irrigating season of three months in the year.

Adjoining Bear Lake there is an extensive marsh, through a corner of which Bear River runs. There are some hay lands on the borders of this marsh, but for the most part it is valueless. Mr. Bothwell conceived the idea of draining this marsh, if practicable, with a view to its total reclamation. On the right bank of Bear River in Cache Valley there is a body of perhaps 100,000 acres of the best bench land. The use of Bear Lake as a reservoir Mr. Bothwell believed would furnish water to irrigate this land. He has not taken up an acre of it, or of the marsh, nor has he contemplated doing so; his object was and is to furnish water, and if his proceedings with that end in view, aside from their possible conflict with the law, are justly liable to be denounced as land grabbing or water grabbing, it is not clear to me why the appropriation under the laws of a quarter section as a farm, or of 20 acres as a mine, or the building of a saw-mill, a factory, or a railroad, are not equally liable to the same denunciation.

This further enlargement of the scheme raised the estimate of cost to $2,000,000 and possibly $3,000,000. The enterprise has now been incorporated, a loan secured, and a contract for the heavy work of the first 12 miles was let on the 17th instant. Millions of dollars have gone into the construction of irrigation dams and canals in California and Colorado. I have never before heard these schemes to transform the desert into fruitful fields spoken of in other than terms of commendation and congratulation.

And as to Idaho, which seems to be all up in arms about this "stealing of Idaho water" as they term it, how can the people of Idaho use the water that passes through Bear River Cañon below them? But it is the storage of water in Bear Lake above them, perhaps, which they refer to. That water it is not proposed to use in Utah unless in some season of extraordinary drought there should be less than a supply for the canal passing Bear River Cañon. The engineers of the Powell survey give the mean flow of the river at the cañon as 5,200 second-cubic feet; the canal is intended to carry 2,000 second-cubic feet, hence the river must shrink more than three-fifths below its average stage before any Utah canal or lands will draw on the reservoir at all, a contingency not likely to happen once in twenty, perhaps in fifty, years.

The river must shrink more than four-fifths from its mean flow before any Utah canal will draw on this stored water for more than 1,000 second-cubic feet. And since storage will provide a flow of 6,000 second-cubic feet for the irrigating season, 1,000 feet could be spared for this Utah canal and still leave the Idaho people a flow of 5,000 feet more than they have now.

This immense volume of water, sufficient to irrigate about 800 square miles of land, can be used only in Idaho on the drained marsh on the right bank in Cache Valley, or wherever on the lower course of Bear River it is needed and can be carried.

I will add that Mr. Bothwell's real scheme is the diversion of the waters which for ages have run to waste through Bear River Cañon upon the arid arable lands of this valley. It is not affected by the Bear Lake storage feature incorporated with it, except as the latter enables him to guard against the remote contingency of a short supply for the canals which are to be entirely in this valley.

At his request I visited with him the scene of his labors in May last, although it has long been familiar to me and I came to thoroughly understand and sympathize with his views, the more thoroughly as I had long entertained similar views upon this project myself. I know that he looked forward with high anticipations to an appearance before this commission, but he was imperatively called away.

Coming now to the relations of Mr. Bothwell's scheme to the law, they would be entirely amicable but for the law of October 2, 1888. How he is going to get along with that I do not know, and I therefore can not discuss it as his representative. From the fact that a contract for construction of 12 miles of the heavest work has been let since the law was published, I infer that he and the parties furnishing the money believe that they see some probable way to carry through their great enterprise without serious obstruction from any quarter.

The **CHAIRMAN.** What objection is there to his damming the lake and using it?

Mr. **HOLLISTER.** I can not see any except that it is against the law at present.

The **CHAIRMAN.** Do the people understand that it is reserved as against their use of it?

Mr. **HOLLISTER.** We understand that it is reserved against everybody's use of it—any lands susceptible of irrigation.

The **CHAIRMAN.** The Government engineers may select it. How does he know but what the Government engineers in the future may designate his land for the purposes of irrigation?

Senator **PLUMB.** Had he not commenced his improvements up there in advance—you say he made a dam?

Mr. **HOLLISTER.** He has not made any dam, and does not propose to make any, except a dam that will raise the river 3 feet.

Senator **PLUMB.** I thought you said he had made an improvement there?

Mr. **HOLLISTER.** No, the first time that he started in was about the first of this year.

Senator **PLUMB.** He made no improvement then?

Mr. **HOLLISTER.** No, he simply gave notice. He made his location and began building a dam across the outlet. His plan would furnish a stream of 600,000 cubic feet. The mountains are high and steep and there is a little water around the shores which he is going to buy, and he does not interfere with anybody above, because he fills his lake during the irrigating season.

The **CHAIRMAN.** The Government having reserved these places for reservoirs, can not the Government be trusted even if he does improve it?

Mr. **HOLLISTER.** But is he not a squatter there, under the present circumstances? If he is not, he would give a good deal to know it.

The **CHAIRMAN.** You have in your statute book a right of way for all ditches over the Government land.

Mr. **HOLLISTER.** But does not the act of Congress supersede that in this respect?

The **CHAIRMAN.** I supposed it was in aid of it—to reserve the lands so that private parties should not prevent the people from irrigating the land.

Mr. **HOLLISTER.** He is a private party. He represents a corporation.

The **CHAIRMAN.** I mean private parties that should prevent irrigation.

Mr. **HOLLISTER.** They cannot take it up for anything but irrigation. There have been a half a dozen attempts made in twenty years to irrigate that land.

The **CHAIRMAN.** Then, by this reservation, you consider yourself in worse condition than before. Were not those places subject to preemption and homestead and other kinds of entries before?

Mr. **HOLLISTER.** We could not cut any timber here under the laws.

The **CHAIRMAN.** No matter about the timber. The places were subject to entry. That was the only trouble.

Mr. HOLLISTER. It has been lawful for us, as I understand it, to go and appropriate water if we wanted to irrigate.

Senator PLUMB. This ditch is now in abeyance, is it?

Mr. HOLLISTER. No, it is not in abeyance, because they believe that they will have influence enough to find favor either with the President, or with Congress, or whoever it may be that controls it, to allow them to go on.

Senator PLUMB. Before this question of reservoirs was broached, or before Mr. Bothwell attempted to conceive or carry out this proposition, he still believed there was water enough. This damming of Bear Lake was, as I understand it, only by way of extra precaution?

Mr. HOLLISTER. Yes; so I conceived, but the beneficence of the scheme had some charm for him.

The CHAIRMAN. Will you state what legislation you think it necessary to have in order to have the people avail themselves of those reservoirs? The statutes have a provision giving right of way across public land for all ditches. That is not repealed. What I understand by the language of the statute is that it reserves the places from sale.

Mr. HOLLISTER. Will you allow me to ask you a question before I answer yours?

The CHAIRMAN. Yes.

Mr. HOLLISTER. Does the Government propose locating the reservoirs and making ditches and furnishing the people with water?

The CHAIRMAN. I never heard of such a proposition.

Mr. HOLLISTER. Does it propose, then, to make surveys for the benefit of the people?

The CHAIRMAN. It does.

Mr. HOLLISTER. Then, I say, repeal the reservation. Give the people the benefit of the reservation and let them use it as freely as now.

The CHAIRMAN. Do you not know that there are many places occupied by private parties withheld from the people?

Mr. HOLLISTER. I do not.

The CHAIRMAN. I have just heard of several thousand acres near Utah Lake. It was to stop people from getting down to the borders of the lake, so that it could not be raised. I suppose that in the case of three-fourths of the good reservoir sites in the arid region you will find that people have come down so low that you have to condemn the property in order to use it at all.

Mr. HOLLISTER. That is because the Government did not start in at it twenty years ago. Since we were informed that you were coming the water commissioners at Big Cottonwood, prompted by the dry seasons, have gone up and located these lakes at the head of Big Cottonwood. They do it for themselves. Is not that all right? Others have located others. I have tried to get the city of Salt Lake to locate Utah Lake as a reservation. Would not that be all right?

The CHAIRMAN. If it had not been withdrawn from sale of what use would be your location? As long as the Government is offering the land for sale can you reserve a place for a reservoir unless the Government does it for you?

Mr. HOLLISTER. The places where you will build your reservoirs are up in the mountains. Nobody will own them for any purpose. The only way to use this as a reservoir is to cut down a throat and let the water come out in the irrigating season, and then in the dry reason shut up the gates.

The CHAIRMAN. Are you perfectly sure that when you come to raise Bear Lake by reservoir there will not be private land that will have owners to be bought off?

Mr. **Hollister**. Mr. Bothwell expects to buy. There is not much of it, but whatever there is he would buy, and, if the Government is going to make a reservoir, it would have to do the same thing.

The **Chairman**. Then you think it was wrong for the Government to reserve whatever land it had there?

Mr. **Hollister**. It would be well enough to do that if they had not reserved everything. Now, a man can not take up an acre of arid land in any State or Territory according to my idea of the law.

The **Chairman**. I am not speaking of the reservation of the land below, but of reservoir sites. As to the reservation of lands below, we will have to have some legislation.

Mr. **Hollister**. There should be some legislation that will enable people to take these lands when wanted.

The **Chairman**. But so far as the reservoirs are concerned, what do you want the Government to do with regard to the sites? Do you want to give the sites to private parties or have the Government to keep them for the people?

Mr. **Hollister**. I do not suppose I am entitled to speak for the people of the West; but I say I want the Government to let them be; to keep hands off.

Senator **Plumb**. That is what they have decided to do.

Mr. **Hollister**. People have lately built a great ditch in California. This improvement up here is to cost three or four million dollars. The Government will not do that work. Wherever there is a chance for it to pay private enterprise will do it.

The **Chairman**. The Government does not propose to do it. What do you want done about the places where the reservoirs are? Do you want to have the land sold by the Government?

Mr. **Hollister**. You are not selling reservoir land. You are not selling Bear Lake.

The **Chairman**. Have not some of them got on land that you want for reservoir purposes?

Mr. **Hollister**. Yes; that is because we did not get there in time.

The **Chairman**. Then, do you want that to happen in every place and have to buy people off?

Mr. **Hollister**. I think you will find that the lands that can be used for reservoirs in this country are not wanted by anybody for any other purpose.

The **Chairman**. Name some of the places where you do not want them.

Mr. **Hollister**. Up on the basalt tops; for instance, there is one place to store water enough to irrigate a thousand square miles of land.

The **Chairman**. You are the first man I have met who did not think it was a good thing for the Government to reserve these sites so that the people should not have to buy them out when they wanted to build a reservoir.

Mr. **Hollister**. If you had stopped at reserving "sites," I would not object.

The **Chairman**. It is Congress that has done that.

Mr. **Hollister**. Then you admit that it is not what you want. What objection would there be to the Government making this examination and publishing it, and letting the people have the advantage of it as they go along?

The **Chairman**. That is exactly what they are doing, and they do not propose to do anything else.

Mr. Hollister. Then, that is all right. We shall be very glad to have that done.

The Chairman. That is all they propose to do. They do not propose to construct reservoirs.

Mr. Hollister. We do not know anything about this land now, except what we learn from engineers.

Senator Plumb. Do you understand that you have not now the right to go on this reserved land to put up a dam there?

Mr. Hollister. I can not see how a man can put a million dollars in such a thing. It seems to me that he has got to have a special act of Congress to do it.

Senator Plumb. I have no doubt of it.

Senator Reagan. The information this committee is trying to collect now is intended to enable Congress to determine what would be a wise disposition of that land and that water in the future.

Mr. Hollister. Yes; but meanwhile you prevent our people from making use of it.

Senator Reagan. Temporarily; but is not that better than letting monopolists take up the water?

Mr. Hollister. I don't see how they can monopolize it.

The Chairman. The Government of the United States never took any advantage of any legitimate enterprise. For seventeen years the miners of the west coast took and held possession of the mines as trespassers. Under the law they were trespassers. The Supreme Court of the United States held them to be such. Yet the Government confirmed their rights. And if persons go on now and improve these water sites or reservoir sites, they will undoubtedly be let alone and will never be disturbed.

Mr. Hollister. If you carry out the same principle and recognize the squatter's right on the public land, then it will be all right. What you have said about the mines is true, but this is a new thing, and I do not think these gentlemen who are putting up their money ought to be left in that position.

Senator Reagan. You think the law is wrong; but this committee has no power to right it.

STATEMENT OF F. A. HAMMOND, OF SAN JUAN COUNTY.

The Chairman. Where is San Juan?

Mr. Hammond. San Juan is in the extreme southeast corner of the Territory; it lies principally between the Colorado and the San Juan Rivers.

The Chairman. What can you tell us about irrigation?

Mr. Hammond. There is a small range of mountains there called the Blue Mountains, and the Elk Mountains situated half way as to north and south, and extending east and west. It is probably not more than a hundred miles all around the base of those mountains. At the south base there are fine mesas of land in an excellent climate and of good soil. Some of them are 30 miles long, and from 3 to 7 miles wide. The little streams that come out from the base of the mountains and that sink in these dry places would, if held back and stored, irrigate these beautiful tracts of land. Two on the south are called Johnson and Recapture Creeks, but they lie down in these dry washes from 100 to 300 feet deep. The sides of these dry washes are perpendicular. If you get into one of them you have to go sometimes 20 miles to get out, and at times the water rushes through there, 15 to 29 feet deep in a solid column. Those are what cause the washouts that you read of on the railroads. Those two creeks could be dammed up and brought out on a level reservoir. The soil would admit of it, being a clay formation. It would hold water like a bottle. I am not able to say, however, which would be the cheaper—to hold the water there and store it, as in a natural reservoir, or to build a reservoir on the mesas. It would not take a large amount of money, however, to handle these two streams.

The San Juan River has been an elephant on our hands. We have operated it ten years, and it has cost us upwards of $100,000 to keep up a 7-mile ditch with about 700 acres of land under it. We have had three surveys made, three different times, at three different locations, in order to attack more land higher up. The formation of the San Juan River bank is of quicksand. It dissolves when the water comes in contact with it. It is thick with mud. Streams in western Colorado go into it, such as Los Animas and the San Pedro and the La Plata and others. As it goes down Utah it is full of mud and is almost thick enough to make adobe out of it. With every little shower the mud comes down. There are three streams that run continuously, and afford a great deal of water during the freshets, during the melting of the snows on the higher levels and mountain-tops, which are probably 5,000 feet higher than our level where we are running these ditches. The cañons are deep and afford a good deal of snow during the wintertime, but when the warm season comes on it goes down in a rush. And even in the dryest season—such a season as this, for example—we have water enough for 340 acres. The South Montezuma stream irrigates quite some portion of land. Adjacent to these streams there is excellent land.

Senator REAGAN. What is the elevation of these valleys?

Mr. HAMMOND. Right where I am living, on the San Juan, it is about the same elevation as Salt Lake—about 4,050 feet.

Senator REAGAN. What is the population of San Juan County?

Mr. HAMMOND. If we were to include the Indians, the population would tally up pretty well; but at present there are not more than forty-five families in the entire county. Perhaps three hundred cowboys are there, who run large herds of stock. It is more a grazing country than a farming country, and that is caused by the want of water. We estimate that there are 600,090 acres of good arable land there. That is a very low estimate. I have traveled over it, and I know there is that much.

The CHAIRMAN. Would Government surveys and estimates of cost for storage reservoirs, etc., be of any use to you in that region?

Mr. HAMMOND. They would be of great use. They would tell us what we have and what we might have to expend if we were able to expend it. I judge that $50,000 would put us in shape there to irrigate fine tracts of land. We could carry that water anywhere along under a 6,000-foot level.

The CHAIRMAN. If such surveys and investigations were made as to determine with reasonable certainty what might be done with these different streams, how water might be stored, and so on, do you think the settlers would combine together and utilize that information to some extent?

Mr. HAMMOND. We would be most happy to do it, but I am afraid the sinews of war would be too weak to accomplish anything. Imagine forty-five families! Sell them out, and the entire thing would not be worth $25,000, perhaps.

The **CHAIRMAN**. But would others come in to help you? If the facts were known would you be likely to utilize the information which the Government supplied?

Mr. **HAMMOND**. Yes, I believe that would be done as far as possible. I have endeavored, in the last five years, in connection with my friends up in the north, to induce some of our wealthy men to take hold of the thing, but without surveys, and without any data upon which to work, capitalists fight shy of it. I know of no part of Utah, south or north, where there is a finer chance for storing water, or a finer chance to hold water on good land. We have a good deal of poor land in Utah, but down there we have an excellent quality of land.

Senator **REAGAN**. What crops do you raise there?

Mr. **HAMMOND**. Down by the river we raise corn, squash, melons, beans, and, about the mountains, the cereals are raised. The climate is about like that of Ogden. There are natural reservoirs in these deep cañons, breaking down through the mountains, perhaps 50 feet wide. Building up a solid dam there would store quantities of water almost beyond calculation.

Senator **PLUMB**. How long have there been settlements in that county?

Mr. **HAMMOND**. Ten years.

Senator **PLUMB**. Is that the section of Utah to which it is proposed to remove the Ute Indians of Southern Colorado?

Mr. **HAMMOND**. The very spot.

Senator **PLUMB**. What portion of this county of San Juan is covered by the agreement between the commissioners and the Indians last year?

Mr. **HAMMOND**. All except a narrow strip on the stream north of the line, perhaps a strip 25 miles wide, as near as one can guess at it by traveling over it. I traveled with the Commission that had the matter in charge. In investigating the land office here in Salt Lake, they found three patents in favor of the Pittsburgh Cattle Company located on the south base of the Lascelle Mountains—the hunting ground of the Southern Utes. When they heard that, they ran the line from Bluff city until it strikes the Colorado line, and then it goes out north. That cut off the Pittsburgh company, to which they strenuously objected. It turned the Utes on to those lands to hunt in the summer.

Senator **PLUMB**. You are willing that the Utes should come there?

Mr. **HAMMOND**. Yes; if they pay us for it.

Senator **PLUMB**. Are your lands there included in that arrangement?

Mr. **HAMMOND**. Yes, but we are "squatters," and we have only Hobson's choice. All we want is to be paid for our improvements.

Senator **PLUMB**. You say that you have spent perhaps $100,000 for irrigating there?

Mr. **HAMMOND**. On one canal; and now the ditch is dry. Away went the river, and left us high and dry two years ago.

Senator **PLUMB**. You say that the entire possessions of these people would not amount to $25,000?

Mr. **HAMMOND**. I did not wish to be so understood. I mean that to all those who are there it would be a heavy tax to raise $25,000 out of their income—whatever they have there.

Senator **PLUMB**. Do you mean the total of what their possessions were appraised at that?

Mr. **HAMMOND**. I do not. That would be something like $50,000. This Bluff Canal figured so largely that every farmer in that county almost had an interest in it. It was a joint stock affair.

Senator PLUMB. Then they must have spent much more than they have left?

Mr. HAMMOND. Most assuredly they have. It was reported by Mr. Childs that it was not a valid claim against the Government because it had gone down—it had been washed away into the gulch.

Senator JONES. I infer from what you say that you are rather sick of your enterprise?

Mr. HAMMOND. I am not sick at all; if we can only get water. It is as good a country as any in Utah, if we only had water.

The CHAIRMAN. But I understand you that the river has gone away and left you?

Mr. HAMMOND. Yes, it has left us high and dry.

The CHAIRMAN. Is that likely to occur at any time?

Mr. HAMMOND. That is an exception; the oldest inhabitant did not know of the river being so low before.

The CHAIRMAN. If your people can not make a living, how do you expect the Indians to live there?

Mr. HAMMOND. They can put in more time than we can at chasing jack rabbits.

STATEMENT OF W. R. SMITH, OF DAVIS COUNTY.

The CHAIRMAN. What is your occupation?

Mr. SMITH. I am a farmer and a stock raiser.

The CHAIRMAN. Have you considered at all the subject of irrigation and water supply in this valley?

Mr. SMITH. To a certain extent.

The CHAIRMAN. Will you please state to the committee what conclusions you have arrived at in this matter?

Mr. SMITH. I am satisfied that there is an opportunity, if means were expended, to store a good deal of water in this country.

The CHAIRMAN. Describe the area within your knowledge.

Mr. SMITH. I am interested in the construction of a canal from the mouth of the Weber River coming around into Davis County, which has cost $150,000. This year and last year being exceptionally dry seasons, the water has failed in the Weber River, so that the canals that would usually have been full of water at this time of the year are now dry. Within the last month myself and another person went to the head of the Weber River for the purpose of looking up reservoirs and observing the opportunities of storing water to relieve the people below in such seasons as the present. We found a few small lakes at the head of the Weber, which we went up to see. We also noticed places below the head where we thought reservoirs could be made. Our conclusions under the circumstances were that in a season like this all the water we could store with safety up that river would not amount to anything to us in Davis County. There was so much land taken in and cultivated above our canal that it would take a regiment of soldiers, if we took the water stored there, to get it down where we could use it.

The CHAIRMAN. It would be of no use to you?

Mr. SMITH. No. We would have to keep it from being turned off. There is a large quantity of land brought into cultivation every year. We found the Sevier River dammed at three points, and it was only what seeped in through the bank that could be got below.

The CHAIRMAN. Would anybody be benefited by storage?

Mr. SMITH. Only those up at the head. Those having small farms elsewhere and having families dependent on them for a living would find it of no advantage.

The CHAIRMAN. If the water were kept up there would it be beneficial to anybody?

Mr. SMITH. Yes, I think it would. The water can be stored to a certain extent, but we did not find a place where the water could be stored with safety so as to be of any use to us who were below.

The CHAIRMAN. Is Weber River the river which is followed up by the railroad?

Mr. SMITH. Yes; it heads near where the Provo River heads. We thought that if we had a reservoir to store the water in the spring we could improve our lands very much.

The CHAIRMAN. Then you think that the extent of country that could be benefited would be considerable and might avail itself of the information which surveys would afford?

Mr. SMITH. Yes.

The CHAIRMAN. You think that reservoirs would help the country generally?

Mr. SMITH. They would help a great deal above, and in the usual and ordinary seasons, such as we have had for say ten years back (with the exception of the last two years), there would be no lack of water for irrigating purposes.

The CHAIRMAN. A ditch coming from the Weber has been supplying you with water?

Mr. SMITH. Yes; we have had no failure, except the last two years. Then we have failed almost entirely.

The CHAIRMAN. Would surveys be of use to your people in determining where to locate reservoirs?

Mr. SMITH. Undoubtedly. We found one reservoir site in the branch of the Weber River—a valley that is narrow at the lower end, and with perpendicular rocks and sides, probably 100 feet high—the widest place across being 120 feet. You can build a dam in there that would raise the water 100 feet up, and with very little expense. It would probably form a lake three-fourths of a mile wide and two miles long.

The CHAIRMAN. If the Government should make surveys and designate the proper points for reservoirs would the people probably combine to utilize them?

Mr. SMITH. I think they would, especially to utilize this one in Cañon Creek, because, below these narrows there are settlements in Cañon Creek that have suffered materially by reason of not having a sufficient amount of water. The only natural reservoirs that I know of that amount to much are Utah Lake and Bear Lake.

Adjourned to meet on Tuesday, the 20th instant, at 10 o'clock a. m.

SALT LAKE CITY, UTAH, *August* 20, 1889.

The committee met pursuant to adjournment.

Present: Messrs. Stewart (chairman), Jones, and Reagan; also Director Powell.

STATEMENT OF F. H. NEWELL, OF U. S. GEOLOGICAL SURVEY.

The CHAIRMAN. State to the committee how long you have been engaged in the examination of Utah; what your conclusions are as to irrigation within its limits, and what facilities it has for storing water by means of reservoirs, etc. Make your statement in your own way.

Mr. NEWELL. I came here in March, and began first a survey of Utah Lake. I made a careful survey of the shore lines and the amount of land that would be overflowed by raising the lake according to the wishes of the people. These were submitted to the Department, and then I proceeded to examine various reservoir sites in different parts of the Territory. So far my work has been wholly confined within the rim of the basin, and all my statements will refer to the country inside, although I doubt not many of them will apply to the country draining into the Colorado.

I would review a little the statements of other witnesses. The people came here inexperienced, without capital to use in the construction of their ditches, and their only hope was to join together and contribute their labor toward the construction of their ditches. Consequently they began in what appeared to be the easy places. Each man in the community took so many shares of stock and agreed to pay a certain proportion in labor, and in that way began the work of constructing ditches. Therefore these ditches were not laid out with engineering skill, and in many instances ditches were dug and abandoned, and settlements were moved because the natural conditions of the country were not suitable for purposes of irrigation, so that the first cost of these works is largely in excess of what they could be restored for, and as the ditches were constructed in the easiest places they were not constructed with a view of covering the most land. But year by year, as the settlements increased, new projects were inaugurated, and in many instances three, four, or five ditches were performing the functions that one would do. Companies were formed to construct ditches. Each company was composed of members who co-operated together in the construction of a ditch, and their co-operation was often of the loosest kind, and often there was friction, by which a great amount of water was wasted.

The CHAIRMAN. State how that may result.

Mr. NEWELL. Each company is anxious to get the largest amount of water that would flow into its ditch, and there is no official, no person, whose duty it is to apportion the water to the ditches. Consequently it is a case of the man highest up the stream usually getting the most water, and it is exceedingly difficult for the companies lower down to force the upper ones to let water flow by their head works except by mutual agreement.

As Judge Smith stated, there is no safeguard by which the shares of the water are held to the land or to the landowners. Each person may transfer his stock, with a limited exception, to any person he chooses, excepting in cases where there is a provision that the water shall not be taken out of the ditch represented by the stock and sold to another ditch. But such sales, so far as I am aware, are very rare. Instances I have seen, but few. The share primarily was intended in most cases to water one acre; but in this season, and other dry seasons, it only watered half or a quarter of an acre. This fall in one instance seven shares only watered one acre.

With a view to collecting information for this committee and for the use of the survey the authorities here in Salt Lake kindly communicated with parties throughout the Territory, asking many questions on this subject. All the answers to those questions have not yet been received. But from those received, and other estimates, it is calculated that the area under ditch in this Territory is 600,000 acres. Of that, this summer, about one-half—300,000 acres—is actually watered; but on those 300,000 acres the largest crops have not been raised.

The CHAIRMAN. Are those 600,000 acres in the basin you are considering?

Mr. NEWELL. No. In the entire Territory. Dry farming in most cases I do not consider can be so termed. In looking into the matter you will find that while the water is not put on the land by ditches, it gets there by seepage, and it is as truly irrigation—underground irrigation—as though the water flowed in definite channels.

The question as to the duty of water has consumed a good deal of time, and has not been satisfactorily answered, from the many sides that it presents. But the conclusion to which I have come is that 1 cubic foot of water per second, flowing in the ditches, has irrigated in this dry season about 75 acres of land. In more favorable seasons the duty is far less. Another way of stating the duty is by the acre-foot. One inch to the acre is in certain parts of the Territory considered to be the ordinary duty of water, meaning by 1 inch a square inch area on the sill of the measuring flume, and not under pressure. Of course this is a very indefinite quantity, but the measurements in the cases examined make this inch equal ten to fifteen thousandths of a cubic foot; the water in the course of the season would thus cover 1 acre from 1.8 to 2.6 feet deep.

It is customary for the water masters of the Territory to divide the water for irrigating streams, and those streams are measured by the eye. An irrigating stream by actual measurement carries from 3 to 5 cubic feet per second, and in seasons of comparative plenty one irrigating stream will water an acre in two hours. Now they go an hour and a half, and even less. But by that calculation one irrigation would cover an acre 6 inches deep.

The water is generally applied by turning it on at the upper end of the field, and it is then allowed to find its way into the small grain by furrows or flooding. As a consequence, the upper part of the field receives all the water. They stop the flow when they see the water at the lower end.

The duty of water has not been large for the reason that the men who built the canals, who own them, and who originally invested in them are also the owners of the land, and their only profit arises from the products of the land; and in looking at the crops they raise they forget the source of supply. In other words, they neglect their ditches. The only annual cost of water is 15 to 30 cents per acre, and in rare cases $3 an acre.

Senator JONES. That is after the farmer owns the water.

Mr. NEWELL. That is merely to get the water to his field each year. In other words, the actual tax is for the water right. That is to say, the care of the ditches only amounts to that per acre. So that, you see, in most of the ditches very little work is put on them, especially as this 15 to 30 cents per acre is often paid in labor, averaging about $1.50 per day of ten hours.

Irrigation by artesian wells has been discussed considerably, and many wells have been put down, aggregating hundreds, in this Territory, but the total acreage irrigated is very small. I have not been able to find a statement of over a few hundred acres. The entire supply has been devoted to household uses, watering stock, and for orchards. The actual condition in this Territory is, that all the water flowing in the streams has been taken, and more land has been brought under cultivation than there is water for its supply.

There are only two hopes for holding this Territory as it is, with the natural development: First, increased rain-fall; second, economy of water and increase of the supply by storage. Economy comes first, because stored water is always more valuable than that which flows in the natural streams, and greater care must be taken of the ditches. The stream beds are rarely, if ever, straightened or improved. In this time of low water the little water that does flow into the stream has to wet the entire bed of the stream, and a large portion of water is lost by evaporation and soaking into the ground, where in many cases it could be increased, even doubled, by intercepting the underground flow or confining that which appears on the surface within definite bounds.

There are two classes of irrigation proper in this Territory. First are towns like those of the San Pete Valley and Nephi, near Juab, in the Salt Creek Valley. The people take their water directly from the mountain streams, which flow through the towns diagonally, and ditches are often taken off at convenient points. The stream itself becomes the canal. They own it. An increase in population depends on the supply. They have no one to contend with. The people can, if they please, go to the headwaters, improve the channel, and store the water.

The other classes are those down along the Sevier River. They take the water from the river flowing several hundred miles through several counties, the water of which is subject to appropriation by the people all along that line. There they can not control the water. Bear River is similar, but I mention Sevier as the best type, as it is wholly in this Territory. The only hope of those lower down is in a reservoir system high in the mountains, and they can not make those reservoirs without some help from the Territory or from the General Government. They have called on the Survey for reservations of those upper reservoir sites, and I have been with some of the residents, some of those who are largely interested in canals, gentlemen who are high in the church, and have made an examination of the possible reservoir sites and every site that I have seen in Utah. Every large site, of more than 100 acres, has been squatted or filed upon in some shape so that the Government is only a part owner in these sites. These men feel that they must have the balance reserved to save them the expense and difficulty of acquiring title. They, therefore, fully appreciate our work and are enthusiastic as to its possibilities.

The **CHAIRMAN**. Are those occupants where you have noticed them squatters in the general acceptation of the term, or have they legal rights?

Mr. **NEWELL**. Wherever the land is surveyed they have made at least declaratory statements.

Senator **REAGAN**. Do you mean in the mountains?

Mr. **NEWELL**. In the mountains, even the highest.

Senator **REAGAN**. Up where those reservoirs are, is there any land suitable for cultivation?

Mr. **NEWELL**. If the land is too high up to raise winter grain, they will turn the streams into the ground—these little basins are exceedingly fertile—and graze their cattle. They are mostly ranchers, and whatever grain they raise is a secondary consideration.

These people down on the Lower Sevier have been year by year losing their water, and when these gentlemen went up into the high plateaus they then saw the cause of it. Settlers have been year by year pushing in there where there was plenty of water and good grazing, and have been taking up the small streams. These gentlemen remonstrated, saying, "You have taken the water out of the Sevier River;" they answered, "These are our creeks, no one has filed on them." The question now comes up: How are the rights down in Sevier County and still farther down at Deseret, to be protected?

As the gentleman from Davis County mentioned last night, there is no hope of receiving any aid from Davis County. They appreciate the hopelessness of getting water 50 miles down that river without some aid. [Indicating on a map]. For instance, here are the towns that have taken up water and are depending upon the Sevier River. The green color represents irrigated land. The river then flows through the cañons, and the water comes through this portion of the country. On these ravines and depressions in the mountains settlers have come in and taken up the water, diminishing it in this portion. Their only hope is from the river which flows through this portion and comes through the gap at Deseret.

The problem we have to solve is this: How to get water. Residents have asked the survey to establish gauging stations at various points on the river to ascertain the amount of water flowing down at different times, so that the people may have some data as to the amount of water that should be due to their reservoirs. They ask more than that, however. They ask that some legislation be passed by which they can force the people at the head-waters to allow the water belonging to the older vested rights to come through. The people above have seven counties, and those below have to contend with them. There is no general system of which they are aware, except, perhaps, an appeal to the arbitration of the church, by which the water can be forced to pass these places. In the valley of the Sevier, in Sevier County, the river is taken out four times, so that the bed is dry.

Senator **JONES**. Taken out at four different places, you mean?

Mr. **NEWELL**. Yes; but when it comes out on to the Sevier Desert, about Deseret, there is apparently as much water as when it enters Sevier County.

Senator **REAGAN**. Notwithstanding that the water has been taken out?

Mr. **NEWELL**. Yes; notwithstanding that the water has been taken out. So that the hope of these people on the desert is to store water at the lower end of Sevier County and also again before the river leaves the cañons to enter this Sevier Lake Desert.

Senator JONES. Have you examined the lakes along there and have you formed any conclusions as to whether these ideas are feasible?

Mr. NEWELL. Yes; they have been examined and reserved by the survey. I may state that the larger reservoirs on this system have been examined and reserved, and the people are preparing to construct at least two reservoirs, and probably will construct others. But now the matter before them is this question of measurement of water. Some person must establish gauging stations so that they may have some data and know where their reservoir water goes to.

Senator JONES. So as to know how this water is distributed?

Mr. NEWELL. Yes; this Territory, as far as I understand it, differs from the others in the method of distributing water in times of scarcity. In many places the system of priority of right has been interlocked with that of equal division, in this way: when water is scarce, by agreement they will determine up to what time acquired water-rights shall be termed "prior." We will say that, in a settlement, all water used before 1867 has a "prior" right. In that settlement all water used between 1867, we will assume, and 1875 has a "secondary" right. All water acquired since 1875 has a "third" right. Then they set off——

Senator PLUMB. Who are "they?"

Mr. NEWELL. The water-land owners, who are also owners in the canal.

Senator PLUMB. In what canal?

Mr. NEWELL. In any canal.

Senator PLUMB. You are speaking now of the law of Utah?

Mr. NEWELL. No, not of the law; it is a matter of general custom.

Senator PLUMB. There is no law about it, then?

Mr. NEWELL. No law at all; simply custom.

Senator PLUMB. There are no water commissioners appointed under the law of the Territory?

Mr. NEWELL. There have been such officers. The county commissioners were water commissioners, but they do not act so now.

Senator PLUMB. The law is inoperative down there?

Mr. NEWELL. Yes. By agreement the men who have used water previous to 1867 make a list of the number of acres cultivated prior to that time. Those between 1867 and 1875 make a list of the number of acres that they have cultivated at that time. Each list may include some men who have come on the prior right; and so with the second and third rights. So that one man may own 20 acres of prior right, and 40 acres of secondary right, and 10 acres of third right. In time of scarcity, then, all the third are cut off (if that be necessary), in order to supply the first and second rights. Then the second rights are cut off, if that be necessary, in order to afford a sufficient supply for the first rights.

After supplying the first rights, if water is still too scare for all, it is apportioned among them. I mention that to give an illustration of the operation of these rights where priority of right is accorded not to individuals but to groups of individuals. The opinion of this Territory is rather against the strict enforcement of the prior right, but rather in favor of a fair division, as far as it may be applicable. That is all I have to say on the general subject.

Senator JONES. Then I understand that under this proposition, if there is water enough simply to give a full supply to the prior rights, they are to have a full supply to the absolute exclusion of the second and third rights?

Mr. Newell. Yes; but that full supply, by the way, is determined by the water-master, who, being elected by all the parties in interest, is more apt to apportion each man less than he thinks his full supply rather than give him an excess.

Senator Plumb. This water-master is not elected under the law at all, but chosen by agreement among the people?

Mr. Newell. That is it.

Senator Jones. Is there any effort made to control this distribution by the laws of the Territory now?

Mr. Newell. Not that I am aware of.

Senator Plumb. Then if this agreement were changed among the people the rights would change; in other words, there is no law that governs the matter, consequently they settle the matter among themselves.

Mr. Newell. Yes.

Senator Jones. It is a mere custom?

Mr. Newell. Yes; I will show you some of their tickets or shares, showing the time of limitation as to water rights.

The tickets are as follows:

No.—
IRRIGATION TIME TICKET.
Mr. ——— ———. Block ———, Ditch No.—, every —— from — o'clock — m., and until — o'clock — m., amount of stream —— of water in said ditch.
W. H. BROWN,
Water-master.
——— ———, *Deputy.*
PROVO CITY, UTAH, *May* ——, 1889.

No. ——
IRRIGATION TIME TICKET.
M——— ———: You are entitled to the use of the water on Block ———, Ditch No. ——, every ——— from —— o'clock — m., and until —— o'clock — m., amount of stream ——— of the water in said ditch; when you are required to discontinue to use and turn it off.
W. H. BROWN, *Water-master.*
——— ———, *Deputy.*
PROVO CITY, UTAH, *May* ——, 1889.

No. —.
TIMPANOGOS IRRIGATION TIME TICKET.
Mr. ——— ———. On —— every alternate week, from — o'clock — m., and until — o'clock — m., ——— amount of stream, all of the water in said ditch.
——— ———
Water-master.

No.——
TIMPANOGOS IRRIGATION TIME TICKET.
Mr. ——— ———: You are entitled to the use of water from the Timpanogos Ditch on ——— every alternate week, from —— o'clock — m., and until —— o'clock — m.,———; amount of stream, all of the water in said ditch; when you are required to discontinue to use and turn it off.
——— ———, *Water-master.*
Per ——— ———, *Deputy.*
PROVO CITY, UTAH, ——— ——, 18—.

No. ——
Am't of labor, ———
Am't of cash, $———
———
Total, $ ———
Issued to and received by
——— ———.
Date, ———, 188—

No. ——
Received of ——— ——— ——— days' labor, $———
Cash .... ———
———
Total .... ———
In full for his water-tax, for the year ending March 1, 188—.
——— ———, *Water-master.*
PROVO CITY, UTAH, ——— ——, 188—.

Senator Jones. You did not state what your conclusions were about Utah Lake and the basin of the Upper Sevier Lake. Have you arrived at any conclusions as to what could be economically done with those, or with Utah Lake, as to the elevation of the lake, or how it should be handled? Is that matter yet in abeyance?

Mr. **Newell**. I made an examination of it. At first it was thought necessary to raise the lake in order to get more water, but on more careful study I think the lake can perform its full functions best by drawing down below the natural shore lines, rather than by raising it above them. In other words, if raised above, the lake will be too large for the evaporation area. The evaporation is even now too great in proportion to the amount of water that can be taken out. My estimates show that the evaporation this spring has been twice as much as the water coming from the Jordan. If the lake is raised that proportion must increase; while if it is lowered, and the outlets consequently are lowered, the proportion lost by evaporation will be less compared with that which can be utilized. A larger stream is flowing into the lake than flows out of it, and most of that water is lost.

Senator **Reagan**. To what extent would it affect irrigation on the land below there?

Mr. **Newell**. The lowering that I had in my mind was a maximum of 3 feet. If they lowered their canals 3 feet I do not think it would reduce the area of land very much. Lowering the canals 3 feet would not throw them very much out of their present line.

Senator **Jones**. It would not require a very great change in the present canal system to do that, would it? I have an idea that in the early location of those ditches they were probably not very judiciously located, and that if this water line were lowered much some of the earlier ditches might become utilized, they having been improperly placed at first. Do you think the water supply could be preserved by lowering the lake level 3 feet?

Mr. **Newell**. It could only be preserved by lowering the head works and improving the grade.

Senator **Reagan**.—Would not that seriously affect the flow of the water below?

Mr. **Newell**. It could not, because the water is all apportioned to different canals.

Senator **Reagan**. What I mean is, would the grade that would have to be adopted retard the flow of the water?

Mr. **Newell**. It would on these upper canals unless the bottoms were greatly improved. Other canals are taken out lower down the river, and of course no change in the lake could affect those.

Major **Powell**. What the Senator wants to know is this; if you change the grades of the canals, if you drop the head works 3 feet, will not that affect the flow of the canals, so that they will not deliver the water?

Mr. **Newell**. It will unless that lowering of the grade is carried a long distance. I have never seen profiles of the canals, so that I can not speak from definite knowledge. But if the head was lowered 3 feet and that distributed through several miles it might be possible by improving the bed of the canals—say by cementing it and making the friction far less than at present—to deliver the water. That would require careful engineering work. But as it is now, with the moss and grass growing in them, such lowering would absolutely destroy them. Do I answer your question, Senator?

Senator **Reagan**. Yes.

Senator **Plumb**. You stated a while ago that there was a probability of the increase of rain-fall in the valley. On what do you base that opinion?

Mr. **Newell**. From the fact that this year's rain-fall is exceptionally small.

Senator **PLUMB**. That is to say, that in a year in which there is more precipitation there will be more than in a year when there is less?

Mr. **NEWELL**. Certainly.

Senator **JONES**. You mean that in an ordinary year the precipitation is likely to be more than it is this year?

Mr. **NEWELL**. Yes.

Senator **PLUMB**. You don't mean to say that there will be any increase of the rain-fall on the average in future over the past?

Mr. **NEWELL**. No. I prefaced my remarks by saying that my observation is based on this year of exceptional drought, and my figures are less than in an average year.

Senator **PLUMB**. In other words, this being a year of extreme drought, some other year would be better?

Mr. **NEWELL**. Yes, sir.

Senator **PLUMB**. You do not mean to say that there will be any precipitation of moisture in the average of years hereafter greater than the average precipitation heretofore?

Mr. **NEWELL**. No, I have made no statement in regard to that.

Senator **PLUMB**. You spoke of the taking up of lands along the margins of the reservoir sites. Has that been stimulated recently?

Mr. **NEWELL**. Not along the margins, but in the bottoms of these prospective reservoir sites. That has been going on for a number of years. I have noticed a number of claims within the past few years, but I do not think they are much beyond the average. This exceptionally dry year, however, has induced people to move up from the lower valleys to places where they could get more water.

Senator **PLUMB**. Have the surveys induced people to take up the claims?

Mr. **NEWELL**. I have not seen many instances yet.

Senator **PLUMB**. But the sites that have been taken up will have to be overflowed in order to make the reservoirs you speak of?

Mr. **NEWELL**. Yes.

Senator **PLUMB**. In other words, the settlers will have to be displaced in order to make these reservoirs?

Mr. **NEWELL**. Yes.

Senator **PLUMB**. You say the law of the Territory does not apply to the matters you have been speaking of?

Mr. **NEWELL**. I was speaking merely of the customs.

Senator **PLUMB**. The people do not carry on the operations of distributing the water under the law of the Territory, but by an arrangement of their own, which is outside?

Mr. **NEWELL**. Their arrangement will be in conformity with the law, I presume. I do not know. I only know what their customs are.

STATEMENT OF JOHN D. PETERS, OF BRIGHAM CITY.

The **CHAIRMAN**. How long have you resided in Brigham?

Mr. **PETERS**. I have resided there for thirty-five years.

The **CHAIRMAN**. Will you make such statement as you think will be useful to the committee in regard to irrigation, the use of water in this Territory, and the sources of its supply?

Mr. **PETERS**. I wish to make first an explanation. I received a telegram last evening when away from home to appear here at 10 o'clock, and bring some fruits and grains raised in Brigham City. I hurriedly got a few samples and came down. As to what other information the committee desires of course I was not aware, but I came prepared to give any information that I can in reply to any inquiry that may be made of me. I have brought a few samples of our produce, which the committee can examine.

The CHAIRMAN. If you have lived here for thirty-five years you are thoroughly familiar with the development of irrigation. State briefly how the people did in the beginning, how they do now, and what the sources of the water supply are. Give us the early history of the irrigation work here.

Mr. PETERS. The county was settled in 1850. There were a few streams that were flowing into the valley from the eastern mountains, which, of course, provided meager supply for the land in that vicinity, and as the settlers located upon these streams they began the clearing-out work to cause, of course, a greater flow of water. The work they performed in the hill-beds and springs by clearing out did increase the flow of the water. In 1855 Brigham City was located and surveyed, and the largest stream in the county, which is known as the Box Elder Creek, was diverted from its natural channel, which is upon the site of the town, which is a dry, gravelly bench-land. At that time there were probably fifty or sixty families, and it appeared as though there was hardly sufficient water for that number.

As the city became settled it appeared as though the water supply increased, and to-day there is a population in the same town of about 2,600 persons. While they do not have a plenteous supply of water they have a pretty fair supply, and do not suffer to any great extent. The size of that town, however, could be greatly increased. The number of inhabitants would be larger if the water supply were greater, because there is a considerable quantity of arid land adjoining the town. It is all good land, if it could only be brought under cultivation.

Senator JONES. Does that increase in the water supply result from a more economical use of the water, and making it go further, or has the volume of the stream increased?

Mr. PETERS. The volume of the stream seems to have increased. I am satisfied it has increased considerably, from what I can remember of the stream. I think the only reason for the increase—indeed I am satisfied that the only reason—is because of the work done in the springs and marshy places, clearing them out somewhat. I would state that the supply for Brigham City originates in large springs in a small cove or valley in the mountains. These springs as they rise seem to form a marshy bottom, and this marsh has been drained. That fact, I think, has increased the water supply more than any one thing.

There is a town commonly known as Willard, which is the next largest town in our county. That was settled about the same time, and received its water supply from a cañon. The source of supply seems to be entirely from snow, and the stream varies in proportion to the amount of snow in the mountain each year. That is not so much the case with Box Elder Creek as with the Willard. For instance, this year the Willard is almost dry. When there is a large supply in the mountains there is a large flow, and they seem to have plenty of water. The same is true as to several other streams.

Senator JONES. Is there much water running to waste, outside of the seasons of irrigation, from those springs?

Mr. PETERS. Yes; there is considerable water running to waste during the spring of the year.

Senator JONES. Is there any larger volume then than in the season of irrigation?

Mr. **Peters**. Yes; there is a larger volume then.

Senator **Reagan**. Would there be found any practicable means of storing that water so as to prevent waste?

Mr. **Peters**. I think there would. The county is one of the largest in the Territory, and there is some arid land in it, I suppose [referring to the map]. Box Elder Creek is the largest creek in the county, excepting the Bear River. Box Elder Creek rises in a small valley about 4 miles east of Brigham. There is a small settlement in this valley known as Mantua. From this valley Brigham City gets its source of supply. These are dry runs in the summer, but in the spring of the year they have a large amount of water.

Senator **Jones**. And it all goes to waste?

Mr. **Peters**. Yes; it runs partly into Box Elder Lake and partly into the Great Salt Lake. Box Elder Lake is now nearly dry. The reason of that is that the Utah and Northern Railroad runs directly through the lake. When the road was built there was a large stream coming from the Hot Springs that furnished its supply to Box Elder Lake. In order that it might not overflow the railroad company cut a channel, which cut off this small creek and let it go into Bear River. Fresh water is now brought on to the borders of the lake, and it produces good hay. There is a little fresh water in the spring.

Senator **Jones**. Bear River runs to where?

Mr. **Peters**. It empties into Great Salt Lake. There is a projected canal, that you will notice on the map. That is projected by the Bear River Canal Company. The canal starts on the boundary line or about the boundary line of Cache and Box Elder Counties, and passes down to Bear River Cañon.

Senator **Jones**. There is a cañon that I saw from the railroad coming down from Cache Valley, where the Bear River came out; what is that called?

Mr. **Peters**. That is Bear River Cañon. Then the canal divides; one portion of it runs in a northwesterly direction and covers a great portion of the arid lands lying west of Bear River.

Senator **Reagan**. Is this red line on your map the proposed Bear River Canal?

Mr. **Peters**. Yes; there are two branches. Another branch runs along the base of the eastern mountain of the Salt Lake Valley, in a southerly direction, to Ogden.

The **Chairman**. The canal, then, with its various branches is indicated by red lines on the map of Box Elder County?

Mr. **Peters**. Yes.

The **Chairman**. Is it high enough to reach most of the arable land on the east side, or could it be taken high enough to accomplish that purpose?

Mr. **Peters**. It could be taken high enough to reach most of it. But there is considerable arid land above the canal that must be irrigated, if at all, by the small streams. There is a stream called Three-mile Creek that I have not mentioned before. That furnishes water for quite a large settlement, but not nearly a full supply.

The next map that I show you is a map of Willard precinct, in Boxelder County.

The **Chairman**. Is it so marked on the map?

Mr. **Peters**. Yes; the first map that I showed you is a copy of another county on a smaller scale. This is the second map, and is a sectional map of the section watered by the streams I have mentioned.

For instance, you will observe Willard City. It receives its supply from the mountains. There is no place there for a storage reservoir. The supply will have to be got by digging or by some other means.

Here is one of those dry runs that I referred to; that is also to be used in making the supply for Brigham City. In this valley, known as the Devil's Gate Valley, there is a very good place for a reservoir. You will see it marked on the map. The length of the dam is given, and the height of the dam, and the acreage covered by the water when diked.

There is another very good place for a reservoir at the head of Three-mile Creek Cañon. A description accompanies the map, showing where it is practicable to store water. That report will give the information in a more connected form than I can give it.

The CHAIRMAN. Then you need not repeat in detail. As I understand you, your efforts to clean out the streams have been successful. You dig them out in the bottom and straighten the channel, I suppose?

Mr. PETERS. Yes.

The CHAIRMAN. To prevent seepage and evaporation?

Mr. PETERS. Yes.

The CHAIRMAN. And by that means you have extended the water supply largely?

Mr. PETERS. Yes. Of course, generally, we have a great amount of water, but it has been going to waste for many years. Bear River runs through our county.

The CHAIRMAN. Is Bear River sufficient to cover all the land you have?

Mr. PETERS. I think so. We have 150,000 or 200,000 acres of land in our county. That is now what you would call dry. A large part of it is farmed by what is called dry farming. A good deal of it is in the land of the Bear River and the Malad River, which is a brackish stream. That is explained in the detailed report accompanying the map.

The CHAIRMAN. You have not attempted storage in that locality?

Mr. PETERS. No. There is another town called West Portage. They have commenced a reservoir there and have put in a good deal of labor, but they are not able to prosecute their work to a finish, and have had to give it up.

(This witness produced samples of wheat, oats, rye, barley, grapes, plums, peaches, and pears, grown on irrigated land, from Brigham City, Box Elder County, Utah Territory; all being of very fine quality.)

FURTHER STATEMENT OF GOVERNOR ALBERT L. THOMAS.

The CHAIRMAN. Will you please give the committee such further information as you think will be of use to them in their inquiry regarding irrigation so far as it applies to the Territory of Utah.

Mr. THOMAS. I observed that you asked several questions with regard to the control exercised by the county selectmen over the use of water. The fact is that they exercise no control whatever. The courts, on a contest, decided that the legislature attempted to confer on those commissioners judicial powers, which the courts said it could not do. The county courts go further than this possibly, and say that the people of an irrigation district might agree on what is known as water dividers, and they could apportion among the people what they find to be their rights at the time. This apportionment is taken to the county court and there recorded. You will find probably on the records of Salt Lake County an apportionment giving the amount of water that each person is entitled to.

Senator **REAGAN**. Is that under the authority of any law, or from custom?

Mr. **THOMAS**. I should say from custom and by mutual consent. It is in effect an arbitration. I wish to make that point clear at the beginning.

Senator **JONES**. It seems to me that it would be well to embody that into a law.

Mr. **THOMAS**. I have a statement that was prepared by Prof. Marcus E. Jones, which is based on the information that accompanies the county maps I have referred to. I will read the statement.

The statement is as follows:

REPORT ON IRRIGATION AND WATER SUPPLY IN UTAH TERRITORY, 1889.

Hon. ARTHUR L. THOMAS, *Governor:*

DEAR SIR: The annual rain-fall of this Territory will not exceed 8 inches per annum, and were it not for the lofty mountains storing up the water in snow the Territory could not be inhabited. Therefore the settlements are to be found along the streams which are fed by the snow, and they are located chiefly at the bases of the mountains, though running out into the valleys as far as there is water.

The Wasatch, rising over a mile above the valleys, run from north to south through the Territory, a little west of the middle, till they reach Iron County, where they turn to the southwest and fade away in Nevada. Their average height will not fall far below 10,000 feet above the sea.

Nearly east of Salt Lake City the Uintahs, still loftier than the Wasatch, abut on them and run eastward till they pass out of the Territory. These are so close to the northern edge of Utah that we get little benefit from them, while to the south of them is an Indian reservation. Nearly due east of Utah Lake, and about 40 miles from the Wasatch, the Coal range starts from the Uintahs and runs southward parallel with the Wasatch for 160 miles, when it joins them at Panguitch Lake. These three ranges form the water-shed of Utah, the Coal range and the Uintahs forming the rim of the Great Basin, while the Wasatch performs a similar part below Panguitch. The Wasatch and Uintahs are narrow, lofty, and rugged, while the Coal range is younger, lower, and broad. The Coal and Wasatch inclose between them some of the most fertile valleys of Utah. The Wasatch reach their culmination near Salt Lake City, and, aided by Great Salt Lake, give the greatest water supply in the Territory. The streams from this source irrigate the bulk of the cultivated area of Utah.

For ease in comprehension Utah may be divided into three divisions, the moist counties, whose rain-fall exceeds 12 inches per annum, the dry counties, with a rain-fall of 6 to 12 inches, and the hot counties, with a slight rain-fall and great heat.

The moist counties are Cache, Box Elder, Rich, Morgan, Weber, Davis, Summit, Salt Lake, Utah, Wasatch, Uintah, San Pete, Sevier, and parts of Emery, Garfield, Pi Ute, and San Juan.

The dry counties are Tooelle, Juab, Millard, Beaver, Iron, and parts of others.

The hot counties are Washington, Kane, and parts of San Juan, Pi Ute and Garfield.

MOIST COUNTIES.

Cache County is situated in the middle of the northern end of the Territory, at an elevation of 4,533 to 5,000 feet above the sea. All the arable land is in Cache Valley, which lies between two ranges of mountains, the Wasatch forming the eastern boundary. The water supply is 420.13 cubic feet per second, and comes from eight streams and rivers. The whole supply will be in use next year. The area of the county is 633,600 acres, of which 43,154 were cultivated this year. One thousand, seven hundred and ten acres were dry-farmed, and 14,385 acres of crops were lost by lack of water. There are forty canals reported, aggregating 110.5 miles. The irrigating season is 122 days long, and land is irrigated 35 hours per year. The duty of water is less than a cubic foot per second to 100 acres. The average depth of snow in the mountains is 3 feet. The committee report water storage as the only means of increasing the cultivated area, since there are more than 420.13 cubic feet per second running to waste for 243 days, enough to irrigate from 50,000 to 75,000 acres. Many good reservoir sites are mentioned, but details are not given.

It is probable that artesian wells can be obtained in some parts of this valley.

Box Elder County.—This lies in the northwest corner of the Territory. The eastern part is very fertile and well supplied with water, but the western and greater part belongs to the dry counties. The area is 2,767,360 acres, of which 53,280 acres are cultivated, and of these latter 19,190 acres are cultivated but not irrigated. The elevation of the fertile parts is 4,215 to 5,000 feet above the sea. There are 12 canals reported, length 76 miles. A branch of the Great Bear River canal is to irrigate a large area in this county. Large quantities of fruit are raised here, and still greater amounts of small grain and hay. The extensive valley of the Bear has been for half a century the recruiting place for overland travelers by team. Artesian wells are very numerous and add greatly to the productive area. Water storage is the main question here. Five reservoir sites are reported in detail, and several others in general. Bear Lake is the natural reservoir for this and Cache County, and will store all the water that will ever flow into it.

Rich County.—This lies at an elevation of 6,000 to 7,000 feet above the sea, in the northeast corner of the Territory, at the eastern base of the mountains. It is high and cold, raising only small grain, hay, etc. It lies all in one valley; is watered chiefly by the Bear River and some streams that flow into the lake. This land takes little water to mature crops, and much produce is raised without irrigation. The soil is sandy. The area of the county is 497,280 acres. There is no report from this county.

Weber County.—This lies south of Cache, extending from Great Salt Lake through the Wasatch to the headwaters of Ogden River. The best portion lies in Salt Lake Valley at an elevation of 4,315 feet, while Ogden Valley, lying along that river, lies east of the Wasatch and is more elevated. The water supply of the county comes from 17 streams and rivers, flowing 323.66 cubic feet per second. There are 117,600 acres under cultivation, of which 29,400 acres are fully irrigated, while the rest is partially irrigated or dry farmed. The soil is sandy, with clay close to the lake. Five thousand one hundred and seventy-two acres are irrigated from artesian wells. The duty of water is one cubic foot per second for 80 acres, or thereabouts. There are 25 canals, length not given. The irrigating season is 122 to 152 days long. This county is one of the most productive that we have, raising all kinds of fruit and produce that is raised in the Great Basin. The only solution of the water question here is storage. There are over 323.66 cubic feet per second going to waste for 213 days, enough to irrigate 30,000 to 40,000 acres. One reservoir site is reported of small dimensions, while others are reported from Huntsville and Wheeler's Creek, and there are numerous sites at the head of the Weber.

Davis County.—This county lies wholly west of the Wasatch, being south of Weber and north of Salt Lake Counties and between them and the lake. There is very little waste land in this smallest county in the Territory, whose arable land lies wholly in Salt Lake Valley. This county is well watered close to the mountains by numerous small streams, and lower down by multitudes of artesian wells. Many acres are not irrigated. This county is full of orchards, gardens, and fields, while roots, small grain, and hay are raised in abundance. The elevation is 4,215 to 4,500 feet above the sea. The area is 160,000 acres. The soil is sandy but with clay near the lake. There is no report from this county.

Morgan County.—This lies directly east of Davis, on the east side of the Wasatch, and occupying Weber Valley as far as Croyden. This is elevated nearly 6,000 feet above the sea, and is only adapted to small grain, root crops, and hay. The water supply is fair and the opportunities for storage good. The area is 675,840 acres, of which about 10,000 acres are cultivated. The soil is chiefly sandy.

Summit County.—This county lies almost wholly in the upper valley of the Weber, and includes Parley's Park. It occupies the angle between the Wasatch and the Uintas, and lies north of the latter. Its cultivated land is elevated 6,000 to 8,500 feet above the sea. It is cold and best adapted to small grain and hay. Much produce is raised without irrigation, and only a small amount of water is required per acre to mature crops. The valley of Weber is a succession of green fields for many miles, while on Chalk Creek and other tributaries are scattered many farms. The area of the county is 2,419,200 acres, of which 7,500 are under cultivation. This county also reports storage of water as the only means of increasing its cultivated area. Deep artesian wells might be successful here. The soil is sandy.

Salt Lake County.—This county lies between the south end of the lake and the Wasatch Mountains, occupying all of the southern end of Salk Lake Valley and lying between the Oquirrh and Wasatch Mountains. This county takes the lead in water supply and position, since the valley is 10 miles wide and 20 miles long, runs north and south, and is watered by the Jordan and by numerous large streams that flow down from the heart of the Wasatch. There are also a few streams flowing from the Oquirrh Mountains. Throughout the lower part of the valley thousands of artesian wells are flowing. The soil is sandy in the upper and clayey in the lower part of the valley. The elevation is 4,215 to 4,500 feet above the sea. The area of the county is 614,400 acres. The cultivated land is 38,587 acres. The water supply is 365.5 to 425.5 cubic feet per second, all in use. The irrigating season is one hundred and twenty-two to one hundred and fifty-two days long, and the duty of water is about 1 cubic foot to 80 or 100 acres. The rain-fall during the irrigating season is only 7.882 inches, being more than double that in many other parts of the Territory.

There are 13,668 acres of lucerne raised; hay, 2,215 acres; small grain, 13,566 acres; roots and vegetables, 3,470.5 acres, and fruit, 1,628.5 acres. There are thirty-seven canals with an aggregate length of 213.8¾ miles. There is enough water running to waste outside of the irrigating season to redeem 44,000 acres. There are eleven reservoir sites in the mountains reported in detail, aggregating 50,250,000 cubic feet, and several others of good size not reported. There are four sites reported in the valleys, and one of them, Utah Lake, if raised 2 feet would irrigate 53,000 acres, and if raised 5 feet would irrigate 133,000 acres. But this lake can never be filled in a dry season; the total inflow last winter was only enough to raise the lake a foot, and for other reasons hereafter given it will never cut much of a figure as a reservoir. The average depth of snow in the mountains is 4 to 10 feet. The relative humidity for the year is 48.3 per cent.; during the irrigating season it is 42.3 per cent. The annual temperature is about 51.2 degrees.

Utah County.—This county lies chiefly in the beautiful Utah Valley with its large fresh-water lake in the center, 80,000 acres in area. Most of the arable land is in this valley, but there is considerable arable land on the Spanish Fork River. The elevation is about 4,600 to 4,800 feet above the sea. Though it is some higher than Salt Lake Valley it is nearly as warm, because of sloping towards the sun. The area of the county is 1,344,000 acres, of which 69,126 acres are cultivated. The irrigating season lasts about 122 days. The duty of water is reported as 40,000 cubic feet per year, but it is probably not less than 1 cubic foot per second for 100 acres. The water supply comes from fourteen streams and one river, whose flow in July was 308 cubic feet per second. There are sixteen canals reported; length, 66.2 miles. There are many artesian wells in the valley. They lost 28,965 acres of crops this year by lack of water. There are eight reservoir sites given in detail in the mountains and two in the valleys; capacity 791,000,000 cubic feet. There are five additional sites given in the valley and nineteen in the mountains; capacity not specified. Enough water runs to waste to irrigate 50,000 acres. About the same amount of rain falls here as in Salt Lake Valley. The average depth of snow in the mountains is 4 feet. The soil in this county is mostly sandy. Along the Spanish Fork River are many farms with an elevation of 5,500 to 6,500 feet above the sea whose supply of water could be greatly increased by deep artesian wells.

Wasatch County.—This lies east of the Wasatch, and the inhabited portion is west of the Coal Range, being south of Summit and east of Utah County. The settled part is a triangular valley at the eastern base of the Wasatch, called Provo Valley, since it lies along the Provo River. This is some 6,000 feet above the sea, has 18,000 acres of cultivated land, and 32,000 acres that could be reclaimed by more water. The water supply is not given, but one-half the crops were lost this year by lack of water. There are 14.5 miles of canals reported. Five reservoir sites are reported, capable or irrigating 14,000 acres. This valley raises small grain and hay chiefly. Water storage is a necessity if the present acreage is to be preserved, to say nothing of extending it. The greater portion of this county of 1,344,000 acres lies east of the coal range on the reservation. There are hundreds of acres there that produce abundant crops of hay when stock is kept off from them.

Uintah County.—This county is situated east of Wasatch, Summit, and Emery Counties. It is mostly an Indian reservation; but just south of the Uintahs is a small cultivated area not on the reservation. The area of the whole county is 4,000,000 acres. The cultivated area is 8,932 acres. The soil is partly sand and partly clay. The elevation of Ashley Valley runs from 4,400 to 5,000 feet. The irrigating season is from 178 to 198 days long, and the duty of water is given as 20,000 to 50,000 cubic feet per acre, but this is doubtless far too small. It takes a trifle more water for clayey than for sandy soil. It takes the same amount of water for small grain as for lucerne, a trifle more for root crops, and one-half as much for orchards. There were 970 acres of crops lost this year from lack of water. The average depth of snow in the mountains is 6 feet. Several good reservoir sites are mentioned. The supply of water in Green River is unlimited, and much land could be reclaimed by proper dams in this river. The supply of water on Ashley and Brush Creeks is quite limited, but could be greatly increased by reservoirs.

San Pete County.—This county occupies an elevated valley between the Wasatch and coal range, and south of Utah County. It is the valley of the San Pitch River and a part of Thistle Valley. The former runs southward from the head of Thistle Creek for 45 miles till it joins the Sevier Valley. The elevation is perhaps a thousand feet or more higher than Salt Lake Valley, and the rain-fall is less. The water supply comes from both sides of the valley in numerous small streams, but the greater number come from the east. This has been called the granary of Utah. The chief product is small grain. The irrigating season lasts 107 to 183 days. The duty of water is about 1 cubic foot per second to 90 acres. Each acre is irrigated 120 hours. Many acres of crops were lost this year through lack of water. The average depth of snow in the mountains is reported as 6 feet. Several reservoir sites are mentioned.

The area of this county is 1,164,800 acres. The amount under cultivation is not reported.

Sevier County.—This county occupies the southern part of the great valley which lies east of the Wasatch and west of the coal range, running from Thistle on the north to Panguitch on the south. This great valley, over 125 miles long, is called the San Pete on the north and the Sevier on the south. It is lowest in the middle where the southward flowing San Pitch and the northward flowing Sevier Rivers unite, and breaking through the Wasatch pass out westward upon the desert in Millard County.

The only arable land in this county lies in the Sevier Valley, which in this county is several miles wide and 50 miles long. It is watered chiefly by the Sevier River, but there are many small streams and springs coming from the mountains on either side. The river measured 70 cubic feet per second at Joseph City on July 26, 1889. No other measurements are reported. There were reported eleven canals aggregating 107.5 miles in length.

The area of the county is 993,280 acres, of which 25,000 acres are under cultivation; all but 7,000 acres are watered by the Sevier River; 100,000 acres could be irrigated if there were more water. There are 2,634 acres of lucerne raised, 11,982 acres of small grain, 710 acres of root crops and vegetables, and 178 acres of orchards.

The elevation of the lower part of the valley is about 5,500, feet and the irrigating season is 244 days long. Some fruit is raised here.

The upper part of the valley is from 6,000 to 7,000 feet above the sea, the irrigating season is 122 days long, and small grain and hay are the chief products. The soil is sandy and very productive.

There are none of the thinly populated counties that have such possibilities before them as this; for there is enough water to irrigate the whole valley if it is properly stored. The depth of snow in the mountains in winter is about 6 feet. Six reservoir sites of great capacities are reported in the mountains. All the present water supply is utilized. Deep artesian wells are possible in some parts of the valley.

Pi Ute County.—The cultivated portion of this county lies in or near the heart of the Beaver Mountains, south of Sevier County, and at the junction of the coal range with the Wasatch. The valleys are elevated and cold, being 5,400 to 7,000 feet above the sea. The irrigating season never exceeds one hundred and seventy-three days. The duty of water is not more than one cubic foot to 100 acres. The land is irrigated from twenty to forty-eight hours per annum. The water supply is 217 cubic feet per second; comes from eleven creeks and rivers, and in some localities is not all in use, while in other places 400 acres were lost and many more injured by lack of water. There are 31 canals. Ten reservoir sites are reported of such capacity as to irrigate 15,000 additional acres, more land than there is to cutivate, The average depth of snow in the mountains is 4 to 5 feet.

The area of the county is 2,368,000 acres. The cultivated area is 12,135 acres, lying in Sevier, Grass and Rabbit Valleys. But little fruit is raised in this county.

Garfield County.—The western part of this county also lies in the heart of the Beaver Mountains, and its cultivated valleys are all elevated 5,835 to 6,273 feet above the sea and cold; best adapted to hay and grain. The irrigating season lasts ninety-seven days, and the duty of water is slight; the land is irrigated but twenty-five days during the year. The water supply is not given. There are 34 canals.

The area of the county is 2,892,800, of which about 5,000 acres are cultivated. Four reservoir sites are definitely reported, and many others are mentioned; enough to irrigate several times all the arable land in the county. Some of these sites could be used to help out Kane and Washington Counties.

DRY COUNTIES.

The larger part of these counties is arable land, and can never be reclaimed because of being destitute of any water, either present or prospective, while the eastern edge of these counties might almost be classed with the moist group.

Box Elder County.—This county lies in the northwest corner of the Territory and is the least arid of them all. The western portion has a few farms and some meagre streams, while that portion next to the lake is susceptible of artesian wells and is quite productive. The mountains in this portion are so low and lose their snow so early that water storage is out of the question.

Tooele County.—This county lies west of Great Salt Lake and Salt Lake County. It is very large, containing 4,140,800 acres, of which only 6,250 acres are cultivated, and these lie chiefly in one valley (Tooele). This valley is a broad one, lying between the Oquirrh and Aqui Mountains, from which it receives its water in eight small streams aggregating 78¼ cubic feet per second. These mountains do not rise high enough to give water all the season. This valley is being greatly developed by artesian wells.

Rush Valley is a magnificent one, being the southern extension of Tooele Valley. There are 200,000 acres that could be redeemed here alone, but there is no surface nor artesian water to be had. Reservoirs might catch some water.

Skull Valley is another large tract lying directly west of the Aqui Mountains. This is capable of artesian wells, and has a small supply of surface water. It is undeveloped.

On the western edge of the county near Deep Creek is some cultivated land.

There are 1,000,000 acres of good land that could be redeemed if there were water for it, but by fully developing all resources by storage and otherwise 100,000 acres is an outside limit of the acres that will ever be cultivated in this county with the present rain-fall.

The elevation of the valleys is 4,400 to 5,000 feet above the sea. All kinds of fruit and produce can be raised here that are raised in Salt Lake County. The duty of water is 1 cubic foot per second to 80 acres, and the irrigating season runs from 122 to 200 days. Several good reservoir sites are reported.

The average depth of snow in the mountains bordering Tooele Valley is 3 feet. The soil is so gravelly near the mountains that fully one-half of the water is lost by seepage before it gets to the fields. Water storage and fluming the canals are the crying needs of this county.

Juab County.—This county lies south of Tooele and runs from the Wasatch to the western boundary. The area is 2,457,600 acres, and fully one-half of it is level land that could be redeemed by water, but outside of artesian wells there is no hope for most of this county. Four thousand acres are reported under cultivation beneath the shadow of Mount Nebo.

All kinds of fruit and grain are raised here that the Great Basin produces. The elevation of the valleys is from 5,000 to 5,500. The average depth of snow in Mount Nebo is 3 feet. Several good reservoir sites are reported. Nearly one-half of the crops were lost this year by lack of water. Water storage and artesian wells are the only hope of this county.

Millard County.—This county lies south of Juab and runs from the Wasatch to the western boundary. This is one of the largest counties in the Territory and has the largest amount of arable land of any, if there were only water for it. The area of the county is 4,492,800 acres, and over one-half of it is good land. Artesian wells are being developed in this county, but generally the flow is so slight that the water is valuable only for drinking.

The settlements lie along the western base of the Wasatch and along the Sevier River. They are from 5,000 to 6,000 feet above the sea, and produce large quantities of fruit, small grain, and lucerne hay. The irrigating season runs from 90 to 122 days. There are 13,500 acres reported as under cultivation; 1,000 acres were reported as lost and much more as injured by lack of water this year. The soil is sandy near the mountains and clayey in the Sevier Valley. There are 42 miles of canals reported. Water storage is not only an imperative necessity in this county, but it is practicable. Much water runs to waste in the Sevier River; probably triple what is used. There are many good sites along the river where from 1 to 3 square miles of water several feet deep could be held back. Back of Scipio a natural lake, now used as a reservoir, could hold 5 square miles of water of considerable depth. It is said that the Sevier River could be turned into it.

There are several good sites in the Wasatch.

Beaver County.—This county has an area of 1,689,600 acres, of which one-fourth is good land; 9,500 acres are reported under cultivation. This county lies south of Millard and runs from the Wasatch to the western boundary. The upper valleys are 6,000 and the lower about 5,000 feet elevation.

The irrigating season lasts ninety-one to one hundred and twenty-two days. The land is irrigated twenty-nine to thirty-two hours per year. There are 45 canals, length not given. The settlements lie chiefly along the Beaver River and its tributaries.

The average depth of snow in the mountains is reported as 8 feet. The Wasatch here rises to a great height and snow lies on the mountains all the year round; 25 reservoir sites are reported in detail, aggregating 17 square miles, sufficient to irrigate 20,000 acres at least; about 10 of these reservoirs are in the valleys and the remainder in the mountains.

Iron County.—This county lies south of Beaver, on the rim of the Great Basin, running from the Wasatch to Nevada. Its area is 2,102,400 acres, and nearly half of it is arable land, some of it capable of artesian wells, but most of it destitute of water; 6,997 acres are reported under cultivation. The irrigating season is given as 142 to 269 days. The elevation of the valleys runs from 5,400 to 6,100 feet above the sea. The duty of water is given as 1 cubic foot to 65 acres in the more arid valleys and from 160 acres to more than double that in the moist valleys. The water supply comes from 8 small streams, capacity 67.63 cubic feet per second. The land is irrigated from fifteen to forty-two hours per year. If the water could be saved, from

10,000 to 20,000 acres could be redeemed 14; reservoir sites are reported in detail. Water storage is the only means of developing the agricultural resources of this county. The soil is chiefly clay.

Emery and Uinta Counties.—To this group belong parts of these two counties, which lie between the Green and Grand rivers. There are many thousands of acres of clayey soil that could be reclaimed by great canals running from these rivers, whose unlimited water supply, greater than all the rest of the Territory put together, will run to waste without assistance is given in constructing such canals. There is no part of the Territory that needs developing more than this. Very deep artesian wells might be successful here.

Emery County.—But a small part of this county belongs to the Dry Counties, still nearly all of the cultivated area lies in that section on the extreme western side of the county. This lies directly east of San Pete and Sevier Counties at the foot of the coal range.

The rainfall does not exceed 10 inches per annum. The water supply comes from four creeks and one river, breaking through the precipitous eastern face of the coal range in narrow cañons. The flow of water is 171.15 cubic feet per second. The area of the county is 5,603,680 acres. The cultivated land is 14,825 acres. The soil is a very refractory clay. The duty of water is 1 cubic foot to about 35 acres. Castle Valley is 4,500 feet above the sea, and the irrigating season is 229 days long. Little Grand Valley is 3,900 feet above the sea, and its irrigating season is 244 days long. There are 34 canals, length not given. One-quarter of the crops was lost this year through lack of water. All the water is in use.

The average depth of snow in the mountains is 4 feet. Twelve reservoir sites are definitely reported, and many others are mentioned. There is enough storage to use double the total water supply. Probably 10,000 to 15,000 acres more could be irrigated by saving the waste water. Great suffering often results from scarcity of water in this county.

All kinds of crops are raised this county, even sugar-cane, fruit, pea-nuts, etc. Figs could be raised in the hotter portions.

HOT COUNTIES.

These counties are far more arid naturally than the dry counties, since they are farther from the lofty mountains, and most of the arable parts are 2,000 or more feet lower, lying in deep valleys shut out from winds and surrounded by great fields of lava with red hills and a red, sandy soil of unknown depth. The heat here is almost unendurable and the rain-fall is almost nothing. This region is valuable for the fruit and cotton that it raises.

Washington County.—This county is situated in the southwestern corner of the Territory. The area is 1,649,920 acres. Of this, 18,892 acres are cultivated. These are situated along the Virgin River or its tributaries chiefly. It is estimated that 18,900 acres could be redeemed by an increase of the water supply. The lower valleys are 2,700 and the upper 4,000 feet above the sea. In the lower valleys the irrigating season is 197 to 228 days long, in the upper 122 to 177 days. The water supply comes from the Virgin River, four streams and many springs, capacity 191.8 cubic feet per second. In the lower valleys the land is irrigated 84 to 90 hours per year, and the duty of water is 1 cubic foot per second to 20 acres. In the upper valleys the land is irrigated 26 hours per year and the duty of water is 1 cubic foot per second to 60, 80 and 128 acres. There are 31 canals, length not given. One-third of the crops were lost this year by lack of water. It is probable that water enough could be stored to redeem most of the arable land in this county. Vast quantities of water go to waste in the Virgin River in the winter and flood time in spring. The depth of snow in the mountains is 2 to 6 feet. This county raised 30,000 pounds of cotton last year. The Sultana seedless grape is grown here and produces from 3,000 to 5,000 pounds of the finest quality of raisins. Both the hard and soft shell almonds are raised in quantities here as well as figs. It is believed that oranges can be raised here. Olives are grown in this county. Peaches and apricots from this region are very fine. They raise 4 to 5 crops of lucerne per year. A crop of small grain and another of corn are raised from the same land.

Kane County.—This county is more rugged than Washington and more elevated except along the Colorado River. It lies east of Washington. The area is 2,659,200 acres, of which 1,825 acres are cultivated, and 13,350 acres are said to be arable. The irrigating season is 182 days long, and the duty of water is from 37½ to 75 acres to the cubic foot per second. The water supply, exclusive of the limitless Colorado River, is 31 cubic feet per second. There are 9 canals, length not given. The crops are greatly damaged by lack of water. Sufficient reservoir sites are reported to irrigate all the arable land in the county. The average depth of snow in the mountains is 4 feet.

The crops in this county are much the same as in the foregoing, though more small grain and hay are raised in proportion to the area cultivated.

San Juan County.—This county lies in the southeastern corner of the Territory. Most of it is now proposed to be made an Indian reservation. Its area is 5,809,920 acres. There is a narrow strip of land along the Colorado and San Juan Rivers that will produce the crops of Washington County, and has an unlimited water supply. Most of the cultivated area is 5,000 feet above the sea, near the La Sal Mountains. There are 1,025 acres cultivated. Dry farming is successful in some localities in the mountains. There are good facilities for storage of water.

Other counties.—Small parts of Garfield and Pi Ute Counties situated along the Colorado are capable of raising the same products as Washington County.

To sum up we find there are about 500,000 acres of land under cultivation at the present time. This area could be doubled from the present canals if there were more water and by new canals, etc. The various counties estimate that about 3,500,000 acres could be redeemed. This is doubtles three and a half times too large. The average depth of snow in the mountains is 4 feet. The length of the irrigating season in the moist counties is one hundred and fifty-two days; in the dry counties it is about the same in cultivated areas; in the hot counties it is about two hundred days. The returns are very unsatisfactory in this respect and must be wholly revised. The duty of water is about 80 acres to the cubic foot per second in the moist counties, in the dry counties it is uncertain, and in the lower hot counties it is about 20 acres. The water supply is about 3,000 cubic feet per second for the moist counties, 250 for the dry counties, and 250 for the hot counties; total 3,500 cubic feet per second. This is probably our minimum water supply throughout the driest years in the counties reported. If we were to add the supply in the Green and Grand Rivers this amount would be more than doubled. Almost all of the present supply is appropriated during the irrigating season and our Territory must remain at a stand-still without water storage. There are 150 reservoir sites reported in detail and nearly as many more mentioned. They vary in capacity from 130 square miles to one acre, and from 2 feet to 100 feet deep. About one-third of the crops were lost this year through lack of water.

Utah, Nevada, and Arizona are the most arid portions of the United States, and therefore the preservation and economical use of all their water supply is an imperative necessity. To show how we differ from Colorado and the East, I have prepared a diagram of the average monthly rain-fall of Salt Lake City for thirty-three years, and of Denver, Colorado, and Des Moines, Iowa, since the beginning of observations there.

During the irrigating season here Des Moines, a place where irrigation is not necessary, has a rain-fall of over 2 acre feet and Denver almost 1 acre foot, while Salt Lake has less than two-thirds of an acre foot, which would make a difference of about 11,000 cubic feet to the acre, which must be made up by that much more water from the streams to irrigate our land as well as that of Colorado is irrigated. But during the same period the relative humidity of Denver is 3 degrees higher and the temperature 2 degrees lower, which would greatly increase the amount of water required to irrigate an acre of land in Utah in proportion to that of Colorado. Besides this, Denver is nearly 50 miles from the crest of the mountains, from which a part of its moisture is derived, while Salt Lake City is but 10 miles and has a lake of 2,000 square miles in area within 7 miles on the other side. These things make Denver fairly representative of northern Colorado in general, while they show Salt Lake City as the place with at least 50 per cent. more rain-fall than the rest of the Territory (save the mountains themselves) and with a very abnormal humidity. Therefore what applies to Salt Lake in the great amount of water required per acre will apply with redoubled force in the dry and hot counties.

We have had evaporating pans located in various parts of the Territory for the last two months, and though these were of necessity placed out of the reach of the wind the evaporation averaged three-tenths of an inch per day, often running up to five-tenths of an inch. Had they been placed where the wind could have reached them the evaporation would have equaled 15 inches per month. The enormous drain upon our water supply can therefore be well understood. This militates against shallow reservoirs in the valleys. If Utah Lake were raised 3 feet its water would all be evaporated during the irrigating season if none flowed in or out. Enough to irrigate 83,000 acres would go up in the air. From records kept in the mountains the evaporation there during the same period was only eight-hundredths of an inch, and never exceeded seventeen-hundredths per day. Therefore reservoirs in the mountains are at least four times as valuable as those in the valleys. We do not yet know the rain-fall in the heart of our mountains, but it will not fall far short of 40 inches nor more than 60 inches per annum. It should be observed that though we have 2 inches more rain-fall in Salt Lake than in Denver, yet but 46 per cent. of it falls during the irrigating season while 73 per cent. of Denver's rain-fall comes when it is needed most.

The possibility of reclaiming Utah by artesian wells has been greatly overestimated. All the wells so far obtained have been found in some one of the basins of the ancient

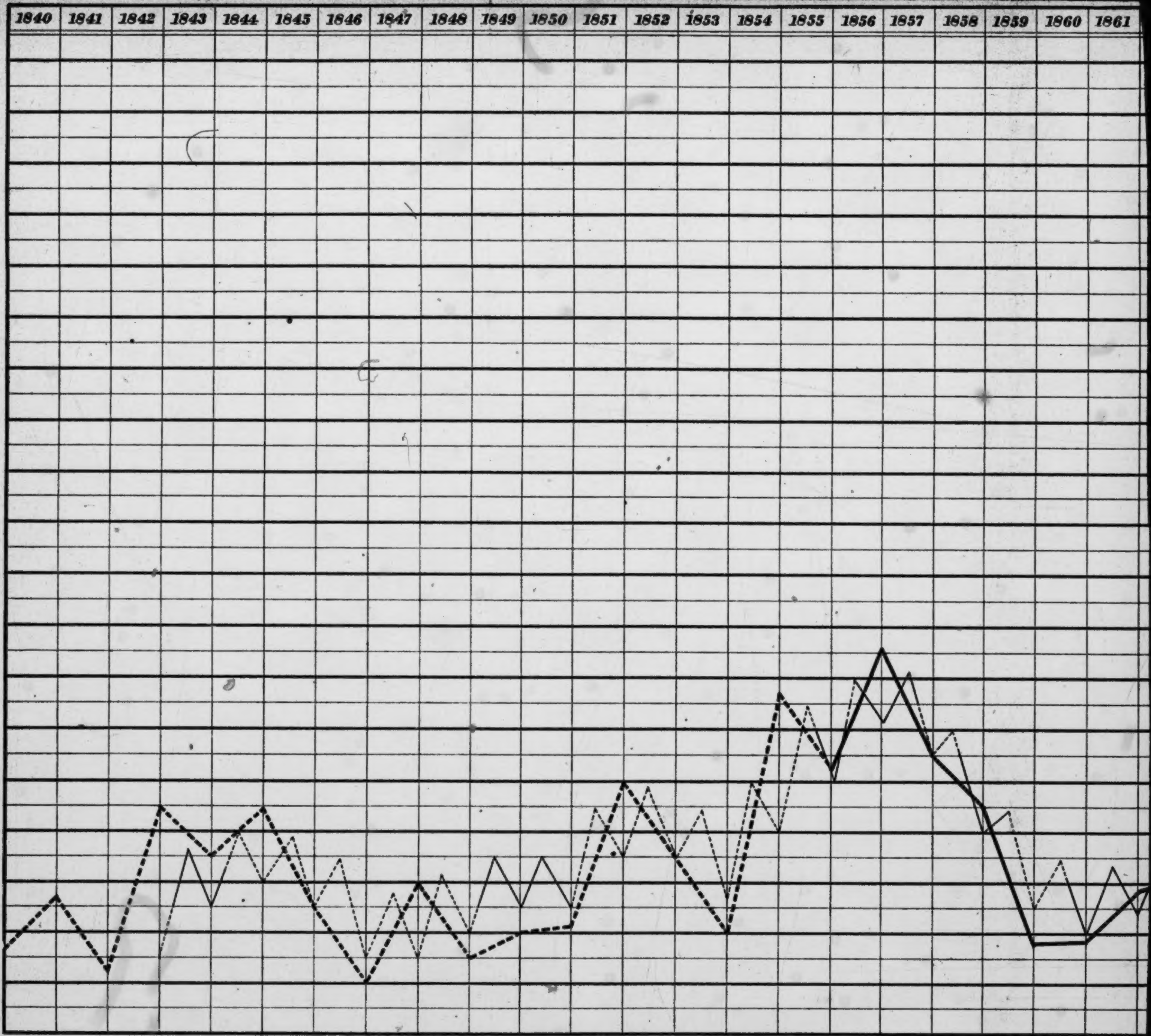
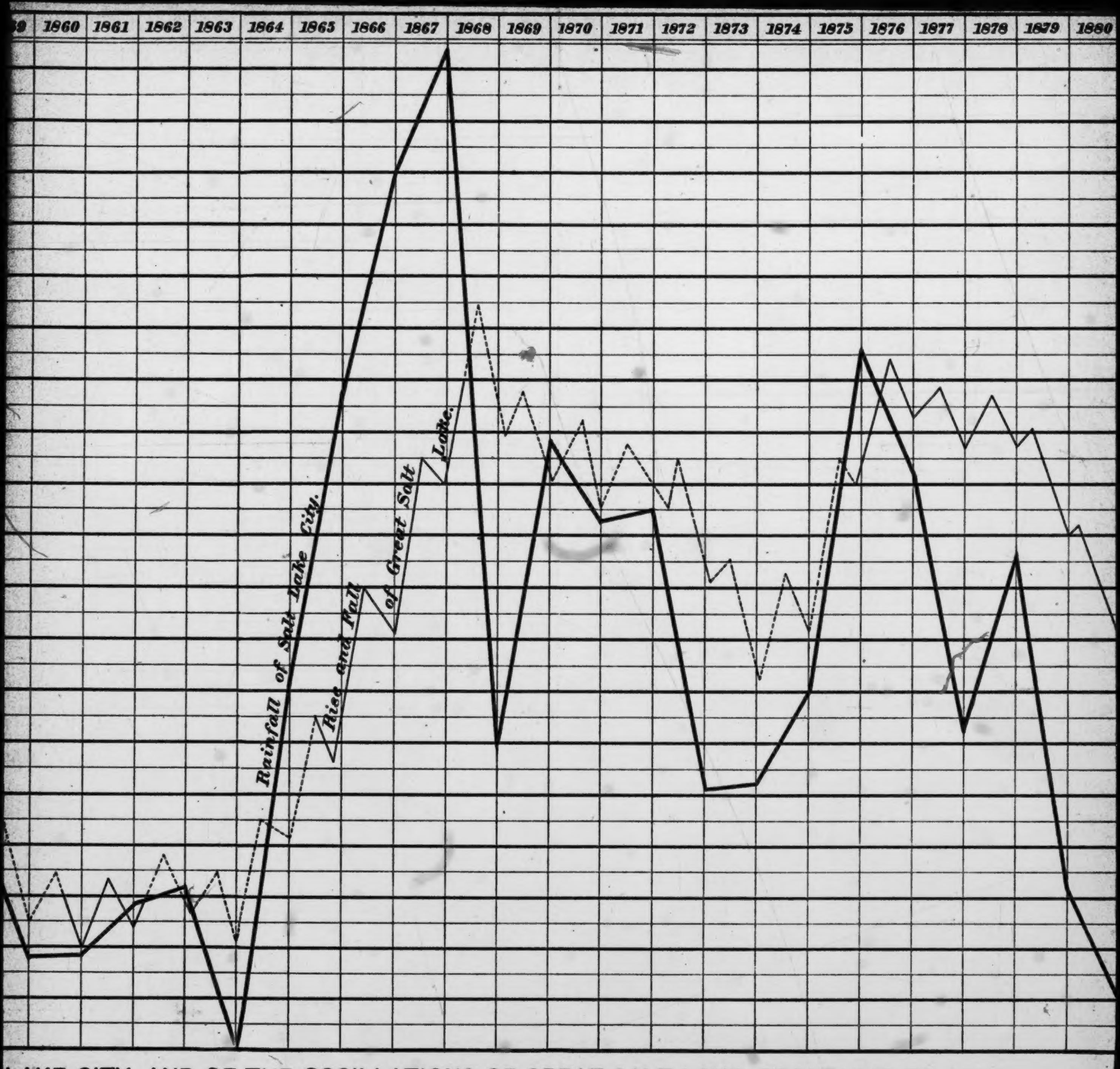
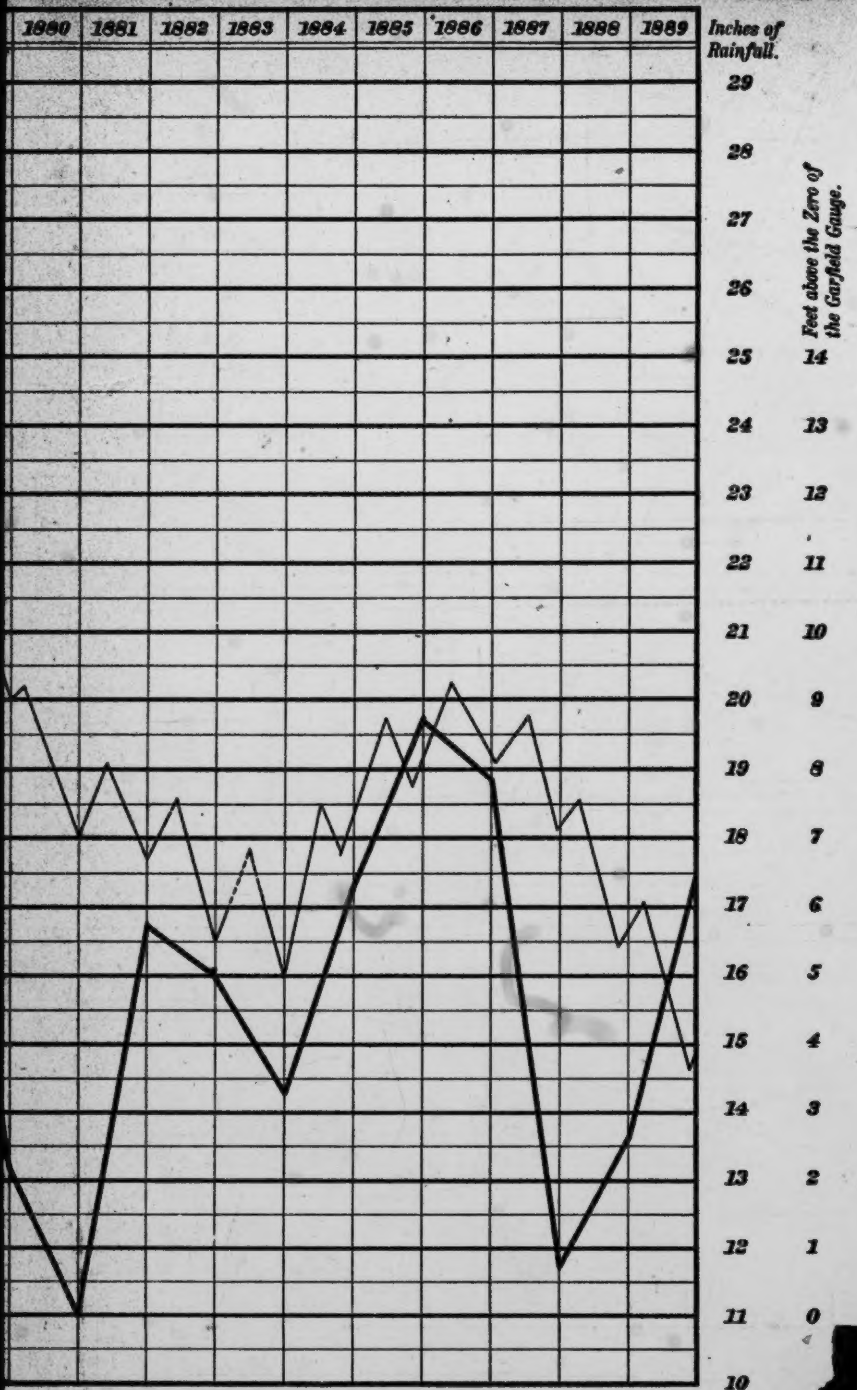


DIAGRAM OF THE RAINFALL OF SALT LAKE CITY,



LAKE CITY, AND OF THE OSCILLATIONS OF GREAT SALT LAKE, FROM 1840 TO 1890.

BY MARCUS E. JONES.


1880
1881
1882
1883
1884
1885
1886
1887
1888
1889
Inches of Rainfall.
29
28
27
26
25
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
Feet above the Zero of the Garfield Gauge.
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0

lake of which Great Salt Lake is the saline remainder; the area of that lake never exceeds 18,000 square miles. The clay sediment from that lake makes the impervious cap of those subterranean reservoirs, whose rims are but slightly elevated above the villages, and the reservoirs are fed from the bases of the mountains where the surface water runs over the gravel débris between the mountains and the clay rim. The average depth of these artesian wells in Salt Lake Valley is about 100 feet, in Utah Valley 200, and in Tooele about the same. In Millard County a few wells have been driven with a depth of about 200 feet and a flow of one-half to 10 gallons per minute through 1¼ inch pipe. Since no solid rock is struck in driving these wells they are very liable to clog up in a few years. The flow in Salt Lake Valley will not average 25 gallons per minute, though some wells far exceed that. A well flowing five gallons per minute will irrigate an acre of ground.

STATEMENT OF MARCUS E. JONES, OF SALT LAKE CITY.

The CHAIRMAN. The committee will be glad to hear anything that you have to say in regard to irrigation here or elsewhere.

Mr. JONES. Perhaps it is hardly worth while for me to say anything in general, but there are two or three points that I would like to correct. It has been stated, for example, that our rain-fall is liable to increase. There is no evidence whatever of that. On the other hand, the evidence is all the other way. The rain-fall of the United States in general reached its maximum in 1879 or thereabouts, and from that time to this the rain-fall, in the western part of the United States at least, has been decreasing, and it is now considerably lower. The average rain-fall of Salt Lake City for thirty-three years is given as 17.26 inches. I have worked the rain-fall out as far back as 1843 from the oscillations of the Great Salt Lake, and the average rain-fall will run but a trifle above 16 inches. My diagram [exhibiting it] represents for a period of fifty years the rain-fall of Salt Lake City.

The CHAIRMAN. Explain to the committee a little how you worked that out from oscillations. How can you get at it in that way?

Mr. JONES. I have a diagram here that will explain it. The heavy marks in the diagram are the rain-fall, while the somewhat fine marks are the oscillations of the great Salt Lake. The oscillations of that lake are about 14 inches per annum, as an average, right through. The oscillations of the Great Salt Lake follow the oscillations of the rain-fall with remarkable accuracy. That diagram begins at 1814 and runs to 1889, and the observations shown there are the ones that are recorded. We have a gauge at the lakes that is read every two weeks, and from it the oscillations are made out.

Senator JONES. What do you mean by oscillations—the rise and fall?

Mr. JONES. Yes; it rises 14 inches on an average and falls 14 inches. Last year it fell 20 inches instead of 14. This year it will fall 3 feet perhaps.

The CHAIRMAN. May not the taking out of the water by irrigation affect it?

Mr. JONES. No; there has been no appreciable effect for forty-seven years. It makes no difference apparently. All the water goes back.

Our correct record goes back to 1856. Then, from 1847 to 1856 I have made out that rain-fall from the daily or weekly paper that was published at that time, and from the diaries of old residents who wrote down whenever there was a rain. Rain is a very important thing here, and they wrote down the dates and the character of the rainfall. From that I have been able to make out this diagram with reasonable certainty to 1847. Beyond and back of 1847 I have not put in the oscillations of the lake, but I shall do so back to 1843 when I have an opportunity.

From 1847 back to 1843 I make out the oscillations of the lake in this way: When General Fremont came here he states that there was a certain percentage of chloride of sodium that was obtained by boiling down the salt of Salt Lake. The more solid that lake is the more it precipitates the less soluble elements and the longer it holds the more soluble elements. Consequently Fremont's residium being nearly all salt shows that the lake was almost saturated with salt, and in that case it must have been 4 feet lower than it is now. Fremont speaks of going across from the main-land to Antelope Island dry shod. That point is 4 feet lower than at present. Consequently the lake must have been 4 feet lower than it is now. From that I make out the rain-falls; because if that were 4 feet lower than it is now it could not have had a rain-fall of more than 13 inches and probably not more than 10. The rain-fall diagram I have made out in the hypothetical way as far back as 1814 by taking the rain-fall records of Philadelphia, Boston, Marietta (Ohio), and some other places. A diagram like this can be made up from data bearing upon other places which very nearly coincide with each other. By putting down my Salt Lake curve below these (of course ours will be from 14 to 20 inches below theirs) I find our curve follows their curve, only that it is about a year behind all the time.

The CHAIRMAN. Since you kept a record you found that it follows theirs, but that it is a year behind?

Mr. JONES. Yes; whereas the curve of San Francisco will follow their record, only that it will be two years behind. Consequently moisture goes westward, contrary to what people have supposed. When I came to where our rain-fall curve stops I could supply it approximately to the beginning of our observation. That is only approximate, but it is valuable notwithstanding. From the rain-fall curve you will see that the rain-fall of the whole country increased in 1814, when the observations began, to 1876, 1877, and 1878. That was the climax of rain-fall, not only in Salt Lake City, but in the whole country. From that time to this it has been going down. The lake is now within 4 feet of the Stansbury record of 1849.

The CHAIRMAN. Have records been kept in any part of the world to know whether this diminishing record of the rain-fall is permanent?

Mr. JONES. It apparently runs by cycles.

The CHAIRMAN. We go down a point and then come up again?

Mr. JONES. Yes. The oscillations of the Salt Lake are shown by a line on the diagram while another line shows the rain-fall. It is not altogether regular, but is comparatively so. There is a three years' oscillation and a nine years' oscillation, and there is a pretty well defined thirty years' oscillation. I am satisfied that it goes in larger and larger cycles all the time.

Senator JONES. What line is this [indicating a line on the diagram]?

Mr. JONES. The old storm line of the lake when Stansbury was here in 1849. This [another line] represents the new storm line. They are about 6 feet apart.

Mr. NEWELL. The vertical lines are years?

Mr. JONES. Yes.

Mr. NEWELL. What do the horizontal lines represent?

Mr. JONES. Inches and feet. In other words, Great Salt Lake is twelve times as sensitive as the rain-fall. Secondly, we must look to the oscillations of the lake to help us out where the records of the rain-fall are too slight to be appreciable.

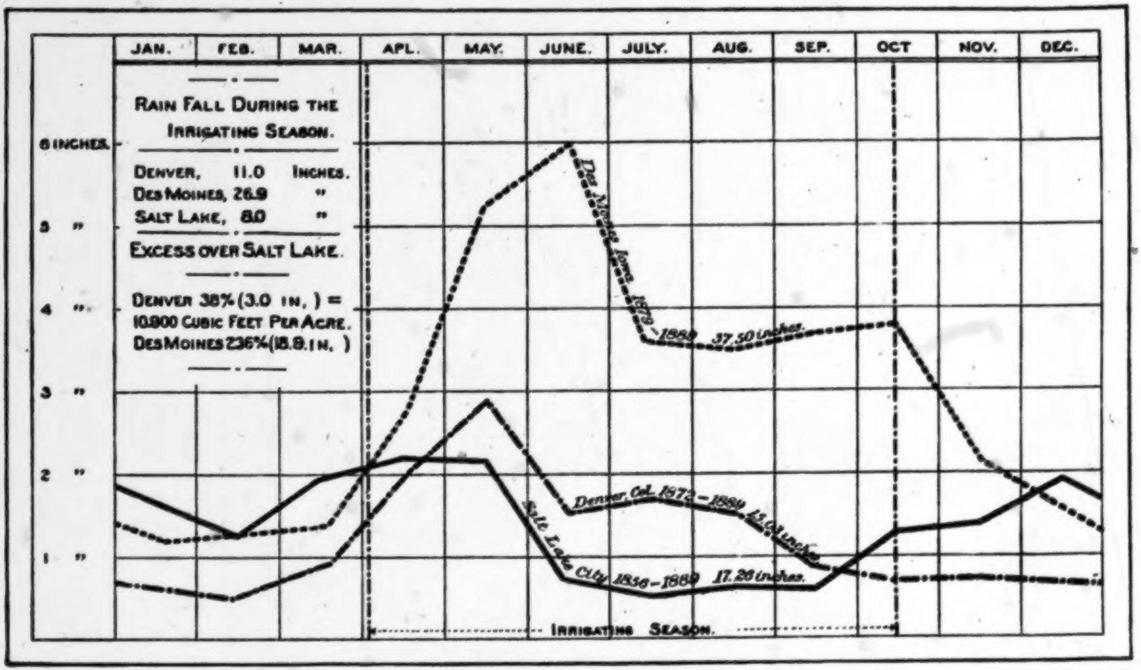


DIAGRAM OF MONTHLY RAIN-FALL (AVERAGE).

Report on Irrigation.

Senator JONES. I understand that the rain-fall reached that point in the year indicated on the diagram?

Mr. JONES. Yes.

Senator JONES. Then these are inches as to the rain-fall?

Mr. JONES. Yes.

Senator JONES. And they are feet as to the oscillations of the lake?

Mr. JONES. Yes.

The CHAIRMAN. Have you a written explanation of this diagram?

Mr. JONES. No; it was made for my own use. It is the result of ten years of study.

The CHAIRMAN. Have you published it?

Mr. JONES. No.

The CHAIRMAN. Do you propose to publish it at some time?

Mr. JONES. I suppose, sometime, when I get it complete. You gentlemen may have a copy of it.

The CHAIRMAN. We will be very glad to have it.

Mr. THOMAS. We will have a copy of it made with a description to accompany it, and sent to the committee.

Mr. JONES. I have been compelled to take the Fort Douglas rain-fall curve, which is not only erroneous but we do not know which way it goes. We do not know whether it is 2 inches too little or 2 inches too much. So, for a period of five years this diagram is liable to correction.

With regard to artesian wells there is one point that I wish to speak of. I heard Major Powell explain a little to you, so that I will not need to go over the whole subject:

Lake Bonneville, of which Salt Lake is the remainder, covered about 18,000 square miles. There were a number of depressions in that lake—Salt Lake now occupying the lowest and Sevier Valley being one of the highest ones. Then Tooele Valley and the desert out here, and others, connected with a smaller depression. The lake deposited sediment to the depth of 200 feet—two layers of clay, then sand. I have a record of several hundred feet down, and every 6 feet downward there is an alternation of clay and sand. After you go down through the first stratum of clay, which Professor Gilbert speaks of as a white clay or marl, you come to a small stratum of sand which gives out brackish water. Then you get to a sandstone that was evidently placed there before Lake Bonneville began. Whenever you strike that you get a flow of water, if you are in one of these artesian basins. The rim of the basin is very slight, probably never over 50 feet above the bottom of the valley. In some places it is 60 feet; but on an average not over 50 feet above the bottom of the valley where the artesian waters are to be found. They get an average of say about 25 gallons per minute. These wells have been considered to be the solution of the irrigation question in this Territory. But in the course of three years they cave in and people have to construct them over.

Senator REAGAN. Can you tell us how this supposed ancient lake got the name of Bonneville?

Mr. JONES. It was named after an army officer by the name of Bonneville.

The CHAIRMAN. Is there a probability of their exhausting the artesian supply if they dig too many wells?

Mr. JONES. There is.

The CHAIRMAN. Is there evidence of their diminishing now?

Mr. JONES. Yes; every well diminishes the supply of the others. Of course, there is one basin in one valley, and another basin, more or less distinct, in another valley; and they have no apparent connection with one another. In the Wasatch Valley it is kept comparatively full. We have perhaps a good many wells in this valley, and the supply of water is diminishing all around. It sometimes happens that a man digs a well near the center of the valley, and another man's well, as a consequence, dries up. The city has dug one, and it has dried up the water at another man's well and he has brought suit against the city.

The CHAIRMAN. What formation furnishes the large supply of artesian wells?

Mr. JONES. You must have rock. You must have the older strata. It does not matter whether it is tertiary or cretaceous rock, but if you go down far enough, and then get to 3 or 4 feet of solid rock, which is located in a proper way, and then, after getting through it, tap the artesian reservoir, anywhere from 600 feet to several thousand, you will get an amount of water coming up that is simply immense.

The CHAIRMAN. You have to get below the stratum that holds it?

Mr. JONES. You have to get below the clay and limestone. Whenever you get below that, you get a supply of water.

The CHAIRMAN. What formation supplies that water?

Mr. JONES. The Dakota supply, I suppose, comes from close to the Rocky Mountains; the Colorado supply comes, I suppose, from a place 30 to 50 miles from there.

The CHAIRMAN. Have you visited the Dakota wells?

Mr. JONES. Yes; I have been all over that section.

The CHAIRMAN. It was a matter in which the committee was much interested. There is in Dakota a magnificient demonstration of the power of these wells; but nobody gave us any account of the wells failing. Have you given much attention to the question of the sources of supply?

Mr. JONES. No; I have not. My impression is that it is under the recent rocks. I have not studied up the subject enough to say positively about that. The supply, however, comes from the west.

The CHAIRMAN. Should you think that a continuous flow could be had from there on a large scale, as at present, or will the wells eventually exhaust the supply?

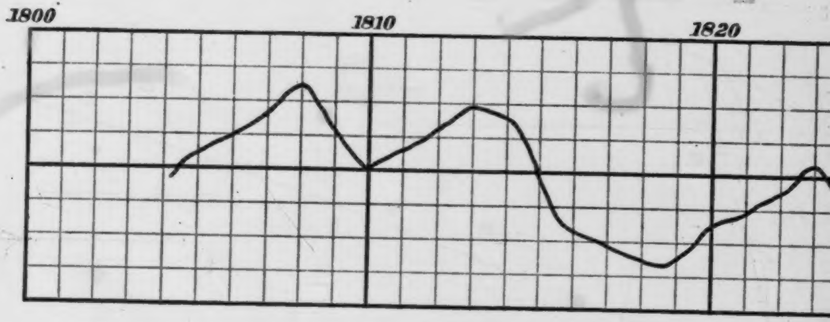
Mr. JONES. I do not think they will, except by very great multiplication of wells. Theirs are the true artesian wells while ours are not.

The CHAIRMAN. Our information was that they went through from 600 to 1,500 feet deep, depending on the altitude of the surface, and that after going through various strata they go through a hard limestone and then a loose sandstone, and that they have not penetrated through that yet.

Mr. JONES. Major Powell can tell you more about that than I can. It may be in triassic sandstone or it may be in the upper tertiary; probably the latter.

The CHAIRMAN. It has a fine flow?

Mr. JONES. I do not think there will be any decrease in the flow there caused by the increase in the number of wells. But in Utah it is very different. The artesian wells or basins are very large, some of them occupying, perhaps, 100 square miles; but the water is obtainable only around on the edge, and when you get out to the middle of the valley, you are so far away from the source of the supply that you will get only about half a gallon a minute, which is only enough for drinking purposes. We can not, therefore, depend on artesian wells in this vicinity for an increase of our water supply.



Report on Irrigation.

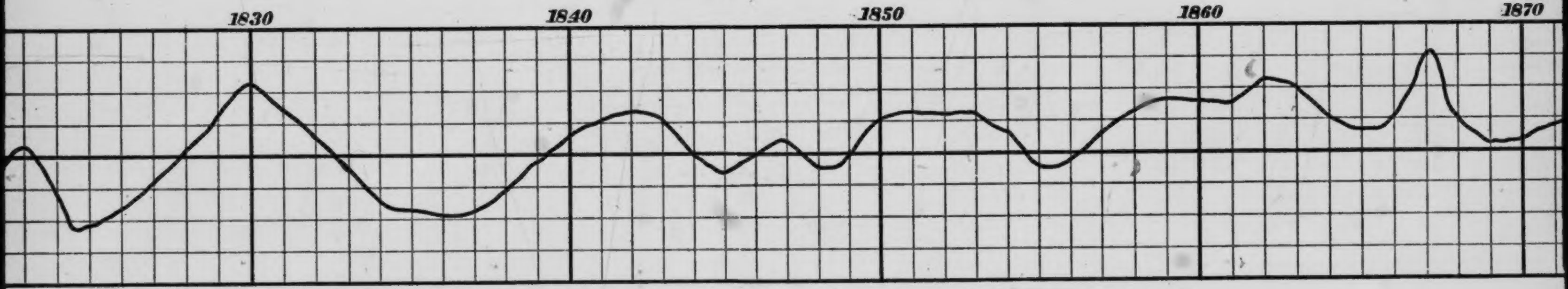
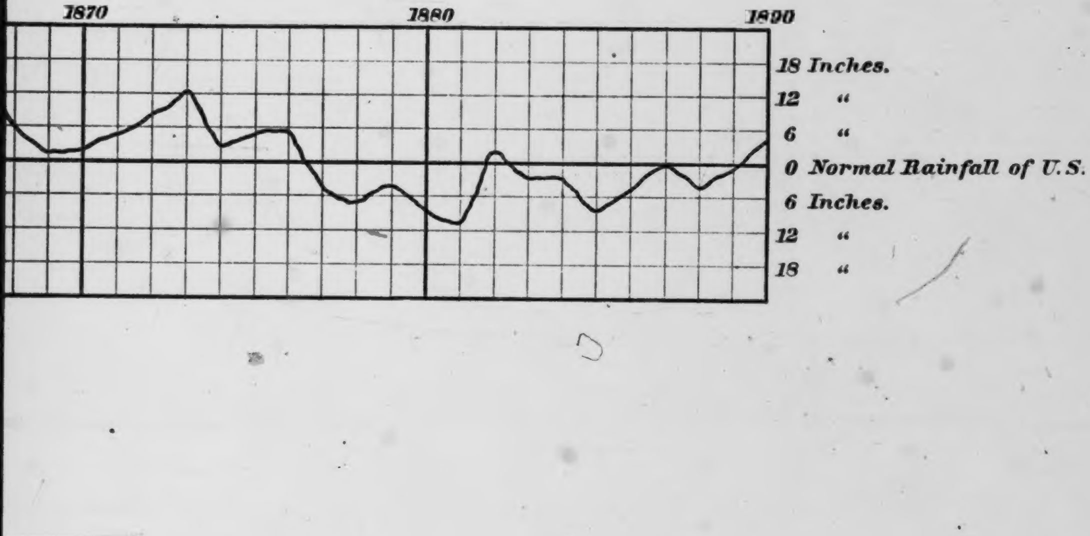


DIAGRAM OF THE RAINFALL OF THE UNITED STATES FROM 1800 TO 1890.

PREPARED BY CHAS. A. SCHOTT, WITH ADDENDA BY MARCUS E. JONES.


1870
1880
1890
18 Inches.
12 "
6 "
0 Normal Rainfall of U.S.
6 Inches.
12 "
18 "

COUNTY STATEMENTS PRESENTED BY THE GOVERNOR OF UTAH.

The reports that follow were made in response to the annexed circular. This was prepared by Governor Thomas, at the request of Mr. Hinton, irrigation engineer, on duty with the committee:

EXECUTIVE OFFICE,
Salt Lake City, Utah, June 12, 1889.

To the County Court of ——— County:

DEAR SIRS: I have received a letter from the irrigation engineer connected with the United States Geological Survey, stating that a special committee on irrigation, appointed by the Senate of the United States, will visit Utah about the 15th of August next, and asking that information be procured for the use of the committee with a view to future legislation to be directed to the reclamation of arid lands by the storage, conservation, and distribution of the water-supply.

I, therefore, respectfully request you to furnish so far as may be possible information covering the following points:

1. The location of all streams, rivers, and irrigating canals. These can best be shown on maps, sketches or tracings, prepared on a scale of 2 inches to the mile.
2. List of canals and ditches, giving as nearly complete as possible: (*a*) name of canal or ditch; (*b*) names of owners or officers and their P. O. addresses; (*c*) date when built or first in use; (*d*) streams from which the water is diverted; (*e*) number of acres irrigated, and of cultivated land; (*f*) number of acres of good land so located that they could be irrigated by an increase of the water-supply in the canals or ditches now constructed; (*g*) number of acres that could be irrigated by new ditches or canals, and new reservoirs; (*h*) the available sites for reservoirs, either in the valley or mountains, and the probable size of such reservoirs.

In addition to the above, you are requested to reply to the following questions:

1. What is the average depth of snow in your mountains during the winter?
2. When does the irrigation season begin and end in each valley?
3. What is the elevation of each valley above the sea?
4. How much water in miner's inches or in cubic feet per second flows through each stream in your county at the point where it can be used for irrigation during the irrigating season?
5. How much water could be stored in suitable reservoirs during the rest of the year?
6. How much water is required in each valley or locality to irrigate an acre of sandy soil for each crop (small grain, grass, root crops, corn, orchards, etc.)?
7. How much water is required to irrigate an acre of clayey or alkaline soil in each valley or locality for each crop as mentioned above?
8. How often and how long at each time, is the land irrigated?
9. How many acres of crops have been lost this year from lack of water?

If the above information could be supplemented by a brief abstract from the county records of the water rights that have been recorded, it would be of special interest to the committee, and would give them reliable data showing the extent of the appropriation of the water-supply. The abstract should show: (*a*) the date of record; (*b*) name of claimant or grantee; (*c*) the amount of water claimed, appropriated or adjudicated; (*d*) nature of claim and whether a first, second, or third right.

At the last session of Congress action was taken by Congress looking to a thorough investigation of the opportunities for building reservoirs and storing water for agricultural purposes, and in pursuance of this purpose the Senate Committee will visit Utah at the time stated.

The water question is of vital interest to Utah, and I urge you to furnish as complete information as possible, and mail it to me before August 10, 1889.

Very respectfully,

ARTHUR L. THOMAS,
Governor.

REPORT ON BEAVER COUNTY.

I hereby submit the following items concerning the waters of Beaver county, Utah, also its distribution and use, together with a statement of available reservoir sites and their capacity and the amount of lands for available agriculture. I am fully satisfied also if persons were appointed to make further investigations in the mountains, that additional reservoir sites could be found to those already enumerated.

I also submit a plat of the Beann and Minersville Valleys, showing the streams coursing through each and the irrigating ditches and canals taking water therefrom, the area of land irrigated from sink ditches, also the area of unoccupied surveyed land that would be available for agriculture with an increase (by storage or other means) of water and the construction of canals and other works.

In addition to the above named lands there are thousands upon thousands of acres of land lying west in "Sage Brush," "Ha Wah Wah," and other valleys that are now practically a desert, and for which some system of artesian well boring will be necessary to make them available for agriculture.

* * * * * * *

C. C. HARRIS.

Reservoir sites and lakes shown upon plat furnished; sites in mountains, and not shown upon plat, and lakes now existing that could be enlarged and utilized.

RESERVOIR SITES AND LAKES (AS SHOWN UPON PLAT FURNISHED).

No.	Local name of sites.	Length.	Width.	Upon what stream located.	Remarks.
		Miles.	*Miles.*		
1	Baker's Cañon	1	[illegible]	Beaver	Outlet, narrow gorge in volcanic rock.
2	Beaver Cañon	[illegible]	[illegible]	do	Do.
3	do	1	[illegible]	do	Outlet, abutting ridge and mountain.
4	Pole Creek	[illegible]	1/10	North Creek	Do.
5	Lower Swamp	1	[illegible]	do	Do.
6	Wild Cat	[illegible]	[illegible]	Wild Cat	Do.
7	Indian Creek	1	[illegible]	Indian Creek	Outlet at end of wash from hills.
8	do	1 [illegible]	[illegible]	do	Do.
9	Minersville	4	1	Beam	Outlet in one volcanic rock and abutting ridge.
10	Minersville Cañon	1	[illegible]	do	Do.
11	Dupaix's Mill	1 [illegible]	[illegible]	do	Outlet between abutting ridge and hills.
12	Minersville Valley	1 [illegible]	[illegible]	do	Depression in the land.
13	do	1 [illegible]	[illegible]	do	Do.
14	do	1	[illegible]	do	Do.

RESERVOIR SITES IN MOUNTAINS (NOT SHOWN UPON PLAT).

No.	Local name of sites.	Length.	Width.	Upon what stream located.	Remarks.
1	Le Baron Meadows	2	[illegible]	Beam	Outlet, gorge in solid rock.
2	Britt's Meadows	2	[illegible]	do	Outlet at intersection of two ridges.
3	Kent's Lake	[illegible]	[illegible]	do	Outlet, at Our Rock (a natural basin).
4	Kent's Adjacent	[illegible]	[illegible]	do	Do.
5	do	[illegible]	[illegible]	do	Do.
6	Matthews' Lake	[illegible]	[illegible]	do	Do.

EXISTING LAKES THAT COULD BE ENLARGED AND UTILIZED.

No.	Local name of sites.	Length.	Width.	Upon what stream located.	Remarks.
1	Puffer Lake	1 [illegible]	[illegible]	Beam	Outlet, solid rock in gorge.
2	Blue Lake	[illegible]	[illegible]	North Creek	Do.
3	Twin Lakes	[illegible]	[illegible]	Beaver	Quite deep and easily enlarged.
4	do	[illegible]	[illegible]	do	Do.
5	Birch Creek Lake	[illegible]	[illegible]	do	Occasionally dries up.
6	Kent's Lake	[illegible]	[illegible]	do	Artificial and noted under reservoir sites

List of ditches and owners in Beaver County.

No. of ditch.	Name of one of the principal owners in each ditch.	Town.	Date of construction of ditch or canal.	Irrigated by each ditch.	Area under each ditch that could be irrigated with increase of water.	Days between each time of irrigating.	Hours to each 5 acres.	Remarks.
	BEAVER RIVER STREAM.			*Acres.*	*Acres.*			
1	F. Harris	Beaver	1885	80	320	14	24	
2	B. Bennett	....do	1879	40	100	14	24	
	E. C. Mathews	....do	1887	80	40	14	24	
3	City canal; Mayor of Beaver City.	....do	1856	2,640	80	7 14	12 24	For city lots Farm lands.
4	W. Allred	....do	1869	26	40	14	24	
5	W. G. Nowers	....do	1859	400	30	18	24	South field
6	G. E. Owen	....do	1867	80	......	16	24	
7	W. Greenwood	....do	1856	115	......	18	24	
8	T. Parkinson	....do	1857	105	30	16	24	
9	E. Patterson	....do	1865	200	30	21	24	
10	J. Jones	Adamsville	1884	40	640	14	24	Adamsville bench.
11	W. Fotheringham	Beaver	1879	80	320	18	24	
12	H. Emerson	....do	1870	60	200	18	24	
13	J. H. Josephs	Adamsville	1863	750	40	14	24	Town canal.
14	......do	....do	1866	330	......	14	24	South side.
15	R. Griffiths	....do	1868	200	......	14	21	Hay ditch.
16	J. T. Josephs	....do	1868	265	......	18	24	
17	M. M. Shepherd	Beaver	1873	40	......	18	24	Rocky ford.
18	J. H. Jones	Minersville	1876	80	40	18	24	
19	J. McKnight	....do	1860	1,200	600	18	24	Minersville town canal.
20	W. L. H. Dotson	....do	1874	80	100	18	24	
21	W. Gilling	....do	1875	70	100	18	24	
22	J. W. Christian	Beann	1879	50	......	14	24	
23	P. S. Martin	Milford	1887	100	200	18	24	
24	J. McGeary	Beam	1876	100	......	....	....	Yellow banks; hay-lan watered in high water.
	SOUTH CREEK STREAM.							
1	O. Puffer	Beam	1879	75	80	16	24	
2	C. Merchant	....do	1860	75	......	16	24	
3	G. Hutchings	....do	1879	80	80	16	24	
4	C. Warby	....do	1882	160	40	16	24	
5	J. Warby	....do	1871	40	40	16	24	
6	J. Lang, jr	....do	1876	40	80	16	24	
7	T. Frayer	....do	1885	60	80	16	24	
8	H. Gale	....do	1866	100	160	16	24	
9	J. Gilles	....do	1879	40	40	16	24	
10	E. Tolton	....do	......	......	......	16	24	
11	J. R. Murdock	....do	1876	300	1,000	16	24	
12	C. Miller	Greenville	1861	224	40	16	24	
	SOUTH CREEK STREAM.							
1	W. J. Cox	Beam	1860	80	......	18	24	
2	E. Tolton	....do	1866	80	80	18	24	
3	G. Mumford	....do	1866	150	40	18	24	
4	W. G. Nowers	....do	1857	200	......	18	24	
5	R. Patterson	....do	1881	70	320	18	24	
	INDIAN CREEK.							
1	A. Tinktell	Beam	1872	200	300	18	24	
2	......do	....do	1859	105	40	18	24	
	WILD CAT.							
1	J. Farrer, jr	Beam	1875	160	200	18	24	
	PINE CREEK.							
1	A. Olsen	Beam	1865	50	400	....	....	

NOTES.

Area of water-shed of the Beaver Mountains, 180 square miles.

Altitude of Beaver Mountains, about 10,000 feet. First highest peak, 11,894 feet (Mount Belknap); second highest peak, 11,730 feet (Mount Baldy).

Depth of snow annually falling on Beaver Mountains, estimated depth not known, but by some placed at 8 feet, it falling from 4 feet to 20 feet in different sections.

AGRICULTURAL LANDS SURVEYED, OCCUPIED, AND UNOCCUPIED.

Beaver Valley.—Occupied (about), 7,500 acres, irrigated; 4,750 acres not irrigated; unoccupied, 97,280 acres, of which about 60 per cent. is available for agriculture, with storage of water. Altitude of Beaver Valley, 6,020 feet.

Minersville Valley.—Occupied (about), 2,000 acres, irrigated; 1,000 acres not irrigated; unoccupied, 131,328 acres, of which about 95 per cent. is available for agriculture, with storage and increase of water. Altitude of Minersville Valley, 5,090 feet.

Irrigating streams.—The cross-sectional area of an ordinary irrigating stream is about 26 inches wide by 5 inches in depth, or 130 inches face. Speed of such irrigating stream about 66 feet per minute, of which it is estimated to run about 80 per cent. of its computed volume (see Leffel's Water Works).

The irrigating season commences about May 15 and ends about August 15 of each year, crops of lucern, potatoes, orchards, and gardens being irrigated one month later.

REPORT ON BOX ELDER COUNTY.

The southeastern part of Box Elder County embraces about 3,600 acres of land under cultivation, of which about 10 per cent. constitutes made or natural meadow. About 2,100 acres of this section is under irrigation, of which, however, but a small portion has sufficient water to produce a good agricultural crop in dry seasons. The water supply, with the exception of a few minor springs claimed by private parties, is obtained from Willard and Three Mile creeks.

Willard Creek, so far as ascertained, furnishes no favorable location for reservoirs, the fall being too great, but experience has proved that about one-third the amount of water could be saved if the bed of the creek was walled up with rocks.

Three Mile Creek has an excellent location for a reservoir at the head of the creek. Here is found a basin with a swampy bottom and containing several minor springs, the whole surrounded by mountains. A dam at the outlet of this basin, 260 feet long, 20 feet high at the bed of the creek, would inclose over 3,000,000 cubic feet of water, sufficient to irrigate 700 acres of land. Cost of dam, $800.

Summary.—Cultivated land in this section, 3,600 acres; irrigated land in this section, 2,100 acres; meadow, 360 acres; proposed reservoir dam site, cost, $800; area subject to cultivation if supplied with water, 2,500 acres.

Willard Creek is owned and controlled by the city. Three Mile Creek is claimed by adjoining settlers. Elevation of agricultural land, 4,230 to 4,400 feet above sea; elevation of head of Willard Creek, 9,200 feet; elevation of Three Mile Creek, 6,300 feet.

The section in which Brigham City, the county seat, is located has an area of nearly 9,600 acres of cultivated land, of which about 5,100 acres are under irrigation. About 1,900 acres are in meadow. Quantity of water insufficient for industrial use.

Reservoir.—East of Brigham City, in what has acquired the local name of "Devil's Gate Valley," owing to the rough inlet at the head, and much above Box Elder Creek, is a good reservoir site. A dam at the contracted place shown by the map, 300 feet long, 50 feet high at the bed of the creek, would inclose over 15,000,000 cubic feet of water, sufficient to water 3,000 acres of land. The water is so far unclaimed, as it ceases to connect with Box Elder Creek during the summer.

Summary.—One reservoir site (proposed dam) cost, $4,000; cultivated land in this section, 9,600 acres; irrigated land in this section, 5,100 acres; meadow, 1,900.

Box Elder Creek owned by Brigham City; creeks at Honeyville owned by that town and farmers; elevation of agricultural land, lower belt, 4,250 to 4,500; Mantua or higher valley, 5,168 feet; reservoir in Devil's Gate Valley, 6,100 feet above the sea; soil subject to irrigation if supplied with water, 15,000 acres.

The next section embraces nearly 12,000 acres of cultivated soil, of which about 1,900 acres are irrigated.

Beaver Creek, in the northeast of the section, has one fine reservoir site (dimensions and location not reported), of which that country is greatly in need. Cost, $600.

The springs on section 29, township 11, are composed of hot and cold, salt and fresh water, respectively. These are separated by a dam and the cold and fresh water conveyed to Honeyville town for irrigation in a canal 1¼ miles long, 4 feet wide, and 2 feet deep, at a fall of 1¼ feet to the mile.

The additional area that could be irrigated in this section if water could be provided is not far from 19,000 acres.

Salt Spring on section 6, township 11 north, range 3 west, is of a brackish nature. The consequence is that it is nearly abandoned for irrigation except on alfalfa, to which it seems to be less injurious. The same note will apply with full force on the waters of Malad River.

Summary.—Cultivated, 12,000 acres; irrigated, 1,900 acres; subject to irrigation if water provided, 19,000 acres; reservoir site (proposed), 1; elevation of farms, 4,280 to 4,500 feet above sea.

The upper section of county contains about 6,000 acres of cultivated soil without water. No site for reservoir is reported. Elevation of farms are from 4,420 to 4,540 feet; subject to irrigation if water is supplied, 600 acres.

A dam is proposed across Bear River with a canal from there. Surveys have been made for a dam 250 feet long and 20 feet high across the river; a tunnel 14 by 10 feet for 1¼ miles out and in through the cliffs, with a fall of 4 feet per mile, and then a canal 70 feet wide and 6 feet deep, fall 1 foot per mile. About one-half mile below the dam it is proposed to flume part of the water across the river into a canal on the west side of the river. On the west side of the river the canal is surveyed for a distance of 45 miles, and on the east side it crosses the boundary line into Weber County, at a distance of about 43 miles.

The Malad River section shows 3,000 acres of cultivated soil. Canals and ditches were built as early as 1868 and the water taken out of Malade River by aid of a dam. The water being of a brackish character proved injurious to the vegetation and the irrigation abandoned, except on alfalfa to a limited extent. About 22,000 acres additional could be cultivated if water was applied.

About 14 miles of canals were constructed. The main canal 4 miles long, 12 feet wide, 2 feet deep, and 1½-foot fall per mile.

There are 80 acres of dry farm at Blind Spring on section 10, township 12 north, range 4 west, and 1,000 acres cultivated in Blue Spring Valley, of which 150 acres are irrigated.

The canals are two in number and 2½ miles in length, 3 to 4 feet wide at bottom, and falls 4 feet per mile. The owner is Promontory Stock Ranch Company, Promontory, Utah.

NOTE.—The canals take all the water and no chance for reservoirs is reported.

About 2,000 acres additional could be irrigated if water is supplied. Elevation is about 4,700 feet above sea-level.

The Portage section represents about 7,000 acres of land under culture, of which 2,500 acres are irrigated for grain or hay.

The main water supply is Malad River through Portage Ditch, 10 feet wide, 2 feet deep, 7 miles long, and falls 1½ feet per mile. The water in said river is good at this point, the bad water running in from some mineral spring below.

Portage Creek supplies Portage town. This creek has a fine site for a reservoir. The settlers had begun construction, but it was abandoned for want of means. Its estimated dimensions are: Length, 600 feet; height, 20 feet; contents, 15,000 cubic yards; capacity, 20,000,000 to 25,000,000 cubic feet of water; $40,000 cost.

This section also has been a thriving Indian settlement, with many houses and good farms. The water supply is inadequate.

Summary.—Cultivated land, 7,000 acres; irrigated land, 2,500 acres; reservoir site (proposed), 1; arable land if water supplied, 3,000 acres; elevation of farms, 4,500 feet to 4,600 feet above sea; elevation of reservoir, 5,000 feet above sea.

Two other sections show, one a cultivated area of nearly 4,000 acres, of which 2,000 acres are under irrigation. There are two chances for reservoirs, but locations and dimensions are not reported. Water supply insufficient. Elevation of farms 5,640 to 5,675 feet above the sea. In meadow, 150 acres.

The other represents a cultivated area of nearly 1,500 acres, including 250 acres in meadow. About 950 acres are irrigated. Nearly 11 miles of canals have been built. Width, 4 feet; depth, 2 feet; fall, 3 feet per mile. Elevation of valley 4,600 to 4,625 feet above sea. Water supply insufficient. Facilities for reservoirs good, but no report made on locations and dimensions. Additional arable land if supplied with water, 2,500 acres.

The most northerly section of country is one that has been very hard for the settlers to subdue, owing to the sterility of the nature.

The area cultivated is nearly 2,500 acres; the area irrigated, 1,400 acres. Elevation of valley, 4,275 feet above the sea. Water supply from Deep Creek in Idaho. Canals 13 miles long, 10 feet wide, 2 feet deep, and 2-foot fall per mile.

Water supply insufficient. Facilities for reservoirs good. Cost and dimensions not given. Facilities for raising 50,000 bushels and homes for one hundred families additional is reported if water was supplied. Additional arable land 9,600 acres.

SUMMARY OF PRECEDING DATA.

	Acres.
Total area cultivated	50,280
Additional not reported	3,000
Grand total	53,280
Total area irrigated	16,100
Total area not reported	1,200
Grand total	17,300
Meadow	2,910
Meadow not reported	300
Grand total	3,210
Arable land not cultivated	76,200
Arable land not reported	4,000
Grand total	80,200

N. P. ANDERSON,
County Surveyor.

REPORT ON CACHE COUNTY.

Streams.	Streams from which water is diverted.	Acres irrigated.	Acres cultivated.	Good land that could be irrigated by increasing water supply.	Land that could be irrigated by new canals.	Flow of water per second.	Length of canal.
				Acres.	*Acres.*	*Cub. ft.*	*Miles.*
Logan, Hyde Park and Smithfield Canal.	Logan River	1,200	1,200	2,500		39	10
Logan and Richmond Canal	do	3,000	4,000			68	8
Logan and Hyde Park Canal	do	2,200	2,200			35	6
Logan and Benson Canal	do	2,800	2,800		1,500	38	7
Providence Canal No. 1	Blacksmith Fork	1,690	2,400		500		
Providence Canal No. 2	do						
Providence Canal No. 6	Providence Cañon						
Providence Canal No. 7	Logan River						
Millville Canal No. 1	Blacksmith Fork and Clear Creek.	2,400	2,400				7
Millville Canal No. 2	do	300	3,000	500	300		
Millville Canal No. 3	do						
Millville Canal No. 4	do						
Blacksmith Fork Canal	Blacksmith Fork	2,500	2,500	2,720	2,720		5½
Paradise Canal	Little Bear River	2,300	2,300				9
Wellsville South Irrigation Canal	do	600	600				9
Claton Canal	Claton Spring	176	176				1½
City Creek Canal	8 per cent. Springs	257	257		1,000		1½
Deep Cañon Creek Canal	Deep Canny Creek	199	199				2
Gardner Ditch	Gardner Spring	290	290				4
Benson and Logan Canal	Logan River	1,000	1,000		1,000		3½
Newton Canal	Newton Reservoir	1,000	1,000	2,500	18,000		2
Newton Reservoir Canal	do	1,000	1,000				2
Birch Creek Canal	Birch Creek	375	375	1,800	2,000		3½
Upper Dam Ditch	Clarkston Creek	200	200				3
Lower Dam Ditch	do	225	225				4
City Creek Canal	City Creek	285	285				4
Trenton Canal	Weston Creek			5,000	10,000		
Cubb River Irrigating Canal	Cubb River	6,000	6,000	6,000			12
Coveville Lower and Upper Canal	Cubb River and High Creek.	1,497	1,497	3,449			
Richmond Canal	High Creek and Cherry Creek.	2,500	2,500	3,000	3,000		6
Smithfield irrigating district	Summit and Birch Creek.	2,970	2,970	1,000	1,160		
Logan River							188.50
East Fork of Little Bear River							18.06
South Fork of Little Bear River							24
Blacksmith Fork River							137.42
Smithfield Creek							*25
High Creek							*25
Lewiston Canal							12.15
West Branch of Lewiston Canal							4
Paradise Irrigating Canal	E. and S. Forks Little Bear River	1,780	1,780	2,204	2,100		
Total		41,444	43,154	30,173	43,280		

*Approximately.

NOTES.—Average depth of snow in mountains during winter, 3 feet.

Irrigation season begins about May 1, and ends about the 1st of September.

The elevation of Cache Valley is 4,533 feet.

About 23 per cent. of the crops of this county have been lost this year from lack of water.

Land is irrigated at intervals of about two weeks when water supply is plentiful and about four hours, time is allowed for watering 1 acre of land.

There are many places in the mountains where water can be stored.

REPORT ON CACHE COUNTY.

Width of bottom.	Fall per mile.	Cost of canal.	When constructed.	Claim to water.	By whom owned.	Shares into which ownership is divided.	Shares issued.	Par value of each share.	Actual selling value per share.	Annual tax or assessment per share per acre.	Arable land under canal.	Actually watered.
Feet.	*Feet.*									*Cents.*	*Acres.*	*Acres.*
12	4	$50,000	1883	Fifth..	Corp'n....	4,000	2,000	100%	100%	25	3,760	1,200
12	7	30,000	1865-'6	Fourth	Ass'n......	......	......	......	......	25	4,000	3,000
12	7	18,000	1860	First..	....do	......	......	......	......	10	2,200	2,200
12	6	15,000	1861	Second	....do	......	......	......	......	10	2,800	2,800
......	......	......	......	......	......	......	......	......	......	......	2,900	1,600
6	......	8,000	1865	First..	Ass'n.....	......	......	......	......	80	2,400	2,400
......	......	......	......	......	......	......	......	......	......	......	3,500	3,000
......	......	......	......	......	......	......	......	......	......	......	......	......
......	......	......	......	......	......	......	......	......	......	......	......	......
8	13	5,500	1860	First..	Ass'n.....	1,000	1,100	$5.00	$5.00	35	2,500	2,500
8	15	5,075	1867	...do ..	....do	1,015	1,045	$5.00	15.00	60	5,300	2,300
8	......	9,000	1886	Third .	....do	......	......	50.00	50.00	......	600	600
3	1	500	1860	First..	....do	......	......	......	......	25	350	176
2	50	400	1858	...do ..	City cor...	......	......	......	......	40	2,000	257
3	50	100	1859	...do ..	....do	......	......	......	......	40	1,000	199
4	1	6,000	1860	...do ..	Ass'n.....	......	......	......	......	......	2,000	290
10	4	4,500	1880	Second	....do	......	......	......	......	25	1,800	1,000
8	6	......	......	......	....do	......	......	......	......	......	14,000	1,000
8	6	7,000	1871	......	....do	280	280	25.00	......	10%	3,200	1,000
2½	......	1,500	1866	First..	....do	......	......	......	......	20	1,800	375
2	......	750	1866	...do ..	....do	......	......	......	......	25	200	200
2½	......	1,000	1866	...do ..	....do	......	......	......	......	20	225	225
2½	......	1,200	1869	...do ..	....do	......	......	......	......	45	285	285
......	......	......	1869	......	....do	......	......	......	......	......	......	......
16	......	52,000	1876	First..	......	1,040	1,040	50.00	......	3%	1,200	6,000
......	......	......	1860	......	Ass'n.....	......	......	......	......	......	3,449	1,497
8	2	......	1860	First..	City	......	......	......	......	20	5,500	2,500
......	......	......	1860	......	......	......	......	......	......	......	......	2,970
......	......	......	......	......	......	......	......	......	......	......	......	......
......	......	......	......	......	......	......	......	......	......	......	......	......
......	......	......	......	......	......	......	......	......	......	......	......	......
......	......	......	......	......	......	......	......	......	......	......	......	......
......	......	......	......	......	......	......	......	......	......	......	......	......
......	......	......	......	......	......	......	......	......	......	......	......	......
......	......	......	......	......	......	......	......	......	......	......	......	......
......	......	......	......	......	......	......	......	......	......	......	......	......
......	......	......	1867-'68	......	......	......	......	......	......	......	......	1,780
......	......	......	......	......	......	......	......	......	......	......	77,409	41,444

REPORT ON EMERY COUNTY.

Snow falls from 1 to 6 feet in our mountains.

Irrigation season commences in May, and ends the latter part of October.

A stream of 6 cubic inches will water 1 acre of sandy soil in twenty-four hours. Four waterings will mature small grain, beets and carrots. Three for potatoes.

A stream of 6 cubic inches will water 1 acre of clayey soil in twenty-four hours. Will take six waterings to mature crops.

The number of acres lost to cultivation this year from lack of water will reach 25 per cent. of total arable.

There are many small streams taken out of the creeks that are not listed.

Our ditches were built between 1879 and 1885.

Area irrigated—14,825 acres.

Area that can be irrigated by present ditches—29,200 acres.

Area that could be reclaimed if water was obtainable—372,620 acres.

There are two good reservoir sites on the head of Muddy Creek. Estimated capacity, 25,000,000 cubic feet. Two on head of Ferron Creek; there is a vast flat. Joe's Valley, or a part of said valley, could be turned into or used as a reservoir. It would cover two or three sections, with a mean depth of 15 cubic feet. Several suitable sites are found at or near Moab and Blake Creeks. Six or eight sites also at Lower Crossing, near Price River, in the mountains, with an average extent of fifteen acres each.

The irrigation seasons are—March 15 to November 1 in Castle Valley; March 1 to November 1, Little and Big Grand Valleys.

The supply in Castle Valley is about 4,500 feet; Little and Big Grand, 3,900 feet; Cottonwood, about 1,800; Ferron, about 1,625; Muddy, about 1,450; Huntington, about 1,750; Price about 1,600.

Green and Grande are both large rivers.

The duty of water is about 4 miner's inches for sandy soil, 3¼ miner's inches for clayey soil.

Water is turned on every twelve or fourteen days, fifteen to twenty-four hours at a time.

On the tributaries of Price River there are many available natural reservoir sites. It is not possible to now approximate size or cost of construction. It is believed, however, that if four reservoirs were constructed, one on each of the following-named tributaries: Wilson Creek, Horse Creek, Gooseberry Creek, and Gordon Creek, that a cient amount of water would be stored to irrigate all lands in Castle Valley north of line of township 17 south—in all, about 150,000 acres. The sites for said reservoirs are natural sites, and reservoirs could be constructed very cheaply; for instance, at the head of Gordon Creek, a dam constructed across the cañon, below "Miller Ranch," 200 feet in length and 75 feet in height, would create a lake 2 miles square; there being an abundance of rock on the ground suitable for use in constructing said reservoir.

List of canals in Emery County.

Name of ditch.	Sources of support.	Name of town, trustees, or owners.
Clipper Canal (increase)	Cottonwood Creek	A. C. Van Buren, president, Orangeville.
Blue Cut Canal (inc.)	do	N. P. Miller, president, Castle Dale.
Castle Dale, Town Ditch	do	Jens Nelson, president, Castle Dale.
Jeffs' Ditch	do	James, Ephraim and Emma Jeffs and C. G. Larson, Castle Dale.
Wilcox Ditch	do	James H. Wilcox, owner.
Upper South Ditch	Ferron Creek	William Taylor, president, Ferron.
Town Ditch	do	Do.
King Ditch	do	Do.
Molen Ditch	do	Do.
Peterson Ditch (inc.)	do	Do.
Lower South Ditch	do	Do.
Casper Christensen Ditch	Muddy Creek	Casper Christensen, Emery.
Muddy Canal (inc.)	do	P. V. Bundersen, president, Emery.
Pioneer Ditch No. 1	Price River	
Pioneer Ditch No. 2	do	F. E. Grauns, Emery.
Price Water Ditch	do	George Fraoulson, Emery.
Wellington Canal	do	Watter Barney, Emery.
Robert Snider Ditch	do	Robert Snider, Emery.
R. M. Watson's Ditch	Coal Creek	R. M. Watson, Emery.
R. R. Hutchinson Canal	Price River	R. R. Hutchinson, Emery.
Smith Ditch	Huntington Creek	Chris Johnson, Huntington.
Hill Ditch	do	Do.
Brockbank Ditch	do	Do.

Lists of canals in Emery County—Continued.

Name of ditch.	Sources of support.	Name of town, trustees, or owners.
Jensen Ditch	Huntington Creek	Chris. Johnson, Huntington.
McHadden and Cleveland Canal	do	Do.
Huntington Canal	do	Do.
North Ditch, Day Upper	do	Do.
Crandal, Day Lower	do	Do.
Wakefield, East Bend (inc.)	do	Do.
Avery Powell	do	Do.
Humble	do	Do.
Green River Canal	Green River	J. T. Farrer, president, Blake.
Pack and Mill Creek Canals	do	George H. Wade, water-master, Moab.

REPORT ON GARFIELD COUNTY.

The facilities for reservoiring at head waters of Sevier River are almost unlimited; large basins, deep and with small outlets, and deep snows in winter; the majority of these basins drain large areas.

There are no facilities for storage in Henrieville, Cannonville, or Coyote, but in Escalante there are a number of small lakes which can be tapped and improved to more than double their acreage. The citizens have initiated a movement to bring a creek across a mountain to increase their water supply.

A pond in township 35, sections 7, 8, 17, 18, is a natural basin with a drainage of 10 square miles, with one opening into creek leading to Panguitch Lake. This opening is in basaltic rock, very narrow, say 3 or 4 rods wide, with material in abundance, quarried by nature, to make a dam. It furnishes for two months a large stream of water from snow; will make a reservoir 6 square miles.

Panguitch Lake is located at township 35, sections 33 and 34, and township 36, sections 43 and 3. This is a natural reservoir and can be made to hold 5 square miles of water at a very moderate cost. The citizens of Panguitch have raised this lake 6 feet, at a cost of $3,000, including land purchases.

Bien Springs Valley could be made to contain 2 square miles of water at a moderate cost; land would cost more than dam.

The right-hand fork of Mammoth Creek could be diverted for eight months of each year (by making a cut 2 miles long) and become a feeder of Panguitch Lake; it would afford five or six streams for irrigating.

Table of ditches, etc., in Garfield County.

NO. I.

No. of ditch.	Name of owner.	Date of completion.	Amount irrigated.	Source of water.
			Acres.	
1	James B. Thompson	July 29, 1884	45	East Fork Pahreah.
2	Willis A. Thompson	do	21	Do.
3	Joseph E. Thompson	do	26	Do.
4	John F. Pollock	do	21	Do.
5	E. Littlefield	do	21	Do.
6	Daniel Goulding	do	23	Do.
7	John Goulding	do	21	Do.
8	John O. Thompson, sr	do	34	Do.
9	Morrison Meacham	do	21	Do.
10	Lucy D. Thompson	do	13	Do.
11	Abraham A. Stevens	do	21	Do.
12	Wm. W. Pollock	do	21	Do.
13	Joseph Ingram	do	43	Do.
14	Samuel Littlefield	do	21	Do.
15	Joseph G. Goulding	do	21	Do.
16	William S. Thompson	do	32	Do.
17	Samuel Meacham	do	21	Do.
18	Cannonville Co	do		Pine Creek.
19	Cannonville Co	do	3½	East Fork Sevier.
20	Edward Wilcox	do	20	North and Birch Creek.
21	Henry J. White	do	20	Butler Farm Creek.
22	Kanana Stock Co	do	1½	East Fork Sevier.
23	Cyrus Hencock	do		Lime Kiln Wash.
24	Albert De Long	do		Do.
25	Mathew McEwen	do		Do.
26	Wm. D. Leflere	do		Do.
27	Welham Lewman			Do.
28	O. S. Hatch			Do.
29	Henry J. White	Mar. 2, 1885	20	North Creek.
30	Owner not named			
31	J. W. Crosby			
32	Owner not named			
33	Edward Allan	June 2, 1885		Poison Creek.
34	Church A. Bros			
35	Haden W. Church			
36	Aaron Assay			
60	Albert De Long	June 7, 1887	118	Sevier.
61	Meltiah Hatch	do	320	Sevier River.
62	Neils P. Clove	July 9, 1887	200	Mammoth and Sevier.
63	Watkins, Reese & Co	June 4, 1888	640	Horse Creek.
64	John L. Levy	Mar. 4, 1889	40	East Fork.
66	Thomas F. Langford	June 7, 1889	610	Do.

NOTE.—There is in addition from twenty to thirty independent ditches for isolated farms and ranches, with a capacity of from 40 to 160 acres.

No. II.

No. of ditch.	Name of owner.	Date of completion.	Service of water per hour.	Source of supply.
			Hours.	
39	Wm. J. Henderson	Sept. 7, 1885	25	West Fork Pahreah.
40	J. Jones	do	22½	Do.
41	K. A. Fletcher	do	23½	Do.
42	D. O. Littlefield	do	36	Do.
43	Owner not named	....	....	
44	O. Christian	do	21¼	Do.
45	J. Clark	do	21¼	Do.
46	Mary Porter	do	16¼	Do.
47	E. H. Thompson	Sept. 8, 1885	14½	Do.
48	O. Anderson	do	12½	Do.
49	O. Hatch	do	1¼	Do.
50	S. M. Meacham	do	2½	Do.
51	Lucy Littlefield	do	1¼	Do.
52	Zion Co-operative	Sept. 7, 1885	1¼	Do.
53	Relief Society	Sept. 9, 1885	1¼	Do.
54	E. Pearce	do	1¼	Do.
55	H. Barney	do	1¼	Do.
56	Wm. Lewman	Sept. 8, 1885	1¼	Do.
57	A. Workman	do	1¼	Do.
58	John Goulding	July 2, 1885	(*)	Do.
59	James Wiley & Co	Mar. 1, 1886	....	All of Lost Creek.
65	Hyrum Williams	June 7, 1886	864 inches	for 320 acres.

* One-third seepage.

REPORT ON MORGAN COUNTY.

This county is situated principally on the Weber River, bounded east by Summit County, south by Salt Lake County, west by Davis, and north by Weber County.

The railway elevation passing through Morgan City is 5,080 feet above the sea-level. There are about 10,000 acres of arable and meadow land in the county. Our water supply is usually abundant, this being the first year we have suffered to any extent for twenty-five years.

There are twenty-seven corporate and company ditches, and nineteen private or individual water ditches. The water is supplied from ten creeks and one river.

The approximate estimate of the flow of water into our county has never been made. The surplus water from the creeks empty into the Weber River, which flows through the heart of our county into Weber and Davis Counties.

Our probable loss of crops this year will amount to 1,000 acres. The west part of the county, supplied from small creeks, has been the principal sufferer this season.

There is one good site for a reservoir in Line Creek Cañon (immediately west of Milton), where a reservoir of 10 acres of water, averaging 10 feet deep, could be made for a small expense. Another good site for a reservoir exists in Deep Creek Cañon, where a reservoir of the same size and depth as above stated could be constructed. East Cañon furnishes a most magnificent site for a large reservoir, at a place known as the "Denês Fate" situated about 4 miles east of Porterville at the head of the valley. Ledges of rocks descend on each side to the bed of Cañon Creek, leaving a gate about 20 feet wide for the passage of the stream. A wall of rocks rises almost perpendicularly for 60 feet. By putting in a strong dam here the water would back the stream 2 miles, covering an area of 640 acres of an average depth of 20 feet.

The average depth of snow-fall in our mountains is 5 feet.

The amount of water to irrigate an acre of land varies according to soil, gravelly soil taking as much again as clay soil; 1 cubic foot per second for 100 acres is an approximate estimate.

Irrigation commences about the 20th of May and terminates about the 1st of September. Small grain is mostly irrigated in the months of June and July. Grain and alfalfa are watered about every twenty days on clay soils, and about every ten days on gravelly soil; gardens every ten days. Two waterings are sufficient on most soils in our county to mature small grain.

Companies and corporations have not claimed the water as such companies. All the water claims have been claimed by individuals and recorded to them. It would make this report too lengthy to make an abstract of all such claims. The accompanying list of companies, ditches, etc., will show the nature and extent of water rights.

S. FRANCIS,
JOS. R. PORTER,
County Commissioners.

Corporate and association ditches of Morgan County.

Number.	Name of canal or ditch.	Names of owners and post-office address.	When built.	Streams from which the water is diverted.	Acres irrigated.	Acres that may be irrigated if there was more water.	Acres that could be irrigated by the construction of new ditches.	Length of canal or ditch.	First cost of construction.	Nature of right.
								Miles.		
1	South Mill Creek	J. Durant *et al.*, Morgan	1865	Mill Creek	150	50	....	2	$400	First.
2	Round Valley Spring Ditch and Weber River Ditch.	E. W. Hunter *et al.*, Morgan	1864	Weber River and Spring	290	70	....	5½	750	Do.
3	West Porterville Ditch	H. Florence *et al.*, Morgan	1866	Mill Creek	500	50	....	4½	1,000	Do.
4	Richville Mill Race Ditch	Herman & Taggart, Morgan	1862	Cañon Creek	330	....	....	3	900	Do.
5	East Porterville Ditch	John P. Porter, sr., *et al.*, Morgan.	1862	do	312	70	....	3½	1,480	Do.
6	East Richville Upper and Lower Ditches.	Mels Peterson *et al.*, Morgan	1862	do	450	50	....	7	1,600	Do.
7	Gordon Creek Ditch Company	John A. Waite *et al.*, Peterson.	1858	Gordon Creek	200	58	....	3½	300	Do.
8	Cottonwood Creek Ditch Company	Buck Miller *et al.*, Peterson	1869	Cottonwood Creek	200	....	....	4	1,000	Do.
9	Peterson Creek Ditch Company	Peterson	1855	Peterson Creek	200	....	....	1½	320	Do.
10	Dalton Creek Ditch Company	do	1862	Dalton Creek	150	....	....	1½	150	Do.
11	Lino Creek Irrigation Company	Morgan	1861	Lino Creek	350	....	....	6	1,400	Do.
12	South Round Valley Irrigation Co.	do	1864	Weber River	120	60	70	3½	720	Do.
13	North Morgan Irrigation Company	do	1864	do	428	....	....	4	1,000	Do.
14	North Morgan Mill Race Irrigation Co.	do	1861	do	300	100	....	2	250	Do.
15	North and South Spring Irrigation Co.	do	1862	Morgan City Springs	37	40	....	1	50	Do.
16	Weber Canal Irrigation Company	do	1864	Weber River	400	....	....	3	6,000	Do.
17	Morgan City Irrigation Company	do	1861	do	360	....	....	4	3,800	Do.
18	Littleton and Milton Cañon Creek Irrigation Company.	do	1888	Cañon Creek	200	....	200	3	200	Second.
19	Deep Creek Irrigation Company	do	1861	Deep Creek	400	400	....	4	850	First.
20	Enterprise Bottom Irrigation Co.	Peterson	....	Stoudart Springs	250	125	....	4	1,500	Do.
21	Spring Hollow Ditch Company	do	1867	Spring Hollow Springs	75	25	....	3	200	Do.
22	Enterprise Bench Irrigation Company	do	1880	Weber River	200	....	....	7	5,000	Second.
23	Loss Creek Irrigation Company	Croydon	1864	Loss Creek	350	....	....	2	1,200	First.
24	Croydon Upper Ditch Irrigation Co	do	1869	do	70	10	....	3	1,000	Do.
25	Littleton Cañon Creek Irrigation Co.	Morgan	1880	Cañon Creek	240	100	....	4	600	Second.
26	Eleven private ditches	Croydon	1880	Loss Creek	380	200	....	10	2,000	First and second.
27	Eight private ditches	Morgan	1858-89	Weber River	300	....	....	5	800	Do.
	Total				7,24[illegible]	1,408	270	109	$34,470	

REPORT ON RICH COUNTY.

According to Monteith's Geography, Bear River Valley is 6,422 feet above the level of the sea. The snow-fall in the mountains adjoining said valley on the south and west is about 5 feet. That is, it becomes about that deep at a time during the winter, taking no account of what melts before the general spring thaw. There was much less snow than that last winter in said mountains.

According to said geography Bear Lake Valley is 6,001 feet above sea level. The snow-fall during the winter in the mountains encircling said valley is usually about 6 feet, but it was much less than that last winter.

Irrigation begins in Bear Lake Valley about the 1st of April and ends about the 15th of September, the latter date being for the last crop of lucern. For grain and vegetables irrigation begins from about the 1st of May to the 1st of June and ends about the middle of August, varying somewhat according to the season and weather. But it has been found beneficial after crops have been gathered to turn water on the land and let it run all winter, thereby moistening up the ground for next season's crop; therefore the irrigation season may practically be considered to continue the year through, except while drying the land enough for gathering crops, plowing, etc.

In Bear River Valley irrigation begins properly about the 1st of April and ends about the 1st of August. But as the main crop of that valley is grass for hay, what water there is in the fall and winter is turned on to the land to prevent the latter from becoming too dry and cracking during hard freezing weather.

At to the quantity of water needed to mature an acre of any given crop, so much depends upon circumstances (season, land, and weather) that it is difficult to lay down any rule in relation to it. In Randolph precinct it has been estimated this summer that a stream, 2 feet 8 inches wide and 4 inches deep, with a velocity of 9¼ seconds to the rod, will only irrigate 60 acres of grain during the irrigation season of three months for that crop. That seems to me to be rather a low estimate; yet it was made on the ground when an irrigator was at work, the soil heavy and clayey, the sun hot, and the weather dry. In Laketown precinct an irrigation stream is made to do much more than that, with the same crop up to nearly or quite twice as much.

Regarding the time required at each irrigation to properly moisten the soil much depends upon the kind and dryness of the land and the distance down to moisture. Water running a few minutes over sandy, loamy, and some gravelly soils will often be sufficient to properly soak the land and moisten the crop; whereas heavy, clayey land, very dry, may require several hours, and then dry out much quicker than the former. Land should be irrigated about once a week for gardens and from fourteen to twenty-five days for general crops according to the weather, kind of soil, whether naturally moist, dry, or heavy, etc.

As to the quantity of water needed to irrigate the various kinds of mineral soils much depends upon the natural character of the land aside from the mineral it contains. If sandy or loamy, much less water will be required than if heavy or clayey. When the land slopes sufficiently to admit of water running off freely the latter can be used very advantageously in washing off the mineral. In fact it seems that there is no land, however strongly impregnated with salt or any other mineral, but can be reclaimed by fresh water running over it long enough.

The loss of crops in this county this season for lack of water for irrigation while considerable is nevertheless difficult to estimate in acres or in any other definite way. Anticipating a dry season, the farmers of Laketown precinct did not put in so much grain last spring as usual, yet over 100 acres of that crop has been lost and about 95 per cent. of the last crop of lucern also. About the same quantity of grain has been lost in Meadowville precinct, and probably about one-third of the hay crop there. Garden City, the remaining precinct of this county in Bear Lake Valley, has had plenty of water for irrigation, therefore no loss has been experienced there on account of drought. In Beaver River Valley the loss on the hay crop (the principal crop raised there) has been about one-half on account of the water failing so materially about the 1st of June. Bear River usually furnishes, at the beginning of the irrigation season, about five hundred irrigation streams, yet about the 1st of July it ceased to flow where it enters this county.

There are sites for reservations in this county to store up all the waste water during the spring thaws, which would about double its volume during the irrigation season. This, during seasons like the present, would probably irrigate about half the lands having claims on water for irrigation, and in years of ordinary snow-fall, would perhaps water a trifle more than said lands. Water rights for irrigation in this county are recognized by date of appropriation and use, not by date of record.

But little if anything can be done in this county towards storing water to irrigate land not already covered by the canals and ditches now constructed. As all that could be stored would hardly be sufficient, such a season as the present one, to irrigate more than one-half the lands having water rights, and in the favorable seasons not water much if any more than said land, the matter of storage seems to be all important. But most of the landholders are hardly able to bear the expense of costly reservoirs. Does the Government contemplate assisting such? Would there be anything more than simple justice in such an act? The farmer or rancher has to pay just as much for his land in the arid region as those in more favored localities as regards moisture or the dews of heaven, and then go to the expense of from $3 to $10 per acre to irrigate it, and often is unable to do it properly at that. Certainly a little equalization would be in order towards encouraging the tiller of the soil in a region denied to quite a degree one of nature's main blessings. The pioneer work of settling the arid region has supplied an important link in the great national chain, a link in the absence of which would have been a broad expanse of dreary waste. Therefore the sturdy manhood that led or took part in the useful work deserves more recognition and encouragement at the hands of our national Government than has as yet been bestowed. Not, perhaps, because of any desire of the officers of the Government to be unappreciative of the efforts of any of its citizens towards advancing the interests of our common country, but because of not fully understanding what has been done and the circumstances under which it has been accomplished.

The characteristic fairness of the American people would, I think, prompt all, learning by experience what it is to settle an arid region and cause it to become fruitful, to cheerfully support the Government in dealing generously with the agriculturist in the dry belt. But in view of past experience in this respect quite a number of intelligent citizens of an adjoining Territory fear that the present move of the Government is quite as likely as otherwise to operate prejudicially to the interests of the present settlers, either by making it more difficult for them to construct reservoirs on the public domain, or of acquiring sites for reservoirs, or by Government building reservoirs and selling stored water from land now needing it.

To prove that Government designs to foster the interests of the unfortunate husbandman struggling with drought and low prices for farm products and beef, I would suggest the sinking of a few experimental artesian wells in Bear River Valley and in Bear Lake Valley, and building a storage reservoir in each of said valleys where such is most needed, or likely do the most good, and let the settlers have the benefits resulting therefrom free of cost.

The Narrows on Bear River near the Utah and Wyoming line is an excellent place to try the reservoir experiment, provided, of course, Messrs. Bothwell & Co. do not object and prevent the Government taking such a step on the public domain.

As regards Bear Lake, I would suggest that the Government make it a reservoir site, much as I suppose has been done with Utah Lake, under such rules and restrictions as will properly guard the interests of all concerned.

If any surplus water of Bear River or any other stream comes where it can be stored in Bear Lake and utilized to nobody's harm instead of going to waste all right. But no individual or company, certainly, should be allowed to strip, as it were, a portion of the little remaining moisture, or sap out of the Bear Lake or Bear River regions and try to take it to some distant point already liberally supplied in comparison with either of said regions with its natural share of water.

The citizens of this region can not but view with apprehension anything likely to lead to drawing the little remaining moisture out of or from their land and to start it to some far away place, much to be wasted in evaporation, etc.

Bear Lake can well be kept up to high-water mark most of the year, but it should never be drained below low-water mark, as the land along or near its shores not only would be dried out thereby, but the drying up of the wide belt of sand and mud around the present outer edge of the lake that would then be left bare to a hot August sun would be likely to produce malarial fevers and possibly other diseases.

The newspapers make Mr. Bothwell say, if I mistake not, that he has filed on Bear Lake and Bear River according to United States law and Territorial statutes of Utah and Idaho. However that may be, both bench and bar of this Territory, sustaining a long established custom, have long construed the law as recognizing rights to water for irrigation as acquired by appropriation and actual use only. There would seem to be a difference between appropriating and using water for years, making canals and ditches of an expensive nature to use more when Providence favors with an additional supply, and filing an intention or notice of such, of storing, taking out and selling water at some future time. Messrs. Bothwell & Co.'s recorded filing may hold good as against any other party or parties trying to do the same thing they contemplate doing, but they can hardly be expected to be allowed to strip the springs and streams of this region to take, as it were, the life blood out of our soil to enrich themselves. Possibly they contemplate nothing of the kind, but if not, they would perhaps do well to instruct their engineers to be a little more cautious about making injudicious remarks while measuring streams long appropriated and used. As before indicated, let them utilize all the surplus water they can without injury to any one, but no Shylock stripping of streams, nor spoiling of Bear Lake, nor arbitrary putting settlers to the trouble and expense of contending against their boasted millions of money.

In conclusion I would say that if the Government were to expend a small portion of the surplus in the overflowing national Treasury towards sinking experimental artesian wells and building reservoirs in the arid region for the encouragement of the struggling settlers, and assist in every legitimate way said settlers towards constructing reservoirs, the interests of the Government and the welfare of its citizens would be advanced thereby.

W. P. NEBEKER,
Special Irrigation Commissioner.

IRRIGATION NOTES.

The special commissioner for Rich County makes the following among other notes: In designating the quantity of water furnished or used, an irrigation stream has been taken as a unit or base of calculation. Such a stream is generally known in Rich County as the quantity of water one man can use in watering grain and vegetable crops, without waste of water or danger of injury to land by washing gullies, etc. The Swan Creek Irrigation Company designates such a stream as 20 inches wide, 2¼ inches deep, under a pressure of 12 inches. By measurement I have ascertained that an irrigation stream, as issued to land holders in Laketown precinct, is (after bringing the water to a standstill against a dam) a sheet of water 30 inches wide and 3 inches deep, falling over a board one-half an inch thick. In this method of measurement the water falls from the surface; therefore there need be no doubt about the pressure or any complex contrivance to obtain it.

I have not attempted any miner's inch, cubic foot, or gallon measurements, for lack of time and necessary conveniences to obtain them. Few men, civil engineers, perhaps, not excepted, unless they are irrigators, know how many miner's inches, cubic feet, or gallons an irrigation stream would represent in any given time. All the granger cares to know is that when his turn comes to use the water he gets all he can well manage without waste or damage to his crops or land.

Mr. Nebeker also suggests, under the name of "Levee," what is believed to be a new system of irrigation in Utah. It consists in dividing up the land into plats by means of embankments of earth thrown up somewhat higher than the most elevated piece of land in the plat to be irrigated. The water is turned into the plat highest up on the canal or ditch, and is allowed to form a pond or lake, covering the plat. After remaining there as long as desired, a gate is opened and the water turned into the next plat, and so on till all the plats are irrigated.

The size of the plats are to be arranged somewhat according to the fall or slope of the land and the quantity of water available for use, as from twelve to twenty-four hours should be sufficient to fill and irrigate each plat. Said embankments can be made with plow and scraper, the same as a railroad grade. But where the land is free of rock what is called a ditcher is more profitable to use. It is a machine on four wheels and somewhat resembles a separator to a thrasher. It has a plow on one side and a carrier to take the earth to the other side of the machine.

In making a ditch, the dirt is thrown each side of the piece plowed, but with an embankment, the ditcher runs each side of where the embankment is to stand, throwing the earth together, much as back furrowing with a plow.

This system of irrigation is especially adapted to meadows on wide creek or river bottoms, having a fall of from 1 foot to 3 feet or a trifle more to the mile and plenty of water; changing the water from one plat to the other when necessary being about all the labor required in irrigation.

Streams and water they furnish in Bear River Valley, Rich County.

No. I.

Name.	Capacity in irrigation streams.		Shrinkage, 1889.	Remarks.
	April 1, ordinary seasons.	July 1, 1889.		
			Per cent.	
Saleratus Creek	10	Failed entirely	100	Inclined to run down early.
Woodruff Creek	20	4 streams	75	Depends mostly on the winter's snow.
Bear River	500	Failed entirely at Narrows.	100	Bed dry at Narrows.
Randolph Big Creek	17	4 streams	76	Not inclined to hold out well.
Randolph Little Creek	3	2 streams	33⅓	Continues good throughout the season.
Otter Creek	15	10 streams	33⅓	Do.
Wells or Sage Creek	1½	Failed entirely	100	Not inclined to hold out well.
Six Mile Creek	2	do	100	Do.

Streams and water they furnish in Bear Lake Valley, Rich County.

No. II.

Name.	Capacity in irrigation streams.		Shrinkage, 1889.	Remarks.
	April 1, ordinary seasons.	July 1, 1889.		
			Per cent.	
Laketown Creek	4	3 streams	25	Generally keeps up well.
Braffit's Spring	2	1 stream	50	Usually holds out well.
Cottonwood Creek	2	....do	100	Failed entirely.
Pine Kanyon Creek	½	....do	100	Do.
Birch Hollow Creek	½	....do	100	Do.
Edgar Valley	2	....do	100	Do.
Meadowville Creek	2	⅛ stream	93¾	Inclined to fail early.
Bisbing Creek	¾	....do	100	Failed entirely.
Swan Creek	30	15 streams	50	Generally a permanent stream.
Falula Spring Creek	1½	¾ stream	50	Do.
South Eden Creek	2	....do	100	Failed entirely.
North Eden Creek	3	1 stream	33⅓	Does not generally hold out late.
Big Spring Creek	14	9 streams	35 5/7	Generally a permanent stream.

An irrigation stream is all the water one man can use in irrigating grain and vegetable crops without waste of water or damage to land by way of washing gullies, etc. In Laketown precinct it has been ascertained by measurement to be a sheet of water 30 inches wide, 3 inches deep, falling over a board one-half an inch thick. In Garden City precinct it is designated as 20 inches wide, 2½ inches deep, under a 12-inch pressure.

Canal or ditch statistics of Bear River Valley, Rich County.

No. III.

Name of canal or ditch.	When built or first used.	Streams from which water is diverted.	No. of irrigation streams furnished by each.	Irrigated.	Irrigable.*
				Acres.	*Acres.*
Randolph Irrigation Co., Upper Big Ditch.	Apr., 1872	Randolph Big and Little Creek.	20	705	795
Randolph Irrigation Co., Lower Big Ditch.	May, 1881	Randolph Big Creek	17	550	585
Randolph and Woodruff Canal	1886	Bear River	500	2,000	4,000
Bear River Irrigation Co	1883	......do	500	1,500	500
Crawford and Dykins Ditch	1887	......do	500	1,000	1,000
Beckwith Ditch	1887	......do	500	8,120	....
Otter Creek Canal Co	1889	Bear River †	500	....	‡10,000
North Otter Creek Ditch	1887	Otter Creek	15	300	300
South Otter Creek Ditch	1887	......do	15	380	340
Booth, Crocker, and Crawford Canal.	1873	Bear River	500	8,000	2,000
Chapman and Strong Canal	1887	......do	500	10,000	18,000
Woodruff South Ditch	1879	Woodruff Creek	20	400	5,000
W. K. Walton Ditch	1874	......do	20	350	400
W. H. Lee's Ditch	1879	Bear River	500	400	200
Bear River Land and Stock Co	1874	......do	....	700	100
Laketown and Round Valley Canal Co.	May, 1888	Big Spring Creek	14	1,016	984
Meadowville Canal	July, 1872	......do	14	402	50
Meadowville Lower Canal	July, 1889	......do	14	1,250	....
Cottonwood Ditch	1868	Cottonwood Creek	2	§252	....
Braffit's Spring South Ditch	1868	Braffit's Spring Creek	2	§251	....
Braffit's Spring North Ditch	1868	......do	2	§95½	....
Laketown No. 1, or North Ditch	1869	Laketown Creek	4	§650	....
Laketown No. 2, or South Ditch	1872	......do	4	§465	....
Swan Creek Irrigation Co. Canal.	Jan., 1877	Swan Creek	30	‖1,505	495
Falula Spring North Ditch	May, 1882	Falula Spring Creek	1½	70	....
Falula Spring South Ditch	Nov., 1883	......do	1½	150	....
Meadowville West Ditch	1874	Meadowville Creek	2	¶200	....
Ira Nebeker Ditch	Apr., 1889	Big Spring Creek	14	400	....

* Good land that could be irrigated by increased water supply in ditches now constructed.

† Is to come from it.

‡ In process of construction; 7 miles done, 23 miles undone.

§ Only about half enough water for the land irrigated.

‖ Plenty of water for all the land this ditch covers.

¶ Hardly half enough water for the land this ditch covers.

Reservoir sites for Bear River Valley, Rich County.

No. IV.

No.	Where situated.	Section.	Township.	Range.	Meridian.	Size.		Acres that could be irrigated by reservoirs.
						Area.	Depth.	
			North.	*East.*		*Acres.*	*Feet.*	
1	Head of Murphy Hollow…	23	7	7	Salt Lake…..	100	15	1,000
2	Head of Saleratus Creek…	7	7	7	….do…..	50	10	2,600
3	Dry Creek……………	7	8	7	….do………	75	8	1,000
4	Dry Lake……………	18	8	8	….do………	300	20	5,000
5	Meecham Cañon……….	19	8	8	….do………	100	10	1,000
6	Narrows Bear River…….	14	18	*120	Sixth principal.	1,000	25	50,000
7	Narrows Bear River…….	10	18	*120	….do………	†4,000	50	67,000
8	Cut-off Woodruff Creek….	16	9	6	Salt Lake…..	500	10	5,000
9	Head of Woodruff Creek…	9	9	6	….do………	100	8	4,000
10	Middle Fork Woodruff Creek	19	9	6	….do………	500	10	3,000
11	Left Fork Woodruff Creek.	32	9	6	….do………	75	8	4,000
12	Head of Cottonwood…….	30	12	5	….do………	15	6½	200
13	Head of Birch Hollow……	8	12	5	….do………	10	9	100
14	Hollow north of Cottonwood Creek…………	10	12	5	….do………	5	9	200
15	Edgar Valley…………	4	12	5	….do………	40	12	200
16	Laketown Cañon……….	6, 7	12	6	….do………	‡3	15	600
17	Tufts, Gebo, and Cheeny Cañons…………	17, 20	13	5	….do………	†10	10	150
18	Head of South Eden Cañon.	36	14	6	….do………	10	9	200
19	North Eden Cañon………	3	14	6	….do………	20	13	350
20	North Eden Cañon………	1, 2	14	6	….do………	80	18	

NOTE.—The acres above are not to be added, as the area that water could be brought upon is often covered partly or altogether by one or more other reservoirs, and the 67,000 acres includes what is covered by all the sites.

* West. † Dam 20 rods long, 60 feet high. ‡ Each.

REPORT OF COUNTY RECORDER.

DEAR SIR: Water rights for irrigation are recorded in this office as follows, to wit:

Salaratus Creek.—Fifteen claimants. Nature of right, first appropriation. Range in acres, from 80 to 720. Total, 3,440. Date, eleven in 1880, two in 1886, and one each in 1887 and 1889.

Woodruff Main Creek.—Has twenty-seven claimants. Nature of right, first appropriation. Range in acres, from 80 to 320. Total, 3,372. Date, nineteen in 1884, one in 1880, four in 1886, and one in 1887.

Otter Creek.—Has twenty-four claimants. Nature of right, first appropriation. Range in acres, from 40 to 3,940. Total, 6,945 acres. Date, twenty-one in 1880, one in 1881, and one in 1888.

Big Spring and Lake Town Streams.—Has seventeen claimants. Nature of right, first appropriation. Range in acres, from 21½ to 360. Total, 1,414¾ acres. Date, ten in 1881, one in 1883, one in 1888, and one in 1889.

Big Spring Creek.—Has twenty-seven claimants. Nature of right, first appropriation. Range in acres, from 20 to 154. Total, 1,293¼ acres. Date, twenty-five in 1881, and one in 1888.

Gebo and North Creeks.—Has twenty-three claimants. Nature of right, first appropriation. Range in acres, from 10 to 500. Total, 1,820. Date, seventeen in 1881, one in 1882, one in 1887, and two in 1889.

Bear River.—Has fourteen claimants. Nature of right, first appropriation. Range in acres, from 80 to 6,000. Total, 20,720. Date, one in 1883, three, in 1885, four in 1886, two in 1887, and four in 1888.

NOTE.—Several claimants have no date at all.

The above does not, however, give the total of the lands in this county having vested or accrued rights to water for irrigation, as some land in some cases have recorded rights on more than one stream or source of water supply. Again, many rights for which water commissioner's certificates are held have not been recorded, but some of said certificates are so worded as to show the total number of acres hav-

ing rights on certain streams, and from the information thus obtained it seems that the following number of acres are entitled to water for irrigation and mill, in the respective precincts of this county, to wit:

Recorded to Woodruff precinct 6,812, shows 7,538.
Recorded to Randolph precinct 6,495, shows 7,000.
Recorded to Laketown precinct 1,414, shows 2,760.
Recorded to Meadowville precinct 1,691, shows 3,574.
Recorded to Garden City precinct 1,820, shows 2,500.
Recorded to Bear River stream precinct 20,720, shows, 30,000.

There is also recorded in his office a notice of intention to make a reservoir of Bear Lake, and a notice of intention to appropriate the surplus waters flowing into said lake and river.

Yours, very respectfully,

JOHN SNOWFALL,
Recorder Rich County.

W. P. NEBEKER, esq.,
Special Irrigation Commissioner.

REPORT ON SALT LAKE COUNTY.

By courtesy of J. Towsen Smith, civil engineer, water commissioner for Salt Lake City, the following data, respecting each stream flowing into Salt Lake County at the dates given, is presented:

***City Creek.*—April 23, 1889, 5,630,288 gallons per twenty-four hours at upper waterworks.**

***Red Butte.*—April 26, 1889, 1,094,669 gallons per twenty-four hours.**

***Emigration Cañon Creek.*—April 26, 1889, 1,013,444 gallons per twenty-four hours.**

***Parley's Cañon Creek.*—April 27, 1889, 3,597,236 gallons per twenty-four hours.**

***Mill Creek.*—May 4, 1889, 7,171,170 gallons per twenty-four hours.**

***Jordan River.*—May 21, 1889, 141,161,315 gallons per twenty-four hours.**

***Big Cottonwood Creek.*—May 23, 1889, 89,670,240 gallons per twenty-four hours; immediately following a heavy fall of rain would probably discharge from 9,000,000 to 10,000,000 gallons per twenty-four hours.**

***City Creek, at the head of Pleasant Valley.*—April 25, 1889, 5,696,110 gallons per twenty-four hours. June 5, 1889, 9,879,340 gallons per twenty-four hours.**

***Parley's Creek.*—May 27, 1889, 8,957,140 gallons per twenty-four hours. June 3, 1889, 4,725,735 gallons used on farms in Mountain Dell.**

***Little Cottonwood.*—Not measured; would compare with Big Cottonwood this season.**

Total number of gallons available for irrigation in the principal streams, 188,277,078.

RESERVOIR SITES.

Messrs. Jensen, of Mill Creek; C. A. Casto, of Brinton, and Joseph Scott, of Mill Creek, report the following respecting reservoirs:

Three lakes in Big Cottonwood, South Fork. Nos. 1 and 2 could be made to store 9,576,000 gallons by constructing dams 12 feet high and 150 feet long. Said dams could be raised 30 feet, thereby storing a much larger quantity.

No. 3 has a storage capacity of 21,142,800 by making dam 12 feet high and 150 feet long.

Silver Lake has a storage capacity of 27,183,600 gallons by raising dam 5 feet high and 600 feet long.

Twin Lakes have a capacity of 16,108,800 gallons each by the construction of dam 16 feet high and 200 feet long.

Dog Lake, a small pond, can be made to cover 10 acres with dam 16 feet high and 200 feet long, 40,272,000 gallons.

Lake Pheobe covers 2½ acres of ground.

Lake Mary covers 5 acres of ground; can be raised 16 feet with dam 50 feet long and store 20,136,000 gallons.

Lake Martha covers 4 acres; can be raised 12 feet with dam 200 feet long and store 12,081,600 gallons.

Lake Catherine can be made to cover 6 acres with dam 12 feet high and 150 long, and store 18,122,400 gallons.

Total capacity, 174,199,200 gallons.

In addition to the above there are two fine sites for reservoirs in Dry Creek Cañon, south of Little Cottonwood Cañon, with a storage capacity of over 150,000,000 gallons each.

LAND AND CANAL STATISTICS, SALT LAKE COUNTY.

The South Jordan Canal, taking water from the Jordan River (creek or spring), in the county of Salt Lake, shows: Length of the canal to be 19¾ miles. The upper end or first section is 3 miles long, 12 feet wide at bottom, and falls 3 feet to mile; the canal then narrows and the next section is 11¼ miles long, 15 feet wide at bottom, and falls 19 inches per mile; the next section is 2¼ miles long, 10 feet wide at bottom and falls 32 inches per mile, the next section is 2¾ miles long, 8 feet wide at bottom and falls 5 feet per mile.

Total cost of canal was $87,000. Of this cost about $45,000 was in cash, and the balance in labor at $1.75 per day of ten hours, and $3.50 per day for man and team. The whole canal could probably be built now at a contract price of $75,000.

The canal was begun in 1869; finished 1878; first water used from it 1875.

This canal claims a first right to one-sixth of the water from Jordan River. This right is recorded in records of Salt Lake County.

This canal is owned by a corporation of which the legal name or title is South Jordan Canal Company, and the control is by directors.

The ownership is divided into 6,000 shares, of which 5,000 shares are now issued and in use; the balance of the shares are in treasurer's hands.

The par value of each share is $25; actual selling value per share is about $17.25. Each share was intended to furnish water to 1 acre. The present year, owing to scarcity of water, one share will give water for only two-fifths of an acre. The annual tax or assessment per share averages about 50 cents, which can be worked out at $1.75 per day of ten hours.

There are, in all, about 10,000 acres of arable land under this canal, but only 4,510 acres are now actually watered. Of this amount now irrigated there are in lucern or alfalfa, 1,800 acres; in other hay-making grasses, etc., 70; in small grains (wheat, oats, etc.), 2,400; in vegetables, corn, gardens, etc., 160, and orchards, 80.

Irrigation begins each year about April 15th and ends about October.

The Utah and Salt Lake Canal, taking water from the Jordan River, is 30 miles in length, and is divided into seven sections, respectively in length 9, 6½, 3, 2, 2, 4, 3½ miles each. The width at the bottom of each section is 20, 16, 14, 12, 10, 8, 4 feet each. The fall of first six is uniform at 19 feet per mile; the last one has a fall of 2½ feet per mile.

Canal construction began in 1862; finished in 1888; was first used in 1882. It claims first right to one-sixth water in river. Recorded in county clerk's office, Salt Lake County. Incorporated with 10,000 shares at par value of $25 each; sells at $12.

Each share represents water for 1 acre. This year it gives water for only one-fifth of an acre.

Annual assessment, $1.50; payable in labor at $2 per day of 10 hours.

Under canal, 15,300 acres; actually irrigated, 6,325 acres. In alfalfa, 2,375 acres; n small grains, 3,200; in vegetables, corn, etc., 350, and in orchards, 200.

The Jordan and Salt Lake City Canal, taking water from the Jordan River, in Salt Lake County, is 30 miles in length and divided into three sections, respectively in length, 7, 15, 8 miles each. The width at the bottom is respectively 20, 20, and 10 feet each. The fall of each section is respectively 2½ feet, 19 inches, and 4 feet each per mile. Cost of canal was $235,853.84, all cash. Could probably be built now for same amount at contract price. Canal construction began in 1879; finished in 1882; was first used in 1882. It claims first right to one-third of the water in river. Recorded in records of Salt Lake County. Is incorporated.

The East Jordan Canal, taking water from Jordan River, is 19½ miles in length and divided into one section. It is 15 feet wide at the bottom, and falls 19 inches per mile.

This canal claims first right to one-sixth of the water in river. Recorded in records of Salt Lake County. The par value of each share is $25; actual selling value per share is about $15. Each share was intended to furnish water to 1 acre.

There are in all about 10,500 acres of arable land under this canal; of this amount about 4,100 acres are now actually watered.

The North Jordan canal, taking water from the Jordan River, Salt Lake County, is divided into three sections, respectively in length $2\frac{3}{10}$, $2\frac{5}{10}$, and $2\frac{8}{10}$ miles each; in all $6\frac{6}{10}$ miles in length. The width at the bottom of each section is respectively 20 feet, 12 feet, and 4 feet each. The fall is, respectively, 8½ inches per mile, 2½ feet, and 3 feet each per mile.

Canal construction was begun in 1850, and finished 1878; was first used in 1879.

Canal claims a first right to one-sixth of the water from Jordan River.

Recorded in records Salt Lake County.

It has four shares at par value of $25. Actual selling value, $12.50.

Under canal, 7,400 acres; actually irrigated, about 4,000 acres.

The Beckstead ditch canal, taking water from Jordan River, Salt Lake County, is 4½ miles in length.

Canal construction began in 1859; was finished in 1859; was first used in 1859.

It claims a first right to one-sixth water from the river. It is incorporated.

Under canal, 700 acres; actually irrigated, 700 acres.

The Parker ditch, taking water from Jordan River, Salt Lake County, is 3¼ miles in length.

Canal construction began in 1853; finished in 1865 or 1866; was first used in 1853.

This canal claims a first right to one-sixth water from river. Is owned by private owners. Under ditch, 300 acres; actually irrigated, 150. Of this amount, in small grains, etc., 125 acres; in vegetables, corn, etc., 25 acres.

The Butterfield ditch, taking water from Jordan River, Salt Lake County, is 10 miles in length, and is divided into two sections, respectively in length 7 and 3 miles each. The width at the bottom of each section is 2 feet and 1 foot each. Its fall is respectively 100 and 75 feet each per mile.

Cost of canal was $1,000, payable $100 cash and balance in labor at $2 per day of ten hours, and $3.50 per day for man and team.

Canal construction began in April, 1850; finished May 1, 1850; was first used 1850.

Recorded in county clerk's office July 13, 1880.

Is owned by private parties and is divided into twenty-three shares, at par value of $300 each; selling value at about $300. Each share represents water for 5 acres. This year it gives water for only 2 acres. Annual assessment, $5, payable in labor at $2 per day of ten hours.

Under ditch, 2,000 acres; actually irrigated, 300 acres. In alfalfa, 200 acres; in other hay-making grasses, etc., 12 acres; in small grains, 80 acres; vegetables, corn, etc., 80 acres; orchards, 25 acres. Irrigation from April 1 to October 1, each year.

The South Willow Creek canal, taking water from the South Willow River, Salt Lake County, is 2 miles in length and divided into one section. The width at bottom is 2 feet.

This canal is owned by private parties, and is divided into three shares. Each share was intended to furnish water to 10 acres.

There are in all about 700 acres of arable land under this canal; but only 30 acres are now actually watered. Of this amount there are in lucern or alfalfa, 30 acres; in small grains (wheat, oats, etc.), 8 acres, and in orchards, 4 acres.

Irrigation begins each year about April 15 and ends about October.

Suitable place for reservoir; could store a great quantity.

The Draper irrigating canal, taking water from Jordan River, Salt Lake County, is 8 miles in length, and is divided into three sections respectively in length 3, 3, and 2 miles each. The width at the bottom of each section is 4, 6, and 3 feet each. The fall is respectively 150, 50, and 25 feet each per mile. The last section is composed of three divisions.

Cost of canal was $15,000. Of this $1,000 was cash, and balance in labor at $2 per day of eight hours, and $4 for man and team. It could probably be built now at contract price of $5,000.

Canal construction began in spring of 1850; finished spring of 1869; was first used in 1850.

Recorded in records of the county court. Incorporated, with 1,010 shares, at par value of $30; sells at about $25. Each share represents water for 1 acre. This year it gives water for only one-tenth of an acre. Annual assessment 50 cents, payable in labor at $1.50 per day of eight hours.

Under canal, 10,000 acres; actually irrigated, 2,000 acres. In alfalfa, 300 acres; in hay-making plants, etc., 100 acres; in small grains (wheat, oats, etc.), 1,000 acres; in vegetables, corn, etc., 500 acres, and in orchards, 100 acres.

Irrigation begins each year April 15, and ends about October.

This canal claims a right in Big and Little Willow Creeks, South Dry Creek, Rocky Mouth, and springs, Bear Canyon, and one-half of the North Dry Creek to July 20, and two-thirds thereafter.

In the early settlement of the country the settlers took advantage of all the natural channels of the streams enumerated in the report, which accounts for the great change in the fall per mile. It will be understood that in assessment there is no cash debt incurred, outside of which labor does the repairing.

The Dry Creek ditch, taking water from Dry Creek River, Salt Lake County, is 5 miles in length and is divided into two sections, respectively in length 2 and 3 miles each. The width, at bottom, of each section is respectively 5 and 4 feet each, and the fall is 20 and 25 feet each per mile.

Cost was $5,000. Of this, $200 was cash and balance in labor at $2 per day of eight hours and $3.50 for man and team. It could probably be built now at contract price of $3,500.

Canal construction began in spring of 1869; finished, 1874; was first used in spring of 1870.

It claims a first right to one-half of the water in Dry Creek and first surplus. It is owned by an association and is divided into 3,200 shares, at par value of $5; selling value about $1.75. Each share represents water for 1 acre. This year it gives water for only one-fourth of an acre. Annual assessment, 25 cents, payable in labor at $1.50 per day of eight hours.

Under ditch, 6,000 acres; actually irrigated, 2,000 acres. Of this amount now irrigated there are in lucern or alfalfa 1,000 acres; in small grains (wheat, oats, etc.), 1,000. Irrigation begins each year about May 1 and ends about October.

The East Jordan irrigation canal, taking water from Little Cottonwood Creek, Salt Lake County, is 5¼ miles in length, and is divided into three sections, respectively in length 2, 1¼, and 2 miles each. The width at the bottom of each section is respectively 6, 6, and 5 feet each. The fall of each section is respectively 20, 20, and 15 feet each per mile.

Cost of canal was $1,550 cash, and balance in labor at $2 per day of ten hours, and $4 for man and team. It could probably be built now at contract price of $10,000 in consequence of enlargement.

Canal construction began in 1866; finished, 1867; was first used in 1866.

It claims a surplus right to water from Little Cottonwood Creek and River. Recorded in county clerk's office of Salt Lake County, May 15, 1886.

It is owned by private parties, and is divided into 766½ shares, all of which are issued and in use. Par value per share is $20. Each share represents water for 2 acres. This year it gives water for only ½ of an acre. Annual assessment, 20 cents, payable in labor, at $2 per day of ten hours.

Under canal, 1,650 acres; actually irrigated, 1,200 acres. In alfalfa, 600 acres; in small grains, etc., 600 acres.

Irrigation begins each year about April 15, and ends about August 20.

The Cahoon and Maxfield canal, taking water from Little Cottonwood River, Salt Lake County, is 5 miles in length and is one section; being 2 miles long, 8 feet wide at bottom, and falls 10 feet per mile.

The construction of the ditch was begun in 1849; finished in 1850; and was first used in 1850.

It claims a prior right to five-eighteenths of the water in Little Cottonwood Creek. Recorded in the county clerk's office December 5, 1856.

It is owned by an association and is divided into 3,000 acres. The annual assessment per acre averages about $1.50 payable in labor at $1.50 per day of eight hours. There are in all about 3,000 acres under ditch; actually irrigated, 2,626 acres. Of this amount now irrigated there are in lucern or alfalfa, 900 acres. In other hay-making plants or grasses, 450. In small grains (wheat, oats, etc.), 800. In vegetables, corn, gardens, etc., 326, and in orchards, 150 acres.

Irrigation begins each year about April 5 and ends about October 30.

The Tanner ditch, taking water from Little Cottonwood, Salt Lake County, is 4½ miles in length, and is divided into three sections, respectively in length one-fourth, one-half, and 3 miles each. The width of bottom of each section is respectively 8 feet.

Canal construction was begun in the fall of 1848; finished spring, 1849; was used first in 1849.

It claims a right to two-ninths of the water from Little Cottonwood River and Creek. Recorded in the minutes of the county court of 1856.

The ownership is divided into 1,288 acres. Each share was intended to furnish water to 1 acre. This year it gives water for only one-half an acre.

The annual assessment per acre averages about 20 cents, payable in labor at $2 per day of ten hours.

There are in all about 1,288 acres under canal but only one-twentieth is actually irrigated.

Of this amount now irrigated there are in lucern or alfalfa, 444 acres; in other hay-making plants, grasses, etc., 200; in small grains (wheat, oats, etc.), 300; in vegetables, corn, gardens, etc., 244, and in orchards, 100 acres.

Union and Jordan irrigating ditch, taking water from Little Cottonwood River, Salt Lake County, is 5 miles in length, and is divided into three sections, two respectively of three-quarters of a mile and one of 3½ miles. The width at bottom of each section is respectively 10, 8, and 6 feet each.

Construction of ditch began in 1850; finished 1850; was first used 1850.

This ditch claims a prior right to five-eighteenths of the water in Little Cottonwood River and Creek. Recorded in the records of the Salt Lake County court, December 5, 1856.

It is owned by association, and is divided into acre shares. The annual assessment per acre averages $15, payable in labor at $2 per day of eight hours.

There are, in all about 2,200 acres under ditch, but only about 1,800 acres actually watered. Of this amount now irrigated there are in lucern or alfalfa, 600 acres. In other hay-making plants, etc., 200; in small grains (wheat, oats, etc.), 700; in vegetables, corn, gardens, etc., 200, and in orchards, 100 acres.

Irrigation begins each year about April 15 and ends about November 1.

The original name of Union and Jordan irrigating ditch was known in the county records as the Union ditch, to convey the waters to the Hammond survey.

The Walker ditch, taking water from the Little Cottonwood Creek, Salt Lake County, is 4 miles in length, is in one section, and is 3½ feet wide at bottom.

Construction of ditch was begun in 1849, and finished in 1850; was first used in 1849.

This canal claims a first right to one-ninth of the water in Little Cottonwood Creek.

The ownership is divided into 500 acres. The present year each share gives water enough for only one-thirtieth of an acre. The annual assessment per acre averages about 10 cents.

There are in all about 500 acres under the ditch, but only 20 acres actually irrigated. Of this amount now irrigated there are in lucern or alfalfa, 150 acres; in other hay-making plants, grasses, etc., 100; in small grains (wheat, oats, etc.), 200; in vegetables, corn, gardens, etc., 25; and in orchards, 25 acres.

Irrigation begins each year about April 1 and ends about October.

The Nichol ditch canal, taking water from Little Cottonwood, Salt Lake County, is 5 miles in length, and is divided into four sections, respectively in length 2, 1, and one-half miles each. The width at bottom of each section is respectively 6, 5, and 5 feet each. The fall is respectively 25, 10, and 30 feet per mile, and the next section 1½ miles to the terminus, 2 feet wide and 10-foot fall.

Cost of canal was $2,000; of this, $300 was cash, and the balance in labor at $3 per day of ten hours, and at $5 per day for man and team.

Canal construction began in April, 1877, and finished May, 1877; was first used in May, 1877. It claims a surplus right to water from Little Cottonwood Creek. Not recorded. It is owned by association, and is divided into 369 shares, at par value of $10; sells at $15. Each share was intended to furnish water to 1 acre. The annual assessment averages about 25 cents. There are in all 997 acres under the ditch. Actually irrigated, 368 acres. Of this amount now irrigated there are in lucern or alfalfa, 220 acres; in other hay-making plants or grasses, 5; in small grains (wheat, oats, etc.), 120; in vegetables, corn, gardens, etc., 17½, and in orchards, 5½ acres.

Irrigation begins each year about May.

Richards Ditch, taking water from Little Cottonwood Creek, Salt Lake County, is 2 miles in length, and is divided into two sections, respectively in length, 1¼ and three-quarter miles each. The width at bottom of each section is respectively 8 and 2 feet each.

Canal construction began in 1849; finished, 1849; was first used in 1849.

This canal claims a first right to one-ninth of the water in Little Cottonwood River. It is owned by private parties and is divided into 415 acres.

Under the ditch there are about 415 acres, but only 220 acres actually irrigated. Of this amount now irrigated there are in lucern or alfalfa, 45 acres; in other hay-making plants or grasses, 92 acres; in small grains (wheat, oats, etc.), 45 acres; in vegetables, corn, gardens, etc., 25 acres, and in orchards, 13 acres.

Irrigation begins each year about April 12 and ends about August 30.

The South Dry Creek Big Cottonwood Canal, taking water from the South Dry Creek River, Salt Lake County, is 1 mile in length, and is 1 mile long, 2 feet wide at bottom, and falls 1 foot.

Cost was $100 cash, and balance in labor at $1.50 per day of eight hours, and $3 for man and team.

Canal construction began in 1848, and finished 1848; was first used 1848. It claims a first right to all the water in South Spring River. Under the canal there are 100 acres; actually irrigated, 100 acres. Of this amount now irrigated there are in lucern or alfalfa, 40 acres. In small grains (wheat, oats, etc.), 49 acres. In vegetables, corn, gardens, etc., 5 acres, and in orchards, 6 acres.

Irrigation begins each year about May 1 and ends about September 15.

Brown and Sanford Ditch, taking water from Big Cottonwood Creek, is 3¾ miles in length and is divided into three sections, respectively in length, ¾, 1¼, and 1¾ miles each. The width at the bottom of each section is respectively 6, 5, and 3 feet each.

Canal construction was begun in 1872 and finished 1874; was first used 1873.

This canal claims a right to one-fifth of the water from Big Cottonwood Creek. Is recorded in the county recorder's office.

The ownership is divided into 195 shares, which are now issued and in use. Par value of each share is about $100. Selling values $100. Each share represents water to 13½ acres. This year it carries no water. Annual assessment, $2, payable in labor at $1.50 per day of ten hours.

Under the ditch there are 2,200 acres; actually irrigated, only 25 acres. Of this amount, there are lucern or alfalfa 800 acres; in other hay-making plants or grasses, 100 acres; in small grains (wheat, oats, etc.) 250 acres; in vegetables, corn, gardens, etc., 40 acres; and in orchards, 40 acres.

Irrigation begins each year about May 1 and ends about October.

The Big Creek has three forks or branches. The first branches off about half a mile from the head and is known as the Miller Fork; it waters about 385 acres. About 2½ miles farther down it forks again, and they are known as the North and South Forks. Between the Miller Fork and the other forks, 425 acres are watered. The South Fork waters about 1,110 acres. The North about 555 acres.

Upper canal, taking water from Big Cottonwood Creek, is six miles in length, and is divided into two sections, respectively in length, 4 and 2 miles each. The width at bottom of each section is respectively 10 and 8 feet each. The fall of each section is respectively 20 and 10 feet each per mile.

Canal construction began in 1850 and finished in 1852; was first used in the spring of 1850.

The ownership is divided into 10½ shares, which are now issued and in use. Each share was intended to furnish water to 130 acres. The present year, it gives water for only 43½ acres. Annual assessment $39, payable in labor at $1.25 per day of eight hours.

Under the canal, 1,630 acres; actually irrigated, 1,556 acres. Of this amount, alfalfa or lucern, 778 acres; in small grains (wheat oats, etc.), 518 acres; in vegetables, corn, gardens, etc., 200 acres, and in orchards, 60 acres.

Irrigation begins each year about May 1 and ends about September.

Big Cottonwood Creek was arbitrated and divided into six shares. There was no record made of the creek that we know of until 1879, when most of the people agreed to arbitrate. The shares were divided according to the acreage.

Big Cottonwood Tanner Canal, taking water from Big Cottonwood Creek, is 4½ miles in length, and is divided into three sections, respectively, in length one-quarter, one-half and 3¾ miles each. The width at bottom of each section is respectively 8, 8, and 6 feet each.

Canal construction began in fall of 1848, and finished spring, 1849; was first used in spring, 1849. It claims a first right to one and one-quarter of the water from Big Cottonwood Creek in low stage of water.

It is owned by private parties and is divided into 1,605 shares, now issued and in use, at par value of $100. Each share represents water for 1 acre. The present year it gives water for only one-twentieth of an acre. Annual assessment, 20 cents, payable in labor at $2 per day of ten hours.

Under canal, 1,605 acres, but only one-twentieth now actually irrigated. Of this amount, alfalfa or lucern, 605 acres. In other hay-making grasses, 200 acres. In small grains (wheat, oats, etc.), 500 acres. In vegetables, corn, gardens, etc., 200 acres, and in orchards, 100 acres.

Irrigation begins each year about April 15 and ends about October 1.

Green Ditch, taking water from Big Cottonwood Creek, is 2½ miles in length, and is divided into two sections, respectively in length 1 and 1½ miles each. The width at bottom of each section is, respectively, 8 and 6 feet each. The fall of each section is, respectively, 10 and 6 feet each per mile.

Cost was $200 cash, and balance in labor at $1.50 per day of ten hours, and $3 for man and team.

Canal construction began in 1848, finished in 1849, and was first used in 1848.

It claims a first right to one-sixth of the water from Big Cottonwood River. The ownership is divided into 625 shares.

Under ditch, 625 acres. Actually irrigated, 625 acres. Of this amount, alfalfa or lucern, 62 acres; in other hay-making grasses, etc., 126 acres; in small grains, etc., 109 acres; in vegetables, corn, etc., 76 acres, and in orchards, 12 acres.

Irrigation begins about May 1 and ends about September 1.

There are 240 acres of pasture and timber which need irrigation.

A. H. Neff Ditch, taking water from Mill Creek, is one-half a mile in length and is one section, being 2 feet wide at bottom, and falls 2 feet per mile.

Canal construction was begun in 1855 and finished in 1855; was first used in 1855.

The ownership is divided into 4 shares, at par value of $1,700, sells at $1,700. Each share represents water for 34 acres.

The present year it gives water for only 6½ acres. Annual assessment $2, payable in labor at $1.50 per day.

Under ditch there are 225 acres and only 25 acres are actually irrigated. In vegetables, corn, gardens, etc., 10 acres; orchards, 15 acres.

Irrigation begins each year about March 1 and ends about November.

At present there is about 24 inches of water in the ditch. This, when carried one-half mile will lose in seepage and evaporation nearly one-half, so that it is impossible to irrigate any lucern from this small stream. Can be used only on orchards and gardens.

Alva Keller Ditch, taking water from Mill Creek, is 1½ miles in length and 3 feet wide at bottom.

Cost was $600, payable in labor. Could probably be built at contract price of $400.

Canal construction began in 1848 or 1849, and water was first used from it in 1848 or 1849.

Each share represents water for 40 acres. This year it gives water for only 8 acres.

Under ditch there are 200 acres; none actually irrigated.

Irrigation begins each year about April 1 and ends about October.

The Keller Ditch was dug in 1848 or 1849, and was enlarged in 1871, and at the arbitration was awarded 4.24 shares of the waters of Mill Creek.

Franklin and John Neff Canal, taking water from Mill Creek, is one-half mile in length, 2½ feet wide at bottom, and falls 40 inches to the mile

Cost of canal was $200. Of this amount $50 was cash. Could probably be built now at contract price of $150.

Canal construction was begun in 1875, and finished in 1875; was first used in 1875.

This canal claims a first right to two shares of surplus water from Mill Creek; is recorded in the decisions of the water commissioners of Salt Lake County. Each share represents water for 34 acres. This year it gives water for only 5 acres. Annual assessment averages about $5. Under ditch there are 200 acres, and 25 are actually irrigated. Of this amount, in lucern or alfalfa, 3 acres; in small grains (wheat, oats, etc.), 10 acres; in vegetables, corn, gardens, etc., 5 acres; and in orchards, 7 acres.

Irrigation begins each year about March 1 and ends about November 1.

There are no shares in the ditch, but each person owns according to the amount he cultivates. The three last summers the water has failed.

Brigham Young Ditch, taking water from the Mill Creek, is one and one-half miles in length. The first section is one and one-half miles in length, five feet wide at bottom, and falls twenty feet per mile. Could probably be built now at contract price of $1 per rod.

Canal construction began in 1852, finished in 1852.

This canal claims a first and second right to fourteen out of sixty shares water from Mill Creek; is recorded in decisions of the water commissioners of Salt Lake County. The ownership is divided into 432 shares. Actual selling value per share is about $75. Each share represents water for 1 acre. This year it gives water for only one-eighth of an acre. Annual assessment, 10 cents. Under ditch, 500 or 600 acres. Actually irrigated, only 432 acres. Of this, lucern or alfalfa 145 acres; in small grains (wheat, oats, etc.,) 50 acres; in vegetables, corn, gardens, etc., 20 acres, and in orchards 20 acres.

Irrigation begins each year about April and ends about October.

There has been no water for secondary claimants for two years.

The Chrisman, Bryon, Stillman, Skidmore, and Russell Canal, taking water from Mill Creek, is 5 miles in length.

It cost $1,500. Of this amount $250 was in cash and the balance in labor at $2 per day of ten hours, and $4 for man and team. Could probably be built now at contract price of $1,000.

Canal construction began in 1848 and finished in 1874; was first used in 1848.

It claims a first right to one-twentieth of the water in Mill Creek; is recorded in Salt Lake County.

It is owned by private parties, with six shares.

Each share was intended to furnish water to 34 acres. This year it gives water for only 5 acres. The annual assessment is 15 cents.

Under canal there are, in all, 1,500 acres; actually irrigated, only 225 acres. Of this amount, lucern or alfalfa, 145 acres; in small grains (wheat, oats, etc.), 40 acres; in vegetables, corn, gardens, etc., 15 acres, and in orchards 25 acres.

Hoagland Ditch, taking water from Mill Creek, is 3 miles in length, and is divided into two sections, respectively, in length, 1½ miles each. The width at bottom of each section is, respectively, 4 and 2½ feet. The fall of each section is 15 and 20 feet per mile.

Cost, $500. Of this, $50 was in cash, and balance labor at $2 per day of ten hours, and $4 for man and team.

Canal construction began in 1849 and finished 1849; was first used 1849.

It claims a first and second right to twenty-three sixtieths of water in Mill Creek. Is recorded in records of water rights of Salt Lake County. It is owned by private parties, with 55 shares. Each share was intended to furnish water to 34 acres. This year it gives water for only 6 acres. The annual assessment is $6.50, payable in labor at $1.50 per day of eight hours and $3 per share in cash.

Under ditch there are, in all, about 1,000 acres. Actually irrigated, only 175 acres.

Of this, in lucern or alfalfa, in early season, 250 acres; in small grains (wheat, oats, etc.), 300 acres; in vegetables, corn, gardens, etc., 70 acres, and in orchards 60 acres.

Irrigation begins each year about April 1 and ends about October.

The Edward White ditch, taking water from Mill Creek, is 1½ miles in length, 3 feet wide at bottom, and falls 5 feet per mile.

Cost $1,000. Of this $200 was in cash and the balance in labor at $2.50 per day of ten hours.

Canal construction began in spring of 1872 and finished 1872; was first used 1872.

This canal claims a first and second right and third right to water from Mill Creek; is partly recorded in records of Salt Lake County. It is owned by private parties.

Under ditch there are in all about 354 acres; actually irrigated, 234 acres; of this, in lucern or alfalfa, 126 acres; in small grains (wheat, oats, etc.), 113 acres; in vegetables, corn, gardens, etc., 10 acres, and in orchards, 11 acres.

Irrigation begins each year about April and ends about October.

Turnbow ditch, taking water from Parleys Creek, is 2 miles in length and 4 feet wide at bottom.

Canal construction was begun in 1849 and finished 1849; was first used 1849.

It claims a first right to water from Parleys Creek. It is owned by private parties. The annual assessment is about 20 cents, payable in labor at $1.50 per day of eight hours.

Under ditch there are in all about 500 acres; actually irrigated, 500 acres; of this, in lucern or alfalfa, 30 acres; in other hay-making plants or grasses, 50 acres; in small grains (wheat, oats, etc.), 210 acres; in vegetables, corn, gardens, etc., 200 acres, and in orchards, 10 acres.

Irrigation begins each year about May 1 and ends about October 1.

Sperry ditch, taking water from Parleys Creek, is 1¼ miles long and 4 feet wide at bottom.

Cost of canal was $1,000 cash and balance in labor at $1.50 per day of eight hours. Could probably be built now at contract price for $600.

Canal construction was begun in 1849 and finished 1849; was first used 1849.

It claims a first right to one part of water below Kennedy ditch. It is owned by private parties, with 260 acre-shares, at par value of $10 each. Each share represents water for 1 acre. This year it gives water for only one-fifth of an acre.

The annual assessment is about 20 cents, payable in labor at $1.50 per day of eight hours.

Under ditch there are in all about 260 acres. Actually irrigated, 260 acres. Of this, in lucern or alfalfa, there are 25 acres; in other hay-making plants or grasses, 25 acres; in small grains (wheat, oats, etc.), 40 acres; in vegetables, corn, gardens, etc., 37 acres, and in orchards, 3 acres.

The Kennedy ditch, taking water from Parleys Cañon, is 4 miles in length. Is the same width and fall all along; 4 feet wide and 5-foot fall per mile.

Total cost, $8,294.40, payable in labor at $1.50 per day of ten hours, and $3.50 per day for man and team. It could be built now for same.

Canal construction began in 1849, and finished 1850; was first used 1849.

It claims a first right to two-fifths of the water from Parleys Cañon. Is recorded in Salt Lake County court records. It is owned by private parties, with 876 shares, all of which are now issued and in use. Each share represents water for 1 acre. This year it gives water for only one-tenth of an acre. The annual assessment is about 50 cents, payable in labor at $1.50 per day of ten hours.

Under ditch there are in all 876 acres. Actually irrigated only 876 acres. Of this, in lucern or alfalfa, there are 175 acres; in other hay-making plants or grasses, 60 acres; in small grains (wheat, oats, etc.), 350 acres; in vegetables, corn, gardens, etc., 175 acres, and in orchards, 116 acres.

Irrigation begins each year about May 1 and ends about September 15.

At the time this ditch was first used all of the water flowing from Parleys Cañon was used, and none passed the dam of this ditch. Hence we claim all the water in Parleys Cañon, when needed, to the exclusion of all other ditches or claims, by reason of this right. Was constructed with pick and shovel, and would have to be now. Most of the ditch is on a side hill; the fall being good, there is no seepage.

Saunders ditch, taking water from Parleys Creek, is 1½ miles in length, 3 feet wide at bottom, and falls 50 feet per mile.

The ownership is divided into 270 shares, all of which are now issued and in use. Each share represents water for 1 acre. This year it gives water for only one-half an acre. The annual assessment, 10 cents, payable in labor at $2 per day of eight hours.

Under ditch there are in all about 270 acres. Actually irrigated, 135 acres. Of this, in lucern or alfalfa, there are 100 acres; in other hay-making plants or grasses, 25 acres; in small grains (wheat, oats, etc.), 75 acres; in vegetables, corn, gardens, etc., 30 acres; and in orchards, 40 acres.

Irrigation begins each year about April and ends about November.

Parleys irrigating canal and ditch, taking water from Parleys Creek, is 3½ miles in length. First section is 3½ miles long, 3 feet wide at bottom, and falls 4 feet per mile. Total cost was $3,000. Of this $1,000 was in cash, and balance in labor at $2 per day of ten hours, and $4 per day for man and team. It could probably be built now at contract price of $3,000. Canal construction began in 1878, and finished in 1881; was first used in 1878. It claims a second right to water in Parleys Creek. Recorded in the records of county court. Is owned by private parties. One hundred and twenty shares are now issued and in use. Par value of each share is $30. Actual selling value, $75. Each share represents water for 5 acres. This year it gives water for only 1 acre. The annual assessment, $2; payable in labor at $2 per day of eight hours.

Under canal and ditch, 1,200 acres. Actually irrigated, 400 acres. Of this, in lucern or alfalfa, there are 300 acres. In small grains (wheat, oats, etc.), 50 acres. In vegetables (corn, gardens, etc.), 25 acres; and in orchards, 25 acres.

Irrigation begins each year about March 15, and ends about July.

The Huskinson ditch, taking water from Parleys Creek, is 1 mile long and 1½ feet wide at bottom.

It claims a primary right to water from Parleys Creek. It is recorded in the county clerk's office of Salt Lake County. It is owned by private parties, with 25 acres. The annual assessment per acre is $1.60, payable in labor at $2 per day of ten hours.

There are in all about 150 acres under ditch. Only 25 acres actually irrigated. Of this, lucern or alfalfa, 20 acres; in small grains (wheat, oats, etc.), 24 acres, and in orchards 1 acre.

REPORT ON SAN JUAN COUNTY.

In addition to information already given I would state that about 1,000 acres of the arable land in the county lies adjacent to, and could be irrigated at considerable expense by ditches from, the San Juan River.

The bulk of the remainder lies around the base of the Blue and Elk Mountains at an elevation of from 6,000 to 7,000 feet and on an elevated plateau known as the Cedar Ridge, lying southwest of the Elk Mountains, between the Colorado and the San Juan Rivers, the mean elevation of which is about 5,000 feet; the soil and climate of the great bulk of this land is well adapted for raising grain and all kinds of fruits and vegetables that are raised in a temperate climate. The mountains afford a good supply of timber and nothing is lacking to make this section a very desirable place to dwell in except water. This want could be supplied to a great extent by a proper system of water storage in the cañons and washes around the bases of the mountains.

There are not to exceed three quarter sections of land in the county on which patents have been issued. This land belongs to the Pittsburgh Cattle Company, and is situated near the south base of the La Salle Mountains. On account of the proposition to turn the county into an Indian reservation all lands in the county were withdrawn from the market on the 13th day of November, 1888, and still remain in that condition.

As the county is unsurveyed and very sparsely inhabited, I am not able to give all of the details asked for by the governor, but Hon. F. A. Hammond, who is one of the selectmen of the county, expects to meet the Senate committee in Salt Lake and can give them personally all of the information that they desire in regard to the climate, soil, topographical features, etc., of the different sections.

PETER ALLAN,
County Clerk.

REPORT FROM SCIPIO, MILLARD COUNTY.

George Munroe writes the governor that——

There is, about 8 miles south of Scipio, on the ridge, a natural lake which we use for storing our water in the winter to irrigate in the summer. The lake now is about 2 miles long and 1 mile wide; when we can get it full it affords sufficient water to mature our crops.

This lake could be made to hold ten times this amount. It is a natural basin for 4 or 5 miles above its present dimensions. It has been supposed that the Sevier River could be brought into this lake; if it can, water can be stored here to irrigate thousands of acres of land that is now a barren waste. In this valley the river runs to waste all winter. I think it is worth investigating; at least, if a survey was made to find if it was possible to get the river to come into this lake, it would furnish homes for a great many people. It would be impossible to find a more favorable spot for a reservoir.

REPORT ON KANE COUNTY.

Three-fourths of the surface of Kane County are mountains covered with timber. The other one-fourth is arid land, all of which would produce good crops by being irrigated. The amount now cultivated in comparison to what could be by an increase of water is very small. I will give an account of each of the principal streams separately.

East Fork of the Rio Virgin.—On the headwaters of East Fork of this stream there are about 300 acres under cultivation, about one-fourth of which is irrigated by numerous small ditches.

Ten miles below, the cañon opens out into what is called Long Valley, with an average width of one-half mile and 7 miles in length. In this valley are situated the towns of Glendale, Orderville, and Mount Carmel, Glendale occupying the north, and Mount Carmel the south end of the valley, while Orderville is centrally located.

Between Orderville and Mount Carmel, in what is known as the cove, there are 50 acres of good land that could be cultivated by an extension of the Orderville ditch and an increase of water.

About 1 mile below Mount Carmel a stream called the Muddy comes in from the west, on which about 60 acres are now cultivated, and 200 more could be by an increase of water. From Mount Carmel the course of this branch of the Virgin for 7 miles is a succession of narrow and small coves, containing in the aggregate about 300 acres of good land. There is a small side cañon at nearly every cove that could be dammed up and filled from the main stream in the winter season with sufficient water to irrigate the cove. This is also the case with the Muddy branch. Many of these reservoirs will be made in time by private enterprise, but in the mountains at the head of this stream, some 10 miles above Glendale, are located several large sites which could be used to hold the water up in the spring. Being natural reservoirs, they are used now by parties who farm 15 or 20 acres near them.

One of these sites, owned by R. G. Jolley, could be made to cover 50 acres 6 feet deep at an expense of $500. Another owned by R. G. Jolley & Co., could be made to cover 100 acres 15 feet deep at an expense of $500. Another, owned by E. Potter & Co., could be made to cover 100 acres 8 feet deep at an expense of $500. And yet another, owned by Mr. Levanger, could be made to cover 40 acres 10 feet deep at an expense of $500.

These sites are all located in the mountains among pine timber and removed from all danger of floods, which might break or fill them with mud or débris. All the present owners ask is to be allowed to use the same amount of water from the reservoirs that they now use. There is always an abundance of snow-water to fill these reservoirs and plenty of use for the water in Long Valley.

Kanab Creek.—On the headwaters of Kanab Creek are some very fine farms, comprising about 300 acres of land under cultivation and twice that amount of pasture land under fence. There are 1,000 acres of good land that could be cultivated by an increase of water and one good reservoir site, on the property of Wooley and Seymiller, which could be made to cover 10 acres 10 feet deep at an expense of $1,000.

Immediately below these farms, at the lower end of the valley, the mountains come almost together, and by building a dam 20 rods long and 100 feet high a reservoir could be made that would cover one-half mile square at an average depth of 30 feet.

Eight miles below this point S. M. Anderson has a reservoir in successful operation. It is a little cove on one side of the narrow valley with an area of about 5 acres. He has constructed a ditch 5 miles long to fill it, which he did last spring in one week, to the depth of 8 feet. He is cultivating 15 acres this season, and will not use half the water. He intends to irrigate 50 acres from this reservoir next season.

Twenty-five miles down from the head of Kanab Creek is the town of Kanab, the county site of Kane County. There are no good reservoir sites in the cañon above it, but along the foot-hills on both sides are numerous good small sites which could be filled in the winter.

Johnson Run.—Along this stream for 20 miles the valley has an average width of one-half mile, all good land, and many side cañons that would make good reservoirs at a small expense. The only land cultivated on this stream is the Schutampah ranch and about 150 acres at the town of Johnson, 12 miles east of Kanab, and this is all watered from springs, the streams being dry during the summer season, except when it rains, when it is a rushing torrent, which is also the case in the spring for two or three months.

But the grandest reservoir site in the county is situated about 3 miles below the town of Johnson. Here is a long valley running east and west, and the Johnson Run crosses right through the center of it and breaks through the mountains on the south side. The gap where it breaks through is not more than one-quarter mile wide, and by building a dam across this gap 50 feet high the water would be backed along the valley for 5 miles in length and 1 mile in width. About 2 miles below this gap is situated about 1,600 acres of the best of land.

Kane County is situated over the southern rim of the Great Basin and falls rapidly towards the Colorado River. The average fall of snow in our mountains is not less than 15 feet. In the spring of the year and during summer rains the amount of water that runs into the Colorado River by hundred of streams that are dry at other times is something that can not be estimated. The major part of the water could be held back by the construction of reservoirs. The amount of land, water, and reservoir sites is practically unlimited; all that is lacking is capital and labor to utilize them. We have a semi-tropical climate and one of the best and most extensive stock ranges in the Territory. But the country is sparsely settled and the people are poor and without the means to develop the great resources of the country.

If the Government would take hold of some of these large reservoirs, and thereby furnish employment to the people, they would then be able to construct many smaller ones by private enterprise, and so the money expended would be doubly used in the one direction.

H. E. BOWMAN,
County Surveyor.

RECAPITULATION OF KANE COUNTY.

Name of ditch and valley in which located.	Date when first built or in use.	Stream from which the water is diverted.	Number acres irrigated.	Good land that could be cultivated by an increase of water.	Good land that could be cultivated by new ditches and reservoirs.
Long Valley:				*Acres.*	*Acres.*
Glendale east ditch*	1871	East Fork of Rio Virgin	150	....	....
Glendale west ditch*	1871	......do	150	....	....
Orderville west ditch*	1871	......do	300	....	50
Mount Carmel City ditch*	1871	......do	300	200	300
Mount Carmel east ditch*	1871	......do	75	....	....
Upper Kanab:					
Upper Kanab ditch†	1876	Kanab Creek	300	500	500
Sink Valley:					
Sink Valley ditch†	1876	Springs	50	500	....
Kanab:					
Kanab City ditch*	1870	Kanab Creek	200	200	500
Kanab field ditch†	1870	......do	300	300	1,000

Name of ditch and valley in which located.	Average fall of snow in mountains.	Water per second flowing through her stream where ditch is taken out.	Nature of soil.	How often irrigated.	How long at a time.
Long Valley:	*Feet.*	*Cubic feet.*			*Hours.*
Glendale east ditch*	15	18	Clay	Every 15 days	5
Glendale west ditch*	15	14	....do	....do	5
Orderville west ditch*	15	10	....do	Every 27 days	12
Mount Carmel City ditch*	15	5	....do	Every 20 days	10
Mount Carmel east ditch	15	1	....do	....do	10
Upper Kanab:					
Upper Kanab ditch†	15	7	....do	Every 18 days	8
Sink Valley:					
Sink Valley ditch†	15	1	....do	Once a year	10
Kanab:					
Kanab City ditch*	15	5	Sandy	Every 7 days	1
Kanab field ditch†	15	3	....do	Every 12 days	2

NOTE.—Irrigation season begins April 1 and ends October 1.
*Irrigates orchard, garden, and hay field crops.
†Irrigates hay and field crops.

There have been no crops lost for the want of water, but crops are materially damaged every year from this cause. Clay soil requires more water than sandy soil. There is no particular difference in the amount of water used for different kinds of crops while the crops are growing, but those crops which are longest growing have to be watered longer; hence require more water.

REPORT ON MOUNT PLEASANT PRECINCT, SAN PETE COUNTY.

The water supply is received from the East Mountains, lying about 4 miles east of this town, through five main channels, which are named as follows: (1) Cedar Creek, (2) Town Creek, (3) Pleasant Creek, (4) North Creek, (5) Birch Creek.

These are all natural channels.

(1) Cedar Creek is equally divided between us and Spring City, and its center forms the boundary line between us and Spring City on the south. It was first in use in 1865; the stream irrigates about 300 acres. There are about 800 acres of good land that could be brought under cultivation and irrigated from said channel if a sufficient water supply could be had.

(2) Twin Creek, first in use in 1860, irrigates about 600 acres of land, while there are 1,500 acres of good land which could be irrigated from said channel with sufficient water supply.

(3) Pleasant Creek, first in use in 1860, irrigates about 1,500 acres of land. There are about 1,500 acres of good land now lying idle which could be brought under cultivation and irrigated under said ditch.

(4) North Creek, first in use in 1860, irrigates about 400 acres of land. There are about 800 acres of good land under said ditch which could not be irrigated for want of water.

(5) Birch Creek. Said channel, or the center thereof, from the boundary line on the north, between Mount Pleasant and Fairview, gives half of the water to Fairview and half to Mount Pleasant. First in use in 1864. Irrigates 400 acres of land. Four hundred acres under said ditch not cultivated or irrigated for want of water.

The average depth of snow in the mountains in winter is about 6 feet. Irrigation season commences about May 15 and ends September 1.

For sandy soil 1 inch of water is required. For clay soil three-fourths of an inch will do. Land is irrigated once in three weeks. An irrigation stream used twenty-four hours for each 10 acres.

About 600 acres of grain is lost this year for want of water.

A reservoir site 5 miles north of Fairview is recommended; also Gooseberry Valley, 8 miles due east; it measures 1 by 1½ miles. A dam 100 feet high and 400 feet long would raise the water over the little valley to the depth of 25 feet on an average. A tunnel of about 1 mile would have to be made; plenty of rocks and material near by for building dam. A stream, measuring about 200 inches in low water, empties in there besides the snow water from the mountains.

REPORT ON SEVIER COUNTY.

We have the honor of submitting, as per the governor's requests of July 8, 1889, and on other dates, requiring the county court of Sevier County, Territory of Utah, to place before you for investigation, and to be laid before the United States Senate committee, who are expected to visit Utah some time during the present month on matters connected with storage of cañon water for irrigation purposes, the following report:

In conformity to said request the county court convened on the 17th day of July, and the subject was fully discussed by the court and a committee was duly appointed, consisting of James M. Peterson, county surveyor, and W. H. Clark, for the purpose of making surveys, establishing heights, and cost of cañon dams and reservoirs, measuring streams, and such useful and general explorations as might lead to a fair understanding of the feasibility of said enterprise. The court, in connection with the appointment of said committee, secured the services of F. H. Newell, of the U. S. Geological Survey, who took an active part in the enterprise and proved a valuable man in aiding the committee in their efforts, possessing a thorough knowledge of the entire work.

It will be seen by the subjoined committee's report and the statistical reports of irrigation canals situated in this valley, together with their length, width, and cost, that they consist of eleven, with a running distance in the Sevier Valley of 104½ miles, which flows over and irrigates about 18,000 acres of land, its fountain head being the Sevier River. In connection with these eleven irrigating canals supplied from the Sevier River, there are about 7,000 acres watered from different springs and creeks, making the total amount of 25,000 acres of land under the irrigation system at present.

In connection with this number of 25,000 acres we have a large body of arid land that with proper irrigation could be brought under a fair state of cultivation. An approximate estimate of the number of acres that could be thus cultivated amounts to over 100,000, lying and being situated in this county and known as the Sevier Valley. The majority of this land lies well for irrigation; quality of the soil good; will make beautiful and productive farms.

In submitting the foregoing and the statistical matter therewith connected, we would most respectfully ask that you would give that due consideration to a matter full of importance and intimately connected with the future growth and prosperity of not only this section of Territory but a great portion of the Western country. The suggestions of Engineer F. H. Newell, who has taken so much interest in the subject we refer to, as most feasible and proper, relating to the distribution of water for irrigation in this Territory similar to that system now existing in the State of Colorado.

L. B. KINNEY,
Probate Judge and ex officio County Judge.
ALBERT D. THURBER,
JAMES S. JENSEN,
B. H. GREENWOOD,
Selectmen.

In relation to the Wells Irrigation Canal taking water from the Sevier River, in the county of Sevier, are the following facts:

The length of canal is 4½ miles. The upper end or first section is 1½ miles long, 6 feet wide at bottom, and falls 1¾ feet to the mile; the canal then narrows, and the next section is 1½ miles long, 5 feet wide at bottom, and falls 2½ feet per mile; next section is 1½ miles long, 4 feet wide at bottom, and falls 1¼ feet per mile.

Cost of canal was $2,500. Of this cost $150 was in cash and the balance in labor at $2 per day of ten hours and $4 per day for man and team. The whole canal could now be built for contract price of $1,500.

Canal was begun in spring, 1872; finished spring, 1878; water first used from it in 1872.

This canal claims a right to .04½ water from Sevier River.

This canal is owned by an association, of which the legal name or title is "Wells Company Irrigation District," and the control is by trustees. Annual tax averages about 40 cents, which can be worked out at $2 per day of ten hours.

Land under canal, about 850 acres; actually irrigated, 530 acres. Of this amount now irrigated there are, in lucern or alfalfa, 160 acres. Other hay-making plants or grasses, 25 acres; small grains, etc., 315 acres; vegetables, etc., 25 acres; and orchards, 5 acres.

Irrigation begins March and ends in November.

Elsinore Irrigation Canal, supplied from Sevier River, Sevier County. Length of canal, 9 miles; upper end or first section, 6 miles long, 8 feet wide at bottom, and falls 2¾ feet per mile; the canal then narrows, and the next section is 3 miles long, 6 feet wide at bottom, and falls 3 feet per mile.

Cost of canal, $8,500; of this about $500 cash and the balance in labor at $1.50 per day of eight hours and $3 for man and team. Canal could now be built at contract price of $6,000.

The canal was begun in March, 1875; ended in April, 1877; water first used from it, 1875.

This canal claims a first right to .08 water from Sevier River.

Canal is owned by a corporation, of which the legal name is Elsinore Irrigation Company, and the control is by directors. The ownership is divided into 942 acres, of which all shares are now issued and in use. Par value of each acre is $9; actual selling value per share is about $9. Each share was intended to cover water to 1 acre. Owing to scarcity of water this year one share will give water for only three-fourths of an acre. Annual tax per acre averages about 30 cents, formerly from 50 to 75 cents, which can be worked out at $1.25 per day of nine hours.

Number of acres under ditch, 950; actually irrigated, 900 acres; of this amount now irrigated there are, in lucern or alfalfa, 50 acres; small grains, etc., 800 acres; vegetables, corn, gardens, etc., 50 acres; and in orchards, 30 acres.

Irrigation begins each year about April and ends about September 1.

The Richfield Irrigation Canal, supplied from Sevier River, Sevier County. Length of canal, 17 miles. Upper end or first section is 11 miles long, 12 feet wide at bottom, and falls 5 feet to mile; canal then narrows and the next section is 4 miles long, 8 feet wide at bottom, and falls 5 feet per mile; next section is 2 miles long, 6 feet wide at bottom, and falls 3 feet per mile.

Cost of canal was $20,000. Of this about $500 cash, the balance in labor at $2 per day of ten hours, and $4 for man and team. Could be built at contract price of $10,000.

The canal was begun in the spring, 1865, and finished in spring, 1875. Water first used from it in 1865.

This canal claims a first right to .36¼ water from river.

It is owned by a corporation legally named Richfield Irrigation Canal Company, and the control is by the directors.

Ownership is divided into 4,000 shares, of which 4,000 shares are now issued and in use. Par value of each share is $5; selling value $5. Each share was intended to cover water to 1¼ acres. Owing to scarcity of water present year, one share will give water for only three-quarters of an acre. Annual tax per share averages about $40, which can be worked out at $1.25 per day of eight hours.

Land under ditch, 7,500 acres; land actually irrigated, 5,000 acres; of this amount now irrigated there are in lucern or alfalfa, 500 acres; other hay-making grasses, 1,000 acres; small grains, etc., 3,390 acres; vegetables, etc., 100 acres; and in orchards, 10 acres.

Irrigation begins each year about April and ends about September 15.

Sevier Valley Canal, supplied from Sevier River, Sevier County. Length of canal, 15 miles; upper end or first section 15 miles long, 12 feet wide at bottom, and falls 4 feet to mile.

Cost of canal to date is $40,000. Of this $500 was cost and the balance in labor, at $2.50 per day of eight hours, and $5 per day for man and team.

The canal was begun in fall of 1884; not finished; water first used from it, 1888.

This canal claims secondary right to water from Sevier River. It is owned by a corporation legally named Sevier Valley Canal Company, and the control is by directors. The ownership is divided into 4,000 shares, of which 4,000 shares are now issued and in use. Par value of each share is $10, selling value, $5. Each share was intended to cover water to one-half an acre. Owing to scarcity of water present year one share will give water for only one-twentieth of an acre. Annual tax per share averages about $1, which can be worked out at $1.75 per day of eight hours. Number of acres under ditch, 6,000 acres; of this amount only 2,000 acres are actually watered during high water in Sevier River. Of this amount now irrigated there are in lucern or alfalfa, 50 acres; small grains, etc., 1,930 acres; vegetables, etc., 15 acres; orchards, 5 acres.

Irrigation begins March 15 and ends June 15 for want of water.

Thirteen miles of this (Sevier Valley Canal Company) was finished in 1888. It is located and leveled for a distance of 15 miles farther, and when finished will cover 6,000 acres in addition to what is now cultivated, making a total of 8,000 acres, depending on high water and contemplated reservoirs on the Sevier River.

Vermillion Irrigating and Extension Company, supplied from Sevier River, Sevier County. Length of canal is 18 miles. Upper end or first section, 9 miles long, 16 feet wide at bottom, and falls 2 feet to mile; canal then narrows and next section is 9 miles long, 12 feet wide at bottom, and falls 2¼ feet per mile.

Cost of canal was $18,000, $1,000 cash, and the balance in labor at $2.25 per day of eight hours, and $4.50 per day for man and team. Could be built now at contract price for $8,000.

Canal was begun in spring, 1876; water first used from it, 1876.

This canal claims a primary right to water from Sevier River.

It is owned by a corporation legally named Vermillion Irrigation Canal Company, and the control is by directors. The ownership is divided into 1,016 shares; par value of each share, $10; selling value, about $10; each share was intended to represent water for 1 acre; owing to scarcity of water, present year, one share will give only water for one-half an acre. Annual tax per share averages about $1, which can be worked out at $1.50 per day of eight hours.

Number acres under ditch, 3,200 acres; actually irrigated, 1,200 acres. Of the amount now irrigated, there are in lucern or alfalfa, 100 acres; other hay-making plants, 350 acres; small grains, etc., 725 acres; orchards, 5 acres.

Irrigation begins about April 1 and ends about October 15.

The first 9 miles was finished in 1880; 12 feet wide in the bottom and enlarged in 1887 to 16 feet wide in the bottom.

The second section of 9 miles was begun in 1887 and finished and water conveyed through in spring of 1889.

The third section of 4 miles was begun in 1887, but part of it is unfinished.

The water in this canal is taken out of Sevier River near the city of Richfield, and when dry seasons, the water consists only of seepage from Richfield, Annabella, and Monroe irrigation districts, and from springs in or near the Sevier River.

Capital stock is 1,016 shares, at $10	$10,160
Assessment on shares for construction	7,840
Total	18,000

Isaacson ditch, supplied from Sevier River, Sevier County. Length of canal is 2 miles. Upper end or first section is 2 miles long, 4 feet wide at bottom, and falls 2¼ feet to mile.

Total cost, $565—cash $25, and balance in labor at $2 per day of ten hours, and $4 per day for man and team. Could now be built at contract price for $250.

The canal was begun in 1871—finished spring, 1875. Water first used from it, 1871.

This canal claims a right to .00½ water from Sevier River. It is owned by a private association, legally named Isaacson Irrigating Ditch, controlled by stockholders. Owing to scarcity of water, present year, one share will give water enough for only one-third of an acre. Annual tax per share averages about 15 cents, which can be worked out at $2 per day of ten hours.

Acres under ditch, 250; actually irrigated, 174; of this amount now irrigated there are in lucern or alfalfa, 24 acres. In small grains, (wheat, oats, etc.), 122 acres; in vegetables, corn, gardens, etc., 25 acres; orchards, 3 acres.

Irrigation begins each year about March and ends about November 1.

Joseph Irrigation Canal, supplied from Sevier River, Sevier County. Length of canal, 5 miles. Upper end or first section is 2 miles long, 8 feet wide at bottom, and falls 5 feet to mile. Canal then narrows and next section is 3 miles long, 6 feet wide at bottom, and falls 6 feet per mile.

Cost of canal was $3,900—$100 cash, and balance in labor at $2 per day of ten hours, and $4 per day for man and team. The canal could now be built at contractor's price for $1,500.

Canal was begun in 1872, finished spring 1876; first water used, 1872.

This canal claims a first right to one-tenth of the water from Sevier River. It is owned by a corporation, legally named the Joseph Irrigating Company, and the control is by directors. Par value of each acre is $3.25. Each share was intended to represent water to 1 acre. Owing to scarcity of water, present year, one share will give water for only one-fifth of an acre. The annual tax per acre averages about 35 cents, which can be worked out at $2 per day of ten hours.

Number of acres under ditch, 1,400 acres; actually irrigated, 1,210. Of this amount now irrigated there are in lucern or alfalfa, 250 acres; in small grains, (wheat, oats, etc.), 850 acres; in vegetables, corn, gardens, etc., 75 acres; orchards, 40 acres.

Irrigation season begins about March and ends about November.

Monroe Irrigation Company's Canal, supplied from Sevier River, Sevier County. Length of canal is 8 miles. Upper end of first section, 4 miles long, 9 feet wide at bottom, and falls 4 feet per mile; canal then narrows and next section is 2 miles long, 7 feet wide at bottom, falls 4 feet per mile; next section is 2 miles long, 5 feet wide at bottom, and falls 4 feet per mile.

Cost of canal $6,900—$500 cash, and the balance in labor at $2 per day of ten hours, and $4 per day for man and team. Canal could now be built at contract price for $4,600.

The canal was begun in spring, 1865; finished spring, 1879; water first used from it in 1865.

This canal claims a first right to one-seventeenth part of the water from Sevier River. It is owned by association, legally named Monroe Irrigation Canal Company, and control is by directors. The ownership is divided into 2,300 acres, of which 2,300 acres is in use. Par value of each acre of water right is $4. Actual selling value per acre is about $4 per acre. The present year, owing to scarcity of water, one acre will give water for only two thirds. The annual tax per acre averages 30 cents, which can be worked out at $1.50 per day of ten hours.

Acres under ditch, 2,500; actually irrigated, 2,000. Of this amount now irrigated there are in lucern or alfalfa 300 acres. Other hay-making plants, grasses, etc., 50 acres; in small grains (wheat, oats, etc.), 1,550 acres; in vegetables, corn, etc., 75 acres; orchards, 25 acres.

Irrigation season begins about April 1 and ends about October 1.

Brooklyn Canal, supplied from Sevier River, Sevier County. Length of canal 4 miles. Upper end or first section is two-thirds of a mile long, 9 feet wide at bottom, and falls 3 feet to a mile; the canal then narrows and next section is 3⅓ miles long, 7 feet wide at bottom, and falls 3 feet per mile.

Cost of canal $5,530—$280 cash, and the balance in labor at $2.50 per day of nine hours, and $5 per day for man and team. Canal could now be built, probably, at contract price for $2,750.

Canal was begun in spring, 1873; finished spring, 1878, and water was first used from it in 1873.

This canal claims a first right to a tenth part of the water from Sevier River. It is owned by a corporation, legally named Brooklyn Irrigation Canal Company, and the control is by trustees. The ownership is divided into 553 shares, of which 553 shares are issued and in use. The par value of each share is $10. Actual selling value is about $10. Each share was intended to represent water for each 2½ acres. The present year, owing to scarcity of water, one share will give water for only 1 acre. Annual tax per share averages about 50 cents, which can be worked out at $1.25 per day of nine hours.

Acres under ditch, 2,000; acres actually irrigated, 1,300. Of amount now irrigated there are in lucern or alfalfa, 700 acres; in small grains (wheat, oats, etc.), 500 acres; in vegetables, corn, gardens, etc., 150 acres; orchards, 25 acres.

Irrigation begins each year about April 1 and ends about October 1.

This canal is a consolidation of a portion of Monroe Canal, all of Foreman ditch, all of Morsen Torensen ditch, and all of Brooklyn ditch.

Annabella Irrigation Canal, supplied from Sevier River, Sevier County. Length of canal, 7 miles. Upper end or first section, 6 miles long, 7 feet wide at bottom, and falls 2¼ feet to mile; the canal then narrows, and next section is 1 mile long, 5 feet wide at bottom, and falls 2¼ feet per mile.

Cost of canal $7,500—$200 cash, and balance in labor at $2 per day of eight hours, and $4 per day for man and team. Canal could now be built for contract price, $4,000.

The canal was begun in spring, 1872, finished spring, 1876. Water was first used from it the spring of 1872.

This canal claims a first right to a one-ninth part of the water from Sevier River. It is owned by a corporation, legally named the Annabella Irrigation Canal Company, and the control is by directors. The ownership is divided into 700 shares, of which 700 shares are now issued and in use. The par value of each share is $10; actual selling value, per share, about $6. Each share was intended to represent water for each 2 acres. The present year, owing to the scarcity of water, one share will give water for only 1 acre. The annual tax per share averages about 50 cents, which can be worked out at $1 per day of eight hours.

Acres under ditch, 3,000; acres actually irrigated, 1,305. Of amount now irrigated there are in lucern or alfalfa, 200 acres; in other hay-making plants or grasses, 600 acres; in small grains (wheat, oats, etc.), 475 acres; in vegetables, corn, gardens, etc., 25 acres; orchards, 5 acres.

Irrigation begins each year about April 1 and ends about October 1.

Rocky Ford Canal, supplied from Sevier River, Sevier County. Length of canal, 15 miles. Upper end or first section is 11 miles long, 12 feet wide at bottom, and falls 2¼ feet to mile. Canal then narrows and the next section is 4 miles long, 4 feet wide at bottom, and falls 2¾ feet per mile.

Cost of canal was $4,000, $200 cash and balance in labor at $1.50 per day of eight hours, and $3 per day for man and team. Whole canal could probably be built now for contract price of $3,000.

Canal was begun in spring of 1875; finished, spring, 1884, and water was first used from it in 1875.

This canal claims a primary right to a tenth part of the water from Sevier River. It is owned by a corporation, legally named the Rocky Ford Canal Irrigation Company, and the control is by directors, who appoint water-master. The ownership is divided into 400 shares, of which 400 shares are now issued and in use. The par value of each share is $10; actual selling value per share is about $10. Each share was intended to represent the water for each 10 acres. The present year, owing to scarcity of water, one share will give water for only 5 acres. Annual tax per share averages about $1, which can be worked out at $1.50 per day of eight hours.

Acres under ditch, 6,000; acres actually irrigated, 2,000. Of amount now irrigated there are in lucern or alfalfa, 300 acres; in other hay-making plants or grasses, 200 acres; in small grains (wheat, oats, etc.), 1,325 acres; in vegetables, corn, gardens, etc., 150 acres; orchards, 25 acres.

Irrigation begins each year about May 1, and ends about end of September.

Water for this canal is taken from the Sevier River, about eleven miles northeast of Richfield. In dry seasons this consists only of seepage from the Sevier River, also water from the Cave River and from springs.

In accordance with the appointment of July 17, 1889, we also proceeded on our way of investigating the rights of the different irrigation companies in this county to water from Sevier River. We visited the following companies and got reports from Joseph Wells, Isaacson, Sevier Valley, Elsinore, Richfield, Monroe, and Annabella Canals; also a report from the Vermillion Canal Company.

On the morning of July 24, in company with Mr. F. H. Newell, United States engineer, we proceeded up the Sevier River to prospect for suitable places to build reservoirs; the first day we drove into the East Fork Cañon.

On the 25th we examined the swamp and meadow on Otter Creek from its junction with the East Fork and up east and northeast. Here we found that a dam 170 feet long will be required; the swamp is about 1 mile long; above is a meadow about 5 miles long; the entire valley here can be covered one-half mile wide by a dam 5 feet high; we think all the ranches here could be bought for $15,000 to $18,000.

On the 26th Mr. Isaac J. Riddle went with us up the East Fork from the junction of Otter Creek, and at the lower end of Plateau Valley we found that a dam 16 feet high would back the water of the East Fork at least 1¼ miles up the valley south and one-half mile wide, with two bends running back some considerable distance behind some lava points; length of dam about 180 feet; material handy. From here we went up to Kanarra Ranche to look at a site which we considered as very fair but not of practical value for this county; we also went up Clay Creek, where a small lake might be reservoired, but not to any direct advantage to us.

On our way back we examined the head of Sevier Cañon, below Marysvale, but owing to the limited time at our disposal we could not make thorough examination of this place, but estimated that a dam 10 feet high would back the water of Sevier River 2 miles up to the lower end of Marysvale Valley; average width one-fourth of a mile. We also prospected in Clear Creek Cañon and some of its tributaries, but in our limited time did not find any suitable sites in the Dry or Fish Creek branches; came on down and measured the Sevier River above Joseph Canal Dam and found a flow of 70 cubic feet per second. We would recommend a further examination of the branches of Clear Creek Cañon.

The foregoing is respectfully submitted.

JAS. M. PETERSON,
WM. H. CLARK,
Committee.

To the Judge and members of the county court of Sevier County.

PARTIAL REPORT ON TOOELE COUNTY.

The several sources of supply are very much scattered and far apart, and in dry seasons, through seepage and evaporation, fail to reach the proper channel, which difficulty could be obviated by the use of pipes or flumes. The inhabitants of this county would receive more direct and immediate benefit from the construction of flumes or pipe conduits to convey water lost by seepage in the mountains than from any other means of conservation or storage, as the main difficulty is in conveying the water over the porous soil to the lands suitable for agriculture.

The amount of arable land in Tooele Valley is 100,000 acres, of which 5 per cent. is under cultivation. The amount of arable land in Rush Valley, Tooele County, is 200,000 acres, of which 1 per cent. is under cultivation. The amount of arable land in Skull Valley, Tooele County, is 300,000 acres, of which one-half of 1 per cent. is cultivated.

The total area of Tooele County is about 5,000 square miles, containing a population of about 5,000 inhabitants. In this area is to be found a very large portion of the Great American Desert, and is therefore drier than most other counties, and its citizens have a harder struggle for existence and to obtain a livelihood than those of more favorable localities.

A great tax is annually levied upon the people for the construction and maintenance of a large system of irrigation canals and ditches in the different irrigation districts.

It is recommended that a geological survey be officially made by the General Government of the several irrigation districts of Tooele County, and a sufficient appropriation to cover the expense of piping and collecting the water from the various sources of supply.

CHARLES A. HERMAN,
HUGH S. GOWANS,
Committee.

Canals of Tooele County.

District and stream, cañon, or source.	Miners' inches with 6-inch pressure.	Cultivated.	Snow-fall.	Miles of conduits or flumes needed.		Average elevation.	What 1 miners' inch will water.
		Acres.	*Feet*	*M.*	*ch.*	*Feet.*	*Acres.*
Toole City:							
Settlement	470	1,558	3	5	66	....	1½
Middle	363			4	10	5,000	1½
Grantsville:							
N. Willow	500	1,000	3	5	23	4,350	2
S. Willow	400	1,000	3	5			2
Box Alder	100			3	50		2
Lake View:							
Pine Cañon	125	250	3	2		5,000	1½
Vernon District:							
Big Creek	375	750	2½	....		5,500	2
Stockton:							
Soldier Cañon	100	150	3	2		5,200	1½
Ophir:							
East Creek	170	350	3	3		5,300	2
St. Johns:							
Clover Creek	175	500	2½	4		5,100	2
Deep Creek:							
15-M. Creek	28	57	3	....		4,400	2
Middle Creek	120	235	3				2
Main Creek	90	175	3				2
East Creek	75	150	3				2
West Creek	40	75	3				2
		6,250					

District and stream, cañon, or source.	Volume that conduits or flumes would increase water.	Duration of irrigation season.	Nature of soil.	Acres to cubic foot.	Remarks.
		Months.			
Toole City:					
Settlement	Add ½	....	Sandy	60	Lucern watered in winter months.
Middle	Double	10	Loam	60	Insures one good crop.
Grantsville:					
N. Willow	Double	12	Clay	80	Subject to cloud bursts.
S. Willow	Double	12	do	....	Do.
Box Alder	Double	12	do	....	Good locations for reservoirs.
Lake View:					
Pine Cañon	Add ½	10	Sandy loam.	....	Do.
Vernon District:					
Big Creek	....	7	Loam clay.	....	Do.
Stockton:					
Soldier Cañon	Double	7	Clay loam.	....	
Ophir:					
East Creek	Double	7	Light clay.	....	
St. Johns:					
Clover Creek	Add ½	7	Clayey	..	Do.
Deep Creek:					
15-M. Creek	....	7	Clay	....	Do.
Middle Creek	....	7	Loam	....	Do.
Main Creek	....	7	do	..	Do.
East Creek	....	7	do	....	Do.
West Creek	———	7	do	....	Do.

REPORT ON UINTAH COUNTY.

There was very little irrigation in Uintah County prior to 1878. Pardon Dods, the first settler, used the first water for irrigation about the year 1874. In the spring of 1878 there were scattered along Ashley Creek about a dozen ranches, some with a few acres of oats and small gardens, but depending mostly on stock-raising and trapping for a living. Among these were R. Veltman, Pardon Dods, John Kelly, R. Snyder, A. Taylor, T. Taylor, A. Beatie, W. S. Powell, John Fairchild, George Thorn, sr., James Reed, William Brit, McFarley and McNight, Charles Lyons, and William Graham.

Jeremiah Hatch, sr., David Johnston, Joseph H. Black, Alva Hatch, A. Johnston, and William Clark settled near the present site of Vernal in April and May. After making several trips for their families' supplies, etc., they began taking out the ditch now known as the Central Canal. This company was soon strengthened by others, among whom were James Hacking, Nelse and George Mercley, Alford and S. Johnson. The ditch was ready for use the next spring, and good crops were raised.

At this time there were more settlers along the creek than on the bench. About one fourth the water was taken on the bench and the remainder run down the creek. This was not sufficient to reach the lower settlers, and at this early date many lost their crops. It was soon discovered that it took less water to run through the Canal than through the creek-bed. At the present time the water is divided at the mouth of the cañon into three equal parts, one running down each of the canals and the other down the creek. Springs have broken out in many places along the foot of the bench and large streams of waste water are continually flowing down the waste ditches of the creek, but this will not reach the lower settlers during the month of July, and many of them annually lose their crops.

The land owners of Ashley Valley have organized into a company, termed the Ashley Consolidated Irrigation Company, for the purpose of constructing reservoirs, increasing the flow of Ashley Fork, and building weirs at the mouth of the cañon to more evenly divide the water. The result is seven fine reservoirs with an average depth of 5 feet and containing 100 acres. Each reservoir has a gate that can be raised by one man. There are several other lakes that will be converted into reservoirs in the near future.

Dry Fork or the West Fork of Ashley, a stream nearly as large as Ashley, sinks in the rocks of Dry Fork Cañon. This could be brought out in a flume 6 miles long. Besides there are several very fine reservoir sites on this stream.

The average depth of snow in the mountains is about 6 feet, though on the highest mountains it is much deeper.

In the south part of Ashley Valley is a tract of land of nearly 9,000 acres that could be used with but little trouble with an increase of water. On the east side is another fully as large. On Green River is another, containing about 3,500 acres, all of which would make good homes by a little care and means.

Hay land, pastures, orchards, and farming lands are included in the acres irrigated and the farming lands are again reported as acres cultivated. The calculations are made from the size of our water boxes—21 square inches—flowing at the rate of about 7 feet per second, from the 1st of May till the 1st of July; if properly handled will produce 40 acres of small grain on the sandy soil of the benches. The clay soil bakes quickly, and must have water every few days till the crops are high enough to shade the ground. Grass and lucern do well on clay soil with about the same water as on sandy soil. Corn can be produced on clay soil with the same water as on sandy soil by an extra amount of cultivating. Wild hay and pasture require but very little after high water, but lucern must have water during the entire season to produce three crops, though any or all the arable land in the county could be made to produce one good crop of lucern each year with the high water, of which there is a very great surplus from the 1st of May until the 25th of June, when it falls very suddenly about 80 per cent. By summer fallowing the land and putting in fall wheat, or waiting till spring and putting in early spring grain, good crops can be raised from the high water. By this means many thousands of acres of land which now belongs to the public domain could be made to produce extra good crops every other year.

JAMES HACKING,
JOHN GLEMO,
Special Committee to Collect and Compile Irrigation Information.

Irrigation canals and streams in Uintah County.

No. I.

Name of canal.	Date when built.	Streams from which water is diverted.
Upper Canal	1879	Ashley Fork.
Central	1876	Do.
Downenor Brooks	1878	Do.
Steinaker	1888	Do.
Rockpoint	1880	Do.
Dodds'	....	Do.
Chadwick	1879	Do.
Union	1884	Do.
McKee	1879	Do.
Powell & Kabell	1880	Do.
Powell & Kabell, south	1878	Do.
Fairchild	1878	Spring Fork.
Chivers & Co	1889	Ashley Fork.
Burton	1875	South Fork Ashley.
Dillman	1882	Do.
Taylor	1881	Do.
Tucker	1883	Do.
Colton	1880	Do.
Snyder	1876	North Fork Ashley.
Dry Fork, north	1878	Dry Fork.
Dry Fork, south	1884	Do.
Burns' Bench	1888	Brush Creek.
Murry	1888	Do.
Burton	1879	Do.
Veltman & Co	1883	Waste ditch No. 3.

Acres irrigated and duty on water in Uintah County.

No. II.

Name of canal.	Irrigated.	Cultivated.	Could be cultivated by an increase of water.	Date of irrigating season.	Elevation above the sea.
	Acres.	*Acres.*	*Acres.*		*Feet.*
Upper Canal	....	....	....	Apr. 1 to Dec. 1	4,800
Central	4,440	3,560	7,400	do	4,600
Downenor Brooks	....	....	400	Apr. 1 to Oct. 1	....
Iteinaker	85	80	1,000	do	4,800
Rockpoint	527	427	1,100	Apr. 1 to Dec. 1	4,800
Dodds'	....	....	....	do	....
Chadwick	300	72	600	do	....
Union	130	57	1,000	Apr. 1 to July 1	4,400
McKee	320	285	....	Apr. 1 to Nov. 1	....
Powell & Kabell	570	385	50,000	Apr. 1 to Oct. 15	4,400
Powell & Kabell, south	220	(*)	(*)	do	....
Fairchild	50	12	15	Mar. 15 to Oct. 1	....
Chivers & Co	36	80	267	May 1 to Nov. 15	....
Burton	250	110	960	Apr. 1 to Oct. 1	....
Dillman	38	31	80	do	....
Taylor	84	31	324	do	....
Tucker	52	25	110	do	....
Colton	60	20	80	do	....
Snyder	245	....	295	Apr. 1 to Dec. 1	....
Dry Fork, north ditch	425	....	425	May 10 to Nov. 1	5,000
Dry Fork, south ditch	75	....	75	do	5,000
Burns' Bench	620	....	2,000	do	....
Murry	340	....	....	do	....
Veltman & Co	65	35	198	May 1 to Nov. 15	4,400

Acres irrigated and duty on water in Uintah County—Continued.

Name of canal.	Amount of water required to irrigate an acre.										Lost by scarcity of water in 1888-'89.		
	Sandy soil.					Clayey or alkaline.							
	Small grain.	Lucern grass.	Roots.	Corn.	Orchards.	Small grain.	Lucern grass, etc.	Roots.	Corn.	Orchards.	Small grain.*	Grass.	Corn.
	Cu. ft.	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*	*Acs*	*Acs*	*Acs*
Upper Canal	22,750	25,500	28,436	11,000	11,000	44,700	255,000	50,000	11,000	11,000			
Central	22,750	25,500	28,436	11,000	11,000	44,700	255,000	50,000	11,000	11,000	....	....	....
Downenor Brooks	22,750	25,500	28,436	11,000	11,000	.....	255,500	50,000	11,000	11,000	300	300	100
Steinaker	22,750	25,500	28,436	11,000	11,000	44,700	255,500	50,000	11,000	11,000	....	....	....
Rockpoint	20,750	22,000	25,000	9,000	9,000	22,000	2,550	22,000	10,000	11,000	15	...	....
Dodds'.	20,750	22,000	25,000	9,000	9,000	22,000	2,550	22,000	10,000	11,000	25	....	....
Chadwick	22,750	25,000	28,436	11,000	11,000	22,750	2,550	25,000	11,000	11,000	....	....	....
Union	......	......	......	......	......	44,700	25,500	50,000	11,000	11,000	...	....	....
McKee	22,750	25,500	......	......	......	44,700	25,500				18	30	20
Powell & Kabell	......	......	......	......	......	......	......	......	......	......	55	30	20
Powell & Kabell, south	......	......	......	......	......	......	......	......	......	......	20	11½	....
Fairchild	......	......	......	......	......	......	......	......	......	......	....	....	....
Chivers & Co	......	......	......	......	......	......	......	......	......	......	....	....	....
Burton	22,750	15,000	25,000	11,000	11,000	......	......	......	......	......	23	....	3
Dillman	......	25,000	25,000	11,000	11,000	......	......	......	......	......	...	....	....
Taylor	20,000	22,000	25,000	9,000	9,000	......	......	......	......	......	...	....	....
Tucker	22,000	22,000	25,000	9,000	9,000	......	......	......	......	......	....	....	....
Colton	22,750	22,500	28,436	11,000	11,000	......	......	......	......	......	...	....	....
Synder	......	9,000	......	......	......	......	......	......	......	......	....	....	....

* Pasture.

REPORT ON UTAH COUNTY.

The county committee find the average depth of snow in the mountains in the winter 4 feet.

The number of cubic feet of water necessary to produce 1 acre of crops, 40,000.

Field land should be watered every fifteen days and orchards once a week. All the water is owned by priority of appropriation and is not of record.

During the winter and spring months there is water goes to waste that could be stored in reservoirs on the east side of the valley, sufficient to water all the land on the east side. Artesian water could be had for all the land on the west side of the valley. The land is owned, however, in 5, 10, and 20 acre lots by people who are unable to build reservoirs or drive experimental wells.

Table showing acres of land cultivated, acres that could be cultivated with increase of water, and acres of crops lost this year for want of water.

Name of precinct.	Natural streams.	When appropriated.	Canals in each precinct.	Cultivated.	Could be cultivated with an increase of the water supply.	Water per second.	Crops lost this year for want of water.
			Miles.	*Acres.*	*Acres.*	*Cu. ft.*	*Acres.*
Cedar Forte	North Cañon Creek and Fort Springs.	1854	18	500	76, 000	12	400
Fairfield	Fairfield Springs	1855	2	300	2, 000	3	None.
Goshen	Salt Creeks	1852–1878	18	1, 500	60, 000	15	500
Lehi	Dry Creek and Spring Creeks	1851	30	7, 800	5, 500	20	3, 334
Alpine	Dry Creek Springs	1850	25	1, 400	1, 300	15	1, 300
American Fork City	American Fork River, Battle Creek, and Provo River.	1851	25	4, 291	7, 000	21	3, 840
Pleasant Grove City	Amreican Fork River and Grove Creek.	1852	20	6, 500	3, 700	21	2, 000
Santaquin City	Summit Creek	1852	15	500	7, 000	9	800
Spring Lake City	Spring Lake	1851	4	300	600	3	100
Payson City	Spring Creek and Petutnut and Salem Canal.	1851–1867	50	2, 000	19, 000	21	3, 000
Spanish Fork	Spanish Fork River	1854–1889	114	1, 192	14, 880	24	5, 313
Springville	Hobble Creek and Spring Creek.	1851–1880	95	5, 025	7, 000	17	1, 700
Provo City	Provo River and Rock Cañon Creek.	1871	175	16, 000	9, 000	95	800
Benjamin	Spanish Fork River	1876	20	5, 000	6, 526	12	2, 500
Lake Shore	do	1866	25	3, 840	3, 840	8	2, 000
Salem	Spanish Fork River and Springs.	1869	26	2, 250	2, 200	12	1, 390
			662	69, 126	225, 340	308	28, 985

IRRIGATION AT SPRINGVILLE, UTAH COUNTY.

A series of mass-meetings held in Springville on the 12th, 27th, and 31st of May, 1889, also one on the 17th of June, consisting of citizens of what is known as Mapleton Ward, which embaces an area of about 9 square miles, and is the southern and eastern portion of Springville corporate limits, resulted in the appointment of John Luckett chairman of a committee to represent to the Senate Committee on Irrigation in the Territory the necessity of irrigation to the aforesaid portion of Springville city, Mapleton Ward.

The object of this communication is to show through said committee the result of the labors of a previous committee appointed by said series of mass-meetings to ascertain if the waters of Strawberry Creek, in Strawberry Valley, and lying in the Indian reservation, could be brought into Springville through Spanish Fork cañon for irrigating purposes.

The last-named committee, or committee of investigation, in Strawberry reported as follows to the mass-meeting held June 17, 1889:

That the water of Strawberry can be taken into Spanish Fork River by constructing a ditch 20 miles in length, with a tunnel through the dividing summit 600 feet long. The amount of water thus obtained will exceed the water running in Hobble Creek, or five or six good irrigating streams.

Nearly the whole of the said southern and eastern portion of Springville is now without water in consequence of the decrease of Hobble Creek, the older water claims taking precedence, and leaving Mapleton people with their grain, fruit, and shade trees already perished.

Our hopes are that through Government means something may be done for our relief in the near future. By order of the mass-meeting.

JOHN LUCKETT, *Chairman.*
O. B. HUNTINGTON, *Secretary.*

REPORT ON PLEASANT GROVE, UTAH COUNTY, IRRIGATION WORKS.

Joseph W. Ash, secretary of the North Union Irrigation Canal, reports:

Names of officers: A. B. Walker, president; Robert Thorne, T. C. Banks, William Kirk, William M. Frampton, A. G. Johnson, and James Backhouse, trustees, all of Pleasant Grove City.

The canal was first used in connection with the Provo Bench Canal and Irrigation Company's canal in 1868, and flows north from Provo River, at the mouth of Provo Cañon. It irrigates about 1,000 acres; number of acres that could be irrigated, about 2,000. Time of irrigation from May 1 to October 1. Water used about eight hours to the acre every fourteen days. The right of water is first-class.

Length of canal, 5 miles; situated on Provo Bench from mouth of Provo Cañon to Pleasant Grove City.

About one-half of the acreage irrigated is devoted to lucerne, and nearly one-half is lost through drought this season.

REPORT ON WEBER COUNTY.

The total number of acres situated under the canals and ditches of this county approximates 117,600 acres, 100,000 acres in Salt Lake Valley and 17,600 acres in Ogden Valley. Of the above about 25 per cent. may be said to be fully irrigated.

The following is a list of the principal streams in the county, with the approximate volume of water in each, in cubic feet per second, as measured by me from the 3d to the 9th of July, 1889. Each stream was measured above the points where irrigating canals are taken out:

Name of stream.	Cubic feet per second.	Remarks.
Burch Creek	0.83	At mouth of cañon.
Buse Creek	0.12	Do.
Bennett Creek	0.79	Do.
Cold Creek	0.33	Do.
Alder Creek	0.30	Near residence of Mrs. Johns.
Middle Fork	0.83	At mouth of cañon.
North Fork	48.00	Near Southwick's mill.
North Ogden Cañon Creek	0.3	At mouth of cañon.
Ogden River	97.0	Do.
Rice Creek	1.7	Near head of stream.
South Fork River	64.0	At mouth of cañon.
Strong's Cañon Creek	0.4	Do.
Taylor's Cañon Creek	0.4	Do.
Water Fall Creek	0.04	Do.
Uintah Creek	0.53	Do.
Weber River	106.00	Do.
Wolf Creek	4.00	Do.

The total volume of water indicated above is increased 20 per cent. from springs and artesian wells.

List of the canals and ditches in Weber county.

Names of canals and ditches.	Stream from which diverted.	Remarks.
Burch Creek Canal	Burch Creek	
Eden Canal	Woolf Creek	
Ferrins ditch	Spring Creek	Small ditch.
Frank Law's ditch	Middle Fork	
Hooper Canal	Weber River	Used also in Davis County.
Huntsville Canal	South Fork	
Harrisville Canal	Ogden River	
Hall's ditch	South Fork	Small ditch.
Hall's J. Ditch	Weber River	
Langsdorf's ditch	South Fork	
Lynne Canal	Ogden River	
Mountain Canal	South Fork	
Montgomery and Roylance ditch	Rice Creek	
North Ogden Canal	Ogden River	
Ogden City Canal	Weber River	
Ogden Bench Canal	Ogden River	
Plain City Canal	do	
River Dale Canal	Weber River	
Riries ditch		Small springs.
Stimpson and Dyke's ditch	Weber River	
Salt Creek Canal	do	Not completed situate near Plain City.
Uintah Canal	do	
Weber and Davis County Canal	do	Only part used in Weber County.
Wilson Canal	do	
Jenkins ditch	do	

A number of available sites for reservoirs may be found in the hills around Ogden Valley to the south and east of Huntsville. Also at the head of Wheeler's Creek in Ogden Cañon, there exists a most admirable site, which could be made to contain at least 300,000 cubic yards of water.

The mean elevation of Salt Lake Valley in Weber County, is approximately 4,315 feet; that of Ogden Valley approximates 5,000 feet above sea level.

The average depth of snow in the mountains during the winter, is 2 feet.

WASHINGTON JENKINS,
County Surveyor.

Water rights from running streams in Weber County, acres irrigated, the sources.

TABLE No. I.

Name of stream.	Used to irrigate.	Remarks.
	Acres.	
Burch Creek	77.4	The first certificate of water right issued is dated December 1, 1880, and the last is dated July 19, 1883.
Do	77.4	
Do	77.4	
Do	77.4	
Do	77.4	
Do		
Do	79.5	
Do		
Do		
Do	76	
Do		
The Mountain Stream	4	Source in mountains northeast of Uintah.
Do	22	Do.
Do	2.25	Do.
The Mountain Stream and Weber River	26.76	Do.
Do	51.49	Do.
Do	1	Source near Uintah.
Do	8.44	
Weber River	8.44	
Do	23	
Do	16.89	
Mountain Stream	16.89	
Do	49.36	
Mountain Stream and Weber River	49.36	
Do	18.5	
Do	57	
Do	81	
Do	52.95	
Do	18.72	
Do	21	
Do	2.5	
Do	18.45	
Mile Creek	65	Both of Slaterville.
Mountain, Quaking Asp, and Dry Springs	40	Source near Uintah.
Dry Cañon Springs and Four Mile Creek	125	
Do	70	
Burch Creek	80	
Do	155	
Bingham Fort Meadow Springs	155	
Four Mile Creek	30	
"The Mountain Water"	4.46	Near North Ogden.
Strong's Cañon Creek	150	Near Ogden.
Strong's Cañon Creek, surplus ditch from	12.22	Do.
Mud Creek	19.06	Near North Ogden.
Do	20.85	Do.
Do	22.55	Do.
Do		Do.
Do	43	
Do	160	
Ditch from Burch Creek	320	
Cold water Creek	17	Source near North Ogden
Burch Creek	15	
Do	260	
Surplus ditch from Strong's Cañon Creek	176.41	
Five Mile Creek	151	Source near Harrisville.
Surplus of Bench Creek during winter	80	
Cold Water Creek surplus	8	Source near North Ogden.
Do	10	Do.
Do	43	Do.
Do	16	Do.

Water rights from running streams in Weber County, etc.—Continued.

Name of stream.	Used to irrigate.	Remarks.
	Acres.	
Surplus of Chatelain Ditch and Strong's Cañon Creek.	14	Source near North Ogden.
Canfield Creek	2.5	Source near Ogden.
Do	7	Do.
Strong's Cañon Creek	2.5	
Do	3.6	
Canfield Creek	6	
Do	2	
Strong's Cañon Creek	4	
Mountain Stream and North Division of Rice Creek, source near North Ogden.	100	During January, February, March, April, May, October, November, and December of each year.
Taylor's Cañon Stream	5	Source east of Ogden.
Weber River, a lake and spring	12	
Strong's Cañon Creek	4	
The "Mountain Water"	135	Source in Isiah Cañon near North Ogden
Strong's Cañon Creek	17.20	
Dixon Creek		
Weber River	35.40	
Mill Creek	8	Source Ogden River.
Do	20	Do.
Do	22	Do.
Do	27	Do.
Mill Creek and Tarr's factory race	40	Do.
Weber River		
Weber River flowing through Taylor's mill race.	171	
North Fork of Ogden River and Woolf Creek Cañon Stream.	4,000	
Mill Creek	101.92	
Weber River	120	
Burch Creek	9	
Weber River	(*)	
Mill Creek	400	Source Ogden River.
Ogden River	500	
Brown Creek		
Mill Creek	383	
Do	5,760	
Weber River	5,760	
Ogden River	5,760	
Strong's Cañon Creek	115	
The Brown section	38	Source in Mill Creek.
Strong's Cañon Creek	13.16	
Berrett's Cañon Creek	100	Source near North Ogden.
Strong's Cañon Creek	30	Source near Ogden.
Spring Creek	240	
Herd House Creek	240	Source Ogden Valley.
North Fork of Ogden River	240	
Ogden River	(†)	
Weber River	240	
Canfield Creek and certain springs	47.05	
Strong's Cañon Creek	12	
Canfield's Creek	20	
North Fork of Ogden River	120	
Spring Creek	160	Do.
Brown Creek	15.85	Source Ogden River.
Paine Cañon and certain spring therein	300	Source near North Ogden.
Lindsay Ditch, including waters of Thimbleberry Creek, Balsam Grove Creek, and the North Fork of Ogden River.	240	Source in Eden.
Mountain Water and Grant Springs	125	Source near North Ogden
Lindsay Ditch, including waters of Thimbleberry Creek, Balsam Grove Creek, and the North Fork of Ogden River.	280	
Taylor's Cañon	5	East of Ogden.
Do	80	Do.
Do	15	Do.
Do	5	Do.
Wester Creek and a certain spring	80	Source Ogden Valley.
Coldwater Cañon Creek and a certain spring; also all springs in Coon Cañon.	80	Source near North Ogden.
Cole Cañon Creek and Thimbleberry Creek	150	
Mice Creek	99	
One Horse Cañon	66	Do.

* A larger section.

† All owned by shareholders.

Water rights from running streams in Weber County, etc.—Continued.

Name of stream.	Used to irrigate.	Remarks.
	Acres.	
Gertison Cañon Creek and certain springs	259.76	Source, the Ogden Valley.
Middle Fork Cañon Creek	25.79	Headwaters of Ogden River.
Do	25	
Mill Creek	21	
Weber River	23	
Do	20.60	
Do	33.46	
Do	28.65	
The old Brown and Cardon Canal	83.89	Source, the Ogden River through Mill Creek.
The old Tracy water ditch	84	Do.
Ogden River	584	
Mill Creek, flowing in Mound Fort section	48.875	Source Ogden River.
Weber River	1,113	
Four Mile Creek	....	Source Weber River, below confluence.
Mill Creek	3.90	
Bennett Creek	480	Source near Huntsville.
Hawkins Creek	200	Do.
Mill Creek	5	Source Ogden River.
Coldwater stream and a certain spring	31	Source near North Ogden.
Rice Creek and Ogden Hole Cañon waters	5	Do
Mill Creek	139.27	Source Ogden River.
Ben's Cañon Creek, surplus, ditch of Burch Creek and a spring.	295.82	Source near Ogden, to the south.
Do	82.03	Do.
A ditch from Strong's Cañon	82.03	Do.
Canfield Creek and Strong's Cañon Creek	10	Do.
Rice Creek and Ogden Hole Cañon stream	12	
Weber River	24	
Alder Creek }	....	Certain lands near North Ogden.
Missouri Creek }		
Beach Creek	15	
South Spring Creek	15	Source in Ogden Valley.
Spring Creek	25	Do.
Spring Hollow	15	Do.
Broom section	37	Source, in Ogden River by Mill Creek.
Mill Creek	20	Do.
Wester Creek	120	Source near North Ogden.
Spring Creek	....	Do.
Herd House Creek	80	Do.
Spring and Chicken Creek	280	
Weber River	100	
Strawberry Springs and Cole Creek, alias Pine Cañon, alias Herd House Creek.	400	
Mill Creek	7	
Rice Creek, or Five Mile Creek }	71.80	
Six Mile Creek }		
Chicken Creek and a certain spring	80	Source near Eden.
The Mountain stream	40	Source near Uintah.
Ogden River and Mill Creek	14	
Burch Creek	80	
Cold Water Creek	7.25	Source near Ogden.
Mill Creek, flowing through Bingham Fort section.	25	
Mill Creek	1,000	
A certain stream in sec. 4 T, 5 N., R. 1 W	....	
Coldwater stream	....	Do.
South Fork of Ogden River }	3,050	
Middle Fork of Ogden River }		
Canfield Creek	1	
Lindsay and Shaw Ditch	280	Source, North Fork of Ogden River.
Waterfall and Strong's Cañon of Canfield Creek	25	Source near Ogden.
Do	5	Do.
South Fork of Ogden River	30	
Weber River	23	
Do	477	

Water rights to springs in Weber County.

No. II.

Name of spring.	Used to irrigate.	Remarks.
	Acres.	
Stone Springs	20	Situate near Uintah.
Willow Springs	80	Situate near North Ogden.
Hooper Springs	(*)	Situate near Hooper.
Certain springs having source in Jonathan Campbell's farm at North Ogden.	77	Situate near North Ogden.
Grant Springs	20	Do.
Garner's Springs	160.21	Do.
Cat Claim Springs	6.33+	Do.
A certain spring situate on Sixth street, Ogden.	2	Situate in Ogden.
Two certain springs in Taylor's Cañon	10	Situate east of Ogden.
Fisher's Spring	300	Situate in Eden.
Springs in One-Horse Cañon	(†)	Situate near North Ogden.
Springs in sec. 18, T. 7 N., R. 1 W.	160	Do.
Springs having source in Jonathan Campbell and A. Chadwick's farms at North Ogden	43.93	
Do	113.75	
Three springs having source in "White Bank," near North Ogden.	100	
Six springs known as Alder Springs, flowing from "Pole-Patch farms."	....	Do.
Three springs, situate on sections 18, 19, and 20, T. 7 N., and R. 1 W.	....	Do.
Springs in sec. 9, T. 5 N., R. 1 W.	100	Situate near Ogden, to the south.
Four springs, situate on Henry Barber's farm in sec. 33, T. 7 N., R 1 W.	4	Situate near North Ogden.
Springs which form Alder Creek, and all waters flowing from mouth of Big Hollow.	50	
Certain springs in sec. 18, T. 6 N., R. 2 E	8	
"Coffin's Springs" and certain other springs situated along the South Bench of Huntsville.	12	
Several springs in sec. 8, T. 6 N., R. 2 E., forming what is called Perry Creek.	14	Situate near Huntsville.
Spring, situated in what has been heretofore known as Bunker's Hollow, in or near Ogden City.	6.60	
Coffin's Springs, having their source in sec. 18, T. 6 N., R. 2 E.	....	Also to run machinery and fish-pond.
Certain springs arising in sec. 18, T. 6 N., R. 2 E, which form below David W. Garner's.	4 to 5	

*Part of sec. 8, T. 5 N., R. 2 W.

†Part of secs. 3 and 4, T. 6 N., R. 1 W.

REPORT ON WASHINGTON COUNTY.

Grass Valley could be used to hold, as a reservoir, the surplus water from the Grass Valley Mountains in the spring, a large quantity of which now runs down the Santa Clara River, and no use whatever is made of it.

It is estimated that enough water could be stored to irrigate 2,000 acres at a cost of $10,000 by making a dam across Grass Valley.

There are good places at the mouth of Pinto Cañon for a reservoir to hold the surplus water from Pinto Mountains, and plenty of good land close by on which to use it.

Little Pine Valley, near Hebron, is also another good place for a reservoir, large quantities of surplus water running to waste in the spring from that section of country.

Dameron Valley, 12 miles north of St. George, could be used to store the surplus water of the Pine Valley branch of the Santa Clara River; this water would be very valuable to the city of St. George, which has the least amount of water for the number of inhabitants of any city or town in Utah.

Average depth of snow in mountains.

	Feet.
Pine Valley Mountains	4 to 10
South of Hebron Mountains	4 to 8
Grass Valley Mountains	4 to 10
Pinto Mountains	2 to 6
Hamblin Mountains	2 to 4
Kolob Mountains	3 to 6

Water necessary to irrigate crops.

	Inches.
Lucern and small grain	2
Fruit (peaches, grapes, etc.)	1
Corn	1

Clay and sandy soil require about the same amount of water. Sandy land requires more at each watering but does not need water as often as the clay land.

Crops need water in the lower part of our county every seven days, and the water should run for at least three hours; in the upper lands of the county once every fourteen days is sufficient.

The Rio Virgin is the most important river passing through our county. At the present time there is not more than 4,000 inches running below Price Canal. It is now our low-water season which usually lasts from the 15th of June until the 1st of September. Some portions of the year large bodies of water flow down caused through the melting of the snows and summer storms. The water of the Santa Clara at this time of year is all used by the Santa Clara Irrigating Company.

You will perceive that our seasons are very long in this section of the country, and in consequence where water is plentiful and land good we raise very heavy crops. We can cut four to five crops of lucern hay per year. Wheat and barley are harvested early in June, and a crop of corn raised on same land, thus you see we can raise two crops on same land per year where water is plentiful. Grapes, peaches, almonds, and such crops grow almost to perfection. All we want is water to put on the land, an abundance of which passes out of our country each spring unused.

Santa Clara irrigating district and St. George City lose at least on an average one-third of their crops each year for want of water; this loss could be saved if water was stored in Grass Valley, Little Cone Valley, and Dameron Valley as described.

NOTE.—The water measurement in this country is made on the "Weir Dam" system with 4-inch head.

On behalf of the county court, Washington County.

THOMAS JUDD,
MARTIN SLACK,
Special Commissioners.

After receipt and filing of these reports, the committee adjourned.

Washington County canals—Acres irrigated and cultivated, etc.

Names of canals.	When first built or used.	Streams from which water is drawn.	Irrigated and Cultivated.	Could be irrigated in new ditches and reservoirs.	Irrigating season.	Elevation above the sea.	Amount of water.	1 Cubic foot irrigates.	Remarks.
			Acres.	*Acres.*		*Feet.*	*Inches.*	*Acres.*	
Atkins and Sons	1876	Rio Virgin	160		Apr. 1 to Oct. 15	2700	350	21.3	
Bloomington	1868	Rio Virgin and Santa Clara	125		Mar. 1 to Oct. 15	2725	350	17	
Bellevue	1864	Ash Creek	120	100	do			...	Plenty water in spring; dry towards midsummer.
Carter's Ranch	1864	Springs	140		Apr. 15 to Sept. 15		100		At midsummer.
Cotton Farm	1876	Rio Virgin	50		Mar. 15 to Oct. 15		100	19	
Duncans	1862	do	94		do		175		
Earl's Springs	1868	Springs	45		May 15 to Sept. 1		60	25	
Grass Valley	1858	do	400	2,500	do		150	80	Considerable meadow.
Grafton	1862	Rio Virgin	117		Mar. 15 to Oct. 15		200		
Hebron	1862	Springs	200	2,000	May 15 to Sept. 15		100	70	Crops, grain and meadow raised without water.
Harmony	1863	Ash Creek	160		do		200	60	Sometimes fail.
Hamblin	1866	Springs	200	500	do		100		Some hay and grain raised without water.
Jarvis	1870	Rio Virgin	130		Mar. 15 to Oct. 15		250		
La Verkin	1889	do	750		do		1500	19	Canal now being built.
Leeds	1862	Quail Creek	300	200	do		400		Sometimes falls to about 100.
Middleton	1862	Springs	125		do		200		
Mountain Dell	1863	North Creek	100		do		150		Sometimes dries up.
Price	1858	Rio Virgin	420	300	do		600		
Pinto	1854	Springs	225	1,000	May 15 to Sept. 1		325		
Rockville	1862	Rio Virgin	270	200	Mar. 15 to Oct. 15		540		
St. George (town)	1862	Springs	300	2,000	do	2850	155		
Santa Clara, Irrigating District.	1854	Santa Clara	2,103	5,000	do				Plenty in spring; fails by midsummer. This includes all in the Santa Clara River, from Pine Valley to St. George field.
Springdale	1862	Rio Virgin	210		do		375		
ohomsburg	1862	do	110		do		200		
STquerville	1858	Springs and Ash Creek and La Verkin.	383		do		775		Water sometimes scarce in dry seasons.
Virgin City	1850	Rio Virgin	165		do		250		
Virgin Field	1862	do	300		do		600		Dam been out of river for three years.
Washington (town)	1857	Springs	375		do		250		
Washington (field)	1858	Rio Virgin	800	5,000	do		1600		
Westover	1876	do	15		do		50		

EXPLANATION OF PROFESSOR MARCUS E. JONES, DESERT UNIVERSITY.*

In the diagrams of the rain-fall of Salt Lake City, and of the oscillations of Great Salt Lake, already presented, the curves are made by letting a square (composed of four squares of the profile paper) represent a year between its vertical sides, and between its horizontal sides representing an inch of rain-fall and a foot of oscillation in the lake. The fine lines represent tenths of an inch of rain-fall and tenths of a foot of lake oscillation, respectively. The rain-fall of each year is drawn to the right side of the square representing that year. The unbroken lines represent known curves, while the dotted lines are hypothetical. The dotted rain-fall lines are merely tentative and may need revision, but there is not sufficient time for me to do this now. It issufficient to say that they are more liable to be too high than too low. As my object is to arrive at the normal rain-fall of Salt Lake City, and so of the whole arid region (for the relation of our rain-fall to the rest of the arid region is pretty well known), the conclusions drawn from these diagrams are sure not to be too low, and therefore the irrigable land in the arid regions that can be supplied with water by our normal rain-fall is equally sure not to be underestimated and is doubtless somewhat less than I have given it below.

The lines thus drawn from one square to another gives a graphic curve which shows to the eye irregularities that would not easily be perceived otherwise.

A comparison of the rain fall curve of Salt Lake City with that of the whole country will show a general conformity, but with local minor variations. The most noticeable feature is that our wet and dry seasons come on the next year after they occur on the Atlantic coast. From the fact that climatic changes are continental it is possible to determine from the rain-fall curve of the whole country what the rain-fall of Salt Lake City has averaged as far back as 1800, by finding the relation of our rain-fall curve with that of the whole country from 1855 to the present.

The diagram of the Salt Lake City rain-fall is based on the records of the Signal Service since 1875, and on those of the post surgeon at Fort Douglas (3 miles east of this city) for the five preceding years, and on the records kept by W. W. and H. E. Phelps from 1855 to 1869. The Phelps records were carefully kept, but there appear many clerical errors in them, as published by the Smithsonian Institute and the Signal Service. Whether these errors were made by the observers in copying them, I do not know. I have therefore discarded the Smithsonian records and taken them as they were made out here, with here and there the correction of typographical errors. These records are uniformly too low by an inch, as shown by the oscillations of the lake, but this is chargeable to the poor quality of the instruments used in those early years. The rain-fall of Fort Douglas since 1877 (kept very carefully) is nearly 2 inches above that of Salt Lake City per annum, but previous to that time they were not carefully kept, and so to avoid understating our rain-fall, I have put the Fort Douglas records into the diagram at their full value.

In getting at our average rain-fall since 1800, we find that the average height of Great Salt Lake since 1884 has been about 7 feet above the Garfield zero. The annual rain-fall since that time that has had to do with the oscillation of the lake† has been about 15.4 inches, but the average height of the lake since 1840 has been over 1 foot below that of 1884 to the present, therefore the average rainfall of this place since 1840 is not above 14.5 inches. By referring to the diagram of the rain-fall of this country, prepared by Charles Schott of the Smithsonian Institute (a copy‡ of which is presented) it will be seen that the normal rain-fall of Salt Lake City for the last fifty years has been in excess of the normal for the century by an inch or more, since the rain-fall for the whole country for the last fifty years has exceeded considerably the average for the century, therefore it is quite probable that the average rain-fall of Salt Lake City since 1800 has been but little above (if not below) 13 inches per annum.

On this basis there are but 300,000 acres that can be cultivated in Utah to-day without additional reservoirs, estimating the duty of water at 1 cubic foot for 80 acres, and if the whole water supply that falls in the winter were saved we could cultivate 600,000 acres, but it will be impossible to save more than one-half of our winter rain-fall. Utah has a greater water supply, and, therefore, irrigable area than either Idaho, Nevada, Arizona, or most of New Mexico. With an annual rain-fall of 17 inches in the last ten years Utah has only 500,000 acres under cultivation, and this, too, with all of the unreservoired water supply fully used, with the exception of the waters of the Grand and Green Rivers, which can not at present be utilized from lack of capital.

---

*Referred to in Prof. Jones's testimony (pages 172-175) and since forwarded to the committee by him.

† The very abnormal rain-fall of November and December, 1889, will be felt in 1890 and so does not belong in 1889.

‡ Added to his diagram (which stops at 1800) the rain-fall of Philadelphia up to 1887 and that of Salt Lake City up to 1890, to make it complete.

Salt Lake City has over twice the rain-fall of the valleys of Utah, Idaho, Nevada, Arizona, and New Mexico west of the Sandia Mountains, and the western half of Wyoming and Colorado. There are but three mountain ranges in this whole region whose snow-fall even slightly exceeds 40 inches of water in fall and winter, and the majority of the ranges have not over half of this snow-fall. On the loftiest of these ranges the snow belt never exceeds 20 miles wide, while in most of them it is very narrow. Viewed from the stand-point of the actual rain-fall of the arid regions, it becomes evident at once that it is impossible to irrigate even 10 per cent. of the 1,000,000 square miles that it is said may be reclaimed by irrigation. It is not probable that more than 10,000,000 acres can be reclaimed by any of the present methods of irrigation that are practicable on a large scale (subsoil irrigation, as at present conducted, is not practicable for general farming because of its great cost) in the arid regions, while the Salt Lake City rain-fall averages 17 inches per annum; while the sub-arid regions, embracing eastern Wyoming, Dakota, western Nebraska, eastern Colorado, western Kansas, eastern New Mexico, northwestern Texas, and parts of California will not bring the whole area up to 64,000,000 acres, *i. e.*, 10 per cent. of 1,000,000 square miles. But the fact that our irrigable area is so small makes it all the more imperative that the people of these regions should receive the aid they so greatly need.

To look at the irrigation question from the stand-point of the actual rain-fall is, in my judgment, the proper way, and this will at once show up the chimerical schemes of people who assume, without reason, that all they need is irrigation ditches, costly reservoirs, and tunnels run far into the mountains, and at once the fountains of waters will be opened and fill them. We can not get more water out of the mountains than falls upon them, nor can we save much more than half of what falls upon them.

The greatest needs of the arid regions to-day are elaborate experiments on the best methods of economy in the use of water (this in my judgment far overtops all others); erection of dams to utilize the larger rivers (like the Snake, Green, Grand, Rio Grande, Colorado, etc.), the building of reservoirs, uniform laws on water rights, uniformity in the methods of measuring water and in gauging streams, and the establishment of many signal stations in the valleys, and many places also in the mountains for the measurement of snow in winter.

As to the future of the arid regions, an inspection of the diagrams will give some valuable suggestions. From these it is evident that there have been two periods since 1800, one of twenty-four years of deficiency, and one of thirty-seven years of excess. We are now fourteen years along in a period of deficiency, and it is quite probable that we may have a decade more of deficiency before we have a long-continued excess.

It also appears that from the crest of the greatest waves of climatic change to the bottom (1808 to 1825, 1835 to 1862, 1862 to 1881, and 1881 to ——*) there are usually three smaller crests between; there is an abnormality in 1830, and an apparent, but not real one, in 1867. The diagram of Great Salt Lake shows that within these second minor crests there is a third series of three years each of comparatively uniform movement either toward excess or deficiency; sometimes there are two sets of deficient or excessive years in a downward or an upward movement, with a break between, but generally a series of three deficient years is followed by a series of three years of excess.

From these facts it is perfectly evident that there are oscillations in our climate. It is also evident that they are not uniform like the movements of a pendulum, and these changes are due to causes which it is out of place to discuss here.

Looking at the future with the evidence of the past, it is probable that we have not yet reached the end of the period of deficiency. Great Salt Lake is still 3 feet above its old level, and it is more probable that it will return to it before beginning its next grand upward movement. Be this as it may, it is reasonable to suppose that within the next fifteen years we shall enter upon a long period of general excess in our water supply over the normal for the last one hundred years, but not an excess over that from 1850 to 1875.

From these diagrams it is equally evident that from 1839 to 1860, when the prairies of the great West were still unturned by the farmer's plow (or but slightly on the eastern side), the rain-fall of the whole country increased, while from 1860 to 1881, the period when the great prairies of Iowa, Missouri, Minnesota, Dakota, Nebraska, Kansas, Arkansas, Texas, etc., were transformed into fields of waving grain, the rain-fall rapidly decreased, and even to the present has been below the normal.

The deserted ranches of the plains to-day also tell a sad story of the weakness of man's power to produce climatic changes, and it is hardly worth our while to plant ourselves in the desert, turn over the sod (if there is any), and expect the heavens to be opened in rain for our benefit and as a reward for tilling the soil.

---

*Period of oscillation yet incomplete.

STATEMENT OF THE BEAR LAKE AND RIVER WATER-WORKS AND IRRIGATION COMPANY, MADE BY JOHN RANDOLPH BOTHWELL.

The project is not a new one. The vast body of arable land lying along both sides of Bear River just north of the Great Salt Lake has attracted attention from the time of the earliest settlement in this country. Here is the largest irrigable body of untilled land in all the mountain country. Bear River is the largest river in the thousand-mile stretch from Denver to Sacramento The diversion of this stream and the distribution of its waters upon the plain on both sides of its banks was looked forward to by Brigham Young even in the days when the Great Salt Lake Basin was sparsely peopled. A somewhat systematic effort in the same direction was undertaken about twenty years ago, and a survey was made with a view to estimating the cost of taking the water out of Bear River. Finding that the project called for a great expenditure, they appealed to Congress during the two following sessions with an appeal for a special act, allowing them to buy all the Government land under the proposed canal at the Government price of $2.50 per acre. One House of Congress passed the bill but it failed to be concurred in by the other, and the enterprise was abandoned.

Two or three years ago a new impetus was given to Utah by the extension westward of the great railways leading out from Chicago crossing the Missouri River, thence across Kansas and Nebraska into the mountain country. The movement was then organized which has resulted in placing the Bear River work under actual construction. A number of irrigation engineers from Colorado and California were called in consultation and the plan of work was laid out. Engineering crews were put in the field; the preparatory work was pushed ahead, and the first contract for construction was let on the 20th of July last. The water service, it is claimed, will be ready for operation for the season of 1890.

Although the works projected call for the expenditure of a large sum of money they are extremely simple in design, and involve no question of structural strength. The site for the headworks is simply ideal in its natural provisions for solidity of construction and for the care of surplus water.

In this company's plans it is claimed that not the headworks alone are in solid rock, but also the entire canal, so long as the great body of water is carried in undivided volume. The earth cuts begin below the point where the water is divided.

The governing consideration has been to secure safety and permanency and the minimum of expense for operation and repairs. Wood structure has been almost altogether avoided. The water is led naturally, instead of being impounded. The river has a fall of 110 feet in the cañon, and the point of diversion is just above the fall. During high water no dam is required, and even in low water the surface must be raised only 3 feet in order to fill the canal to a depth of 10 feet.

The diverting dam is a movable structure, about 5 feet high, which can be taken out by two men in half a day. The canal at its initial point in mid-stream will be 7 feet under the surface of the river at low water. A subterranean channel is blasted out into the river with a flaring mouth opening out up-stream. As the channel reaches the rocky side of the cañon along shore, its bottom is 7 feet below the river level. The removable dam gives the extra 3 feet, making the water in the canal 10 feet deep. The headworks are to consist of eight gates, each 5 feet wide, the whole inclosed in masonry abutments, and protected by wing walls. The canal will then be carried down the cañon through the solid rock with a cross-section of 24 by 10 feet, and a grade of 4 feet to the mile—the estimated capacity being 2,000 cubic feet per second. At a distance of 6,800 feet from the headworks an iron bridge is to be thrown across the river and one-half of the volume of water is carried across to the westerly side. Both canals will then continue along the river banks for about 5 miles. The west branch is then to run across the plain on a grade of 1 foot per mile to the foot-hills on the west side, and to be flumed across the Malad River.

On reaching the foot-hills the canal turns south to Point Lookout. Here power will be developed by dropping 600 cubic feet per second 30 feet, amounting to 2,030 theoretical horse-power. Five hundred cubic feet are to be carried on around Point Lookout, in a southerly direction to Connor's Springs and Blue Creek. Main laterals will run from the west branch to water the country between the Bear and Malad Rivers and to supply Bear River City. A second lateral will be carried east of Little Mountain toward Corinne, and across the Central Pacific track to the Lakeside Ranch property. The east branch will run along the base of the Wasatch Mountains, gradually diminishing in width until it arrives at Hot Springs with a volume of 600 cubic feet per second. Of this amount 350 feet (cubic) will be dropped to the level of the plain, developing 1,388 theoretical horse-power, and from thence it is to be conducted to Plain City. The remainder, 250 cubic feet, is carried on to Ogden City and south, under the Union Pacific and Denver and Rio Grande Railway tracks, to the vicinity of Kaysville.

Reference to the map shows the district to be irrigated by this system to have a north and south length of about 70 miles. and a varying width east and west of from

15 miles down. It extends from township 4, north of the base line at Salt Lake, to township 13 north, or from a point about half way between the cities of Ogden and Salt Lake City to a point 50 miles north of Ogden. The Wasatch Range marks its eastern line, while the Promontory Range and the lake bound it on the west.

In an official report to the Department of the Interior at Washington, J. W. Powell, chief of the U. S. Geographical and Geological Survey, gives the following measurements of the irrigable lands which may be served:

	Square miles.	Acres.
Bear River Delta, Malad Valley and Connor's Spring Valley	218	139,520
Weber Delta Plain	219	140,160
Total	437	279,680

These lands were once a portion of the bottom of the Great Lake, whose lines are now distinctly marked on the surrounding mountain-sides hundreds of feet above the present level of the plain. For many years portions of the land near springs and creeks have been irrigated, and hundreds of small orchards and farms demonstrate the capability of the soil when supplied with water.

On the west side of Bear River the proposed canal does not intercept any streams except the Malad, which runs between steep banks far below the level of the plain and can not be diverted. On the east side of Bear River the canal intercepts several rivers and creeks which flow out from the Wasatch Mountains. The larger of these streams are the Weber and Ogden Rivers and Box Elder and Willard Creeks. These streams were appropriated by early settlers, whose lands were located on the lower plains where water could be distributed at the least cost. With the growth of the country cities were located near the mountains upon higher and choicer land. For several years past the demand for water for the growing villages has far exceeded the supply remaining to them after providing for prior appropriators. The only possible increase of supply must come from the Bear River.

NEVADA DIVISION.

CARSON CITY, NEV., *August* 22, 1889.

The committee met pursuant to the call of the chairman.

Present: Messrs. Stewart (chairman), Jones, and Reagan; also Director Powell.

STATEMENT OF MR. T. D. EDWARDS, SECRETARY OF THE NEVADA STATE BOARD OF RECLAMATION AND INTERNAL IMPROVEMENT.

Mr. Chairman and gentlemen: In behalf of the Navada State Board of Reclamation and Internal Improvement, which I represent, I beg leave to present the following facts for your consideration.

The CHAIRMAN. As I understand, that is a report gotten up by the State Board of Reclamation and Internal Improvement.

Mr. EDWARDS. Yes.

The report is as follows:

To the honorable Senate Committee on Irrigation:

The Nevada State Board of Reclamation and Internal Improvement beg leave to submit the following statement:

PHYSICAL CONDITION AND ADAPTABILITY.

Nevada lies between the thirty-fifth and forty-second degrees of north latitude, its boundaries commencing at the northwest corner of Utah Territory and the southern line of Idaho, at the intersection of the thirty-seventh degree of longitude west from Washington (and 114° 03′ 57″ west from Greenwich) and in latitude 42 degrees north, and running thence west along the southern line of Idaho and Oregon to longitude 43 degrees west from Washington; thence south along the eastern line of California to latitude 39 degrees north, which falls in the southeastern part of Lake Tahoe; thence southeasterly along the California line to the intersection of the Colorado River, in latitude 35 degrees north and opposite Fort Mohave; thence north and easterly up the center of the Colorado River to its intersection with the thirty-seventh degree of longitude west from Washington, which is the eastern line of Utah Territory; thence north along the said western line of Utah Territory to the place of beginning, containing within said boundaries 112,090 square miles or 71,737,600 acres.

Of this area there are surveyed, according to the report of the Commissioner of the General Land Office for 1887, 32,793,702 acres, and unsurveyed 38,943,898 acres. This area is approximately classified as follows by the State surveyor-general in his report for 1887-'88:

	Acres.
Water area	1,081,600
Forestry	2,000,000
Grazing	30,000,000
Agricultural lands	20,000,000
Mineral lands	15,000,000
Saline, borax, niter and sulphur deposits, alkali flats and deserts	3,656,000
Total	71,737,600

The agricultural class may be subdivided as follows: Irrigable lands about 12,000,000 acres, non-irrigable lands about 8,000,000 acres. By non-irrigable lands are meant lands that are agricultural in character, but upon which water can not be brought by reason of their elevation, but which, at the same time, can not be denominated grazing lands as they would be productive if irrigated.

Of the irrigable lands not more that 120 square miles are tilled in the State, and not more than one-third can now be irrigated on account of water running to waste by reason of imperfect utilization of the natural streams and springs and the failure to provide artesian and other artificial sources of supply. By the proper and scientific construction of reservoirs, dams, ditches, canals, artesian wells, and tunnels we are of the opinion that all, or nearly all, of the 12,000,000 acres of irrigable agricultural land in the State might be successfully irrigated.

TOPOGRAPHY.

The topography of Nevada is an elevated plateau, situated in the northwestern portion of the great basin. It has an altitude of 800 feet at the southeastern boundary, on the Colorado River, and nearly 7,000 feet at the northern boundary above sea-level, averaging about 4,000 feet.

It is traversed in a northerly and southerly direction by high parallel ranges, of mountains. These are separated by valleys from 5 to 25 miles in width and some of them are 50 miles in length, and one is 350 miles in length. Sage-brush covers nearly the entire surface of the State. It has been ascertained, by actual experiment, that wherever sage-brush grows the land will produce bountiful crops of vegetables, grains, and grasses, when irrigated.

LAKES THAT MAY BE UTILIZED.

Several important lakes are situated within the State, the most noted of which is Lake Tahoe (about one-third of which is in Nevada), it being the source of the Truckee River. It is 28 miles in length, 12 miles in width, and over 1,700 feet in depth.

Pyramid, Carson, and Walker Lakes are important bodies of water, receiving the waters discharged by the rivers of their respective names and having no outlets. All of these lakes can be readily utilized for the purpose of irrigation. The most important lakes in Nevada are as follows:

Name.	County.	Area.
		Sq. miles.
Pyramid	Washoe	462
Carson (lower sink)	Churchill	440
Walker	Esmeralda	230
Humboldt	Humboldt	192
Carson (upper sink)	Churchill	160
Winnemucca	Washoe	144
Tahoe (portion in Nevada)	Washoe, Ormsby, and Douglas	78
Ruby	Elko	37
Franklin	do	32
Washoe	Washoe	18
Snow Water	Elko	12
Massacre	Washoe	4
New Year	do	3
Carico	Lander	1
Marlette	Washoe	½
Forty-nine	do	½
Pahranagat	Lincoln	[illegible]

The Commissioner of the General Land Office, in his report for 1880, states the number of rivers and smaller streams in Nevada to be thirty-five and the number of lakes and ponds to be nine hundred and twenty-five.

RIVERS.

The principal rivers of the State are the Humboldt, Carson, Truckee, and Walker. The Humboldt River rises in the northeastern part of the State and flows southwesterly, emptying its waters into Humboldt Lake.

The other three rise in the Sierra Nevada Mountains (their sources being in the State of California) and flow eastward into the Carson, Pyramid, and Walker lakes respectively, all of which have no outlets. The Owyhee and Bruneau rivers, in the northern portion of Elko County, discharge their waters into the Snake, and the latter into the Columbia River, thence to the Pacific Ocean.

The Virgin and Muddy, in the southeastern portion of Lincoln County, empty their waters into the Colorado River, and thence to the Gulf of California.

Rich, fertile valleys, and numerous natural meadows extend along the various streams.

Following is a statement of the most important streams in the State:

	Miles.
Humboldt	350
Carson (length in Nevada)	190
Armagoza	150
Colorado (length on boundary of Nevada)	150
Reese	140
Little Humboldt	110
Walker (length in Nevada)	110
Truckee	97
Quinn (length in Nevada)	80
Owyhee (length in Nevada)	80
Virgin (length in Nevada)	80
Salmon (length in Nevada)	55
Bruneau	45
Mary's	42
King's	42
Muddy	40

If the waters of these rivers were utilized for the purpose of irrigating the valleys through which they pass, by a correct construction of reservoirs, dams, ditches, and canals, millions of acres that are now useless would be made to produce large crops of hay, cereals, and fruits of all kinds, adapted to the temperate and semi-tropical zones.

VALLEYS.

The following described are some of the principal valleys in the State, all of which can be irrigated from the waters of the rivers and tributaries flowing through them, if the waters thereof were systematically stored and judiciously used. The soil of these valleys is very rich, mostly alluvial deposits and highly productive. All the grains, grasses, fruits, and vegetables of the temperate and semi-tropical zones grow to perfection and in abundance whenever the soil is properly irrigated.

DOUGLAS COUNTY.

In this county is situated Carson Valley, 25 miles in length and an average width of about 10 miles, all of which can be irrigated from the waters of the Carson River.

The county assessor, in his report, says:

> In this county there are thousands of acres of land, which in its present state, are entirely worthless, but whenever water can be obtained the land is exceedingly productive. Probably 90 per cent. of the water of the Carson River now runs to waste. If it could be stored in reservoirs in the mountains and used in the dry season, large tracts of land might be reclaimed and converted into homes for settlers.

In this county nature has provided most advantageous sites for reservoirs.

CHURCHILL COUNTY.

In Churchill County there is a valley, at and around the Sink of the Carson, with an area of about 40,000 acres, which could be irrigated by the waters of the Carson River, as estimated by the county surveyor.

WASHOE COUNTY.

In Washoe County the Truckee Meadows and Washoe Valley are situated with an area of about 25 miles in length and from 5 to 10 miles in width, all of which could be irrigated by a proper use of the water of the Truckee River.

In the same county we have Eagle Lake Valley, estimated at about 500,000 acres, which also can be readily irrigated from the waters of Eagle Lake by an open cut.

Spanish Springs Valley, Lemmon Valley, and Warm Springs Valley, estimated at 125,000 acres, can be irrigated with the waters from the Truckee River by the use of dams and reservoirs.

HUMBOLDT COUNTY.

In this county at a place called Lovelock's there are at least 100,000 acres of very fertile valley land, all of which is susceptible of irrigation by storage and a judicious use of the waters of the Humboldt River.

Humboldt Valley is one of the largest valleys in the State. It is estimated at 350 miles in length with a width in places of 20 miles and at other places it is narrow with an average width of about 8 miles. It extends through the counties of Lander, Humboldt, Eureka, and Elko.

This entire valley could be irrigated by the waters of the Humboldt River by a scientific series of storage dams, canals, reservoirs, and ditches.

Little Humboldt Valley and other small valleys adjacent thereto, including Paradise Valley, which is an extensive valley, are estimated at 250 square miles, all irrigable land.

King's River Valley is estimated at 40 miles in length with an average width of 8 miles, and can be irrigated by the waters of King's River.

Kelly and Rebel Creek Valleys, situated in Humboldt County, can be irrigated from the creeks adjacent and from which they take their names.

Pleasant Valley and many other valleys in this county are wholly susceptible of irrigation, and by a correct system of irrigation in these valleys a large area of valuable farming land could be reclaimed and made largely productive.

Quinn River Valley is about 42 miles in length by 12 in width, all fertile land and irrigable by the waters of Quinn River. This is one of the richest and most important valleys in the State.

ELKO COUNTY.

In this county is the south fork of the Humboldt River, which passes through a fertile valley, which is estimated at 150 square miles, of rich farming land, all of which could be irrigated by the waters of said stream.

Clover Valley, estimated at 50 square miles, is susceptible of being irrigated from the waters of adjacent streams and springs.

Mary's River Valley, Black's Fork, Susie Creek, and Maggie Creek Valleys, estimated at 100 square miles, can be irrigated from the creeks and streams passing over and through them. The soil of these valleys is very rich.

Independence Valley is estimated at 100 square miles, and is all susceptible of irrigation.

Bruneau and Owyhee Valleys, on the rivers of the same names, are large valleys and susceptible of irrigation by the use of the waters of said rivers. Also, Pleasant Valley, 30 miles in length by 6 in width, Lamoille Valley and Star Valley, the dimensions of which can not now be given. All very rich.

EUREKA COUNTY.

Pine and Garden Valleys are estimated at 50 miles in length and 8 in width, all irrigable land.

Diamond Valley has an area of 500 square miles, all rich land, that could be irrigated by an artesian system.

Grubb's Valley, a part of Monitor and Antelope Valleys, contains about 500 square miles, and can be irrigated by the artesian system.

WHITE PINE COUNTY.

In this county we find Newark Valley, which is estimated at 200 square miles. It could be irrigated by the artesian system. There are also many springs and streams in this county that could readily be utilized for irrigating purposes.

Steptoe Valley is estimated to have an area of 500 square miles of rich, arable land that can be thoroughly irrigated by the use of the waters of the creeks and streams passing over and through it, and by springs in said valley and the surrounding hills.

Spring Valley contains a large area of rich land, and can be irrigated from adjacent springs and streams, if these waters were stored and judiciously used; area estimated at 250 square miles.

LINCOLN COUNTY.

Lake Valley and a part of Snake Valley, comprising a large body of rich land, are susceptible of irrigation by the storage of and the proper use of waters of streams on the land and of those adjacent thereto. This body of land is estimated at 50 square miles.

Eagle Valley is a large valley of importance, the area of which can not now be estimated.

Pahranagat Valley has an area of 150 square miles, very rich soil which will produce semi-tropical fruits and vegetables, and, by a system of storage, could be irrigated by streams upon and near it.

Muddy and Virgin River Valleys have an area of 150 square miles, and can be all thoroughly irrigated by the storage and use of the waters of the Virgin and Muddy Rivers. The climate here is semi-tropical.

Las Vegas Valley has an area of 50 square miles, and is irrigable.

Meadow Valley and Cave Valley, as estimated, have an area of 100 square miles, all fertile lands, and susceptible of irrigation.

NYE COUNTY.

Pahrimp Valley, which lies partly in Lincoln County, has an are of 65 by 35 miles. There is no richer or more fertile land on the globe. It rivals the richest portion of the Mississippi Valley. Seventeen hundred and fifty square miles of this valley are in Nevada. This valley could be irrigated successfully by an intelligent use of the springs thereof and the artesian system.

Duck Valley, in this county, has an area of 400 square miles, all of which is irrigable.

LYON COUNTY.

In this county there is Smith Valley, which has an area of about 50 square miles. It is rich farming land, about one-third of which is under an imperfect state of cultivation. The entire valley could be thoroughly irrigated by husbanding the waters of the West Walker, which now run to waste in the early part of the season in consequence of there being no system of storage.

In the same county we find Antelope Valley, the approximate area of which is 120 square miles, about one-fourth of which is under cultivation. It is watered by the West Walker. This valley is in the same condition as the previous mentioned valley. There is sufficient water in the West Walker thoroughly to irrigate both valleys if stored and economically used, but having no water storage in the early season the waters from the melting snows and early rains is wasted and lost.

ESMERALDA COUNTY.

In this county we find Mason Valley, with an approximate area of 250 square miles, watered by the East and West Walker. About one-fifth is imperfectly cultivated. If the waters of said rivers were properly stored by dams and reservoirs there would be sufficient to thoroughly irrigate the entire valley.

If the waters which pass over, through, and adjacent to all or nearly all of the foregoing valleys as the snows melt in the early season could be systematically and scientifically stored in reservoirs and dams, advantageous sites for which are abundant, and economically used during the irrigating season, there would be sufficient thoroughly to irrigate these valleys from the 1st of May to the 1st of October, which in this country constitutes the irrigating season. As the practice now is, fully nine-tenths of the water running down our streams goes to waste.

Many of these valleys are surrounded by or in the vicinity of high mountains, upon which, during the winter, deep snows fall, and on the summits of some the snow is perpetual.

In the early spring these snows melt and produce large quantities of water, which pass down the mountain sides and smaller streams, and sometimes create floods, passing on and finally sinking in the deserts, being lost for irrigating purposes. If this vast amount of water could be stored as the snow melts and runs down the mountains, we claim that there would be ample to irrigate the valleys during the irrigating season. Nature has provided numerous and advantageous sites for the construction of such reservoirs in all parts of our State.

SPRINGS.

As shown by the bulletin of the U. S. Geological Survey, No. 32, the State of Nevada is even better off in regard to springs than as to streams of running water. They form an important auxiliary, and might be caused to aid materially the agriculturist in the increase of his tillable area of land.

Nevada occupies a prominent place as a mineral-spring State; both hot and cold springs are found in every county. The warm and hot springs are found mainly in connection with geological fault-lines or fractures of the strata. Can we not, from these facts, reasonably conclude that the sinking of artesian wells would not only be advisable, but that the probabilities of obtaining large streams of water therefrom are great?

The following is a list of mineral springs, as given by the U. S. Geological report:

ALKALI SPRINGS.

Seven miles north of Montezuma, Esmeralda County.
Ten miles northwest of Lone Mountain, Esmeralda County.
Allen's Springs, south of Carson Lake, Churchill County.
Alum Spring, 5 miles northeast of Steamboat Springs, Washoe County.
Bitter Springs, 15 miles southwest of St. Thomas, Lincoln County.
Butte Spring, north end of Hot Springs, Butte, Humboldt County; 182° Fah.
Double Spring, north of Walker Lake, Esmeralda County; temperature, warm.
Double Hot Springs, southwest flank of Black Rock Range, Humboldt County; 165° to 191° Fah.
Elko Hot Springs, Elko, Elko County; resort.
Franktown Hot Springs, Franktown, Washoe County.
Golconda Hot Springs, Galconda, Humboldt County, six spring; 150° Fahr.; character of water, chalybeate and sulphur; resort.
Goodrich Springs, 12 miles from Schellbourne, White Pine County; flow in gallons per hour, 28,000; 160° to 185° Fah.; unimproved.
Granite Creek Hot Springs, near Alkali Lake, north of Granite Creek Desert, Humboldt County.
Gypsum Springs, 20 miles northeast of Las Vegas, Lincoln County.
On north side of Thousand Creek Valley, southwest of Stein Mountains, Humboldt County; 130° Fah.; unimproved.
In Soldier Meadows, 15 miles south of Camp McGarry, Humboldt County.
At south end of Stein Mountains, Humboldt County; 178° Fah.

Ten or 12 miles north of Mason's Crossing of Quinn River, Humboldt County; number of springs, 2; 118° to 134° Fah.; character of water, calcic.

On east side of Independence Valley, Elko County.

At northeast end of Ruby Lake, Elko County.

East of Division Peak and south of Pah Ute, Humboldt County.

On northeast side of Pine Valley, north of Mineral Hill, Eureka County.

South of Alkali Lake, east side of Crescent Valley, Eureka County.

On northeast side of Pah Ute Mountains, Churchill County.

In Antelope Valley, near Eagle Lake, Elko County.

Northwest of sink of Quinn River, Humboldt County; number of springs, 2.

Near Egan Cañon, 15 miles northwest of Schellbourne, White Pine County; used for quartz mill and for bathing.

At northwest end of Pyramid Lake, Washoe County.

At north end of Pyramid Lake, Washoe County.

On Carson River, 6 miles northeast of Genoa, Douglas County.

At south end of Smoke Creek Desert, Washoe County.

At north end of Toquima Range, 18 miles southeast of Austin, Lander County.

Near junction of Beef and Virgin Creeks, Humboldt County; 108° Fah.

On Little Humboldt, north of Hot Spring Creek, Humboldt County; 130° Fah.

In Kobeh Valley, near Grubbs' Wells, Eureka County.

On west side of Smith Creek Valley, Churchill County.

On west side of Gabbs' Valley, Esmeralda County.

One mile east of Carson City, Ormsby County (at State's prison); 111° Fah.; improved.

Ten miles north of Wellington, Lyon County (Hinds'); flow of water per hour, 91,000 gallons; 40° to 140° Fah.; resort.

East of Hot Springs Station, Churchill County; number of springs, 6; 158° to 187° Fah.

East of Winnemucca, Humboldt County; 189° Fah.

At head of north branch of Little Humboldt, Humboldt County.

At head of south branch of Little Humboldt, Humboldt County.

On southwest side of Black Rock Range, Humboldt County; number of springs, 3.

At south end of Black Rock Range, Humboldt County.

Near south end of Pine Forest Range, 7 miles from Mason's Crossing of Quinn River, Humboldt County; 155° Fah.

In Emigrant Cañon, northeast of Tulasco, Elko County.

At south end of Thousand Springs Valley, Elko County.

At Cephas Kyles, 7 miles south of Sue Springs, Churchill County; 124° Fah.

At base of Shoshone Range, Reese River Valley, Lander County; 85° to 117° Fah.

In Steptoe Valley, southwest of Ruby Valley, White Pine County.

Near Silver Peake, Esmeralda County, eleven springs; 69° to 117.8° Fah.; saline, etc.

Fourteen miles south of Toyiabe City, Nye County, one spring; flow in gallons, per hour, 35,000; temperature, boiling.

In Diamond Valley, 30 miles north of Eureka, Eureka County.

In Hot Spring Range, Nye County; two springs; temperature, boiling.

In Salt Valley, east side of Carson Sink Mountains, Churchill County.

Hot Sulphur Springs, Carlin, Elko County.

Kyle's Hot Springs, 12 or 15 miles east of Star Peak, Humboldt County; resort.

Las Vegas Springs, Las Vegas, Lincoln County, 73° Fah.; calcic.

Leach's Hot Springs, Pleasant Valley, 25 miles south of Winnemucca, Humboldt County; 118° Fah.

Mesquit Springs, 10 miles east of Las Vegas, Lincoln County.

Miller's Hot Springs, 10 miles north of Franklin, Ruby Valley, Elko County; 170° Fah.

Mineral Hill Hot White Sulphur Springs (Bruffy's Hot Springs), 4 miles north of Mineral Hill, Eureka County; five springs; flow in gallons per minute, 150; temperature, boiling; sulphureted; resort.

MINERAL SPRINGS.

Opposite Stonehouse Station, Humboldt County.

West side of Smoke Creek Desert, Washoe County.

Muddy Springs, northwest of West Point, Lincoln County; twenty springs; temperature, hot.

Mud Springs, Desert Wells, Nye County.

Nelson Springs, 20 miles south of Golconda, Humboldt County; temperature, hot.

Red Bluff Springs, 10 miles east of St. Thomas, Lincoln County; alkaline, saline.

Rotten Egg Springs, west side of Mud Lake, Washoe County.

Salt Well, 1 mile north of Stone's Ferry, Lincoln County; 89.5° Fah.; saline.

Shellbourne Hot Springs, Shellbourne, White Pine County; two springs; used for irrigation.

Shaw's Hot Springs (formerly Swift's), 2 miles northeast of Carson City, Ormsby County; one spring, flow in gallons per hour, 4,000; 120° Fah.; soda, borax, iron, magnesia, arsenic; resort.
Hot water of Ophir Mine, Comstock Lode, Virginia City, Storey County.
Smoky Valley Geysers, Nye County; flow, 4,200 gallons per hour; boiling.
Soda Lakes, 3 or 4 miles east of Ragtown, Churchill County; alkaline, saline.

SODA SPRINGS.

East of South Carson Lake, Churchill County; 178° Fah.
South of Silver Peak, Esmeralda County.
Near Butterfield's Warm Springs, west of Railroad Valley, Nye County; saline, etc.
Steamboat Springs, Steamboat, Washoe County; 204° Fah.; resort.
Sne (or Gilbert's) Hot Springs, north end of Osobb or Salt Valley, Humboldt County; 160° to 165° Fah.

SULPHUR SPRINGS.

In Esmeralda County, 12 miles southeast of Wellington.
In Sodaville, Soda Springs Valley, north of Columbus, Esmeralda County; improved and used as a resort.
At south end of Diamond Valley, Eureka County.
Seven miles east of Montezuma, Esmeralda County.
Eight or nine miles northeast of Toyabe City, Nye County.
Twenty miles south of Freibergh, Lincoln County.
In Pahrimp Valley, Lincoln County.
At Sand Spring Flat, 15 miles south of Stillwater, Churchill County; hot.

THERMAL SPRINGS.

On east side of Little Cedar Mountains, Elko County.
At east base of Keene Mountains, San Antonio, Nye County; three springs; alkaline.
Five miles east of Patterson, Lincoln County.
Virgin River, Lincoln County; strongly saline.
Volcanic Springs, Whirlwind Valley, Eureka County, 10 miles south of Beowawe.
Wabuska Springs, Wabuska, Lyon County; 138° to 162° Fahr.
Walley's or Genoa Hot Springs, Genoa, Douglas County; six springs; flow 600 gallons per minute; hot; iron and sulphur; resort.
Ward's Hot Springs, foot of Granite Mountains, Humboldt County; boiling.

WARM SPRINGS.

North of Shoshone Mesa, west of Rock Creek, Lander County.
On White River, in Sierra Valley, 20 miles northwest of Butterfield, Nye County.
South of Sonoma Range, Humboldt County.
On west side of King's River Valley, Humboldt County; number of springs, two; 76° to 80° Fahr.
Eight miles southwest of Camp Halleck, Elko County.
At Hiko, Lincoln County; 90° Fahr.
In Pahrimp Valley, Lincoln County.
West of Robert's Mountain, Eureka County.
Northwest of Tecoma, Elko County.
South of Alkali Lake, Reese River Valley, Lander County.
On west side of Warm Spring Valley, Nye County.
At north end of Grass Valley, Lander County.
In Storey County, 10 or 12 miles south of Wadsworth; 73° Fahr.
At north end of Carrico Valley, Lander County.
At east side of Sonoma Mountains, Humboldt County.
In Fish Spring Valley, southeast of Danville, Nye County.
Six miles north of Hot Springs, Smith's Creek Valley, Churchill County.
In Ash Meadow, Nye County; 81.6° Fahr.
At north end of White Pine Valley, White Pine County.
West of Fish Creek Range, Lander County; 140° Fahr.
Warm Sulphur Springs, south end of Spring Valley, White Pine County.
Whelan's White Sulphur and Mineral Springs, Pine Valley, 12 miles north of Mineral Hill, Eureka County; three springs; flow per hour, 5,000 gallons; 108° to 112° Fahr.; local resort.

The above list includes only mineral springs, besides which we have many important springs. Some of these have very large flows, notably two at Bennett's Ranch, in Pahrimp Valley, which irrigates 2,500 acres, and three in Pahranagat Valley (Hiko, Logan, and Ash), each of which has a flow of from 1,000 to 2,000 inches.

RESERVOIRS AND ARTESIAN WELLS.

According to the assessors' reports to the surveyor-general for 1888, there were in our State only eighteen reservoirs, their total capacity being 591,576,000 gallons.

Natural depressions between the summits and ridges of the many mountains, and in the foot-hills at their base, form sites admirably adapted for immense and inexpensive reservoirs.

There were, in 1888, sixty-five wells sunk in our State, ranging in depth from 109 to 310 feet, twenty-five of which were 6 inches in diameter, averaging in flow about 20 gallons per minute.

The others have a diameter of 3 and 4 inches, and vary in flow from 11½ to 33 gallons per minute.

In a dispatch from Washington to the San Francisco Chronicle, January 3, 1889, referring to Major Powell's report, we find the following:

> Early in November, H. M. Wilson, with parties under his immediate charge * * * was transferred to Nevada, near the headwaters of the Truckee, Carson, and Walker Rivers, and immediately began the work of an irrigation survey. Speaking of Lake Tahoe, he says: "This is a lake filled from a catchment basin of 500 square miles. This storage lake, constructed by nature, has only to be tapped and gateways constructed and it can be used at once, and the water which is gathered through the non-irrigating season, may, through the irrigating season, be discharged again into its natural channel, in addition to the waters which fall from the heavens during that season; the whole to be carried down to diverting dams in the valley below and turned into irrigating canals to be spread over the land in the total area available for irrigation to which the water of the Truckee may be carried.
>
> "It is probable that an acre-foot of water, *i. e.* an acre of water 1 foot deep will abundantly irrigate an acre of land through one season, and it is possible to store in Lake Tahoe 500,000 acre-feet, which can be made to irrigate 500,000 acres of land. This can be done by providing for the discharge of 4 feet of water from the surface of the lake through each irrigating season, and providing for the conservation of the same amount annually contributed by the clouds. The survey has not yet proceeded far enough to determine where these lands can be selected.
>
> "This case has been here cited simply as an illustration of the manner in which the natural lakes of the mountain regions of the arid land can be economically utilized as storage reservoirs. Such lakes exist in great numbers. Altogether there are several hundred, each of which must be carefully examined and carefully surveyed in order to determine the methods by which it can be used."

Wells and reservoirs.

[From surveyor-general's report, 1887-'88.]

Counties.	Artesian wells—1888.				Reservoirs—1888.	
	Number.	Depth.	Size of pipe.	Flowing capacity 24 hours.	Number.	Capacity.
		Feet.	*Inches.*	*Gallons.*		*Gallons.*
Churchill	2	1....300 1..2,100	4	2,000	....	....
Douglas	2	1....225 1....310	3	43,200	....	....
Elko	....	....	....	....	....	....
Esmeralda	1	....	....	....	1	....
Humboldt	....	....	....	....	1	....
Lander	25	150 to 200	6	*28,800	2	876,000
Lincoln	....	....	....	....	....	....
Lyon	....	....	....	....	....	....
Nye	....	....	....	....	6	581,000,000
Ormsby	35	1....109 1....150 1....138	3	48,960 15,000 15,000	6	2,500,000
Storey	....	....	....	....		
Washoe	....	....	....	....	1	7,000,000
White Pine	....	....	....	....	1	200,000

*Average.

CLIMATE.

Nevada possesses an equable climate. Extremes of heat and cold are seldom experienced.

The precipitation of melted snow and rain, as shown by the report of the Nevada State weather service, is as follows for the year 1888:

Station.	County.	Months.	Precipitation.
			Inches.
Wellington	Douglas	12	8.11
Hot Springs	Churchill	7	2.22
Burner's Ranch	Elko	8	18.53
Eureka	Eureka	9	7.15
Mill City	Humboldt	8	5.08
Battle Mountain	Lander	11	10.92
Pioche	Lincoln	12	18.27
Dayton	Lyon	8	4.86
Carson	Ormsby	12	7.12
Reno	Washoe	11	6.62
Lewer's Ranch	do	6	6.14
Ely	White Pine	10	9.64

Nearly all of the above stations are situated in valleys, where the precipitation is much less than on the surrounding mountains.

AGRICULTURE.

Possessing as rich a soil and as fine a climate as any region in the temperate zone, Nevada, with a systematic and scientific plan of irrigation, which could be brought about by an intelligent system of water storage and artesian wells, would be one of the most productive States in the Union. Her farmers are beginning to realize the fact that the agricultural resources of the State are comparatively undeveloped. The mineral composition of the soil renders it superior to the rich, black loam of the Western States, its elements being those that give enduring strength, by constantly receiving benefits from the decomposition and segregation of rocks, pregnant with mineral properties, which tend to fertilize it.

As shown by the reports of the assessors, there are planted 279,279 apple trees, 39,833 grape vines, 4,452 almond trees, all of which are flourishing and yield abundantly, showing that the climate is adapted to the production of both temperate and semi-tropical fruits.

Timothy, red clover, and natural grasses produce as much if not more to the acre than elsewhere, when the soil is properly irrigated. Alfalfa is produced in abundance whenever the land can be given sufficient water—two and sometimes three crops, and in southern Nevada, from four to six crops from the same land in one season, each yielding from 2 to 2½ tons per cut to the acre, and in some localities even more.

All fruits and berries adapted to the temperate zone grow to perfection, and being free from diseases and insect pests yield abundantly and command higher prices in the market than like products from other States.

In Lincoln and Nye Counties grapes and all the semi-tropical fruits, in addition to those of northern climes, can be grown as successfully as in California or Florida. In the Vegas, Pahrimp, Pahranagat, and Rio Virgin Valleys grapes are successfully cultivated. In the last-named valley, 30,000 grape-vines and 3,452 almond trees are owned and cultivated by Daniel Bonnelli, esq., who reports them to be as thriving as those in the most favored sections in France.

Cotton, tobacco, and citrus and semi-tropical fruits of all kinds and of the best quality flourish in these valleys.

A brief sketch of Pahranagat and Pahrimp Valleys may not be inappropriate in this connection.

PAHRANAGAT VALLEY.

This valley is situated in Lincoln County, and lies at an elevation estimated at from 6,000 to 7,000 feet above sea-level, but, for so great an altitude, the climate is warm and pleasant. This is accounted for by its being in a measure open to the valley of the Colorado and the warm region of the south. Very slight snow-storms are experienced in winter, and frosts are not severe. Springs and streams afford water for irrigating a large area, and with good soil and mild climate combine to generate such products of the farm, garden, and field as the people desire. The springs, of which there are three (Hiko, Logan, and Ash), are natural curiosities, because of the volume of the water they pour forth (from 1,000 to 2,000 inches each) and the peculiarity of their high temperature (from 65° to 75° Fahr.). In the neighborhood of each of these are farming settlements, and at Hiko and Logan small villages.

PAHRIMP VALLEY.

Situated south of the great Armargoza Desert, west of the Spring Range of mountains, in longitude 116 degrees west, latitude 36 degrees north, lying partly in Nevada and partly in California, is Pahrimp Valley, destined some day to be famous for its fertility, and is one of the most, if not the most, fertile of spots in the United States.

Pahrimp Valley is partly surrounded by mountains, varying from 6,000 to 12,000 feet high, and covered with a heavy growth of timber, principally yellow-pine, nut-pine and tamarack, which will afford, almost forever, a continual supply of lumber and fuel for all who need them. The scenery of these mountains is particularly magnificent, and standing upon one of the knolls or hills that skirt the edge of the valley, one can see stretched out before him a plain 65 miles long by 35 miles in width, and covered with a dense undergrowth of sage-brush and grease-wood. If you go down into the valley you will find beneath this gray exterior a soil that is excessively rich, and at intervals springs of flowing water. In this valley there is at least calculation 250,000 acres of as fertile land as there is on the globe. To prove this assertion we will describe a farm there known as Bennett's. On this place there are two springs of flowing water which irrigate 2,500 acres of land, and this land is no more fertile than several hundred thousand other acres in the valley just like it. The principal crops at Bennett's are alfalfa, grain, corn, fruits of all kinds, and grapes, in fact, everything belonging to the vegetable kingdom that has been tried there has flourished. Alfalfa is cut four times a year and then leaves good pasturage; corn yields as abundantly as on the famous Mississippi bottoms, and certainly better than in any of the Western States, while fruits do excellently, figs, almonds, walnuts, apples, nectarines, peaches, pears, apricots, etc., being raised in abundance.

Upon the summits of the surrounding hills, the snow-fall is quite heavy, ranging from 2 to 12 feet, and upon Charleston Peak is perpetual. A greater part of it melts early in the season and runs down the hillside to sink in the soil, re-appearing as the aforementioned springs.

In the valleys of the Virgin and Muddy Rivers cotton is successfully raised. The report of the assessor of Lincoln County, for 1888, shows that 49 acres are cultivated, with a yield of 19,600 pounds (or 400 pounds per acre), of a quality equal to any grown in the United States.

As there is no home market in Lincoln County for this article, and almost no transportation facilities, it is not extensively raised; but the above shows that with improved irrigation facilities (and with the consequent enlargement of the resources of the country better transportation facilities will be obtained), a large area of land would be opened up, on which all the staple products of the semi-tropical zone could be raised in abundance.

We are largely indebted to the State surveyor-general's report for 1887–'88, for many of the figures and facts above stated, and we believe that many of our estimates are under rather than over the real facts. The annexed tables will illustrate this:

Principal agricultural products of Nevada in the years 1887–'88.

Counties.	Land.				Wheat.			
	1887.		1888.		1887.		1888.	
	Inclosed.	Cultivated.	Inclosed.	Cultivated.	Acres.	Bushels.	Acres.	Bushels.
	Acres.	*Acres.*	*Acres.*	*Acres.*				
Churchill	....	....	34,715	6,023	....	....	275	4,466
Douglas	33,084	14,826	33,100	14,713	820	14,760	750	*14,760
Elko	....	....	219,530	47,150	....	....	1,060	25,497
Esmeralda	....	....	6,000	4,000	....	....	100	1,000
Eureka	....	....	36,348	12,405	....	....	250	6,250
Humboldt	195,600	8,400	141,500	26,234	3,500	85,000	10,030	200,890
Lander	....	....	55,643	2,500	....	....	300	9,000
Lincoln	10,511	3,612	10,550	3,700	898	9,962	400	9,962
Lyon	....	....	34,000	8,600	....	....	600	12,000
Nye	....	....	....	....	....	....	....	....
Ormsby	4,676	1,943	5,009	1,871	196	3,800	180	3,600
Storey	....	1,650	....	700	....	....	20	600
Washoe	43,430	8,560	45,148	8,700	2,040	24,960	1,713	20,376
White Pine	20,000	12,900	25,000	5,500	100	4,000	100	4,000
	309,301	50,291	646,343	141,496	5,054	142,484	15,718	311,901

Counties.	Barley.				Oats.			
	1887.		1888.		1887.		1888.	
	Acres.	Bushels.	Acres.	Bushels.	Acres.	Bushels.	Acres.	Bushels.
Churchill	....	....	567	15,080	....	....	53	1,500
Douglas	1,305	83,700	1,305	*33,700	1,960	49,000	*1,900	47,500
Elko	....	....	2,840	78,150	....	....	2,270	91,470
Esmeralda	....	....	10	400	....	....	20	150
Eureka	....	....	600	21,000	....	....	150	5,250
Humboldt	3,400	84,200	15,049	375,960	100	4,000	250	20,900
Lander	....	....	2,200	38,000	....	....	5	200
Lincoln	1,040	26,012	1,200	30,000	209	7,315	250	8,950
Lyon	....	....	1,300	32,500	....	....	260	9,100
Nye	....	....	1,780	52,917	....	....	150	6,250
Ormsby	415	7,885	469	8,711	116	4,060	7	*245
Storey	....	....	3	120	....	....	....	....
Washoe	1,820	12,130	1,418	10,855	660	11,492	571	11,313
White Pine	1,000	30,000	1,000	40,000	400	20,000	150	6,000
	8,480	194,027	28,741	737,393	3,445	95,867	6,035	208,918

Principal agricultural products of Nevada in the years 1887-'88—Continued.

Counties.	Potatoes.				Hay.			
	1887.		1888.		1887.		1888.	
	Acres.	Bushels.	Acres.	Bushels.	Acres.	Tons.	Acres.	Tons.
Churchill			8	2,200			6,140	10,120
Douglas	120	7,500	80	*5,040	10,372	15,558	16,572	*15,658
Elko			305	25,065			40,650	44,370
Esmeralda			6	1,400			1,200	2,000
Eureka			300	45,000			11,000	15,500
Humboldt	50	5,000	107	12,490	20,000	25,000	50,652	200,166
Lander			215	20,600			6,000	5,400
Lincoln	91	5,460	93	5,580	3,342	6,684	3,400	6,800
Lyon			268	85,760			12,480	24,960
Nye			160	10,667			2,323	4,645
Ormsby	120	10,800	140	13,140	880	1,980	897	2,018
Storey			60	4,550			300	1,000
Washoe	397	43,620	359	49,676	18,460	41,120	18,523	43,077
White Pine	500	50,000	100	10,000	8,000	12,000	4,000	5,000
	1,278	122,380	2,201	301,183	61,054	73,342	168,137	380,914

*Counties.	Butter.		Cheese.		Wool.	
	1887.	1888.	1887.	1888.	1887.	1888.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
Churchill		7,900		1,500		148,000
Douglas	20,000	22,000			2,000	2,300
Elko		32,000		1,000		196,800
Esmeralda		1,000				
Eureka		40,000				97,987
Humboldt		24,000			400,000	666,600
Lander		15,000				126,900
Lincoln	9,800	10,000	6,000	6,000	46,800	46,800
Lyon		38,000				70,000
Nye						108,550
Ormsby	9,740	9,480				
Storey		1,800				700
Washoe	90,740	91,105	28,200	21,050	400,000	350,000
White Pine	10,000	15,000	2,000	1,000	150,000	210,000
	140,280	286,285	36,200	28,550	998,800	2,024,337

* Crop for that year unknown, and the previous year is taken as basis.

Smaller crops—total for the State.

Product.	1887.		1888.	
	Acres.	Bushels.	Acres.	Bushels.
Corn	446	13,760	610	16,626
Rye	167	1,727	207	1,930
Onions	68¼	2,509	49½	2,768
Peas	68½	1,632	189	4,077
Beans	66	1,615	66	1,685
Cabbage	82½	*324	121	*364½
Hops			10	†2,000

* Tons. † Pounds.

Trees and vines in the State.

Trees.	1887.	1888.	Trees.	1887.	1888.
Apple	253,969	279,259	Walnut	1,721	2,014
Peach	8,000	11,628	Willow	5,803	5,841
Pear	10,471	14,002	White maple	5,631	7,723
Plum	9,720	12,009	Poplar	107,894	98,423
Cherry	7,332	8,059	Cottonwood	206,840	315,228
Nectarine	278	252	Elm	25,813	26,601
Quince	1,058	1,087	Box elder	14,616	12,795
Apricot	[illegible]	1,475			
Fig	245	278		308,318	468,715
Lemon	....	1			
Orange	2	....	Miscellaneous (including ornamental trees, shrubs, etc.)	80,562	43,064
Pomegranate	....	6			
Prune	3,025	4,032	Grapevines		
Mulberry	831	875	Strawberry, gooseberry, raspberry, and currant bushes.	37,588 365,665	39,075 625,401
Almond	3,371	3,452			
	299,228	336,415		403,253	665,376

HOW SHALL THIS GREAT WORK BE DONE?

Many of the States and Territories in the arid region advance the following propositions:

(1) The General Government to undertake the reclamation of the arid lands and provide for their settlement and sale.

(2) That the desert-land law be so amended as to encourage individuals and companies to construct the necessary works for the reclamation of large bodies of said land.

(3) That Congress grant to each State of the arid belt, or to each Territory, upon its becoming a State, all the irrigable land within its borders, held by the General Government, such States to be charged with the supervision of their reclamation, and with their disposal to actual settlers.

Of these, we favor the last. If the General Government feels that it would not be warranted in donating outright the money necessary to accomplish the desired end, then let it act as liberally as it can without detriment to the equity of other States, whose humidity is sufficient for all their requirements, and transfer in fee-simple to the State of Nevada all the lands in that State the title to which is now in the General Government and not otherwise appropriated.

Were these lands put in legal condition to be sold to actual settlers, firms, corporations, and syndicates, the money derived from such sales could be placed in a fund to be known as the "State reclamation fund," the sale of said lands and the control of said reclamation fund to be managed by a State board. The money accruing to this fund could be used for the purpose of reclaiming such lands, and for the construction of storage reservoirs, canals, and tunnels; and thus induce the purchase, by the farmer, of lands upon which he would be guarantied the necessary water for irrigation.

Thus all the irrigable lands in the State would be in demand by actual settlers, and money would flow in as fast as it could be utilized, and the fund would be found ample to do the work required.

Should the General Government be unwilling to make a donation of money, but will make this donation of land, the end would be accomplished, no doubt, as readily and thoroughly as by any other means.

AID TO NEVADA.

The State has but a small tax-roll compared with other States. This board was only organized May 9, 1889. The State has appropriated $100,000, so that this board could make a beginning. It is to the General Government that we most look for aid to carry on this great work. The title to most of the irrigable land in the State is in the Government, so that should the Government assist us it would at the same time benefit itself.

Again, while other States have had large Congressional appropriations for river, harbor, and other improvements, Nevada has received nothing. Would it not be even-handed justice if, in lieu of river and harbor appropriations, we should have an appropriation for the construction of reservoirs?

The fostering care of the General Government should be extended to all the States of the Union without distinction or discrimination. Nevada, as one of the integral parts of the Union, asks that this be done in its behalf now, at a time in its history when its needs are more pressing than at any period since its organization as a State. Its mines, which for many years were the envy of the world, have very materially fallen off in their production of gold and silver, and very many of the people engaged in that industry have departed to other fields. There now remains a population of probably 63,000. Of these the great majority are engaged in other pursuits than mining. The miner, having dug his treasures from the bowels of the mountains, had no further use for the country, and left behind him only the tiller of the soil, or, to speak more in the parlance of the great West, the rancher. This individual, with a persistence worthy of better success, has made productive every acre of arable land to be found along the water-courses of the State, or where, by small expenditure, land could be irrigated, he did so with much success, considering the capital invested and the opportunities presented. There being no more land available for farming in this way, if the area of producing land is to be increased, it must be done by a system of irrigation fostered by the General Government. Of what that system shall consist, or how it shall be established, perhaps others more versed in such problems than ourselves should determine; but it must be done, or the State, which has within its borders thousands of acres of productive land, must remain as it is, poor in wealth and sparse in population. Such being the condition of things, can the General Government refuse to render assistance, or will it allow one of its sovereign States to languish, when a very small moiety from its treasure-house would place it in a condition of permanent prosperity, and add to that State's capacity for increasing its wealth and supplying homes for a greater number of inhabitants? Surely the policy of this great Government is broad enough, is expansive enough in its conception of what is beneficial for the good of its whole people, not to allow the parsimony of the huckster to stand in the way of aiding and fostering one of its great commonwealths.

One of America's greatest statesmen said that the three most pressing needs of primitive man were food, raiment, and defense. Of the latter the people of Nevada stand not in need. But food and raiment are as much a part of their pressing needs to-day as they were to primitive man, and successfully to get them is as much a problem to the average sage-brusher as it was thousands of years ago, when the world was young.

The General Government can help solve this problem by aiding this struggling people in a manner different from the aid given to the people of other States. Nevada has no harbors within its confines to be sea-walled or dredged, nor does it ask for expensive light-houses to light the commerce of the world to its custom-house doors, nor has it a river requiring improvement or the expenditure of money to make it navigable, save, indeed, the Colorado, which in other years may be deemed a stream of sufficient importance upon which the Government may expend labor.

Nevada is particularly an inland State, and, not being in condition geographically to ask the Government for aid to be applied as other and older States do, it does not seem presumptious or extravagant to ask for aid and assistance for a system of irrigation which, when carried out faithfully, honestly, and conscientiously, will people its confines with American citizens, and will create homes for the progeny of American citizens in a land where only educated labor and a pride in American institutions are required to make the most prosperous and happy people on the face of the globe.

Finally, we have endeavored to show that there is in this State a large body of irrigable agricultural land, and that there is ample available water within the borders of the State, if properly stored and used, to irrigate this land.

The foregoing is respectfully submitted for your consideration by the Nevada State Board of Reclamation and Internal Improvement.

EVAN WILLIAMS, *Chairman*,
J. R. BRADLEY,
L. A. BLAKESLEE,
HERMAN SPRINGMEYER,
Commissioners.

T. D. EDWARDS,
Secretary.

STATEMENT OF W. L. FULTON, OF RENO.

The CHAIRMAN. Have you a prepared report?

Mr. FULTON. Yes. I represent a commission consisting of five members of Washoe County. Fearing that we would not have an audience, we had it printed. There is some data in the report, and it contains such facts as we thought would be appropriate. We have not taken section by section and given the detail of the reservoir sites in the mountains; but we have prepared a map that shows the headwaters of the Truckee and the irrigable portions of our county, as well as the ditches that have been constructed.

The report is as follows:

GENTLEMEN: The board of commissioners of Washoe County, with a patriotic desire to afford you every assistance possible, has selected five of her citizens to welcome you to our State and impart any information we have, and fearing that the uncertainty attending your movements and the pressure upon your time might prevent a personal attendance, we take this method of extending to you the freedom of our county and town, and inviting you most cordially to spend any time at your command with us in a closer study of the problem you have in hand; and, while we take great pleasure in extending a cordial welcome to the distinguished members of your committee and to the eminent gentlemen in your company, permit us to hope that the slurs cast upon us, as a State, by the dismal funny men and political Pharisees, have not caused you to come among us asking the ancient question modified—"Can any good thing come out of Nevada?" Like Nazareth of old, our State is held to be extremely common by the more esthetic and wealthy portions of the nation, but we believe it can be shown to you that while no State or Territory is poorer or more neglected now, that not one of them will receive the relative benefit from your labors that Nevada will. It seems almost providential that such great bodies of fine land can be found lying immediately under the immense natural and possible reservoirs of the Sierras, and any adequate plan of water storage and for bringing water and land together will do more for Nevada, in all that goes to make a State, than can be done for any other part of the arid region.

As you have already ridden through the State from east to west, we need not say that Nevada needs irrigation. With our scanty rain-fall of 5 or 6 inches we are limited to a very small area for agriculture or pasture, but with sufficient water storage we can cultivate a large portion of our State. The great American desert is a desert only because it is dry, for its soil is good and its climate unsurpassed. Nevada contains about 109,000 square miles, of which less than 3 per cent. can be used by the present water system, and about 33 per cent. if water could be provided. We can not expect much from artesian wells, for experience is against us. There are a few shallow wells in the State, but no deep ones have been found, and none at all capable of irrigating more than a few acres. At Battle Mountan several are down about a hundred feet, but they are only valuable for gardens. One or two near the State line would be useful for watering stock, and a number are found just across the border in California, flowing from five to ninety gallons a minute. A few years ago a well was sunk by the railroad company to a depth of 2,346 feet at White Plains, the lowest point on their line in the State, but it ended as dry as it began. Previously one at Lovelocks, over 1,000 feet deep, had met with failure, as did others in widely separated portions of the State, so that we may say that Nevada's future growth depends solely upon the use of her opportunities for water storage. That she is worth reclaiming is very easily proven. No more delightful place to live can be found upon the continent; no part of America has so many days of sunshine with delicious evenings and nights of comfort; no corner of the Union has the freedom from malaria, consumption and kindred diseases, and in no State is agriculture pursued with greater ease or larger profit. The farmer is certain of his crop, as well as of his market. Ready sale can be had for all that can be raised. His hay is all needed for keeping the fat beef gathered off the ranges in fit order for the city markets, and in supplying mining, milling, and stage stock; his grain is taken at the mills the moment it is ready to be sold, at market prices, freight added; his fruit is absorbed as soon as it is ripe in preference to the imported article, and all the products of his industry net him in cash better prices than can be realized almost anywhere else in the civilized world.

Nor is nature stingy either in the quantity or quality of her bounty. With a warm sun and a certain supply of moisture there can be no failure. The constant stream is loaded with liquid fertilizers gathered along its way and sinks with them down to the roots of the tree or plant, producing a rapidity and perfection of growth absolutely astonishing. Whatever grows here grows to the limit of quality. The wheat, in grain and straw, is as clean as the gold from the mine. The potato is a sealed package of white meal, the apple is the best of its species. In addition to all kinds of grain and grasses Nevada is particularly well adapted to the apple, the potato, the plum, and the pear, besides all small fruits and berries, while certain kinds of grapes grow to perfection. But we claim the superlative in apples, potatoes, and wheat; and to prove our claims the product of our soil bore off the prizes at New Orleans and other great fairs.

Some idea of the capacity of the State can be gained from studying our own county of Washoe, which raises yearly 60,000 tons of the best kind of hay, besides wheat and other grains. It seems especially well adapted to alfalfa or lucern, as it is known to Americans, which grows luxuriantly but does not grow to woody stalks as it does in California. As well, however, as our fields and farms look to the traveler, in contrast to the sage-brush stretches, they do not take in our best lands. They have been chosen by the settlers because they lie nearer the streams and can be reached by ditches at less expense, but the higher benches and valleys, stretching for miles, have a soil superior in strength and quality, and freer from rock and alkali. While the lower lands have been covered with water during the glacial or some later period of high floods, carrying off much good loam and leaving the land covered with rocks and bowlders, the lands beyond were being formed by rich sediment, and the ground can be reclaimed and irrigated by simply burning off the brush. Millions of acres of such land in Nevada are only waiting for the water to enrich the hands that may till them.

The map which we file with your engineer will give you a good idea of what has been done in Washoe County by individual enterprise. The lines of ditches which you will see thereon have been dug by single individuals engaged in farming the land covered, or by half a dozen combined, and in no case has such an undertaking been put through by moneyed men for the sake of the investment. All this vast outlay of time and strength has been made by the hard-fisted sons of toil, who labored often with a rifle at hand to stand off hostile Indians, and who deserve as much credit and consideration as the Puritan fathers or the Kentucky pioneers. Beyond these ditches, however, lie not only the best of our lands, but by far the larger portion.

At least a quarter of a million acres of the best of land could be reclaimed in Washhoe County alone, and put to producing crops right where the farmer can get the highest prices, enjoy the best climate, live near good schools and churches, and have all that man needs to be comfortable and happy. We have the land and we have the water, if it could be saved. An ocean runs to waste every spring, and goes out into the hot desert to be absorbed by the dry and thirsty air. In the grand background which rises to the west you can find abundant opportunities to save the floods. One class of reservoirs is the natural lakes—Donner, Webber, and Independence—which have extensive water-sheds extending right up to the eternal snows of the summits, that send down floods sufficient to raise them 20 feet. Lake Tahoe, however, is the great hope of Western Nevada, and one foot put on its surface would equal all the other lakes combined. It has 175 square miles, with a water-shed capable, in ordinary years, of raising it 8 or 10 feet, and an outlet which can be perfectly controlled by a timber dam with wooden gates, worth a few hundred dollars. Another system of lakes which will be extremely valuable can be made by taking the hundreds of mountain meadows, which abound in the Sierras, and closing the mouth of each with a dam. They are used now for summer dairies by parties who winter in California, and though many of them are owned, none are improved to any extent. For about five months in the year they are occupied and the rest of the time they are left to be filled from 5 to 40 feet deep with snow. They are from a few yards to a few miles in extent, and have all the materials for dams on the ground. We regard these as next in importance to Tahoe and the other natural lakes. Many of them have large water-sheds and a good supply of water, with excellent dam sites at their outlet.

Another excellent proposition would be to divert waters from their beds during flood tide and hold them in favorable places, large or small, until needed. A great many very good-sized lakes could be thus kept full, and the work of walling them in on one side would not be expensive. They would be especially popular with parties near the foot-hills, who could use them as adjuncts each to his own farm. The opportunity for this class of works is limited only by the amount of money that can be controlled, and in time they will dot the map by hundreds and thousands. This system of tanks, as they are called there, has done very much to feed the swarms of people in India, and in time will many times double our capacity for supporting population. The mountain reservoirs, however, will always have one great advantage in the way of evaporation. In the central and eastern part of the State this amounts to from 70 to 90 inches, while it must be much less in the cooler and higher regions. A number of very useful reservoirs could be created by damming up the Humboldt, Carson, Truckee and other rivers at favorable places and flooding level valleys behind. The lands which in such cases would be covered are now very generally farmed, and on some are large and important towns, crossed by railroads in some cases, and it would be a matter of calculation whether any of them would be worth more as reservoir sites than for present purposes. Up in the mountains are Prosser Creek, Little Truckee, and other large streams with sufficient water-sheds and many excellent reservoir sites to form lakes many miles in extent.

Now, gentlemen, we believe that with our mild but invigorating climate; with our extensive valleys and benches of good land extending in convenient locations, from high up the mountain sides down to the lowest altitudes in the great basin on the one side and our unsurpassed possibility for water storage on the other, that we can offer more solid and substantial return for every dollar put into engineering works than any other part of the West. For the first time in its history, the Anglo-Saxon race has undertaken to reclaim a desert. All our blood and kin have had to contend with too much instead of too little water, and make laws to regulate drainage instead of irrigation. Our sturdy forefathers drove their weaker neighbors down on the dry lands of France, Spain, and Italy, taking the well-watered portions for themselves. And when we come to apply their theories to this arid region they fail to work. Coming thus handicapped to the task, our water suits have been costly, tedious, and embarrassing. Contests, murder, oceans of perjury and other crimes have been but part of the evil results of the national mistake of applying old ideas to new conditions; but at last a start, at least, is promised and the work is being intelligently investigated by the only power that can handle it. You must be convinced that the task of reclaiming this vast region has gone as far as it can in this way and, indeed, as far as it should. A point has been reached where it becomes the duty of the national Government to take the matter in hand, and permit us to say, that since its formation it has had no higher or nobler opportunity. You are engaged upon the grandest work of this century; no political event of a hundred years equals in importance the making of homes for thrifty and intelligent millions over two-fifths of the United States. The time is coming when large classes of American citizens will be found asking, not where can I go and make money, but where can I go and eat? Where can I go and earn a living for my family? The answer will depend, we believe, very largely upon your conclusions, and upon your report and recommendations to the Senate. We await in breathless anxiety the result. If it be announced as the policy of our Government that no aid shall be extended to the struggling settlers who are giving their whole lives to the work of fitting these sage-brush deserts for homes for future generations; if the policy of the past few years is maintained, by which surveys are discontinued, leaving large tracts without township or section lines; if patents are withheld and the privileges of settlement hedged about with technical obstructions, then Nevada, at least, has a barren future and many people will have to go elsewhere for the means of life. But we do not believe such a policy can find favor in your enlightened minds. We believe the Anglo-Saxon needs no example from Mexico, Spain or Lombardy, but will find in itself the intelligence, virtue, and grit to conquer this land as it has every country where it has ever set its foot. We believe that no higher duty or more precious privilege has ever been assigned to a nation, and it is the grandest office a Government of the people, by the people, and for the people can ever have.

R. L. FULTON.
T. V. JULIEN.
JAMES MAYBERRY.
T. K. STEWART.
C. H. STODDARD.

RENO, NEV., *August* 19, 1889.

The **CHAIRMAN**. You may give an explanation of the map you present.

Mr. **FULTON**. We start with a part of Lake Tahoe, a part not being in our county. On the summit of the Sierra Nevadas the snow-fall is one of the largest known in the world. The Truckee leaves that point [indicating] and is 90 miles long. It runs into Pyramid Lake, and it falls gradually all the way from this point [indicating]. About 3 miles above Verdi a series of benches set in, and ditches have been begun at that point. We have ditches already constructed in our county covering 50,000 acres of land. There are in all about 25 ditches.

I would like to say in connection with these ditches that every one of them has been constructed by private enterprise, not one by capital for the sake of investment. A great many of them have been constructed by men with their rifles at their sides to keep off hostile Indians and they are as much entitled to respect as the Puritan fathers.

The land above these ditches [indicating] is the best land. That below them is the land that was washed in the river channel a great many years ago, and it has left the bowlders and everything like that to be removed before the land can be irrigated. But above these ditches, in this valley, you can hardly find a rock without it is on a little ridge.

The natural lakes, Weber, Independence, and Donner, have full water-sheds, extending right to the summit of the Sierras, and receive a steady flow from the snow banks which will raise them 18 or 20 feet a year. But the great resource of western Nevada is Lake Tahoe, which has 175 square miles of surface, and a total water-shed of 400 miles. capable of raising it 6 or 7 feet a year. The outlet is narrow and can be controlled by a cheap timber dam with wooden gates, the whole thing costing only a few hundred dollars. Such a dam is already in operation, holding back the spring floods. The mills at Truckee draw from it, and they only shut the gates when there is more water than is needed for their purpose. Last winter about 17 inches was saved, and the previous year more.

A very important class of reservoirs can be created by damming up the water in the hundreds of mountain meadows which are found in the Sierras. They are used as dairies now by people who drive up their cows from the Sacramento Valley in the spring and back in the fall. They are inhabited fully five months of the year, and the balance of the time are left to be filled with from 5 to 40 feet of snow. Materials for building dams are now on the ground, and the water-sheds are generally large enough to create good sized lakes from a few rods to a few miles in extent.

Another class of reservoirs could be created by conducting the water from its natural channel to places where, by building a wall on the lower side of a flat or cañon, tanks, as they are called in India, can be made.

They form a valuable supply to the acres of an immense population there, and in time will dot the map by thousands. The only limit to them will be the amount of money to be had.

Another class could be made by damming up the Truckee, Humboldt, Prosser, and other streams at favorable places, flooding flats behind. On all these streams are flats or beds of former lakes, which can be reserved and used for reservoirs. Some of them are inhabited and farmed and in some are found towns and villages, and it would be a matter for calculation as to whether such would be worth more for reservoirs than for present uses.

The CHAIRMAN. Leaving out Tahoe, suppose the water that comes from the other water-shed were equally well economized, how much land could be irrigated with it?

Mr. FULTON. I think with the water saved up we could irrigate all the land in our country, all the north side of the Truckee River.

The CHAIRMAN. About what percentage of the Truckee is now used?

Mr. FULTON. I do not think we use over 2 per cent. of the Truckee River.

The CHAIRMAN. Taking the flow for the year?

Mr. FULTON. Season after season, for the year round. I think the balance goes to waste.

The CHAIRMAN. Take Washoe, for an example. To what extent can the population be increased and the land reclaimed by small irrigation works?

Mr. FULTON. We have found very little help from any investment as an investment.

The CHAIRMAN. If the facts were made known by surveys, to what extent would the land be reclaimed? Is it in the reach of an ordinary association of farmers?

Mr. FULTON. If the Government stood in the position of Divine Providence, and could increase the flow in these ditches, the ditches would be built by private enterprise. I am not so certain about the reservoirs. If the reservoirs were built and the water turned into these natural streams, it would be a different proposition to build a ditch. But I am not prepared to answer what the disposition of our people would be toward saving the water.

The CHAIRMAN. Suppose settlers should come in here to make homes, how much of this work is within their reach without the aid of accumulated capital, the facts being known?

Mr. FULTON. We do not know to what extent they want to come.

The CHAIRMAN. Suppose they wanted to come very much?

Mr. FULTON. They could come and make homes, but I do not think they could make homes in much less than two or three years.

The CHAIRMAN. If intelligent settlers should come here with the intention of going to work, they could find fine opportunities for constructing reservoirs and storing water to reclaim land?

Mr. FULTON. Yes.

The CHAIRMAN. At what cost?

Mr. FULTON. About $10 an acre.

The CHAIRMAN. What would be the value of the land when reclaimed?

Mr. FULTON. Sixty dollars, I think. I think in Lehman's Valley there is good land, no better on the face of the earth. There they could go and build a ditch and make homes for a thousand persons.

STATEMENT OF B. F. RILEY, OF HUMBOLDT COUNTY.

The CHAIRMAN. What is your occupation?

Mr. RILEY. I am assessor of Humboldt County. I have no regular report. I have simply facts and figures. I will file this paper, and after having done that, I do not think it is necessary to make any further remarks.

Senator JONES. What is the paper which you wish to file?

Mr. RILEY. It is in regard to the storage of water, and the land to be cultivated.

Senator JONES. Is it your own individual expression of opinion on the subject, or is it prepared by some society or association?

Mr. RILEY. It is made by me as assessor of Humboldt County, of this State. I am appointed by the county to make this report.

Senator JONES. Then it is a paper of your own production?

Mr. RILEY. Yes.

The paper is as follows:

The principal valleys of Humboldt County, Nev., are Quinn River Valley, Paradise Valley, including Little Humboldt, Clover Valley, including Kelly Creek, and the Humboldt Valley, including the Big Meadows. Their area in square miles is as follows:

Quinn River Valley, 750 square miles.

Number of acres of land, 480,000.

Acres now in cultivation and irrigated, 15,000.

Number of acres uncultivated, 465,000.

Number of streams flowing into the valley, 8.

Volume of water flowing into the valley during the months of March, April, and May, 40,000 miners' inches.

Amount of water required per acre, 1 miners' inch.

Time required each year to irrigate land, 30 days.

Amount of water required to irrigate present amount in cultivation each year, 15,000 miners' inches.

Surplus water for thirty days each year, 25,000 miners' inches.

Amount of water running to waste each year for sixty days, 40,000 miners' inches.

Amount of land that could be brought into market and placed in cultivation by the storage of water, 65,000 acres.

Streams on which large amounts of water could be stored to great advantage: Quinn River and McDermit Creek; smaller amounts of water could also be stored on Eight Mile Creek, Flat Creek, Willow Creek, Rebel Creek, and Buffalo Creek, on Quinn River. Two dams 100 feet long and 25 feet high would back water over at least 200 acres of land; one dam on McDermit Creek, 40 feet high and 200 feet long, would back water over 300 acres of land.

The area of square miles of Paradise Valley and Little Humboldt is 400.

Number of acres of land, 256,000.

Amount of land in cultivation, 60,000 acres.

Amount of water flowing into valley during March, April, and May, 60,000 miners' inches.

Amount of water required to irrigate present amount of land in cultivation each year for thirty days, 60,000 miners' inches.

Amount of water running to waste for sixty days each year, 60,000 miners' inches.

Amount of land that could be brought into market and cultivation by the storage of water, 120,000 acres.

Streams on which water could be stored: Little Humboldt River, Martin Creek, and Cotton Wood Creek. On the Little Humboldt River a dam 50 feet high and 100 feet long would back water over 2,000 acres of land. A dam on Martin's Creek 100 feet long and 50 feet high would back water over 500 acres of land. Two or three small dams on Cotton Wood Creek would store large amounts of water. There are a number of other streams running into the valley where water could be stored.

The area of square miles in Clover Valley and Kelly Creek is 125, about 80,200 acres. There are in cultivation 8,000 acres.

There are three good-sized streams running into this valley on which water could be stored, which would bring into market and cultivation several thousand acres of productive land.

The area of the Humboldt Valley, including the Big Meadows, is 400 square miles, or 256,000 acres.

There are in cultivation in this valley 50,000 acres.

There are in the Big Meadow Valley alone 227,000 acres, of which there are in cultivation and irrigated 20,000 acres, leaving a balance of uncultivated land in this section of the valley of 207,000 acres, which could by the storage of water be brought into market and cultivation. The Humboldt River flows through the whole length of this valley with a flow of 144,000 inches of water during the months of April, May, and June, and, as this water is not used for irrigating purposes before the middle of April, large amounts could be stored for irrigating purposes later in the season. There should be at least three reservoirs built on the river between Oreana and Humboldt stations. These dams or reservoirs should be from 6 to 8 miles apart. There are points on the river that dams from 200 to 300 feet would span the river, and dams 25 feet high would back the water in the river 6 or 8 miles, and would cover at least 3,000 acres of land, and would hold sufficient water to irrigate at least 150,000 acres of land, which would produce 60 bushels of wheat or barley to the acre, or 6 tons of hay per acre each year.

There are many other small valleys in the county where water could be stored to great advantage and good agricultural land reclaimed and brought into cultivation and good crops produced.

STATEMENT OF R. G. WHEELER, OF PARADISE VALLEY.

The CHAIRMAN. What have you in your hand?

Mr. WHEELER. This is a paper prepared at a meeting of the people of Paradise Valley.

It is as follows:

PARADISE VALLEY, NEV., *August* 10, 1889.

In pursuance of the request of Surveyor-General Jones for representatives from the different committees to meet with the Senate Committee on Irrigation at Carson, and in accordance with the resolution of the county commissioners of Humboldt County, the people of Paradise Valley, Humboldt County, in mass-meeting assembled, unanimously passed the following resolutions:

Resolved, That we earnestly request the aid of the General Government to build reservoirs for the storage of waters passing in large quantities through the creeks and streams of Paradise Valley in the early part of the season, which if stored would be sufficient to reclaim thousands of acres of productive soil now utterly useless.

Resolved, That in the opinion of this meeting if the natural facilities for the storage of water in this valley were taken advantage of the population instead of decreasing would be greatly increased and more prosperous.

Resolved, That if the waters of the Owyhee River were diverted so as to empty into Dry Cañon, from whence they would pass into the Little Humboldt River, it would result in the reclaiming of many thousand acres of land in the lower end of Paradise Valley.

Resolved, That R. G. Wheeler be appointed to represent the interests of our people before the Senate Committee on Irrigation at Carson, Nebr., August 15, 1889.

P. M. PALMER,
President of Meeting.
R. G. WHEELER,
Secretary.

STATEMENT OF JOHN O'KANE, OF BIG MEADOWS.

The CHAIRMAN. Have you a written report?

Mr. O'KANE. No; I have not a report, but a petition. This is a petition from the citizens of Big Meadows, in Humboldt County. It was handed to me to present to the committee.

Senator JONES. Can you state the contents of the petition?

Mr. O'KANE. I have not read it; but it sets forth the condition of the people of that section at the present time. The country there is very dry, and the people of that locality are suffering a great deal from the drought.

The petition is as follows:

LOVELOCK'S, *August* 1, 1889.

To the honorable the Senate Committee on Irrigation and Water Storage:

SIRS: Your petitioners would respectfully represent that—

Whereas in the year 1875 in this section of Humboldt County, namely, Big Meadows, there was practically no acreage of land under irrigation or cultivation; and

Whereas there are now cultivated by the use of natural waters in irrigation about 9,500 acres; and

Whereas there still remains a large area, that is about 250,000 acres, which with proper use of the surplus waters of the Humboldt River could be profitably tilled and produce a great variety of crops; and

Whereas there annually runs to waste within said county a very large quantity of water and enough to irrigate the whole of said 250,000 acres and more; and

Whereas there are along and adjacent to the natural streams within this section eligible sites for reservoirs and other means of water storage; and

Whereas we earnestly believe that a fair inspection of this section would show that it offers prime reasons for investment of private or public funds for such works: Now therefore,

We, the undersigned, do respectfully request and urge that your honorable committee do submit said county and this section either to inspection personal or through your representatives, as we believe the same will result in the discovery of great natural resources, and the building up of permanent and prosperous communities within the county of Humboldt.

The meeting at which these resolutions and requests were authorized will cause to be made all suitable preparations upon notice for your courteous reception and the lightening of your labors in all possible ways.

Your petitioners conclude by praying for your early and favorable response hereto.

W. C. Ruddell, chairman; H. C. Marker, John Harrison, D. S. Baker, F. X. Banks, D. D. Grannis, J. C. Damm, C. Bastian, S. B. Smart, P. N. Marker, L. F. Herrod, J. Rouge, S. Billups, George Keating, Ed. M. Emmons, R. Akers, Robt. Reed, Geo. McKenzie, Navore Walle, Lewis Rees, G. W. Ladd, N. Nelson, J. Damm, W. F. Randolph, S. R. Young, Peter Anker, Jos. Marzen, A. Westfall, John Hill, M. Metcalf, Geo. Lovelock, sr., N. P. Dann, L. L. Downs, John Clary, L. G. Metcalf, P. A. Ostrander, John Ryan, W. P. Smith, A. Olson, John O'Kane, P. K. Reid, H. F. Martin, Paul Reid, L. N. Carpenter, L. M. Donelin, Joseph Hill, Antone Feliz, B. F. Grosser, Geo. Young, J. H. Thies, J. T. Hauskins, Eugene Cozzens, G. W. Tavener, Emmet Reid, J. T. Reid, Geo. Singer, A. Hull, J. C. Bestbright, H. J. Bender, T. P. Esberg, D. L. Davies, Phill. Skewes, J. Barker, Jesse G. Welch.

The CHAIRMAN. You are a farmer in Humboldt County?

Mr. O'KANE. Yes; I have been farming there for twenty years.

The CHAIRMAN. What is the character of the crops you raise?

Mr. O'KANE. The character of the crops is chiefly, barley, wheat, potatoes, and alfalfa.

The CHAIRMAN. Is the land suitable for all kinds of crops?

Mr. O'KANE. It is suitable for all kinds of crops that can be raised in the northern or central States.

The CHAIRMAN. Do you raise fruits?

Mr. O'KANE. We do not raise much fruit. It is only within the last few years that we have planted fruit-trees; but the trees are doing well, though they are not old enough to bear fruit; they are experimental thus far.

The CHAIRMAN. What kind of crop of alfalfa do you raise?

Mr. O'KANE. Six tons a season; but much more has been raised.

The CHAIRMAN. What would be a good crop of potatoes?

Mr. O'KANE. We raise from 250 to 300 bushels to the acre. The soil is particularly adapted to the raising of potatoes.

The CHAIRMAN. How about beets?

Mr. O'KANE. We have very few beets; I have seen beets grow there, though, sugar-beets. I have seen them grow there so large that they would weigh 12 pounds each.

The CHAIRMAN. What is a crop of wheat in your section?

Mr. O'KANE. We can produce from 45 to 50 bushels to the acre; on an average.

The CHAIRMAN. And how with regard to barley?

Mr. O'KANE. I have seen wheat produced 100 bushels to the acre; of barley we raise 50 bushels to the acre.

The CHAIRMAN. How about oats?

Mr. O'KANE. Eighty to 90 bushels.

The CHAIRMAN. But you have a deficiency of water there now?

Mr. O'KANE. Yes; we are drier this year than ever before.

The CHAIRMAN. In the Humboldt River in good seasons, what volume of water comes down? Have you paid attention to that?

Mr. O'KANE. I can not state the number of inches in ordinary years in the Humboldt; but I could give you a very good idea of what it is. The Humboldt River, where it enters Big Meadows, is about 100 feet wide, and in seasons when it is flowing an ordinary flow it will be from 12 to 15 feet deep. I think it will flow about 3 miles per hour. That is the current for flood season.

Senator JONES. I would like to ask about that wheat of which you spoke. Is it grown on irrigated land?

Mr. O'KANE. On irrigated land. The soil will not produce anything without irrigation.

Senator JONES. Was it ever tried on that land?

Mr. O'KANE. It may have been tried, but I do not think it produced anything without irrigation. They sow the wheat in the spring, and it comes up with a natural moisture, and then in May they irrigate once. That insures an excellent crop. The soil retains the moisture. It is a spongy soil, and it is easily moistened. It holds the moisture a long time.

Senator JONES. Without irrigation you can produce nothing?

Mr. O'KANE. Nothing at all. There has been plenty of water in former years flowing there to irrigate all the land we have in that valley.

The CHAIRMAN. You mean in the river bottom?

Mr. O'KANE. Yes; just at the head of the sink and around the sink.

STATEMENT OF J. H. THIES, OF LOVELOCK'S.

The CHAIRMAN. You are a farmer at Lovelock's?

Mr. THIES. Yes.

The CHAIRMAN. How long have you been there?

Mr. THIES. Eighteen years.

The CHAIRMAN. You heard what was stated by the gentleman who preceded you. Is that substantially your idea of the production of crops in this country.

Mr. THIES. Yes; there has been more raised than that, but what was stated is about the average.

The CHAIRMAN. How much land have you under cultivation?

Mr THIES. I have about 700 acres at Lovelock's at the present time. At Lovelock's there are about 10,000 acres under cultivation.

The CHAIRMAN. What do you say about the volume of the water running in the Humboldt in good seasons, at flood times?

Mr. THIES. What Mr. O'Kane said is true. It is about 100 feet wide and about 10 or 12 feet deep.

The CHAIRMAN. If the water were drawn out in flood times for the purpose of irrigating your 10,000 acres of land, would it have any perceptible effect upon the river?

Mr. **Thies**. No. In 1879 that lake went dry, as it is now.

Senator **Reagan**. What lake is that?

Mr. **Thies**. Humboldt Lake. In 1882, after irrigating all the land there under cultivation, it was higher than ever before. So that shows there is an enormous amount of water that has gone to waste every spring except this spring.

The **Chairman**. From your observation can you state to what extent Humboldt Valley could be reclaimed, if the water above were stored in proper reservoirs and economized? Take the whole valley of 200,000 acres of rich loam.

Mr. **Thies**. Yes, and there are only about 10,000 under irrigation. We have about 500 population there now. With proper management of the water, I could not say to what extent.

The **Chairman**. Give your observation.

Mr. **Thies**. It certainly would be a large percentage of increase. It would afford homes for quite a number of persons.

STATEMENT OF A. W. HESSON, OF ELKO COUNTY.

The **Chairman**. Have you a report?

Mr. **Hesson**. I have no report to present. I was not prepared to meet this committee. I was informally requested to come here.

The **Chairman**. You have assessed the county repeatedly, and are familiar with it?

Mr. **Hesson**. Yes.

The **Chairman**. Give a short description of the county and the land under cultivation, and state what are the chances for the cultivation of more land, if any?

Mr. **Hesson**. We have at present in Elko County some 60,000 acres, or thereabouts, under cultivation; that is in various crops. That, by the storage of water, could be increased four or five times with a small outlay of money in different places.

Senator **Jones**. In your judgment, if the water were saved to its utmost capacity, how much land could you have under cultivation?

Mr. **Hesson**. It is safe to say that we could have from 250,000 to 300,000 acres.

Senator **Jones**. Then you mean four times as much?

Mr. **Hesson**. Yes; four times.

The **Chairman**. Describe Squaw Valley.

Mr. **Hesson**. In Squaw Valley we have storage, but I am not prepared to say the number of acres the dam covers, but it holds sufficient water to irrigate 2,000 acres—something in that neighborhood, and it can be increased so that it will irrigate 4,000 acres. That is working successfully at the present time.

The **Chairman**. Describe the streams that are tributary to it.

Mr. **Hesson**. The principal one is what is called Willow Creek, a mountain branch of water, and water is stored at its head.

The **Chairman**. How much water would there be in it at the irrigating season if there were no dam there?

Mr. **Hesson**. I do not think there would be any land irrigated at that point.

The **Chairman**. It is entirely artificial?

Mr. **Hesson**. Yes; there was no land tilled in that vicinity until this dam was built.

The **Chairman**. Could the water have been taken out or the land tilled without the dam?

Mr. HESSON. No. The water went off in the flood season, in the spring of the year.

The CHAIRMAN. Are there abundant or quite extensive opportunities for similar dams in Elko County?

Mr. HESSON. Yes; there are quite a number of places where similar dams could be built, and larger ones. The reservoirs are greater than at this place, particularly on the North Fork of the Humboldt, and also on the South Fork.

The CHAIRMAN. What are the products they raise by this dam in Squaw Valley?

Mr. HESSON. They have been principally of alfalfa. They have raised wheat and barley.

The CHAIRMAN. Whatever they have tried to raise they have been successful in?

Mr. HESSON. Yes; they have been successful in raising grain.

The CHAIRMAN. What is the average crop in Elko County?

Mr. HESSON. In this particular place it has been an average of 45 bushels of wheat to the acre.

The CHAIRMAN. And other cereals in the same ratio?

Mr. HESSON. The oats would go away up into the sixties. That would be an average, though they go higher than that.

The CHAIRMAN. How much alfalfa?

Mr. HESSON. Five tons.

The CHAIRMAN. What are the principal localities? Are there any?

Mr. HESSON. Ruby Valley is an extensive farming country. They raise wheat and barley principally in that valley. That is not quite as productive as this other valley. It is colder, and the crops are not so certain. Clover Valley is right across the mountain from Ruby, immediately east from the first-named valley.

Senator JONES. What was the cost of that dam in Squaw Valley?

Mr. HESSON. What I have been informed is that it was in the neighborhood of $100,000—something less than that, but in that neighborhood.

The CHAIRMAN. Then water is carried from that main ditch to the land that is irrigated?

Mr. HESSON. Yes.

The CHAIRMAN. Have you any idea of the cost of that ditch?

Mr. HESSON. No; I have not, of the first named ditch. It is a ditch some 10 miles in length, and about an average depth of 2 or 3 feet.

The CHAIRMAN. You have some idea of its approximate cost.

Mr. HESSON. The approximate cost of that dam is in the neighborhood of $8,000.

The CHAIRMAN. The dam, as at present constructed, will retain water enough, you think, to water 4,000 acres, or would there have to be additional work done to reclaim 4,000 acres?

Mr. HESSON. I think the dam will hold sufficient water to irrigate 4,000 acres. It has been enlarged. That was done a year ago, and since the enlargement there has not been water enough to fill the dam.

The CHAIRMAN. You think that 4,000 acres is the capacity of the present works?

Mr. HESSON. Yes.

The CHAIRMAN. And since the enlargement there has not been water enough to fill the dam?

Mr. HESSON. No; not since it was completed? It was raised 15 feet.

The CHAIRMAN. Then there is a cost of $20 for every acre under it to be cultivated?

Mr. HESSON. Yes.

The **Chairman**. Is that the average cost of the storage works which you think might be inaugurated through that country? Will they all be as costly per acre as that?

Mr. **Hesson**. No, I think not. I think dams can be constructed for much less per acre than that has cost. This was an experiment. The first dam that was built on this side was washed out. The parties were inexperienced.

The **Chairman**. Do you include in that $100,000 the cost of the washed-out dam?

Mr. **Hesson**. Yes.

The **Chairman**. What do you suppose the present dam cost?

Mr. **Hesson**. I do not think the present dam has cost over half that, outside of the ditch.

The **Chairman**. Have you any information in regard to the cost, except what you have heard on the outside?

Mr. **Hesson**. No, I have no reliable data on this matter.

Senator **Jones**. You think other land could be reclaimed at less expense? If your estimate of the cost of the present dam is correct, that would make a cost per acre to the land that could possibly be reclaimed by this ditch $12.50. Do you think there are other lands in the county that could be more cheaply reclaimed than at a cost of $12.50 per acre?

Mr. **Hesson**. Yes, so far as the water storage is concerned.

Senator **Jones**. What is your idea of the average cost of storage per acre under the eligible locations for dams in your county?

Mr. **Hesson**. I do not think the average cost would be less than that. In certain localities it would be less, and in others it might be greater.

STATEMENT OF CHARLES W. IRISH.

The **Chairman**. Are you familiar with Squaw Valley dam and its cost?

Mr. **Irish**. Yes; I visited it last week.

The **Chairman**. State the facts in regard to it.

Mr. **Irish**. In regard to the cost of the dam it was in round figures $40,000. So I was informed by the person who constructed it.

The **Chairman**. That is the first dam?

Mr. **Irish**. No; the present dam.

The **Chairman**. What was it about the one that was washed out?

Mr. **Irish**. I do not know anything about that.

The **Chairman**. How much land is irrigated?

Mr. **Irish**. They have the greater part of three sections under cultivation from the water stored by that dam.

The **Chairman**. If the dam were filled with water, how much land would it cover?

Mr. **Irish**. It would furnish water enough for the irrigation of six sections of land throughout the crop season. That is its calculated capacity.

The **Chairman**. That dam never has been filled since it was raised?

Mr. **Irish**. No; except once just after the spring season. Then it was filled. It was completed only last year, and this dry season has prevented it being kept full of water this year.

The **Chairman**. How much water shed is tributary to that dam?

Mr. **Irish**. I think somewhere between 14 and 20 square miles. I am not quite certain about that.

The **CHAIRMAN**. What is the effect of irrigation upon land, what is the quantity of water required, the most water, and can the amount of water necessary to irrigate the land be reduced as time progresses?

Mr. **IRISH**. It requires most water to produce the second crop of hay.

The **CHAIRMAN**. Which year can you do the most with the same quantity of water, the first or second year?

Mr. **IRISH**. I think the first year's crop of well-cultivated land would be the largest.

The **CHAIRMAN**. As to the quantity of land. At what time do you reach the maximum of the amount to be irrigated?

Mr. **IRISH**. That depends altogether on the quality of the subsoil. I think the effect of irrigation is to improve the porous soils. Where the subsoil is porous it requires the most water the first few seasons of croppage. But I notice that as the seasons pass on and the water is brought on to the land it closes up the porous soil and causes it the better to retain the water. But the clay subsoil will remain the same from year to year. That depends altogether on the porosity of the subsoil.

The **CHAIRMAN**. Have you traveled over the State?

Mr. **IRISH**. I have traveled generally over the State.

The **CHAIRMAN**. What is the general condition of the southern portion of the State, as to arable lands, valleys, and water?

Mr. **IRISH**. The general condition as to tillable lands, I would state in plain English, is a condition of neglect.

Senator **JONES**. Do you mean the lands under cultivation?

Mr. **IRISH**. I mean to say that they are neglected.

Senator **JONES**. You mean the lands under cultivation have not been properly cultivated?

Mr. **IRISH**. Not in all cases.

The **CHAIRMAN**. What are the opportunities there?

Mr. **IRISH**. The opportunities are wide. I think there are more tillable lands to the townships toward the southern part of the State than in the northern parts. There is a greater spread of tillable land in the southern half of the State.

The **CHAIRMAN**. Have you ever been over Lincoln County?

Mr. **IRISH**. You might say I have been over half of Lincoln County.

The **CHAIRMAN**. Extending your observations there, what do you say of Lincoln County?

Mr. **IRISH**. I think Lincoln County is the best county in the State, so far as agriculture is concerned. It has a greater range of products than any other part of the State. In Lincoln County can be raised any of the crops that can be raised in the Gulf States. They can raise corn, cotton, and sugar cane.

The **CHAIRMAN**. You have the land and the water there to do it?

Mr. **IRISH**. We have the land and the water. We have large quantities of both; it simply requires some system to bring the water on to the land to produce the crops.

The **CHAIRMAN**. What would you say of Lincoln County, if a population of settlers should desire to occupy it? Are the opportunities there within the means of an ordinary association of settlers?

Mr. **IRISH**. I think they are.

The **CHAIRMAN**. What opportunities are there in that section of the State for settlers to come in and make homes at a reasonable cost, if they knew the facts?

Mr. **IRISH**. Settlers in Lincoln County could more readily bring land under cultivation than in any other portion of the State. The opportunities there are greater to that end, and at a less expense.

The CHAIRMAN. If surveys were made by the United States and the facts were shown, would it be possible for emigrants to avail themselves of the information thus obtained and make homes in that section of the State?

Mr. IRISH. Oh, yes.

The CHAIRMAN. To what extent?

Mr. IRISH. I think that there are not less than 60,000 acres of land in the portion that I have in mind that could be brought under improvement by a system of storage reservoirs for supplying the water for the purpose.

The CHAIRMAN. At what expense per acre? Did you figure on that?

Mr. IRISH. No; I have not figured on it particularly. But the cost of supplying water there would be less than in this part of the country, for the reason that it would not have to be carried so far. The necessity for long ditches would not exist there.

The CHAIRMAN. Are there high mountains in that section and sufficient snow-fall?

Mr. IRISH. There are high mountains; but the snow-fall is not so good as in this part of the country. All the rain and snow-fall there occurs in the winter season, the temperature going down to 20 degrees below zero. We consider that winter is the time for planting crops. There is no frost there to interfere.

The CHAIRMAN. You can start your crops then?

Mr. IRISH. The time they do plant their crops is in midwinter.

Senator REAGAN. Are the seasons long enough for cotton and sugar to mature?

Mr. IRISH. They have raised cotton there. I am satisfied that cotton was raised there for centuries previous to this time. I have seen bunches of cotton taken out of the burial places of the ancient inhabitants of that country. The burial places are the only traces left of them. I have cotton taken out of the crevices of the rocks.

Senator REAGAN. Is the season long enough for the sugar cane to mature?

Mr. IRISH. Yes, they have successfully planted and matured sugar cane there.

Senator JONES. Was this cotton of which you speak the seed or picked cotton?

Mr. IRISH. It was nice clean cotton. The manner in which they stowed away the remains of the dead was putting the bones in an earthen jar and then packing cotton all around them, and that cotton came out fresh, clean, and white. I think in a week I could bring you a specimen of the cotton.

The CHAIRMAN. I wish you would furnish the committee a specimen of the cotton you find. Are there other evidences that this country was inhabited by people who had some civilization?

Mr. IRISH. Yes; these people, whoever they might have been, lived in aggregated colonies. Wherever they could procure the water they irrigated the lands, as the lands will have to be irrigated now if they are to be successfully cultivated. Those people left the marks of their irrigation works on the soil.

Senator JONES. Are the marks of those works there now?

Mr. IRISH. Yes; they had a system of storing water, not as we would, by going into the mountains and building a dam, but they brought water down in canals, in a bowl shape right to the plain, and there used it.

Senator Jones. Are any of those canals there now?

Mr. Irish. I have seen two of them.

Senator Jones. What is the largest one?

Mr. Irish. About 500 feet across, and the small one 350 feet.

Senator Jones. How were they constructed?

Mr. Irish. They were built by taking round bowlders, rocks, larger than a man could handle with his hands, and placing them in the wall, well defined, with a nice curve on the inside, and the wall cemented by an adobe clay; and the wall was water-tight.

Senator Jones. Were they covered in any way?

Mr. Irish. No, I do not think they were. They were open reservoirs.

Senator Jones. You agree with the gentleman who made a statement just before you that the cost of storing water in Squaw Valley would be about $12.50 an acre.

Mr. Irish. I think that the work which they have done there might be considered the maximum of the work in this State. I will tell you why. The dam which furnishes the water is built low down on the slope, and the consequence is the canal bringing the water down to the ground, where it is used, runs on a very small grade, and for that reason the ditch carrying the water has to be made of a large size, larger than anywhere in the State. In order to carry the requisite quantity of water the canals must be made larger.

Senator Jones. That relates to the canals, not to the reservoirs.

Mr. Irish. Yes.

Senator Jones. You agree with the gentleman who preceded you that the cost is $12.50 per acre.

Mr. Irish. Yes, that would be about the cost. That reservoir will, I am satisfied, do as estimated by the contractor; that is to say, I believe that the reservoir will irrigate about five sections of land when in complete use.

Senator Jones. That would be a little over $12.50 an acre, 3,000 acres and the cost of the dam $40,000. The gentleman who preceded you stated that that was his impression. It seems you agree about it. He said the cost of the ditch to take the water from the reservoir to the land would be about $8,000. That would be an additional cost of between $2 and $3 an acre. Do you think that is reasonable?

Mr. Irish. That is about right.

Senator Jones. What is the land worth—a fair market value for it now?

Mr. Irish. That is worth to-day $150 an acre—a fair market value for it.

Senator Jones. Do you think it would sell for that?

Mr. Irish. Yes.

Senator Jones. It would cost $15 an acre to put water on it, and it would sell for $150 an acre?

Mr. Irish. Yes.

The Chairman. What would make it $150 an acre?

Mr. Irish. Its productive quality.

Senator Jones. Is that land off from the railroads?

Mr. Irish. Yes.

Senator Jones. Is not that a fanciful price for the land?

Mr. Irish. No.

The Chairman. Explain how it would be worth that much.

Mr. Irish. The land will produce in a fair average season six and eight tons of alfalfa hay to the acre. That is worth in that region $15 per ton.

The CHAIRMAN. To feed stock?

Mr. IRISH. Yes.

The CHAIRMAN. How does it happen to be worth that?

Mr. IRISH. Its feed value makes it worth that? Alfalfa hay is as rich a feed as corn is in the Mississippi valley. It answers all the purposes of corn. It is not simply hay; it is a fat-producing food. Gentlemen who have had experience in feeding alfalfa hay to stock and animals say that it will fatten as well as corn.

The CHAIRMAN. And being surrounded by a region of country where there is abundance of summer food it helps to keep your stock. Is that the idea?

Mr. IRISH. Yes. I will describe the locality, and you can draw your own conclusion:

The Squaw Valley is surrounded by a range of mountains, varying in form, and the outlet of the waters from that valley is a narrow cañon on the south side, which was cut within recent years. That drains the valley and makes it dry land. The mountainous land surrounding that valley is rich and produces feed for summer stock. The people can put their stock on the mountains and fatten them in the summer, and in the winter they can feed them at the stalls with this alfalfa hay produced in the summer season. That makes its value; and I am satisfied to say that it is worth $150 an acre.

Senator JONES. Alfalfa hay is worth more there than it is here?

Mr. IRISH. Yes. It sold last year all over the country at $20 a ton.

Senator JONES. Is that the demand for it?

Mr. IRISH. Yes.

Senator JONES. Is the demand unlimited there?

Mr. IRISH. Yes. It is unlimited all over this country.

The CHAIRMAN. I think I know that there is an unlimited amount of feed in summer for the cattle, and that it costs very little to raise cattle in summer if you can feed and take care of them in winter. Would the statement that you have made with regard to the particular land you have in mind be true of all the land that could be brought under cultivation through that portion of the State?

Mr. IRISH. It would be true for that portion and all portions of the State. It will be a long time before the farmers of the country will catch up with the demand for feed.

The CHAIRMAN. I wish to ask you this question: What opportunities are there in this State for settlers, if they knew the facts, to go and make homes by such combination as they can make among themselves without accumulated capital?

Mr. IRISH. The opportunities are very good. If I had the time I could take a map and point out a great many localities in this State where aggregated settlements of thousands could be made, and every acre of land obtained and brought under cultivation could be made to produce as I have described; and being made to produce, would be equally valuable per acre with the land of which I have been speaking.

The CHAIRMAN. Of what value would surveys be in pointing out these places where water could be stored, and what amount of land could be irrigated if they were mapped and pointed out?

Mr. IRISH. It would be of the greatest value, because the people residing outside of the country generally look upon it as a barren waste, whereas it is not a barren waste. The only way in which they can be reached is by something official, which would be considered reliable.

The CHAIRMAN. In your official capacity you have traveled extensively over the State, and have given particular attention to this subject?

Mr. **Irish**. Yes.

The **Chairman**. Have you made any report calling attention to these matters that would be useful?

Mr. **Irish**. I have. I have made two reports to the Commissioner of the General Land Office in regard to these matters, and in the reports have given reliable information gathered from reliable persons, men who are thoroughly located and have been located for a number of years in various portions of the State. I gathered from them the results of their labors.

The **Chairman**. Have those reports been printed?

Mr. **Irish**. I have just sent one off to Washington.

The **Chairman**. Could you, for the use of the committee, furnish another report?

Mr. **Irish**. That is my intention. I have one partly prepared. Official duties prevented me getting it completed for this occasion.

The **Chairman**. We want in that report attention directed to the opportunities of settlers, not for capitalists, with a general idea of how many dollars per acre it would take, showing the chances for market, etc. And you might have it accompanied by a map with a short explanation.

Mr. **Irish**. I intended to make it embrace something about the amount of water that could be stored every season, with the average amount of evaporation, so that some estimate could be made of the amount of land that could be irrigated.

STATEMENT OF TRENMORE COFFIN, OF ORMSBY COUNTY.

Mr. Chairman and gentlemen, I have no detailed report for the reason that I thought you would have a sufficient amount of detail. I have been appointed by the county commissioners of this county to appear before you, and all I wish to say is a word about what the people want. I have talked with the people of this State, and they wish information as to how they shall improve the opportunities which they have.

It is a well known fact that there are many millions of acres of land in this State that need irrigation, and that a great deal of water goes to waste. But how to get the land and water together the people do not understand.

I am engaged with some of my neighbors and friends in constructing an irrigating canal, but the difficulty we find in our way is the absence of practical knowledge of how irrigating canals can be built, where reservoirs can be established, and what precautions are necessary to be taken to prevent disaster in times of flood. If the people had more information that is definite and reliable to depend on a great deal more could be done.

Senator **Reagan**. We are not engineers, and can not give you information on that head. We are seeking information.

Mr. **Coffin**. If the Government could say how and where reservoirs could be built, that information would be valuable. It is considered by all parties that 90 per cent. of the water of this State goes to waste, and from an agricultural stand-point the value is in the water. There is no question about the land and the water, but the safe means of getting the two together is what we need information about.

Senator **Jones**. Then if the Government were to examine the country and point out the reservoir sites, with other information of that sort, you think it would about solve the difficulty with which you have to deal?

Mr. COFFIN. It would solve the beginning of it. I think in this State the limit is reached where an individual, a poor man, can go out and find a home, as in Illinois, Indiana, and Ohio—where he can go individually and alone and take out water to irrigate his land. But there are thousands of places where a small colony could go together, and by a combination of their forces and means construct a canal and make homes for themselves. But it is beyond the reach of the individual, of the poor men. If the information were given showing where a colony could go and expend their means in this way, a great deal of land could be brought into use which is now going to waste. It is no use now to the Government, to the State, or to individuals.

The committee took a recess until 3 o'clock.

The committee re-assembled at 3 o'clock p. m.

STATEMENT OF WILLIAM THOMPSON, OF RENO.

The CHAIRMAN. What can you tell us in regard to irrigation in Nevada?

Mr. THOMPSON. I wish first to present the report of the special committee appointed by the State Board of Trade of California, which was prepared for your committee, and which is quite extensive, and which gives a very interesting account of irrigation on this coast.

[The report will be found in the record of the committee's proceedings in California.]

The CHAIRMAN. That relates to California mostly, I suppose?

Mr. THOMPSON. Principally to California, but it also relates to Nevada. It shows the amount of land that can be reclaimed, and gives a very full and complete account of the lands, the climate, and so forth. I wish to present it to you because it interests this part of our State very much.

The CHAIRMAN. Have you been interested in the subject of irrigation?

Mr. THOMPSON. I have been interested in the subject of irrigation in this State for about thirty years. I have owned land in this section of the country for that period of time.

The CHAIRMAN. What success have you had with land when you have employed water for irrigation?

Mr. THOMPSON. The finest kind of success. I never made a failure of a crop where I had water, nor did my neighbors ever make a failure of a crop where they had water.

The CHAIRMAN. What is an average crop of wheat in this State, where you have water to irrigate it?

Mr. THOMPSON. About 20 bushels, but it is sometimes as low as 10 or 15; sometimes it will go as high as 30, 40, or 50 bushels to the acre, depending on the soil and locality. The average might be called 20 bushels to the acre. It will average more than California.

The CHAIRMAN. Will not irrigated land average more than 20 bushels?

Mr. THOMPSON. In certain localities, certainly it will. But the average will not go, I think, over 20 bushels. We do not raise a very extensive crop of wheat in this section. In some sections it is good and some not very good. In some parts they raise 15 bushels, and in other parts 40 and 50 bushels to the acre. But I think from 20 to 25 bushels would be a very fair average. The wheat is of the very best quality.

We got the first premium in the United States for the best wheat produced in the country.

The **CHAIRMAN**. How much barley?

Mr. **THOMPSON**. Our people have in a great measure quit raising barley, on account of the teaming interest having been all done away with. They raised fair crops of barley—more than of wheat. It will do with less water.

The **CHAIRMAN**. How is it as to the crop of potatoes?

Mr. **THOMPSON**. The finest potatoes that are raised on the coast are raised in Nevada.

The **CHAIRMAN**. How much do they yield?

Mr. **THOMPSON**. From 5 to 10 tons to the acre.

The **CHAIRMAN**. How many bushels?

Mr. **THOMPSON**. I can not estimate it by bushels; we estimate such things here by tons.

The **CHAIRMAN**. Have you attempted to ascertain the amount of land that could be reclaimed in Washoe County if water could be had?

Mr. **THOMPSON**. Yes.

The **CHAIRMAN**. How much is there that can be reclaimed?

Mr. **THOMPSON**. In one valley north of Reno, in that section of country, there is probably 50,000 acres that could be reclaimed. That amount could be increased to a considerable extent—it could be continued up to probably 100,000 acres on the north side of the river.

The **CHAIRMAN**. What is land worth about Reno, that is, land under cultivation?

Mr. **THOMPSON**. It averages about $100 an acre.

The **CHAIRMAN**. Does it pay interest on that amount?

Mr. **THOMPSON**. Yes; it pays 10 per cent. on that amount, by good management. I wish to say that we are all deeply interested in the question of irrigation, but we have met with this difficulty: All the sources of water supply are in the State of California, and when you come to investigate it you will find they are owned by private parties.

The **CHAIRMAN**. How are they owned?

Mr. **THOMPSON**. Parties have Government titles and patents, and they claim to own the land. It is therefore difficult to do anything with it.

The **CHAIRMAN**. Has anybody a Government patent to Lake Tahoe?

Mr. **THOMPSON**. They have a patent for the outlet.

The **CHAIRMAN**. At any rate not more than one-third or one-half of your water-shed comes from Tahoe.

Mr. **THOMPSON**. But the other lakes are in the same fix.

The **CHAIRMAN**. I do not think the lakes belong to individuals. The Government owns the lakes.

Mr. **THOMPSON**. But the Government does not intend to build reservoirs.

The **CHAIRMAN**. The Government owns the lakes and is going to reserve them for the people. The Government has not sold the lakes, and nobody can get any title to the lakes. The Government has already reserved the right of way to construct ditches, and if any man has got in the way of the right of way, we will have to condemn the right.

Mr. **THOMPSON**. Our people would willingly raise funds to construct reservoirs and ditches if we could get rid of the difficulty I spoke of.

The **CHAIRMAN**. There is no difficulty. There is no necessity for considering Lake Tahoe indispensable; you have plenty of water without it. I believe you have many times as much water as you now use, without Lake Tahoe.

Mr. THOMPSON. A great deal of water undoubtedly goes to waste from the Truckee.

The CHAIRMAN. At least three-fourths of that comes from sources other than Lake Tahoe.

STATEMENT OF GEORGE NICHOLL, OF BELMONT.

The CHAIRMAN. How long have you resided in Nye County?

Mr. NICHOLL. Since 1871.

The CHAIRMAN. What is your occupation?

Mr. NICHOLL. I am a prospector, assayer, millman, and miner.

The CHAIRMAN. Have you given any attention to irrigation?

Mr. NICHOLL. Considerable.

The CHAIRMAN. Have you any report from Nye County on that subject?

Mr. NICHOLL. I have a short report.

The CHAIRMAN. Who made it?

Mr. NICHOLL. I did.

The CHAIRMAN. What does it relate to?

Mr. NICHOLL. It relates to the arid lands of Nevada and the means of supplying water for irrigation.

The CHAIRMAN. Are all your views contained in that report?

Mr. NICHOLL. Not all.

To the honorable Senate Committee on Irrigation:

By resolution of the board of county commissioners of Nye County, a certified copy of which is herewith presented, the undersigned was appointed to collect such facts and data in relation to the water supply and make suggestions as to how it might be increased; also to make an approximation of the amount of arid land which could be rendered suitable for agricultural purposes within Nye County, and report the result to your honorable committee.

In performing the duties expected of me I will endeavor to be as brief as possible, being well aware of the additional labor imposed upon your honorable committee and the brief space of time allotted you for the purpose of investigating this important subject.

No other question of the day is attracting so much attention in our county as the water question. The long-continued drought, extending back for several seasons, has rendered it necessary that some action should be taken, both for the agricultural and stock interests, each of which is suffering and feels the need of an additional supply of water at the present time.

It is universally acknowledged to be a wise step taken by the Government in making appropriations for the purpose of reclaiming the arid lands in these western States and Territories—a step which may, and no doubt will, repay it many hundred fold in the near future by opening up to settlement tracts of rich lands now practically uninhabitable for want of the knowledge and means of utilizing the waters annually running to waste. It shows the wise forethought of this great Government in providing for the future of its people by making it possible for them to acquire cheap homes in a fertile and healthy climate, where by industry they may secure wealth, independence, and comfortable homes.

I find it to be nearly the unanimous wish of all the citizens of this county that the hydrographic surveys, now in progress in the western portion of our State, be extended into Nye County at an early date. Certainly no portion of the United States needs the benefit that may be derived from its operations more than this.

It is not only my opinion, but the opinion of substantial citizens who have given the subject close and earnest consideration, that it will be the best investment for the future prosperity of the nation that it can enter into, not only to continue the surveys, but to increase the Government appropriations for the purpose of aiding in the construction of the necessary work and in the development of the country for artesian water where small quantities of extra rich land are situated and it is found impossible to obtain a supply of water from other resources.

Such works as are required are often too expensive for any single individual or a small body of men to undertake, and should be a national undertaking. If a constant and sufficient supply of water could be obtained by any means it would create a demand for the unsettled lands at better prices than can be obtained at present, create taxable property, and encourage the immigration and settlement of a healthy and industrious class of citizens, which would soon increase both the wealth of State and nation, and this at present desert land would in a few years become the garden of the United States.

The resources of Nye County are scarcely known or heard of outside of its own boundaries. It is generally supposed to be a great barren desert, composed of sand and sage-brush, of little account except for grazing purposes, with a few low-grade silver mines and a limited supply of arable land.

It may be a surprise to some of your honorable committee to find a different state of things presented for your consideration. The county has an area of about 12,500,000 acres. Of this vast territory I am fully convinced that over 6,000,000 acres are capable of a high state of cultivation. Some good judges place it at about 8,000,000, of which less than 800,000 is under cultivation or under fence for grazing purposes.

Where sufficient water can be obtained for irrigation I find the following cereals and vegetables grown to perfection, viz: Of cereals and grasses, wheat, barley, oats, corn, rye, beans, peas, buckwheat, timothy, red-top, blue-joint, clover, alfalfa, millet, wild oats, wheat, and rye, and bunch grass of several varieties; of vegetables, potatoes, cabbage, onions, turnips, tomatoes, rutabagas, carrots, parsnips, pea-nuts, radishes, beets, melons, squash, horse-radish, cresses, etc.

The hops and sugar-beet will, I think, be a source of great revenue in the near future, as they yield immensely and both take to the soil like natives.

Of the wild native grasses and forage plants there are a great variety, chief among which are the sand bunch grasses, white sage and wild clover of the valleys, and the bunch grasses and mountain or burr clover of our mountains and hill-sides.

Of fruits we cultivate the apple of many varieties, pears, apricots, nectarines, plums, cherries, grapes, nuts of several kinds, and many of the small fruits and berries. This industry is in its infancy yet, but it has been successful, so far, beyond our greatest expectations.

Of timber and wood we have the yellow, black, and white pine, and fir in limited quantities, an abundance of nut-pine, juniper, cedar, mountain mahogany, cottonwood, balm of Gilead, quaking-asp, willows, etc.

Of shrubs, the mountain aloes, sage-brush, and greasewood of many varieties, rabbit-bush, Spanish broom, etc.

Of wild fruits we have but few—wild currants, gooseberries, cherries, buffalo berries, cactus, etc.

For the variety and abundance of its mineral deposits it is not excelled by any county in the State. We find gold, silver, copper, lead, zinc, antimony, cinnabar, and other metals; building stone in great variety, granites, porphyry, slates, limestone, gypsum, hydraulic cement, fire-clay, chalk, soapstone, borax, soda, salt, alum, etc., and excellent material for both fire and building brick, etc.

Wood for fuel, mining, and fencing purposes is in abundance. Our great needs are a sufficient supply of water for agricultural purposes, the return of silver to its original standard of value, and railroad communication with the outside world, so that we can obtain our needed supplies at reasonable rates and find egress to markets for what we produce.

By careful inquiry, I find the following to be the yield per acre where sufficient water can be obtained for irrigation,. viz: Wheat, barley, and oats produce from 1,200 to 3,000 pounds per acre; timothy, about 1 ton; alfalfa, two or three crops per season, with a yield of 3½ to 5 tons per acre. Of the other products of the soil, such as vegetables, fruits, etc., no definite amount can be fixed upon, as no account is kept. Such products are used up for home uses, or sold in small quantities as they mature. Without water the yield is too small to be taken into account, except in rarely wet seasons.

The situation of Nye County as regards water is peculiar differing from nearly every county in the State, as it has neither lakes, rivers, nor large streams from which to draw a supply for irrigating purposes, and it is entirely dependent upon the snow-fall in the winter and the rains, when we have any, through the summer, and the large natural springs found near the bases of the mountain ranges and in the valleys for its supply, which is barely sufficient to irrigate the acreage under cultivation in favorable seasons and for stock and domestic purposes, owing to the great loss while the snow is melting in the mountains in the spring, and summer rains. This loss I estimate at fully eight-tenths of the whole.

Under present circumstances it is impossible to arrive at anything like a correct estimate of the yearly amount of water used for irrigating purposes or the amount wasted. It would require a person equipped with the proper instruments to be on the ground and make an examination every month, from March to August, to get at it in any reliable form. I had only a little over a month, and that when the waters are nearly at their lowest state, and I find that no regular system of irrigation or measurement has yet been adopted by the farmer. Their ditches are all made in the way "the Missourian made the plow," and are calculated to carry what water they can get, regardless of waste. Not one of them that I have met can estimate the number of inches, miner's measurement, their ditches will carry, or the amount furnished by streams used by them. Few of the ditches have been surveyed, or have any regular grade, and only in three or four instances does the same ditch supply more than one farm, so that getting the data you require is not only difficult, but impossible, during the time at my command and the extent of territory embraced within the county lines.

I would suggest that Colonel Bridges, who has charge of the work, send a competent person, upon whose judgment he can depend, to Belmont next April or May, to make an investigation of the waters used and also running to waste at that season, also to examine the facilities for storage reservoirs, etc. I will willingly spend a few weeks in showing him what I have myself observed, and give him an opportunity to converse with all the prominent ranchers in the county.

It will be seen by the county map that it has numerous cañons which afford streams—estimated from my familiarity with mining ditches in California—varying from 50 to over 2,000 inches of water for a short period, and springs varying from a few inches to 800 inches, with numerous excellent sites for storage reservoirs in the mountain parts, cañons, foot-hills, and valleys.

The importance of impounding and storing these waters for irrigating purposes in these arid sections is so well understood at the present day that argument or comment is unnecessary. But in connection with these works I have a few suggestions to add, which, I think, if carried out, would add materially to the water supply.

I have noticed that only those cañons and ravines whose sides are lined with trees and underbrush furnish any considerable amount of water. The trees and shrubs form a lodgment and shelter for the snow, allowing it to accumulate, and protecting it from the fierce rays of the sun and hot winds, and the decayed vegetation forms a soil which holds and gradually conveys the moisture from the melting snow on the hill-side downward to the beds of the cañon.

If the planting of the seeds of such trees and shrubs as would grow on the hill-sides was encouraged, a great additional supply of water might be obtained in time.

If the water branches and springs, which are found near the base of all the mountains, were properly opened and kept free, it would add to the supply; as the cattle in search of water tramp the soil in the vicinity of these springs into a thick mud, which prevents a natural flow. These should be opened and piped into strong tanks, where cattle can drink the water conveniently. It would afford an ample supply for stock which is now suffering, as the flow of the springs is thus obstructed.

If the large springs in the valleys and foot-hills—I call them natural artesian wells—were opened by means of pipes driven through the mud and sand, and cleaned out by means of sand-pumps or jetting apparatus, it would increase the flow, and in many places furnish a good supply not otherwise obtainable.

Small reservoirs could be built at little expense. Many of these are now in use in our country, some of them containing less than 10,000,000 cubic feet of water, but which are of very great benefit.

If the large streams which issue from the cañons in the spring (and which could not be impounded to advantage) could be carried over the heavy beds of loose gravel deposited by the spring floods, and usually extending a mile or two below the mouth of the cañons, to soil capable of conveying the water in ditches without much loss it would be of immense benefit to the farmers, as many heavy streams are lost in these deposits in flowing less than a mile.

I have suggested piping and fluming, but both are too expensive where only one or two ranches can be benefited and the freight on pipes and lumber generally exceeds the first cost of the material.

I have also suggested the use of canvas hose, which could be stretched upon the ground and taken up after the irrigating season is over. Also the use of thin sheet or galvanized iron, on which the freight would also be light as compared with pipes or lumber. The sheets would come in bundles and could be shaped on the ground, into either square or V shaped troughs, and where the fall is great—usually over 300 feet to the mile—would carry a large amount of water. The boxes could be made to fit into each other an inch or two, and the grade would prevent leakage at the joints; only slight excavations would be necessary to hold them in place, and they could be taken up and stored when not in use. These boxes would not be damaged by heat and exposure, like lumber or canvas, and the expense of deep trenches and covering would be avoided.

Another source of supply I am satisfied can be obtained from artesian deposits. Much of the rains and heavy snows deposited on the mountains never reach the valleys, but are absorbed and disappear in the crevices of the bare rocks, especially where they are much tilted. These act like a sponge and as feeders to the water deposits below.

The central and southern portions of the county should be well tested for these artesian basins, as much of the best arable land lies in this vicinity, and no attempt has been made at cultivating this portion of the soil, for the want of water, from a short distance south of Belmont until you reach Ash Meadows and Pahrimp Valley, near the extreme southern portion of the county.

I have no doubt also that underground streams exist to a great extent, which might be utilized, as fish of the chub species varying from 1 to 6 inches in length are found in many of the large springs. In some of the warm springs these fish are numerous. The question is where do they come from? We have neither surface streams nor lakes in which fish are found, unless transplanted from abroad.

Near Twin Springs, in this county, are several large water holes which abound in these fish. These holes have been sounded to the depth of several hundred feet, but no bottom has been found. If, in the early morning sunrise, you gaze steadily into the clear water, you will see the bottom of the crust of earth which overlies these waters. The valley evidently has an underground lake, and these springs are either where the force of the water has worked its way to the surface, or the crust has from some cause broken in and disappeared in the depths below. There are many of these water holes in the county, which may be utilized in the future.

In the Hot Creek Range, near Tybo, is a butte, where, by placing the ear to the crevices in the rock, the rushing sound of water may be distinctly heard.

In Cave Valley, formerly in Nye County, but now in White Pine, I am informed there is a cave which in the spring of each year regularly discharges a large amount of water for about six weeks, then it suddenly ceases. There are many other evidences of underground waters in this county.

The main reason why so little interest has been taken in developing the water supply in this county arises from the fact that all the products of the farm are dependent on the home market, and the supply of all farm produce is in excess of the demand of late years. I wish to call your honorable committee's attention to this fact, that since the demonetization of silver and the heavy reduction in its price nearly every industry in the county has fallen off. While silver was at or near its par value the mining towns afforded a market at good prices for all the farm products that could be raised; but under the present discount of silver mine after mine, mill after mill, and all the furnaces in the county have been obliged to close down, with the exception of one small concentrator of a capacity of about 30 tons per day. Mining towns and camps containing populations of from 1,000 to 2,000 have been deserted, or nearly so. For example, unground barley, which formerly found a ready market on the ranches at 5 cents per pound, and retailed at from 6 to 8 cents per pound, is now retailed, ground, at from 1¼ to 2¼ cents, and other farm products in proportion, with little demand for anything at present.

Not having a mile of railroad within our county by which we might find an outlet for our products, you will perceive that the business of farming, as well as mining, is handicapped. In fact there is no encouragement for enterprise as formerly. How long this state of affairs is to continue remains with you and your colleagues in Congress to say.

With mines enough to furnish work for thousands of miners at remunerative wages, unsettled land enough to furnish homes for thousands of industrious families, who would also add to the wealth and prosperity of the nation, but only a few scattering settlers exist, and those only by turning their attention to stock raising to eke out an existence. Soil as deep and rich as can be found in any portion of the Union, grasses and forage plants, succulent and nutritious, grow on hill and valley.

There are other precious metals and other minerals in every mountain and valley, with numerous excellent sites for storing water in the mountain parks, cañons, foothills, and valleys.

We await but recognition on the part of the General Government to place Nevada among the foremost in the galaxy of States.

GEO. NICHOLL,
Commissioner on Irrigation from Nye County, Nevada.

The CHAIRMAN. You estimate that there are 6,000,000 acres of arable land in Nye County?

Mr. NICHOLL. Yes.

The CHAIRMAN. How much of that 6,000,000 acres could be irrigated?

Mr. NICHOLL. Probably a little more than half of it could be irrigated—3,000,000 acres.

The CHAIRMAN. In addition to what you have there already?

Mr. NICHOLL. Yes.

The CHAIRMAN. If from surveys and maps the facts were known with regard to the arable land, the sources of water supply, and such other information as might be necessary to enable settlers in advance to understand what they could do, would it be possible for settlers to combine and do anything with that country?

Mr. NICHOLL. I think it would be. We are very anxious now to have some one go there and examine the country for the purpose of locating reservoirs—anxious to have Mr. Bridges go there and obtain some information for us. Indeed, I am the only one in the county who has tried to force anything through. The people there are very much discouraged by the home market, and about the situation at the present time on account of silver—it is a mining country altogether—and they are finding no market for their produce.

The CHAIRMAN. Have anything else you wish to say?

Mr. NICHOLL. I have a report on the state of the weather in that section which I would like to have incorporated.

The CHAIRMAN. Very well, it may be inserted in the record.

The report is as follows:

Nevada State weather service.

[Daily report of observations for the month of July, 1889. Place of observation, Belmont, county of Nye, State of Nevada. Latitude, 38° 33'; longitude, 116° 45'. Height of ground above sea-level, 8,100 feet.]

Day of month.	Hour of observation.	Temperature.			Wind, prevailing direction.	State of weather.	Remarks.
		Maximum.	Minimum.	Range of.			
1	7 a. m.	86	56	30	Southerly and varying	Clear	Light breezes.
2	...do	86	51	35	...do	...do	Do.
3	...do	89	57	32	...do	...do	Do.
4	...do	90	64	36	...do	...do	Do.
5	...do	95	62	33	...do	...do	Do.
6	...do	96	64	32	...do	...do	Distant thunder.
7	...do	95	61	34	...do	...do	
8	...do	89	55	34	...do	...do	
9	...do	81	58	23	...do	Clear and cloudy p.m.	
10	...do	78	56	23	...do	Clear	Strong breezes.
11	...do	80	57	23	...do	...do	
12	...do	82	58	24	...do	...do	
13	...do	86	67	19	...do	...do	
14	...do	83	64	19	...do	...do	
15	...do	85	54	31	...do	...do	
16	...do	80	57	23	...do	...do	
17	...do	77	54	23	...do	...do	Light breezes.
18	...do	79	55	24	...do	...do	Do.
19	...do	80	56	24	...do	...do	Do.
20	...do	86	60	26	...do	...do	Do.
21	...do	88	61	27	...do	Cloudy	Do.
22	...do	81	60	21	...do	Clear	Do.
23	...do	85	63	22	...do	...do	Do.
24	...do	86	59	27	...do	...do	Do.
25	...do	87	55	32	...do	...do	Do.
26	...do	88	61	27	...do	...do	Do.
27	...do	87	55	32	...do	...do	Do.
28	...do	86	56	30	...do	...do	Do.
29	...do	82	56	26	...do	...do	Do.
30	...do	94	73	21	...do	...do	Do.
31	...do	93	74	19	...do	...do	Do.

JOHN REYNOLDS,
State Weather Observer.

The CHAIRMAN. What is the average rain-fall?

Mr. NICHOLL. It comes at various times. Sometimes we will have a large amount—a flood. I have seen the streets of Belmont that high with water [indicating a foot].

STATEMENT OF JAMES MAYBERRY, MEMBER OF THE STATE BOARD OF COMMISSIONERS.

The CHAIRMAN. Have you given much attention to the subject of irrigation in the district in which Washoe is situated?

Mr. MAYBERRY. I have given it some attention.

The CHAIRMAN. Can you add anything to the information we have already obtained on the subject? What have you to say about it?

Mr. MAYBERRY. I do not know that I could add to what has already been said.

The CHAIRMAN. Give us the result of your observations; what you have seen there, and what can be done.

Mr. MAYBERRY. The situation there now is this: There is hardly enough water flowing in the river to irrigate the land which is now under cultivation.

The CHAIRMAN. What is under the water-shed? Is there enough under the water-shed if it were saved?

Mr. MAYBERRY. Yes, and to irrigate more land than they have in the county.

The CHAIRMAN. More than can be reached from the Truckee River?

Mr. MAYBERRY. Yes.

The CHAIRMAN. How much land could be reached from the Truckee?

Mr. MAYBERRY. Probably 150,000 acres on the north side.

The CHAIRMAN. In addition to that under cultivation?

Mr. MAYBERRY. In addition to that.

The CHAIRMAN. Is that all—150,000 acres?

Mr. MAYBERRY. Probably there could be more than that at a greater expense——

The CHAIRMAN. How much an acre would it cost to irrigate the 150,000 acres—to bring the water so that the parties there could use it?

Mr. MAYBERRY. If the sites for reservoirs, ditches, etc., were free, I think that $10 or $12 an acre would do it.

The CHAIRMAN. What would the land be worth when that was done?

Mr. MAYBERRY. Anywhere from $40 to $60 an acre.

The CHAIRMAN. It would be as valuable as that already irrigated?

Mr. MAYBERRY. That land is more valuable.

The CHAIRMAN. And the unirrigated is better land?

Mr. MAYBERRY. Better land—that is to say, deeper soil, and would take less water to irrigate it.

The CHAIRMAN. Have you examined the storage basins in these rivers above?

Mr. MAYBERRY. Yes. I have examined around those lakes and natural meadows and outlets to them, and there are chances to put in storage dams.

The CHAIRMAN. Are the opportunities abundant?

Mr. MAYBERRY. Yes, more than abundant.

The CHAIRMAN. Some of the land is public land?

Mr. MAYBERRY. I do not know about that. It seems to me that most of the land is taken.

The CHAIRMAN. Then the land would have to be condemned?

Mr. MAYBERRY. It would have to be condemned and bought.

The CHAIRMAN. The land is all surveyed.

Mr. MAYBERRY. Yes, and as well as I can get at it it is owned by individuals.

The **CHAIRMAN**. Except the lakes.

Mr. **MAYBERRY**. Except the lakes. The margins of the lakes are owned. In some of them you would have to raise water, and if you raised it 15 or 20 feet you would overflow some meadows or pasturage land used by stockmen in summer.

The **CHAIRMAN**. Have you anything else to say about this matter that would be of value to the committee?

Mr. **MAYBERRY**. No, nothing further than to say that if the people had the right to go to work and put dams at these outlets they would do it themselves. But they have no right to shut up those streams, because somebody else would require them to be opened.

STATEMENT OF GEORGE S. HAWKINS, OF CARSON CITY.

The **CHAIRMAN**. Have you been engaged in the business of boring artesian wells in Nevada?

Mr. **HAWKINS**. Yes.

The **CHAIRMAN**. Make a statement of the wells you have sunk, and state with what success you have met.

Mr. **HAWKINS**. I have bored about 5,000 feet of wells, varying from 40 to 400 feet in depth.

The **CHAIRMAN**. In what section of the State?

Mr. **HAWKINS**. Most of them in this county. I bored one well in Churchill County and one in Douglas County.

The **CHAIRMAN**. About how many have you sunk in Ormsby County?

Mr. **HAWKINS**. About thirty.

The **CHAIRMAN**. About how many are flowing wells?

Mr. **HAWKINS**. About two-thirds.

The **CHAIRMAN**. What is the average depth?

Mr. **HAWKINS**. The artesian water comes within 120 feet. That is to say, that which is of any consequence.

The **CHAIRMAN**. What sized wells are they?

Mr. **HAWKINS**. Three inches.

The **CHAIRMAN**. How much water do they flow?

Mr. **HAWKINS**. The best of them struck in this county flow about 30 gallons a minute, and the others, as the formation is finer, flow less; some of them only two or three gallons a minute.

The **CHAIRMAN**. What are the formations through which the drill passed?

Mr. **HAWKINS**. Alternate strata of sand and clay down to the bottom of the artesian belt, and that becomes a finer formation, such as you would find in the bottom of lakes—sedimentary.

The **CHAIRMAN**. There is sand where you get the water?

Mr. **HAWKINS**. Yes.

The **CHAIRMAN**. And above that is clay?

Mr. **HAWKINS**. The sand is between two beds of clay, which are impervious to water.

The **CHAIRMAN**. You sunk a well in Churchill County?

Mr. **HAWKINS**. Yes; for the Vail Brothers.

The **CHAIRMAN**. Near the Carson River?

Mr. **HAWKINS**. Right on the Carson River.

The **CHAIRMAN**. How far above or below Carson?

Mr. **HAWKINS**. East of Carson City.

The **CHAIRMAN**. How far down the river?

Mr. **HAWKINS**. Between 40 and 50 miles.

The **Chairman**. To what depth did you sink that well?

Mr. **Hawkins**. To a depth of 400 feet.

The **Chairman**. Did you strike water?

Mr. **Hawkins**. I struck pump water; no water that came to the surface.

The **Chairman**. What formations did you pass through?

Mr. **Hawkins**. Beds of quicksand; very few beds of clay. The majority was quicksand, which I imagined had been carried through from here down into the sink.

The **Chairman**. At the bottom of the well what did you find?

Mr. **Hawkins**. Sand. I struck a belt of clay 12 feet thick, and between that and the sand, the top stratum was yellow clay and the bottom blue.

The **Chairman**. Did you go below the bed of clay?

Mr. **Hawkins**. Yes.

The **Chairman**. What did you find?

Mr. **Hawkins**. Quicksand.

The **Chairman**. Did you go through that?

Mr. **Hawkins**. No; the parties for whom I was sinking the well did not care to go deeper and I stopped there. I think if they had struck nearer the river they would have gotten artesian water.

The **Chairman**. It is not prospected there?

Mr. **Hawkins**. No.

The **Chairman**. Are there any wells sunk down on the bed of the Carson?

Mr. **Hawkins**. Yes; one at the lower end of the valley, where a flow was gotten at a depth of 300 feet. It was a light flow.

The **Chairman**. Do you know through what formation they passed?

Mr. **Hawkins**. The same formation, I understand, that I passed through.

The **Chairman**. They did not get down through the quicksand?

Mr. **Hawkins**. No. This water is found in fine sand.

The **Chairman**. You do not know what may be below?

Mr. **Hawkins**. That region has not been prospected.

The **Chairman**. There is no region that is prospected, I mean near the Sierra Nevada Mountains, in Carson Valley.

Mr. **Hawkins**. In Douglass County I sunk two wells, and each of them flows 30 gallons a minute.

The **Chairman**. To what depth did you go?

Mr. **Hawkins**. Three hundred and seven feet is one, and 310 feet is the other.

The **Chairman**. Through what formations did you pass?

Mr. **Hawkins**. I struck sand and bowlders. I struck three strata of bowlders that were about 20 feet thick in one well, and in the other I struck two.

The **Chairman**. Clay bowlders?

Mr. **Hawkins**. Sand bowlders.

The **Chairman**. No seams of clay in the bowlders?

Mr. **Hawkins**. No. But above there was.

The **Chairman**. What was immediately above the flowing water?

Mr. **Hawkins**. There was in the Rosser well—the lower well—a kind of hard pan and blue sand that was partially cemented together, so that after the well was struck portions of it as large as my fist would come up through the pipe.

The **Chairman**. That was impervious to water?

Mr. **Hawkins**. Yes.

The **Chairman**. What did you find below that?

Mr. **Hawkins**. There I stopped in blue sand.

The **Chairman**. There you got the water?

Mr. **Hawkins**. Yes; I got the water. And I struck a granite sand in the other. That was deeper.

The **Chairman**. What did you have above the granite sand?

Mr. **Hawkins**. A small streak of clay.

The **Chairman**. You think that is prospected?

Mr. **Hawkins**. I think there is water there, and an abundance by going down deeper. The deeper you go the more water. At 90 feet the water came to within 6 inches of the surface; at 100 feet, 10 inches above the surface, and at 310 feet it flowed 6 feet above the surface.

The **Chairman**. Is that all the prospecting you did for water in western Nevada?

Mr. **Hawkins**. Yes. There have been other wells sunk which they did not make a success of, and there have been wells sunk in Washoe Valley that struck pretty fair flows.

STATEMENT OF SILAS E. BURBANK, OF SMITH'S VALLEY.

The **Chairman**. In what part of Lyon County do you reside?

Mr. **Burbank**. I am from Smith's Valley.

The **Chairman**. Have you any document prepared showing the condition of things in Lyon County?

Mr. **Burbank**. Parties from Lyon were not in here, and there is no mail except twice a week, and they have not prepared to meet the committee at this time.

The **Chairman**. But they have made some preparation in that county to give the situation?

Mr. **Burbank**. Yes.

The **Chairman**. How long have you resided in Lyon County?

Mr. **Burbank**. For about twenty-five years.

The **Chairman**. Can you give any information about that county?

Mr. **Burbank**. Yes; I can give you information about the amount of land that is under cultivation in that county.

The **Chairman**. How much land is under cultivation there?

Mr. **Burbank**. The stream is pretty long, and there are two forks to it. We would have to start with the valleys at the head of it. There are a few small valleys about which I am not posted.

The **Chairman**. Give the amount of land in the aggregate.

Mr. **Burbank**. There is in Lyon County somewhere about 30,000 acres of land cultivated by means of irrigation.

The **Chairman**. Do they cultivate all that can be brought under cultivation?

Mr. **Burbank**. No; not more than about one-tenth.

The **Chairman**. Then you think they can get 300,000 acres under cultivation?

Mr. **Burbank**. Yes. Eight years ago they had 125 miles of irrigating canals, some of them 12 feet wide, 4 feet deep, with about 6 feet fall to the mile.

The **Chairman**. Have they put that information in the report which they will send?

Mr. **Burbank**. I presume they will do so.

Mr. **Irish**. I wish to correct a statement made by me in the forenoon. In speaking of the area which I knew could be brought under cultivation in Lincoln County, I said it was 60,000 acres. I should have said sixty townships instead of 60,000 acres.

STATEMENT OF T. B. RICKEY, OF CARSON CITY.

The **CHAIRMAN**. In what business are you engaged?

Mr. **RICKEY**. I am engaged in the business of farming, ranching—raising stock.

The **CHAIRMAN**. Where are your ranches?

Mr. **RICKEY**. Principally on Walker River.

The **CHAIRMAN**. Where is that river?

Mr. **RICKEY**. It lies south and east of Carson City.

The **CHAIRMAN**. Part of it is in California and part in Nevada?

Mr. **RICKEY**. Yes.

The **CHAIRMAN**. Have you paid any attention to the subject of irrigation?

Mr. **RICKEY**. Some little; yes.

The **CHAIRMAN**. How much land have you reclaimed by irrigation?

Mr. **RICKEY**. I can not tell you exactly how much.

The **CHAIRMAN**. About how much; approximate it.

Mr. **RICKEY**. I should judge somewhere in the neighborhood of 15,000 actually reclaimed from a desert condition.

The **CHAIRMAN**. You have diverted upon this land the water of what river?

Mr. **RICKEY**. Walker River.

The **CHAIRMAN**. What use do you make of the reclaimed land?

Mr. **RICKEY**. It is principally used for raising stock.

The **CHAIRMAN**. What kind of grass do you raise there?

Mr. **RICKEY**. All kinds—redtop, timothy, alfalfa; in fact, all kinds.

The **CHAIRMAN**. About what is a fair crop of each kind of grass where the land is well cultivated?

Mr. **RICKEY**. I suppose what you mean is an average crop, where it has been well irrigated and well cultivated. I should say the timothy from a ton and a half to two tons an acre; probably a ton and three-quarters to the acre is an average crop.

The **CHAIRMAN**. How much of red clover?

Mr. **RICKEY**. English clover you would get two tons and a half.

The **CHAIRMAN**. Can you cut red clover more than once?

Mr. **RICKEY**. Yes; but your second crop of red clover in this country is not very heavy.

The **CHAIRMAN**. How much of alfalfa?

Mr. **RICKEY**. We calculate to cut an average of 4 tons to the acre.

The **CHAIRMAN**. In your place you cut only twice.

Mr. **RICKEY**. Yes.

The **CHAIRMAN**. What is about the altitude of your farm?

Mr. **RICKEY**. The altitude there is between 5,000 and 6,000 feet.

The **CHAIRMAN**. Lower down, where it is lower, you might cut more.

Mr. **RICKEY**. Oh, yes; we cut the third crop there, but we do not think it wise to do so.

The **CHAIRMAN**. Have you ever given the subject attention so that you would be able to state how much land there is below the flow of the Walker River and its tributaries that might be irrigated if there were water enough?

Mr. **RICKEY**. I have no means of making any estimate, except from observation.

The CHAIRMAN. That is all we expect.

Mr. RICKEY. I never thought anything about it.

The CHAIRMAN. You have passed over the country?

Mr. RICKEY. I should think that there are 150,000 acres of land that could be reached from the Walker River.

The CHAIRMAN. And much more?

Mr. RICKEY. Yes; that is a rough guess.

The CHAIRMAN. Is there any way of turning the Walker River over in the Carson valley in the Still Water Basin?

Mr. RICKEY. It could be brought over at Fort Churchill.

The CHAIRMAN. Have you been down in Churchill County to examine that country?

Mr. RICKEY. Yes.

The CHAIRMAN. Is there a large body of land there?

Mr. RICKEY. Yes, large tracts—a large country.

The CHAIRMAN. What is the character of the land?

Mr. RICKEY. It is large enough for a state.

The CHAIRMAN. Is it very fertile land?

Mr. RICKEY. Very.

The CHAIRMAN. And you could raise three crops of alfalfa there?

Mr. RICKEY. There would be no trouble in raising three crops of alfalfa in this country, and no trouble there—that is to put the water on the land at the proper time in the spring.

The CHAIRMAN. Are you familiar with the headwaters of the Walker and its various branches?

Mr. RICKEY. Yes.

The CHAIRMAN. Are these meadows and flats near the headwaters?

Mr. RICKEY. Yes.

The CHAIRMAN. What do you say as to the opportunities for storing water at the headwaters of the Walker River?

Mr. RICKEY. There would be no trouble at all. There can be water enough stored on the headwaters of the Walker and its branches to irrigate every acre of land that may be reached, and, I think, twice as much if all the water were stored. And there are facilities for doing it. has the best facilities that there are on this side of the mountains. There are facilities on the Carson, but they are better on the headwaters of the Walker than any I have seen. The water can be stored more cheaply there than at any other place.

The CHAIRMAN. Walker Lake is about 30 miles long and 10 miles wide, is it not?

Mr. RICKEY. It is about 15 miles in width, 12 or 15.

The CHAIRMAN. Is it a deep lake?

Mr. RICKEY. Yes, a very deep lake.

The CHAIRMAN. That lake is made from the surplus water of the Walker River, and it is all wasted?

Mr. RICKEY. Yes.

The CHAIRMAN. Then there is no difficulty in irrigating this Carson Sink if these waters were saved?

Mr. RICKEY. None at all.

The CHAIRMAN. To what extent have parties taken possession of the country that would be suitable for storage reservoirs?

Mr. RICKEY. To a very limited extent. That is my idea about it. I think plenty of places could be found for the storage of the waters of the Walker River. There are places though where the land has been taken up, but in a majority of the cases where the people own that land they will vacate it, because, as a rule, the land belongs to men who own below, and they would be perfectly willing to have the water stored. There is fertile land enough on Walker River, in my opinion, to supply 300,000 of population. That land is right on Walker River. I am not making any wild statement; I have figured on this. On Virginia Creek, which is the extreme eastern branch of the Walker River, we have several lakes reservoired by constructing bulk-heads, and I have had water furnished me this season for 4,000 acres of land. Therefore, the entire expense of doing that would not reach over $3,000.

The CHAIRMAN. By means of those reservoirs you have irrigated how much land?

Mr. RICKEY. Four thousand acres of land which I could not have irrigated at all had it not been for those reservoirs. My idea is that the storage of water on the Carson is the most expensive of any of the streams. I am familiar with the headwaters of all those streams, and the storage of water is not so cheap there. At Twin Lakes, on one of the branches of Walker River, at what is called Robinson Creek, the people on Big Meadows thought they were going to have a scarcity of water. So they joined together and agreed to pay in accordance with the number of acres of land they owned. They dammed both of these lakes, and I was told when I was up there that it cost between $1,400 and $1,500, and the water is a little over 9 feet deep.

The CHAIRMAN. What is the size of the lake?

Mr. RICKEY. I think that the surface of the water would be a half mile by three. The grasses that we grow over here are so much more nutritious than in any other part of the world. Our grass here is equal to the corn grown in the East. I can take the grass here and fatten a steer, and put more actual meat on it in weight than they can with corn in the East.

STATEMENT OF D. C. WHEELER, OF RENO.

Mr. Chairman and gentlemen, I wish to tell you what we can do down on the Truckee Meadows, as shown by actual experiments. Around Reno we can put up any kind of stock, horses, cattle, or sheep that may be poor in the fall, and turn them out fat enough to kill in the spring. I have seen that done. We can put 2 gross pound of meat a day on a steer by putting it on alfalfa hay. The alfalfa here is worth more to fatten cattle than wheat, oats, or corn.

The CHAIRMAN. How is it for hogs?

Mr. WHEELER. It does well.

Mr. RICKEY. I have fattened a hog on alfalfa.

Mr. WHEELER. I think the hay for horses the best in the world.

The CHAIRMAN. Do horsemen use it?

Mr. WHEELER. On the Truckee meadows they use it altogether. We work the horses hard day in and day out without a bite of grain—give them nothing but alfalfa.

The CHAIRMAN. Do they use altalfa hay anywhere else except in Nevada?

Mr. WHEELER. It is shipped and used in California.

The CHAIRMAN. Do they not take it to New York?

Mr. WHEELER. Not alfalfa. They do take Nevada hay and timothy. I know parties shipping timothy hay for horses from here to New York.

The CHAIRMAN. How is it about the hay for feeding fine horses?

Mr. RICKEY. Horsemen consider the timothy produced in Nevada superior to any hay in the world. They have bought and shipped hay from here to New York for horses. Haggin did it.

Mr. **Wheeler**. We can put two gross pounds of meat a day on a steer by feeding it on alfalfa hay. We can put up stock after a five-hundred mile drive and have them fat in the spring without feeding them on grass at all, simply by feeding them on alfalfa hay. I have seen horses that were hide-bound really fat in three months after having been fed on alfalfa hay And alfalfa does not exhaust the vitality of the land. You can take a piece of land that has been ten or twenty years in alfalfa and then put it into grain and it will raise more than ever before.

The **Chairman**. How long will the alfalfa last?

Mr. **Wheeler**. In Truckee meadows it is 25 years old. It depends on the soil.

The **Chairman**. What is its condition now?

Mr. **Wheeler**. As good as it ever was.

The **Chairman**. Did you ever know it to diminish?

Mr. **Wheeler**. The yield generally diminishes as the plant gets old. It gets poor. You might injure the plant by not irrigating enough, and if the land be shallow the plant gets stunted.

The **Chairman**. What would you call an old plant?

Mr. **Wheeler**. It depends on the land. On some land down there with a foot of soil it gives out.

The **Chairman**. When?

Mr. **Wheeler**. In five or six years. Then we plow it up and reseed.

The **Chairman**. That renews it again?

Mr. **Wheeler**. Yes; it is then just as strong as ever. Two or three meadows down there have deep soil, and it is twenty-two and twenty-five years old, and it is as good as ever.

Mr. **Mayberry**. I have some that was put in in 1863, twenty-six years ago, and I have cut 3 tons to the acre the first cutting.

The **Chairman**. Is it good and fresh?

Mr. **Mayberry**. I think it is better and requires less irrigation.

Mr. **Wheeler**. I want to say that outside the land in Washoe County is 40 to 50 per cent. better than what we are cultivating. There are from 100,000 to 150,000 acres. That is the estimate they put upon it.

The **Chairman**. How much do you estimate it to be?

Mr. **Wheeler**. I do not care about estimating.

The **Chairman**. How much better is it than the land that is cultivated, that which we see about Reno?

Mr. **Wheeler**. Forty to 50 per cent. better. The cost to irrigate that land would not be 10 per cent. of its value. Ours is covered with rocks, and it would cost $30 to $40 an acre to take the rocks off. On this uncultivated land of which we speak you can hardly get a stone to throw at a bird.

Mr. **Rickey**. That is the case in every valley in this State. The lowlands which were most accessible to the water were, of course, the first lands settled. That was because they could get water on them cheaper, and they are the poorest lands in all this valley; they are the alkali lands. They are either rock or alkali. When you get back near the bench lands the soil is deeper and much richer. That is my observation all over this State. Get back to the foot-hills in some of those valleys, and it is wonderful to see the crops they produce there.

The **Chairman**. It is warmer there?

Mr. **Rickey**. Yes; and it is much better for everything.

The committee adjourned to meet on call of chairman.

STATEMENT OF C. W. FRIEND, OF CARSON, NEV.

Under date of Carson City, December 4, 1889, Mr. Friend, chief of the State service, forwarded to the committee the following review, which has been ordered filed for report:

The Nevada State weather service was established in February, 1887, by the following act of the legislature:

AN ACT to establish a weather-service station in Nevada and to provide for the appointment of director thereof, and appropriating money to pay the expenses of the same.

The people of the State of Nevada, represented in senate and assembly, do enact as follows:

SEC. 1. The establishment of a weather-service station being necessary to secure as complete a history of the weather of Nevada as possible, in order to furnish trustworthy material for a study of its climate, to acquaint the people of the State and nonresidents with the physical conditions of every locality, based upon reliable climatic data, thereby greatly benefiting the agricultural, commercial, manufacturing, and municipal interests, there is hereby established at Carson City, in this State, a central weather station, to be under the supervision of a competent director, to be appointed as hereinafter provided.

SEC. 2. The duties of said director shall be to establish volunteer weather stations throughout the State, at least one in each county, and to supervise the same; to receive reports from said volunteer weather stations, reduce the same to tabular form, and prepare and have printed monthly reports, copies of which shall be, by said director, sent to all colleges, high schools, hospitals, public libraries, agricultural societies, and newspaper proprietors who shall in writing request the same.

SEC. 3. Said director shall also prepare an annual report of his labors, and of the work done by the volunteer weather service, and present the same to the governor for publication. Fifteen hundred copies of said report shall be printed by the superintendent of State printing, of which five hundred shall be for the use of the State officers and one thousand for the use of the legislature. The superintendent of State printing shall do all printing necessary to carry out the requirements of this act, and the secretary of state is authorized to furnish said director whatever stationery he may need in the proper performance of his duty.

SEC. 4. Said director shall be appointed by the governor, and, in addition to the other duties required under the provisions of this act, he shall file with the State librarian monthly reports of the meteorological observations provided for in the third section of this act; and the same shall be carefully preserved by said librarian, and be open to inspection during office hours to any one applying therefor. For the performance of the duties prescribed by this act the director hereinbefore mentioned shall receive a salary of six hundred dollars a year, payable in monthly installments, upon the claims being allowed by the board of examiners, and said claims shall be paid as other claims against the State are paid, and shall be in full for all demands of said director, including traveling expenses.

SEC. 5. Said director is authorized to provide for the equipment of such volunteer weather stations as shall be established by him, of which there shall be at least one in each county, at a cost not exceeding twenty-five dollars for each station so established. Each station shall be supplied with the following instruments: One maximum thermometer, one minimum thermometer, one dry-bulb thermometer, one wet-bulb thermometer, one rain-gauge, with overflow attachment, and such other instruments as may be necessary, of which the cost shall not exceed the sum of twenty-five dollars for each station, as hereinbefore provided. Said director shall apply to the United States Central Signal Office in Washington, D. C., to have the weather stations in this State recognized and registered as volunteer stations, auxiliary to the United States Weather Service, and shall also apply for and receive the printed blanks, franked envelopes, and books of "instructions for voluntary observers of the Signal Service of the United States Army," and such other stationery as is usually supplied to volunteer observers. All instruments purchased with State funds by said director for use in any department of the weather service in this State, and all charts, maps, diagrams, and tabulated forms made by him in his official capacity, shall be the property of the State solely.

SEC. 6. For the purpose of paying the salary of the director herein mentioned during the years 1887 and 1888, the sum of twelve hundred dollars is hereby appropriated, out of any moneys in the general fund not otherwise appropriated.

SEC. 7. The sum of five hundred dollars is hereby appropriated, out of any moneys in the State treasury not otherwise appropriated, to be applied in purchasing the instruments provided for in the fifth section of this act.

SEC. 8. The county auditors of the respective counties of this State are hereby constituted volunteer reporters of meteorological observations, and shall keep and record such observations and reports as are required by the provisions of this act and report the same to the director of the State weather service station, and shall perform such duty without compensation additional to that now allowed by law for the performance of other duties of their office.

REPORT.

INTRODUCTION.

The issue of the monthly weather reviews made by the observer of the Nevada State weather service, as provided by law, was begun in February, 1888. The first stations were established in September, 1887, and observations were begun on the 1st of October following. One station was established in each county, the county auditors, by act of the legislature, being constituted *ex-officio* State weather observers. Other stations have since been added to the list. The total number of stations at present from which reports are received is thirty-eight. Of these four are rain-fall stations, located at the following places: Cherry Creek, White Pine County; Burner's Ranch, Elko County; Crane's Ranch, Elko County, and Secret Valley, Elko County.

Many difficulties have beset the work of organizing the State weather service, and the outlook at first was not at all encouraging, but through determined effort and a deal of labor the service has assumed proportions and given promises of success far exceeding the most sanguine expectations of its friends and promoters. A very considerable degree of interest has been aroused among the people in various parts of the State in the study of our climate, and a disposition is manifested to make such study profitable by making intelligent application of the knowledge thus acquired. The United States surveyor-general, Mr. C. W. Irish, has rendered the service very valuable assistance, and its present status is largely due to him.

The Chief Signal Officer has very kindly rendered us all the aid in his power, and caused the daily weather indications to be telegraphed to all important towns in the State requesting the same. In order that the indications might be generally known and more beneficial to the people of the towns at which they are received, it was decided that a display of signals be made. This display of signals has been made at Carson City since October 4, 1887, and has given general satisfaction to the citizens of that place and vicinity. The signals consist of a set of four flags, the cost of which is very small, and it requires but a few minutes' time each day to make the display. These weather indications, received for the past year, have in nearly every instance been verified, and there is good reason to hope that they will ultimately be of great benefit to the State.

It is hoped to secure the service of at least one efficient observer in every county of the State. One of the provisions of the law of 1887 makes it the duty of the several county recorders to make the necessary observations and report the same; but it was a duty imposed on these officers after they had gone into office, and in many cases has been disregarded. There is no reason why this duty should not be as imperative as any other imposed by law.

The object of the weather service is to observe and utilize every feature of the weather that affects the prosperity of the inhabitants as to crops, health, life, etc., omitting, perhaps, only those few items already provided for by the General Government at Washington, such as general predictions. The State service is, therefore, essentially a plan for gathering and utilizing local climatic data, and eventually it will define precisely the locations most favorable or unfavorable to special crops, diseases, etc. Some of the advantages derived from a State weather service are as follows:

It will enable the Chief Signal Officer at Washington to trace upon charts all the atmospheric changes that occur in the State, and from such data make it possible to forecast the weather. It will give to every county the Government standard of temperature, rain-fall, humidity, etc., which is useful information. It will educate the people in the physical and climatic conditions of the country in which they live. It will put within reach of the local agricultural societies means of accurate observations which, in the course of years, must be valuable to any locality in the object of their pursuits. It will form reliable records in legal cases. It is invaluable to the State bureau of immigration, as it will invite immigration, by publishing the reports and showing the climate of the State. It will aid the medical profession in the study of diseases. It will show to the whole United States the large amount of water, by actual figures, that there is in the State, and be a basis for Congress and our legislature to convert thousands of acres of otherwise waste lands into beautiful and profitable farms and gardens, and it will show thousands of people who are dying in various humid parts of our country where they can prolong their lives and, in many cases, live to a good old age.

IRRIGATION.

In this connection I deem it both relevant and proper to specially refer to this very important subject. While I realize that water is a precarious element, wherever irrigation is necessary, other States have been able to enact effective and satisfactory laws governing the distribution of water for irrigating purposes, and I see no good reason why Nevada should not do likewise.

The desert region of Nevada is only a desert when deprived of water, the soil being generally productive when irrigated, and the amount of land capable of being brought under cultivation is only limited by the water supply.

The rain and snow fall is much greater in the mountain than in the valley districts; more particularly is this the case along the eastern slope of the Sierra Nevada range of mountains. Truckee, Carson, and Walker Rivers have their source in these mountains of perpetual snow, and give the western portion of the State its only trustworthy supply for irrigating purposes.

During the months of April, May, and June these streams overflow and endanger land and property in the valleys through which they flow. In these spring floods immense bodies of water pass uselessly by, not being needed at that season of the year. Scarcely is the débris cleared away from the rush of water, when in August, September, and October a season of drought sets in and a general water-famine prevails.

Good authorities estimate that 80 per cent. of the annual discharge of these streams passes down during the months of April, May, and June, and not more than 10 per cent. in August, September, and October. This 10 per cent. is subject to excessive loss from evaporation (owing to the smallness of the streams and consequent sluggish flow), which, added to the wasteful manner in which it is used by persons intent on securing their own advantage, reduces the amount judiciously appropriated at least one-half more.

It is safe to estimate that there is sufficient precipitation in western Nevada and its adjacent water-sheds, if properly disposed of, to increase the area of land now under cultivation tenfold. The importance of saving these waste waters, and the great benefits which would inure to the State by a successful solution of the problem of storage and distribution, needs no amplification.

CLIMATE.

On the whole, the climate of Nevada can not be surpassed in the United States. In the winter there is just cold enough to destroy the insects and the effects of decaying vegetable matter, and in the summer just heat enough to ripen vegetation and give a vigorous growth to all animal and vegetable life. The nights are always cool and refreshing during the hottest months of summer. Thousands of people are dying in Oregon and in the Eastern, Southern, and Northern States because they have not a Nevada atmosphere to breathe.

The State bureau of immigration alludes to our climate as follows:

"The climate of Nevada is the most delightful and salubrious in the known world. Neither the prostrating heats and destructive cyclones, nor are the Arctic frosts and deadly blizzards of the Western States known here. The consumption-breeding fogs and countless insect pests that swarm in other lands are also strangers in Nevada. The warmest days of summer are modified by soft southwest winds, laden with the sweet odor of wild flowers and the invigorating aroma of the indigenous sage, while the nights are seasons of transcendent loveliness, rendered so by the gentle mountain breezes that waft health and vigor to the sleeper. In June and July occasional thunder storms cool the air and freshen the face of nature. The winters, with the exception of a few cold days, are spring-like, the snow remaining only a short time, except at great altitudes. Malarious fever and pulmonary consumption are exceedingly rare, and are usually imported cases, while smallpox, measles, and kindred diseases are shorn of their terrors by the dryness and purity of the atmosphere. Scrofula, salt rheum, and similar inherited taints of blood are, in a few years, almost entirely eradicated from the system by the wonderful healing properties of Nevada's matchless climate. Nevada may be justly styled 'the world's great sanitarium.'"

PRODUCTIONS.

Nevada extends from the thirty-fifth to the forty-second degree of latitude; consequently her productions are necessarily varied and embrace wheat, barley, oats, alfalfa, all variety of garden vegetables, cotton, tobacco, almonds, figs, grapes, etc. It is one of the few States that can produce both apples and peaches of excellent quality. Currants are produced in abundance and are a sure crop.

Concerning the tropical portion of Nevada, read what Mr. D. Bonelli, observer of Rioville, Lincoln County, says: "I settled here in 1868, first at St. Thomas, 25 miles north of here, where the thermometer would go to 123 in the shade and 156 in the sunshine. This temperature will hatch out eggs left in the cupboards in the houses, if they get an occasional movement, and it will steep tea in the sun and boil eggs in sand exposed to the sunshine, though it will not melt lead. The excessive heat, of course, limits the range of vegetation, and makes it necessary to grow grain in the winter. It is sown in October and November and ripens the first of May. Figs are ripe by the middle of May; almonds full grown last of April; grapes ripen the last of June. Snakes, lizards, horn toads, and tarantulas take a sort of hibernating spell in the hottest weather for a month, and are extra active about February and March, by which time our main forage crop, lucerne or alfalfa, is growing. It is cut by the middle of April, and five additional crops are cut if water be plentiful. The articles mentioned are the main productions that will stand the climate; everything else languishes in the summer-time. I am now getting some esparsette to try, a European forage plant that does well in dry and hot soils there and may prosper here.

"This region is sparsely settled, since there are only a few margins of arable land along the streams and transportation facilities are lacking to market the products. Railroads come near enough to spoil the produce market we used to find in mining camps, and not near enough to take off our surplus. If there is nothing found suited to the climate that will pay to export, and no mineral discoveries of value are made, it will only be the question of a few years when the white man must disappear from this region in spite of the many efforts made in the past for its settlement. If anything exists in nature that is valuable for food, clothing, or medicine that requires just such a climate, it would be charity to introduce it."

INSTRUMENTS.

The instruments in use by the observers of the Nevada State weather service are the maximum and minimum thermometers and the rain gauge, and at a few stations the dry and wet bulb thermometers are added, all of which are standard and of uniform pattern.

Full instructions for using and properly exposing the instruments are furnished to observers from this office, but as a rule not strictly carried out, and it is very essential that in order to ascertain as nearly as possible the temperature of the air proper instrument shelters of cheap construction and modern pattern should be provided for the stations. It would also be advisable to supply a few stations in different parts of the State with self-recording barometers and thermometers.

OBSERVERS.

Much credit is due to the many good observers, whose untiring efforts have brought regularly carefully compiled reports without the slightest compensation for their efforts.

The following is a complete list of persons reporting to the State service:

Station.	Observers.	Station.	Observers.
Leonard Creek	N. W. Derby.	Lewers' Ranch	Miss Kate Lewers.
Palisade	J. L. Fast.	Virginia City	Mark Averill.
Tuscarora	Prof. M. D. Bowen.	Dayton	Prof. Robert Lewers.
Winnemucca	John P. Slaughter, Sig. Corps.	Carson City	C. W. Friend.
Gold Mountain	H. H. Robinson.	Ely	J. F. Cupid.
Elko	C. H. Sproule.	Genoa	G. W. Dungan.
Mill City	J. A. Ferraro.	Sodaville	T. T. Keay.
Humboldt	Samuel H. Kitto.	Downeyville	Dutton Fowler.
Beowawe	Ira G. Hoag.	Belmont	John Reynolds.
Punch Bowl	I. G. McMonigal.	Hawthorne	George Garrison.
Crane's Ranch	W. T. Crane.	Candelaria	W. H. Shockley.
Burner's Ranch	Prof. J. F. Burner.	Pioche	N. P. Dooley.
Ruby Hill	W. B. Lawler.	Rioville	Daniel Bonelli.
Hot Springs	Miss L. Merrill.	El Dorado Cañon	P. W. Davis.
Reno	W. S. Devol.	Keeler, Cal	D. C. Grunow, Signal Corps.
Verdi	C. R. Carter.	Cedarville, Cal	Jackey and Drouillard.
Furguson's Ranch	J. W. Furguson, esq.	Younts' Ranch	Harsha White.
Austin	O. B. Vincent.	St. Clair	L. Allen.
Eureka	M. M. Ley.	Pyramid Agency	Rodney and Richardson.

This is a work that all ladies should take a great interest in, especially as they can do the work well, and generally more conscientiously than the "Lords of Creation." The Signal Service observers render us very valuable assistance.

A REVIEW OF THE WEATHER FOR TEN MONTHS IN 1889.

JANUARY.

The first eleven days of the month were characterized by warm, sun-shiny weather and a total absence of precipitation; from the 12th to the 18th there was a period of cold and rainy weather, nearly all of the precipitation for the month occurring between these two dates, but more particularly on the 18th, on which date thirteen out of a total of twenty-four stations reported precipitation in amounts ranging from .03 at Beowawe to .86 at Tuscarora. The remainder of the month was attended by clear and warmer weather, with very little precipitation. The highest temperature during the month, 64.8, occurred at El Dorado Cañon on the 17th, and the lowest temperature, 22, at Elko on the 17th, the absolute range of temperature for the State being 86.8.

Nearly all of the lowest temperatures reported occurred between the 16th and 20th, during the prevalence of a severe cold wave.

The greatest daily range of temperature, 66, occurred at Elko on the 20th, and the least daily range, 6.5, at Eureka on the 14th.

FEBRUARY.

A summary of the weather conditions during the month, compiled from reports received from twenty-three stations, shows that the mean temperature for the State, 33.6° Fah., was slightly colder than the average February temperature, 36.4. Eldorado Cañon, in the extreme southeast portion of the State, reported a temperature of 75.2 on the 28th, the highest for the State. The lowest temperature, 11° below zero, occurred at Elko on the 1st, making the absolute range for the State 86.2°. The weather was generally clear. It was coldest in the northern part of Eureka County, in the vicinity of Beowawe, and was warmest in the southern part of Lincoln County, around El Dorado Cañon, the mean monthly temperature at the latter place, 55.2, being about 3 degrees warmer than that of San Francisco and nearly 5 degrees warmer than that of Sacramento, Cal.

Precipitation (including rain and melted snow) was reported from twelve stations, six of which in the extreme western and six in the northeastern and eastern portion of the State, the average fall for the State, .37 of an inch, being but little more than half the average for the same month last year. The largest amount of precipitation which fell at a single station in any twenty-four consecutive hours was .64 of an inch at Ely, on the 15th. Pioche reported the largest monthly rain and snow fall, .79 of an inch. Although 26 inches of snow fell in the southern part of Elko County and 12 inches in the northeastern part of Lincoln County, yet Pioche is the only station at which snow was reported as being on the ground on the last day of the month.

MARCH.

The weather was generally clear and warmer than usual. The mean temperature for the State, 44.1, as deduced from reports received from twenty stations, was 2.5 degrees higher than the average March temperature. The highest temperature, 85.1, occurred at El Dorado Cañon, in Lincoln County, on the 29th, and the lowest temperature, 12° above zero, occurred at Elko, Elko County, on the 31st, and also at Wellington on the 19th, making the absolute range for the State 73.1°.

Unlike the preceding month, very heavy rains fell generally throughout the State, particularly in Douglas, Lyon, and Ormsby Counties; also in the southern part of Washoe, and the southeastern part of Elko County. The monthly rain fall at some of the stations in the above-named counties was unusually heavy for this time of year. Although snow fell in Humboldt, Elko, Eureka, White Pine, Douglas, and Lincoln Counties, yet nearly all of the precipitation reported occurred as rain.

APRIL.

The past month will long be remembered as an exceedingly dry and generally windy one; the average temperature for the State, 53.5, as computed from twenty-four reports, was about normal; the days were generally clear to fair. El Dorado Cañon reported the highest temperature, 100.2, on the 26th, and Eureka reported the lowest temperature, 15.5° above zero on the 18th, making a total range for the State of 84.7°. The highest temperatures nearly all occurred during the warm period of the 24th to 27th, while the lowest temperature occurred from the 14th to 18th.

The rain fall was greatly deficient at all stations except Burner's Ranch, in the southeastern portion of Elko County, and at Pioche, Lincoln County. The average for the

State, .45 of an inch, is less than the normal. At the majority of stations observers reported crops of all descriptions suffering greatly from the persistent drought. Very few stations reported any snow-fall during the month, and when it is considered how little snow yet remains in the mountains the prospects are discouraging to agriculturists and mill men.

MAY.

The remarkable features of the weather during the past month were the heavy storms of the 5th to the 8th, and 15th to the 17th, the remainder of the month being attended with fine spring-like weather. The storm on the 5th, which was general throughout the State, is the heaviest on record for the past ten years, and was characterized by unusually cold weather and very heavy rain-fall in all sections. The mean temperature, 57.8, was a trifle below the average. The warm periods were from the 24th to the 29th, the highest temperature for the State, 106, occurring on the 28th and 29th at Eldorado Cañon. There were two cold periods, from the 6th to the 8th and from the 15th to the 17th. The lowest temperature reported, 20 degrees above zero, occurred at Wellington on the 8th, and also at Ruby Hill on the 16th. The total range of temperature between the warmest and coldest stations was 86 degrees.

The rain-fall throughout the State was greatly in excess of the average, and was particularly so in the northern and western counties. The long-continued drought which threatened this section of the country for some time past has at last been broken; the aspect of the country has been entirely changed, and crops of all kinds have been materially improved. The prospects are at present more encouraging than they have been at any time this season.

JUNE.

The month was attended with fine, clear, pleasant but rather dry, weather, particularly so in the central and southern counties. There were no general storms during the month, the only atmospheric disturbances being in the shape of thunder and hail storms in different parts of the State. The mean temperature for the State, 70 degrees, was slightly above the normal for this month. There were two very warm periods, from the 24th to 26th, and from the 29th to the 30th. The highest temperature for the State, 110, was observed at Eldorado Cañon on the last day of the month. Between these two warm periods there was a cold one, from the 27th to the 28th. The lowest temperature reported was 30.5, at Tuscarora, on the 2d, making the absolute range of temperature for the State 79.5 degrees.

The average rain-fall of the State for this month indicates a deficiency of .10 of an inch. The rain-fall was heaviest in Elko and Douglas Counties and least in Lincoln County. The effect of the drouth is again being felt in all sections; farmers and millmen complain of the scarcity of water in the streams, which are lower now than for several years past.

JULY.

The weather during the past month has been unusually warm in all sections of the State; there was a very large percentage of sunshine, each station having an average of a little over twenty-four clear days. During the last few days of the month smoky and hazy weather prevailed to a considerable extent all over the State. Two well-defined warm waves passed over the State, the first from the 30th to the 5th, and the second, which was by far the most intense, from the 27th to the 30th. Nearly all of the highest temperatures reported occurred on the 29th.

The mean temperature for the State, 76.1, is only .5 of a degree higher than the average, but the number of stations which reported maximum temperatures above 100° this month is far greater than that reported during the same month last year. The temperature ranged from 119 at Eldorado Cañon, on the 27th, to 36.0 at Elko, on the 16th, or 83°.

Precipitation.—There were no general and but very few thunder and hail storms during the month. The rain-fall, which was very small and much below the average, was very unevenly distributed, and fell chiefly in the southwestern part of Elko County, central portion of Esmeralda County, and in Lincoln County. The total absence of rain in the remainder of the State has greatly injured crops of all descriptions. Farmers are complaining of lack of water in streams and springs, and predict a hard time for themselves and the cattlemen. Cattle all over the State are suffering from this disastrous drought. Of twenty-nine reporting stations this month, only five reported rain, while during the same period last year rain fell at nineteen out of a total of thirty-three stations, and was well distributed.

AUGUST.

The temperature during the past month was about normal. The mean temperature for the State, 73.2, is only .9 of a degree lower than that of the same month last year. The atmosphere was generally smoky and hazy all through the month. The hottest monthly mean temperature, 95.5, is that of Eldorado Cañon, and the coldest monthly mean, 62.0, at Ely. There were two warm periods, the first from the 1st to the 3d, and the second from the 14th to the 16th. The majority of the lowest temperatures recorded occurred during the cold period of the 18th to the 20th. The highest maximum temperature for the State, 117.3, occurred at Eldorado Cañon, and the lowest minimum temperature, 29.0, occurred at Elko on the 29th. The range between the two extremes for the State is 88.3 degrees.

Precipitation.—The disastrous drought was broken in portions of Eureka and Elko Counties, in Esmeralda, Nye, White Pine, and Lincoln Counties, but still continues in other counties. Rain fell at thirteen out of a total of twenty-eight stations, with an average rain-fall for the State, this year, of 1.06 inches, which is .45 of an inch more than that of the same month in 1888. Thunder-storms were frequent at Belmont, Nye County, and Pioche, Lincoln County, and were attended with heavy rain-fall. Frosts occurred at Crane's ranch on the 20th, at Pioche on the 29th, and at Ruby Hill on the 20th, doing little damage. The supply of water for irrigating and milling purposes is still very short all over the State.

SEPTEMBER.

September will go down in the meteorological annals of Nevada as an exceedingly dry and comparatively cool month. There was an average of twenty-three cloudless, four partly cloudy, and four cloudy days for each station. The mean temperature for the State, as deduced from twenty-three monthly reports, 61.7, is nearly 5 degrees below the normal, and about 10 degrees cooler than that of the same month last year. Eldorado Cañon reported the highest temperature, 110 degrees, on the 6th, and also the highest mean maximum temperature, 97.4. The lowest temperature for the month, 13 degrees above zero, occurred at Elko, which station reported also the lowest mean minimum temperature. There were two warm periods during the month, the first from the 3d to the 7th, inclusive, and from the 28th to the 30th, inclusive, and two cold periods, from the 11th to 14th and 22d to 24th, respectively. The atmosphere was smoky and hazy in many portions of the State, owing to extensive forest fires which were raging during the month, causing a great loss of timber. Frosts were reported from a number of stations throughout the State on the 12th, 13th, 14th, 24th, and 25th, doing little damage to vegetation.

Precipitation.—Excepting a few favored localities, the effects of the terrible and long-continued drought were felt all over the State during the month. Rain fell this year at only seven out of a total of twenty-four stations, principally in Elko, White Pine, Nye, Esmeralda, and Lincoln Counties, while this month last year rain was reported from twenty-three out of twenty-four stations, and was well distributed. There were no general or extensive storms during the month. On the 19th and 20th thunder storms, accompanied with rain, occurred in the above-named counties. Many mills have shut down, owing to the scarcity of water in rivers all over the State, and will remain so until November, unless heavy snow-storms occur before then. Cattle-men are despondent. Cattle are in such condition that an inclement winter will kill thousands of them, and if the coming winter is an open one, with but little snow, they will starve next summer. The average rain-fall per station was .55 of an inch. The largest amount of precipitation which fell at any one station during the month was 2 inches, at Pioche. No snow fell during this month.

OCTOBER.

The temperature during the month was about normal all over the State. The average, as deduced from twenty-six reports from all over the State, is 52.2. There was an average of ten cloudless, nine partly cloudy, twelve cloudy, and six rainy days per station. The highest temperature reported was 103, at Eldorado Cañon, on the 4th, and the lowest temperature was 14 degrees above zero at Ely, on the 28th. There was a well-defined warm period from the 4th to the 6th. The highest temperature at nearly all stations occurred on the 4th. The three last days of the month were very cold all over the State. The extensive and destructive fires which were raging during September and part of October, obscuring the atmosphere to a great extent, were extinguished by the general rains during the latter part of the month. Frosts were general all over Nevada on the 8th, 9th, 10th, 11th, and from the 24th to the 31st.

Precipitation.—The terrible drought has at last been broken. The rain-fall during the month was generally unusually heavy in all counties except in the southeastern portion of Humboldt County, and in Storey and Churchill Counties. It was well distributed throughout the State, as will be shown by the fact that an average of 1.48 inches of precipitation fell at every reporting station in the State. The average rain-fall for the State, 1.48, is 1.11 inches higher than that of October, 1888, and .56 inch in excess of the normal. Rivers and streams throughout Nevada have risen somewhat, but are still low. Some of the mills in the mining regions have resumed work. The general aspect of the country was considerably changed by the generous rains. Nearly all of the precipitation reported was in the form of rain. Snow fell at Tuscarora, Burner's Ranch, Eureka, and Virginia City, ranging in amount from 2 to 11 inches. There was no snow on the ground at any of the stations on the last day of the month. Taken all in all, the weather conditions during October have been very favorable, and farmers, cattle, and mill men are in consequence jubilant, the prospects being better at present than they have been for several months past.

STATEMENT OF T. D. PARKINSON, OF FAIRLAWN.

[In relation to the water storage system of the Nevada Land and Cattle Company.]

In response to the committee's request I furnish a report of our works and what had been accomplished. The report it is hoped will be of practical value. A brief history of our works is embodied, as it is (as Senator Stewart reports) the first step taken in America for the reclamation of arid lands by water storage. I therefore submit the following:

Squaw Valley is located in Elko County, Nev., at an elevation of 5,100 feet above sea-level. The valley lands embrace an area of about 30,000 acres. Like the generality of valleys lying within the State, the soil is exceedingly fertile, but entirely unproductive on account of the aridity of the climate.

The valley is surrounded by high mountains, which are covered with snow for about six months in the year. During the spring and early summer months large bodies of water, created by the melting snow, course through the various channels in the mountain cañons and, concentrating in Willow and Rock Creeks, are exhausted in the Humboldt River and its "sink."

The difficulty this State and many other arid districts labor under for the cultivation of its soil is the light rain-fall that takes place in the spring months, and the exhaustion of its waters from the melting snow at a period too early for irrigation. Nature, however, seems to have provided a way to overcome this difficulty in placing in its numerous cañons natural sites for dams whereby the husbanding of water by storage enables the apparent worthless land of its valleys to be made productive by irrigation.

At the point where the Willow Creek debouches into Squaw Valley is a natural reservoir embracing fully 2,000 acres. At its outlet is a narrow defile in the foot-hills of the mountains. The rock bluffs at this point are about 100 feet in height and about 175 feet apart.

The Willow Creek Dam and the storage reservoir thus described presents these features:

As this enterprise was entirely experimental, and probably the first of its kind in America, the uncertainties attached to it were too great to justify a very extensive outlay.

In the construction of the dam no masonry was used; the retaining wall is simply loose rock dumped into the cañon from the adjoining bluffs, the rock allowed to take its natural slope, forty-five degrees. The upper face of the revetment is covered with a sheathing of plank three inches in thickness, the joints of which are securely calked with oakum, and the face then covered with heavy felt asphalt roofing.

The sheathing laid horizontally is securely spiked to 8 by 8 timbers placed 4 feet apart. To guard against the danger of an undermining of the foundation, which is the most serious difficulty in dam construction, particularly where great depth of water is obtained, a pit was sunk through the clay to solid rock, thus joining the two bluffs.

The expense attending the construction of this pit, on account of the large body of water encountered with quick-sand, was great, and its abandonment at times thought advisable, which idea I am happy to state was not carried out. The bed-rock having been secured in this pit, the sheathing before spoken of was started upon it, and carried up to the foot of the rock embankment and thence to the top of the dam. As a question may arise as to the durability of these foundation timbers, I will state timber subjected to moisture alone, free from air, will remain intact for years.

The present size of the dam (September, 1889) is as follows:

Height from bottom of cañon	Feet.
Width on top	50
Width of rock bank at base	20
Length on top	120
Length at base	175
	125

The sheathing is covered by earth to a height of about 20 feet and carried back about 100 feet, making the entire width of dam at base about 220 feet. The cost of dam, tunnel, and gates was about $35,000.

The Tunnel Waste-Gates and Supply-Gates.—Seldom, in the construction of enterprises of this kind, have been found so many natural advantages as possessed by the site of the Willow Creek Dam.

In a country like that of Nevada, where rain seldom falls, water spouts or "cloud bursts" frequently occur, and to guard against any disaster that might occur by their visitation, water-ways must be constructed to take the overflow. Again, in our case, the spring freshets occasioned by the melting of snow on the plains and mountains is severe, making a mountain torrent of Willow Creek. The subjection of our dam to this sudden pressure is objectionable, and to allow the water to accumulate slowly is advisable. Few dams, however, can allow this, as the surplus water can only be discharged through weirs over the dam. The north bluff of the Willow Creek Cañon, consisting of a spur of the mountain only 80 feet in width at the base, a tunnel was constructed through it with a cross-section of 10 by 10 feet with its base on a level of that of the base of the dam. This channel, it will be readily seen, is amply sufficient for the greatest flood that might occur. The area covered by this water storage, with a depth of 50 feet at the dam, embraces about 500 acres; as the bottom of the reservoir is a plane surface the average depth can be assumed at 25 feet, thus containing 544,500,000 cubic feet of water, sufficient to cover 12,500 acres 1 foot in depth.

Irrigating capacity of this body of water.—No definite rules have as yet been established in irrigation to form any base for calculating the amount of water 1 acre of land requires per season to produce a crop of grain or hay. The system of producing crops by irrigation, though now carried on extensively in California, may be said to be in its infancy. Each irrigating district has been found to have its peculiar advantages or disadvantages, but so wide has been the difference in the amounts of water required per season no uniform base for calculation can as yet be established. This can be readily understood when it is apparent that in such calculation character of soil, natural moisture, humidity and evaporation must be taken into consideration. Practical experience alone can only be the guide.

In our case it is only after a series of irrigating seasons can such a base be determined upon. This conclusion was forcibly impressed upon me, from my experience in the irrigation of our alfalfa fields this past season, as this question of water supply is all important to the success of our enterprise. I will briefly give my experience in the irrigation of the Rock Creek Ranch this past season, leaving it to the minds of those interested to draw their deductions. With this relation could also be given the experience of the larger irrigating enterprises of California which are familiar to me, but the subject is too exhaustive to enter into in this report.

Rock Creek ranch is situated about 10 miles from the Willow Creek dam, about 175 feet below the base of the reservoir. The water taken from the reservoir follows the channel of Willow Creek 2 miles, thence by ditch 8 miles, to the Rock Creek Valley. The flowing capacity of the completed portion of this ditch at present is about 3,333,000 cubic feet of water per twenty-four hours, though but 1,500,000 cubic feet was allowed to flow through it last year. The irrigable land lying under the Willow Creek reservoir embraces an area of about 15,000 acres.

The soil of Rock Creek Valley is of the richest character, comprising the deep black alluvium of the low-lands and the yellow, gravelly loam of the mesa or upland. The former is well adapted for the cultivation of the finer grasses and cereals, while the latter, being of a warmer nature, is better fitted for alfalfa. The annual precipitation of moisture in this State is light, and in Squaw Valley rain seldom falls, though snow is sometimes found 1 foot in depth; it falls in the winter when the ground is frozen and incapable of taking the moisture by its melting. The mesa ground in particular is very dry, the moisture seldom penetrating 8 inches below the surface.

At the commencement of the irrigating season, I was greatly surprised to find the amount of water that was being used on our fields, but when the dryness of the soil was taken into consideration, with the rapid evaporation that must be going on under a summer sun, this apparent loss was accounted for. It was with no little anxiety the daily decrease in the reservoir was witnessed, and grave fears were entertained that a storage capacity could be obtained sufficient to warrant a large acreage of alfalfa. On estimating the daily flow distributed per acre, it was found to be so enormous investigation was made, and on an examination of wells, sloughs, and other depressions in the neighborhood of the irrigating sections, water or moisture was found within a few feet of the surface where before 8 to 10 feet it was encountered.

In one instance a well was sunk 50 feet before water was encountered, the position of the well being about 1 mile from the irrigating fields. In ten days after the irrigation of a field about one-half mile distant the water in the well rose to within 8 feet of the surface and remained in this position for months after irrigation had ceased. It is a well-established fact that the soil when once thoroughly moistened will retain its moisture for a long period of years, the surface alone becoming dry. This is proven to be a fact in the great irrigating plains of California, where formerly nothing could be produced, now yield large crops of alfalfa without irrigation.

Evaporation.—In an arid climate like that of Nevada, where there is but little humidity in the atmosphere, evaporation is excessive, shallow bodies of water evaporate faster than those of greater depth. From this we may expect less proportionate loss of our water storage, as greater depth is attained by the raising of the dam. The greatest loss by evaporation is found in the irrigation of new land. The mesa land of the Rock Creek Valley, when turned by the plow, resembles an ash-heap, and exposed to the temperature of a summer sun retains heat sufficient to often blister the feet of the plowman. This excessive evaporation takes place only during the first year of alfalfa cultivation. On the second year the surface of the ground has become solid and compact, the plant in the first season being seldom cut, the natural moisture of the ground is retained, and before irrigation is required the plant has obtained sufficient growth to protect the ground from the sun, and thus lessening the amount of evaporation in a great degree.

Though the irrigating capacity of the Willow Creek reservoir when full will, no doubt, in time be far beyond the present estimate, placed at 6,000 acres, which at the best can be but approximate. It has not been deemed advisable by the owners to advance the irrigating fields yearly beyond a certain limit, that the great basin, naturally very dry, in which their fields are located, may become first thoroughly moistened, thereby enabling the alfalfa, which is the principal crop raised, in case of drought or shortage of water, to find natural moisture sufficient to survive a dry season.

Present area under cultivation.—There are at present about 1,500 acres of land lying under the main canals that are seeded to alfalfa, or grain and lands ready for cultivation. On account of the droughts which have occurred for the past two years, the progress of the work has been considerably retarded, yet the result of prosperous years has been so satisfactory—ample proof has been presented—that the enterprise entered upon as an experiment is no longer one of doubt, but a success, and plans are being carried out to complete the work of reclamation to the full extent of the water storage and to the construction of another dam.

At the present date there has been constructed upon this ranch about 22 miles of main supply ditch, the size of which average 3 by 12 feet, with a carrying capacity of about 3,333,000 cubic feet per twenty-four hours, sufficient to cover 300 acres with 3 inches of water per twenty four hours.

The chief crop that is cultivated upon this ranch is alfalfa, which is fed to beef cattle and for winter provision for breeding stock. Grain is also raised, but only for farm purposes. Two crops of alfalfa are produced annually, yielding for the season about 4 tons per acre, though on choice ground, when great care has been used, as high as 4 tons per cutting has been obtained.

Vegetables of all kinds, suited to the latitude, are produced in abundance, a failure in the crop being unknown; as high as 550 bushels of potatoes have been gathered in one season upon 1 acre of land.

STATEMENT OF J. W. HAINES, OF DOUGLAS COUNTY.

[On behalf of a committee of citizens.]

The following facts are submitted in regard to our irrigating interests as well as the same interests in Churchill, Lyon, and Ormsby Counties, through which Carson River flows. It is the source from which our lands are principally supplied with moisture. Our valley, known as Carson Valley, in Douglas County, Nev., has an area of 25 miles in length, and an average width of about 10 miles. Carson River heads in Alpine County, Cal. It has there area of about 5 miles in length, and from 3 to 4 miles in width. In Churchill and Lyon Counties, within this State, it has an area of about 60 miles in length, and from 4 to 10 miles in width. In Ormsby, the area is about 4 miles in length, and 1½ miles in width. About one-fourth of the above area is now being irrigated, using less than two-thirds of the water required for a full crop. Therefore, the loss is equal to one-third on the land now under cultivation. We think that with a proper amount of moisture we can safely say that all of the above are capable of producing first-class crops of wheat, from 20 to 30 bushels per acre; oats, 35 bushels; barley, 30 bushels; alfalfa hay, from 4 to 6 tons; timothy, 2½ tons; clover and other grasses, 1½ tons per acre. Potatoes and other root crops yield equal to or superior in quantity and quality, when cultivated with the same care and attention that they receive in the Eastern States.

We have an abundance of water falling during the twelve months to supply us with all the water required for all purposes on the above specified area of land to enable us to raise a first-class crop yearly. We have first-class locations for reservoirs, and by utilizing them for impounding surplus waters during the wet season, many thousands of acres situate in the low hills and adjoining valleys may be brought under cultivation and add to the resources and wealth of our State. These waters may be held when safely impounded, from June 1 to September 1, to be utilized when required at least three or four months in each year. Col. Lyman Bridges, a civil engineer of the U. S. Geological Survey, will report fully on our great advantages in the way of storing waters to be used during the three months above specified. We usually have sufficient water to furnish all the moisture required up to June 1 for all the area specified in the different counties. In excess of what we now have we require the storing of water in the available localities which our mountains possess. The area of good lands for farming purposes could be increased many thousand acres if they were made available by the use of water so impounded.

STATEMENT OF DWIGHT E. HOLLEY, SECOND LIEUTENANT, FIRST INFANTRY, U. S. ARMY, FORT McDERMIT.

The soil of this part of the country is excellent, and when properly irrigated is very fertile, while without irrigation nothing thrives upon it but sage-brush. The valley of Queen River is some 60 miles in length by 12 to 16 miles in width. No land except that bordering on streams is cultivated for any purpose on account of the scarcity of water during the irrigating season. The valley slopes gently towards the south. The fall from the foot-hills on either side to the center of the valley is from 20 to 50 feet.

At the extreme northwestern part of the valley is Oregon Cañon, which would be capable of storing a large quantity of water. On the western side of the valley, and nearly west from this post, is McDermit Cañon, the mouth of which is about 70 yards in width, and the sides are vertical walls nearly 200 feet in height. The cañon widens towards the west, and has an average width of perhaps 200 yards. Queen River Cañon, in which this post is situated, has a narrow point about a mile east of the post. At this narrow point the cañon is some 30 yards in width, with rocky walls of about 100 feet in height. East of this the cañon widens considerably. In ordinarily moist seasons both McDermit Creek and Queen River furnish by far the greater part of the water supply for the southern half of the valley.

While it is impracticable to estimate the quantity of water that could be stored, or the amount of land that could be reclaimed, it is evident even from a casual observation of these cañons that a sufficient acreage of land could be reclaimed by storing this waste water to amply repay for the expenditure of constructing reservoirs at the points mentioned.

CALIFORNIA DIVISION.

San Francisco, Cal., *August* 26, 1889.

The committee met pursuant to call of the chairman.

Present: Messrs. Stewart (chairman), Jones, and Reagan; also Director Powell.

The **Chairman**. The Committee on Irrigation of Arid Lands of the Senate is here to take testimony of such witnesses as may desire to appear. We wish information on the subject of irrigation, how it is conducted in California, and how it can be facilitated. We understand that you have had a good deal of experience in this State, and that you have made preparation to furnish us the desired information.

STATEMENT OF M. M. ESTEE, OF SAN FRANCISCO.

Mr. Chairman and gentlemen, the State Board of Trade some months ago received, and I also received, a letter from Mr. R. J. Hinton, irrigation engineer of the U. S. Geological Survey (who of course voiced your wishes), asking for information. Pursuant to that request, and pursuant to the request made by you, Mr. Chairman, at a previous meeting of the board of trade, it appointed a committee to take into consideration the questions which you are now investigating. That committee, composed of nine members of our board, and representing different parts of the State, made a report in writing, which is now in print. It represents, we think, the views of the best-informed people of this coast, so far as it goes.

This report was not intended to be a "boom" pamphlet, nor was it intended to be full of technical knowledge. That comes from the surveyors, and from the distinguished people whom you will examine. It was intended to show a bird's-eye view of California, so far as it relates to the question of irrigation—to present the necessities of our people for irrigation, the extent of our water-shed, the amount of water we have for that purpose, the amount of land that can be practically and successfully irrigated, the results of irrigation so far as it has been practiced, and also the necessity of having certain surveys made whereby catchment reservoirs may be established in certain places. That report I now present to the committee.

RECLAMATION OF ARID LANDS BY IRRIGATION.

The questions presented are:

What is the physical condition of California so far as it relates to irrigation?

What amount of irrigable land is there in the State?

What amount of water can be obtained for the purpose of irrigation?

What are the advantages of irrigation?

In this connection, does irrigation pay?

What is the condition of irrigation as at present practiced in California, and what interest has the National Government in the subject of irrigation on the Pacific coast and in relation to all that extent of country known as the "arid region" which lies west of the Missouri River?

I.—THE PHYSICAL CONDITION OF CALIFORNIA AND ITS ADAPTABILITY TO IRRIGATION.

California lies between the thirty-second and forty-second degrees of north latitude; it has a coast line of over 900 miles, and in width is from 150 to 200 miles, and has an area of 157,801 square miles. Two ranges of mountains extend north and south through the whole length of the State. The coast range, which lies just back of the ocean, parallels its shore line from one end of the State to the other. In many places it is but a range of low hills covered with timber and open pasture lands, while in other places great valleys cut wide swaths through the hills to the sea, like the Salinas Valley, Santa Inez and Santa Ana Valleys. But generally this range of low mountains or high hills forms a continuous western wall from the northern boundary of the State to the Mexican line. In some places this range of mountains rises in height to from 4,000 to 6,000 feet, and is cut up in every direction with small but fertile valleys, fed by cañons which carry living streams of water, flowing both inland and to the sea.

The other and principal range of mountains is the Sierra Nevadas. This mountain range also extends the full length of the State, north and south, and for the greater part forms its eastern boundary. Its sides are covered with timber and its summits with perpetual snows. Its average height is about 8,500 feet, while its loftiest peaks are Mount Shasta, in the extreme northern end of the State, which rises 14,440 feet above the level of the sea; Lassen Peak, which is 10,557 feet in height; Mount Whitney, which is 15,000 feet in height; and Mount San Bernardino, which stands a solitary sentinel at the extreme southern end of the State, and which is 11,000 feet above the sea-level. Both of these mountain ranges are "storm-gatherers." Along the Coast Range the rain is excessive in winter; and, as a rule, heavy fogs prevail during the summer months.

In the Sierra Nevada range, the rains are also very heavy in winter. In some places, for instance at the base of Mount Shasta, there has fallen as much as 80 inches of water in a single season. The depth of snow in winter on this range of mountains averages from 8 to 20 feet.

Between these two mountain ranges is the great valley of California. In the central and northern part of the State this valley is divided into the valley of the Sacramento and the valley of the San Joaquin. These valleys are in width from 30 to 75 miles, and their combined length is 450 miles. South of these valleys lies another one of surpassing beauty, which extends through the whole length of Los Angeles and San Bernardino Counties, and in which irrigation has recently been largely and most successfully introduced.

II.—THE PECULIAR TOPOGRAPHICAL ADVANTAGES OF CALIFORNIA FOR IRRIGATION.

The advantages for irrigation will be noted when we observe that nearly every stream heading in the Sierra Nevada Mountains comes from the snow belt, and is supplied by the melting snows, which continue until July or August of each year.

The two great valleys before referred to are almost on a sea-level. Sacramento, which is 89 miles from San Francisco, has an altitude of but 30 feet. Bakersfield, in Kern County, which is distant from San Francisco 314 miles, is 282 feet above sea-level. Redding, in the north, and which is nearly at the head of the valley of the Sacramento, is 299 miles from San Francisco, and has an altitude of 556 feet. Add to this the fact that in these great plains there is very little rolling land, that there is an uniform trend of the surface of the ground from the foot-hills of the Sierra Nevadas west to the Sacramento and San Joaquin Rivers, and we must note the peculiar advantage of this country for irrigation. Perhaps there is no country in the world where so much land can be regularly and profitably irrigated without making any serious changes to the surface of the land as in California. These conditions of things are found to exist in all the great valleys of the State. The two valleys of the Sacramento and the San Joaquin, according to General Alexander, alone cover an area of about 12,000,000 acres of irrigable land. The drainage of this vast country is effected through the Sacramento and San Joaquin Rivers.

III.—THE PECULIAR PRODUCTIONS OF CALIFORNIA.

The peculiar productions of California is another reason why irrigation will soon be a great feature in our agriculture. California is situated quite differently from any other Pacific coast State or Territory. Indeed, many of the productions of its soil are peculiar to it. For instance, there are planted in California, according to authentic data, 50,000 acres in orange and lemon trees; all these must be irrigated. Last year there were shipped East for sale 1,850 car-loads of oranges and lemons, and about 600 car-loads were consumed at home. There are over 20,000 acres of olive trees planted in California. Most of these are not bearing; some of them are; but enough are in bearing to show that this remarkable fruit grows here with wonderful luxuriance and bears abundantly. The olive thrives nowhere else in the United States. Last year there were produced in this State 3,400 cases of olive oil, and of the very best quality. There are 140,000 acres of land now planted in grape-vines in the State of California; and for the year 1888 there were produced 18,000,000 gallons of wine, 20,500,000 pounds of raisins, and 1,000,000 pounds of dried grapes. These vines are the European varieties, which will not grow where the ground freezes; and they are not successfully cultivated in any other part of the United States. Both our wines and raisins are successfully competing with European productions. There are about 1,000,000 prune trees growing in California, outside of the acreage planted during the winter of 1888-'89. This most-needed fruit is not produced in the United States except on the Pacific coast.

In 1888 California produced 7,000,000 pounds of prunes; and it will be observed that there were imported into the United States for the same year, for consumption in America, over 70,000,000 pounds. In a very short time, California will be able to supply the American market. There are 300,000 fig trees planted in California; and the figs produced here are of the very best quality. The trees grow luxuriantly and thrive well. It must be admitted that it is of infinite importance to our country to encourage the production at home of all these articles which otherwise we would be compelled to import.

In this connection, it may be added that California is a great nut-producing country; the almond grows well and produces well. There are now over 25,000 acres of land planted in almond trees, and this acreage is yearly increasing. In 1888 California produced 180,000 pounds of almonds. The so-called English walnut is also a most valuable California nut, and grows well in nearly all sections of the State where the soil is deep or irrigation possible. No mention is made of the peach, the cherry, the pear, the apricot, the nectarine, the plum, or the apple. All these fruits are grown in California in such abundance that the mention of them seems unnecessary. Add to these fruits the whole berry family, conspicuous among them the strawberry, the blackberry and the raspberry, and we may well observe the unlimited capabilities of this State for fruit culture.

IV.—THE FACILITIES WITHIN THE STATE OF CALIFORNIA FOR AN AMPLE WATER SUPPLY FOR IRRIGATION.

This is the most vital question we have to consider, because, however much irrigation may be needed in this State, if there is not an ample supply of water, it would be more than useless to attempt to carry on any extensive system of irrigation. Owing to the peculiar topographical situation of California, and the fact that for over 900 miles it borders the Pacific Ocean, the great ranges of mountains before referred to and their high altitude, there are a large number of living streams of water flowing from both these ranges of mountains into the valleys below, and which make the water supply most abundant. Two of these streams are navigable rivers, namely, the Sacramento and the San Joaquin—the Sacramento for fully 200 miles and the San Joaquin for about 100 miles. On the extreme southern boundary of the State is the Colorado.

V.—THE NAMES AND CHARACTER OF THE STREAMS THAT MAY BE UTILIZED FOR IRRIGATION.

The principal rivers which flow into the Sacramento from the east, and whose tributaries reach the highest altitudes in the Sierra Nevada Mountains, are the Feather, Yuba, Bear, American, and Cosumnes Rivers. There are a large number of smaller streams which head in the snow belt of the Sierra Nevada Mountains, and which flow down through the foot-hills across the Sacramento valley and empty into that river. On the west side of the Sacramento Valley there are no large rivers which are tributaries to the Sacramento; but there are a large number of creeks which have a very extensive water-shed and which bear a great amount of water down their courses during the winter. Some of them are perennial streams. Among the larger of these streams flowing from the Coast Range east to the Sacramento are Putah, Cache, Stoney, and Cottonwood Creeks.

The San Joaquin Valley is watered by a number of rivers, all of which have their sources in the great snow belt of the Sierra Nevadas. Chief among these rivers are the Mokelumne, Calaveras, Stanislaus, Merced, Tuolumne, San Joaquin, Kaweah, Kings, and Kern Rivers; all of these flow down into and through the San Joaquin Valley. The combined water-shed of these rivers is 38,500 square miles.

The Mojave River lies south of the San Joaquin Valley, and contains a large amount of water which can be successfully used for irrigation on what is known as the Mojave Desert. The Mojave Desert is a desert only in this sense: there is not rain-fall sufficient to make grass and crops mature; but the soil is rich, the climate genial, and with water almost anything will grow with luxuriance. The capabilities of this river are more fully referred to hereafter. South of this and forming the extreme southern boundary of the State is the Colorado River, which, with the exception of the Columbia, is the largest river on the Pacific coast. It bounds the State of California on the south, and it borders what is known as the Yuma Desert. Wherever water has been applied on this desert the soil has proven productive, instance Indio and other points. Much of this desert is below the level of the river, and some of it below sea-level; it is nearly all susceptible of irrigation, and by bringing water upon it would make this one of the most fertile places in the world. It is estimated that this river will successfully irrigate 1,000,000 acres of land; the most of which that can be thus irrigated is public land and is now of no value.

VI.—The Rain-fall in Different Parts of California.

In considering the amount of water that can be appropriated in California for the purposes of irrigation we must take into view the average amount of rain-fall in the different parts of California, and what portions of the State most need irrigation.

The average annual rain-fall at San Francisco is 23.5 inches. In the foot-hills of much of northern and central California the average rain-fall exceeds 30 inches, while in the great valleys of California it is much less, varying in different localities, but generally increasing as you go north from the lower part of the San Joaquin Valley, where it is about 7 inches, until you reach Shasta at the upper end of the Sacramento Valley, where the annual rain-fall is 35 inches. At San Diego it is 9.2 inches. In California fair crops can be raised from a rain-fall of from 10 to 12 inches, if it comes at the right time, but it rarely comes that way. The trouble is that the annual rain-fall is not uniform, that is, uniform one year with the other. Some years there will be an abundant rain-fall, and another year there will be altogether too light a fall of rain to make good crops.

To illustrate, at Fort Redding one year the rain-fall was 37.4 inches, while the next year it was 15.9 inches. At Sacramento the rain-fall one year was 27.9 inches, while the next year it was but 12 inches. At Fort Tejon one year it was 34.2 inches, while the next year it was 9.8 inches. Clear Lake had one year a rain-fall of 66.7 inches, and the next year it had only 16.2 inches. Visalia one year had 10.3 inches of rain, while the next year it had but 6.7 inches. These are extreme cases and only referred to as an illustration, but it shows that everywhere on the Pacific coast there are years of drought and years of floods. It is true that in the northern and central parts of the State there is rarely a failure of crops; by summer fallowing and careful farming good crops are generally produced. In the coast counties north of Monterey there has never been a failure, though some years have been much better than others. South of Monterey, for the years 1868, 1869, 1870, and 1871, there was a noticeable drouth; stock-raisers were compelled to drive their stock to the mountains or drive it north. In the San Joaquin Valley very little hay and less grain was grown. Even the irrigation now practiced in that great valley would have been of infinite importance. From Tulare to San Diego in 1871 the country was almost barren of verdure, except in favored localities, there was no grass for stock; thousands of sheep, horses, and cattle were lost. It is so long since this occurred that we have almost forgotten it, but still it is an historical fact, and what has been once may be again. It is the part of wisdom to recognize the danger and provide against its recurrence. This could have been avoided if proper systems of irrigation had been introduced. Even now, should a drought occur, the irrigation that is practiced in the central and southern part of the State would largely protect the people against disaster.

VII.—The Area of Lands that can be Successfully Irrigated in California.

According to the survey made by General Alexander, and a report he afterwards submitted to Congress, the area of land in California which may be readily irrigated is about 7,650,000 acres. This does not include the so-called swamp and overflow lands. But should we include these and also include the low foot-hills in this estimate, there would be about 12,000,000 acres of irrigable land in the State of California. Nearly all the foot-hill country of the Sierra Nevada Mountains is not only irrigable, but is wonderfully productive when irrigated. This is now demonstrated in the counties of Placer and Butte, where irrigation is very extensively carried on for the purpose of fruit-raising. Practically only a small portion of this State as compared to its whole area can be irrigated. We should now add 1,000,000 of acres to the above estimate, which would include Mojave and Yuma deserts, Sierra and Honey Lake Valleys, making quite 13,000,000 acres of irrigable land in California.

The area of catchment or water-shed outside of the lands to be irrigated, and which forms a water-shed of the irrigable lands, is estimated at about 3¼ square miles to each square mile of land to be irrigated; and when we bear in mind the fact that this water-shed is most of it in high altitudes, where storms are excessive and snow falls to a great depth and remains for a large part of the year, it will be readily observed that if catchment reservoirs are made in the most favorable localities, and if the running streams are utilized, there is more than ample water in the State of California to irrigate every foot of land which is susceptible of irrigation.

VIII.—IS IRRIGATION ADVANTAGEOUS?

The advantage of irrigation is twofold: first, the water is applied at a time when it will do the most good, and when the ground is in such a condition that the grain or the fruit trees will get the full benefit of all the water that is run upon the land; and second, where irrigation is practiced there are no droughts. In countries where there is ordinarily an ample rain-fall, the crops often fail by reason of droughts. This arises from the fact that the rain falls in vast quantities, but at unpropitious times, when it does little or no good to the crops.

In California, from about the middle of May until the last of October, we have no rains. During this period grain is harvested.

The use of water is often more valuable for fruit growing than for small grains. We doubt whether the wheat fields of California will ever be irrigated, because fruit is more valuable and the irrigation of orchards is more readily accomplished than the irrigation of the small grains; and because, as a rule, in the great wheat-producing portions of California, irrigation for the purpose of producing one crop of cereals is not necessary. But California is especially a fruit-growing country. Its adaptability to almost all kinds of fruit is peculiar. Perhaps no country in the world is its equal; and in some of the great interior valleys of the State, and also in the foot-hill counties, successful fruit-growing can be made certain only by irrigation. With the orange and lemon, irrigation is a necessity. Where orchards require irrigation, it has been proved that to sustain the trees in their growth and fructification, water need not be put upon the land more than from three to five times during the summer and fall months. The practice is to run water in small ditches between the rows of trees through the orchard about once a month, commencing in June and ending in September. Then immediately after irrigating the ground, by allowing the water to flow through these small ditches, the practice is to put in the cultivator, stir up the ground anew, so that the evaporation will not be rapid, and the ground will not settle down and become hard. The land thus remains friable, and the trees grow with great rapidity.

The orchards and vineyards in the coast counties and in central and northern California have hitherto never been irrigated. Where the size of the grape is an especial and important factor, like in the making of raisins, the irrigation of the vines is advantageous, and especially where the vineyard is planted in very hot and dry situations, like at Fresno and Merced. Up to this time no grapevines nor orchards have been irrigated in any of the counties of Santa Clara, Alameda, Contra Costa, Solano, Sonoma, Marin, or Napa, and the fruit trees and the vines grow there with great luxuriance and produce abundantly; and yet in each of these counties vegetables and the smaller fruits, like strawberries, are now irrigated during some of the summer months.

IX.—THE AMOUNT OF WATER NECESSARY FOR IRRIGATION IN CALIFORNIA.

There will not be required the same amount of water for successful irrigation in California as is used in India. In India it requires about 1 cubic foot of water running every second to irrigate 200 acres of land to produce cereals. In Granada, Spain, where cereals are produced, 1 cubic foot of water running per second irrigates about 250 acres.

One inch of water running continually irrigates in southern California about 10 acres. Even less than this amount would be required in portions of central and northern California.

X.—THE RESULTS OF IRRIGATION IN CALIFORNIA.

Los Angeles and San Bernardino Counties are conspicuous illustrations of what irrigation can accomplish. Nothing can picture the change which has there been made by means of irrigation. A great plain, which once looked like a desert, is now covered with beautiful homes, surrounded with orange orchards and vineyards, dotted with towns and cities, which have grown up everywhere as if by magic. The population has more than quadrupled in a single decade. Lands which sold ten years ago at from $5 to $25 per acre now sell at from $100 to $1,000 per acre, and these prices seem to be fixed from what the lands actually produce. Nor is this condition of things peculiar only to southern California. In Placer County water has for some years been used for the irrigation of orchards and vineyards there planted. It is impossible to describe the change thus created. Orchards of every variety of fruits, from the orange and lemon to the apple, and vineyards of every rare variety of grape, and nuts of all known varieties grown in semi-tropical climates, and the fig and the olive, all seem to flourish in the foot-hills of Placer County; nor does the result in Placer County seem to be peculiar to that locality, for everywhere in the foot-hills of the Sierra Nevadas, where irrigation has been introduced, the result has been equally surprising.

The foot-hill country about Oroville, in the county of Butte, where water has been introduced, is no less conspicuous for its luxuriant tree-growth. Within the last four years 1,500 acres of orange orchards have been planted, and these trees seem to be thriving well. The oranges are rich in color, luscious in taste, and attractive as to size. This is mentioned only to show the effect of irrigation upon both the foot-hill and valley lands of the State of California.

More marvelous still is that section of country lying about half-way between the extreme northern and southern part of the State. We refer to Fresno. The writer of this has seen Fresno a veritable desert; it is now a garden of surpassing luxuriance and great beauty. Within the past few years a town has been built there, which has a population of over 10,000; the surrounding country is cultivated in everything the farm can produce. Indeed, Fresno County is to-day the great raisin-growing center of the State, and nearly every variety of fruit grows abundantly. There a beautiful orchard stands side by side with an alfalfa or grain field. Homes are literally hid away by the remarkable ornamental tree-growth which irrigation has caused. Ten years ago the lands of Fresno sold at from $3 to $20 per acre; now the same land with water on it sells at from $75 to $750 per acre. This is all due to irrigation. Kern County is another conspicuous landmark on the road to successful irrigation; more than 80,000 acres of land is being irrigated in that county. The production is generally alfalfa.

Everywhere in California during the summer months garden vegetables are raised by irrigation. In the fall, winter, and spring months in most parts of the State they require no irrigation, except such as they get from the natural rain-fall. So with strawberries; this fruit is universally irrigated. In Santa Clara County alone it is claimed there are 1,500 acres of land cultivated in berries, all of which are irrigated; and that there are over 500 acres cultivated in garden vegetables, which are also irrigated. Even in northern counties like Napa, where the annual rain-fall is almost three times as great as in some parts of southern California, strawberries, other small berries, and garden vegetables during the summer months are universally irrigated.

Without wishing to select any portion of the State to give it especial prominence in this report, yet it would seem both wise and necessary that the most conspicuous object lessons found in California, in the way of irrigation, should be particularly and exhaustively referred to. We do this for the purpose of illustrating what irrigation has done in the past, what it is doing now, and what its possibilities for the future are. Your committee has therefore selected, as special examples for this purpose, some portions of southern California and the San Joaquin Valley, where irrigation has been carried on for a great many years, and where it is now largely and most successfully adopted. And as this report is intended, in so far as we are able to do so, to place facts before the people both of our own State and the people of other sections of the country, as well as the committee of Congress which is soon to visit us, we have ventured to select the most marked and illustrious examples within the range of our knowledge to give more forcible expression to what is known upon this most interesting subject. Los Angeles and San Bernardino Counties are most conspicuous illustrations of what is being done in irrigation; and we therefore venture to present the following carefully-prepared yet conservative reports from those two counties, and also an equally interesting and conservative report from a part of the San Joaquin Valley.

XI.—Necessity for Irrigation in Portions of northern California.

The Sacramento Valley contains no lands strictly arid; but most of that great valley would be benefited by irrigation, and as to which the Government might well lend its assistance, at least to the extent of determining the water-storage supply or other means of irrigation.

Large areas of plain or bench lands, lying above the bottom lands of the river, are to be found in Shasta, Tehama, Butte, Colusa, and other Counties. They are all within reach of the water flowing down the Sacramento River and its lateral tributaries. Most of the streams emptying into the Sacramento from the Coast Range sink and disappear during the summer not far below where they debouch from the mountains into the open country; but at their sources there are large quantities of water and extended areas of water-sheds. It is believed that excellent facilities for water storage can be found on all these streams.

The creeks flowing from the Sierras, on the contrary, are generally constant and unfailing, though diminishing in quantity through the summer.

In Lassen and Modoc Counties, especially in Lassen, will be found an extended field of usefulness for Government work. There are few places to be found in all the regions to be examined by the Senate committee, covering an area of excellent lands, worthless without irrigation and invaluable with it, where all conditions are so favorable for immediate results as in Lassen County. Nature has built a reservoir in Lassen County called Eagle Lake, covering an area of 35,000 acres, and of great depth, in many places over 1,500 feet. A tunnel 7,000 feet long would tap the lake 12 feet below the surface; and, by an additional open tunnel of like length, the lake could be tapped 20 feet below the surface. It has a water-shed of over 400,000 acres in the regions of our heaviest rains and snow-fall. Its elevation is 5,115 feet.

Willow Creek was probably once its outlet, and through subterranean passages now receives its first escaping waters. This creek runs through Willow Creek Valley today and into Honey Lake Valley.

The Susan River rises west of Eagle Lake, and has a water-shed separate from that of Eagle Lake, and about as large. It flows into Honey Lake Valley; very fine storage sites are to be found near the source of this stream, consisting of lakes and extended flats.

The irrigable lands of Lassen County, lying about 1,000 feet below these sources of water, are not far from 500,000 acres; and east of these lands, in the State of Nevada, is an area of like extent, which would form a part of this scheme of irrigation. The lands are rich, sandy loam, productive with water, but comparatively useless without. The climate of Honey Lake Valley is most delightful, being free from excessive heat and not subject to very low temperatures. Hardy fruits excel here, and with irrigation alfalfa grows luxuriantly, producing three crops in a season. To many Eastern people the climate would be preferred to the lower valleys. Here there is a region of nearly or quite 1,000,000 acres of public lands that can not now be settled upon, but are nevertheless capable of sustaining a large population.

A rough calculation shows that in Eagle Lake there is already stored enough water to irrigate 500,000 acres of land; and at the head of Susan River comparatively cheap reservoir sites are available to store water sufficient for a half million acres more.

North of this region lies Madelin Plains, a large area of good lands if irrigated.

In Modoc County like areas are lying idle and useless, yet are capable of high cultivation and of sustaining a large population.

These lands are all within reach of water, but the work of survey is expensive, and there being no way by which capital can acquire the land, there is no probability of any relief ever coming to these regions except by Governmental interposition.

If it is true that there are 1,000,000 acres of land which may be irrigated at an expense of $1,000,000, and that these lands lie upon the great interior desert plain of our continent, by what possible scheme could the Government hope that enough people would go there in advance and expend the money which they must do before the land is available? The Government must either do the work, or it must give to capital something more than the vague expectation that people will buy the water.

As a first step, the surveys of irrigable land and sites of reservoirs will prove beneficial. The duties of the Senate committee must reach beyond the mere demonstration that land and water may be brought together. It must show how this may be done and ought to be done by the General Government.

XII.—OWENS VALLEY, IN INYO COUNTY.

Inyo County, Cal., is especially adapted to irrigation, particularly that part of it known as Owens Valley. From Olancha to the head of Round Valley is 100 miles; the whole of this distance, a strip of country from 4 to 6 miles in width, is susceptible of irrigation. There are from 300,000 to 400,000 acres of land of unsurpassed fertility which are utterly worthless without the use of water. It is claimed by experienced engineers that the Owens River carries on an average, and during the summer months, water enough to place at least a surface depth of 15 inches upon an area of 300,000 acres of land, and this without preparing catchment reservoirs. A large portion of this country is still a part of the public doman. Less than 12,000 acres of land are now cultivated in Owens Valley.

XIII.—IRRIGATION IN LOS ANGELES AND ORANGE COUNTIES.

In considering the subject of irrigation in Los Angeles and Orange Counties, we find it a complicated one. The number of ditches run into the hundreds, and the number of systems and subsystems, companies and associations, to several scores. The length of the ditches is hundreds of miles, irrigating many varieties of soil and crops. The area of actually-irrigated lands in the two counties is in the vicinity of 150,000 acres.

The sources of the irrigating water supply of these counties are the rivers Los Angeles and San Gabriel, in Los Angeles County, the lower part of the Santa Ana in Orange County (the upper part being in San Bernardino County), many creeks and small streams whose flow is of short duration, springs and springy lands (called cienegas), and many hundreds of artesian wells. The rivers, except the Los Angeles, rise in the high mountains and are practically perennial. It is true their waters disappear in their sands during most of the dry season soon after debouching from the mountains, but they reappear at intervals all the way to the sea, and can be taken out at almost any point along their channels by simply running ditches into them. The water supply in the rivers alone is sufficient to irrigate all the land of the counties to which water could be advantageously applied, if properly stored and distributed. The volume of the streams in winter is enormous—utterly beyond computation, and but a small portion of it would need to be saved for use in the dry season. The average summer flow of the San Gabriel River is about 10,000 inches; that of the Los Angeles River is 3,750 inches, and that of the Lower Santa Ana 4,000 inches. This estimate is of surface flow only. During the usual three months of the irrigating season the water is all appropriated; it is not all utilized, however, as much is wasted both by seepage and evaporation in the open, porous-earth ditches in which it flows, and much is allowed to run to waste. The streams whose waters rarely show outside the mouths of their gorges, except under the influence of considerable rain-fall are capable of furnishing a great quantity of water for storage. In many instances they are the only source of supply for the higher mesa and foot-hill lands, and are well worth the expenses of storing; for some of these lands yield fruits in the greatest perfection, and they are unquestionably the most healthful and delightful dwelling places. A great deal of water is obtained from springs and springy lands. These lands are found all the way from the mountains to the sea; but the greater number of those used for irrigation are situated on the higher plains or at the base of the main range. The most notable instances of these sources of supply are the springs and marshy lands of Pomona on the eastern border of Los Angeles County, the springs of Santa Anita and San Gabriel, the marsh lands of the Rio Honda and Paso de Bartola near the center, and those at the head of the Los Angeles River, on the San Bernardino Plains near the west line. They furnish many hundred inches of water, and are among the most reliable and valuable of water rights.

THE ARTESIAN WELLS OF THE TWO COUNTIES AFFORD A VERY LARGE AMOUNT OF WATER.

Pomona orchards are largely supplied by them. So are those of the Santa Anita and San Gabriel Valleys; while the lower coast plain has hundreds of such wells irrigating fields of alfalfa, vegetables, and most varieties of fruit. These wells have an average bore of six inches, depth of 150 feet, and a flow of two inches. Not more than one-third of them, however, are flowing—that is, about 1,500.

There is promise of the development of great quantities of water by the construction of submerged dams in the gravel-filled channels of the streams. There are several such dams in the county; but I have been unable to get statistics with regard to but one. That was built in the Pacorima, a stream in the northeast corner of the San Fernando basin. The owner claims it to be the largest in the world; it is 600 feet long, with an average depth of 60 feet. It consists of a wall 6 feet thick, of granite bowlders and Portland cement, built up from bed-rock and filled against, back and front, with sand and gravel. It developed a subterraneous stream 40 feet wide and 16 feet deep. Unfortunately, through some fault in construction, the dam was unable to retain the waters but a short time after its completion last year.

SUB-IRRIGATING SYSTEMS HAVE BEEN CONSTRUCTED.

They consist of cement pipe of the smaller dimensions laid at a depth of the deepest plowing. The pipe cannot endure much pressure, and requires to be laid nearly level. The ends of the pipes are perforated to admit a flow of the water into the earth about the roots of the trees. By a patented process, a continuous pipe is laid at the required depth. Subirrigation requires much less water and no surface work except cultivation. It discourages the growth of weeds and prevents the hardening of the ground about the trees. As at present applied, however, it does not uniformly moisten the earth inclosing the roots, and is not regarded as a complete success.

THE FACILITIES FOR STORAGE.

There is a difference of opinion among engineers. Some think there are many basins and cañons in the mountains which are adapted to the purpose, and others think these, on most streams, are wanting. Most, however, agree that the bench lands furnish abundant opportunities for the construction of reservoirs. The storage of water in the cañons may be effected by throwing dams at favorable places across the mouths of such cañons or basins as have the least wash, and afford the largest capacity and possibility of leading the water into them from adjacent streams.

The reservoirs on the bench lands may be constructed by excavating, and at much less expense than those in the cañons, and be of much safer character. They would not, however, be able to deliver their waters at so high an elevation, and would leave considerable land to be supplied from other sources. The filling of such reservoirs is effected by piping, fluming, or ditching from the upper waters of the streams. There are a number of reservoirs of both kinds, finished and in process of construction, of capacity varying from a few thousand to a billion gallons. One on Mormon Creek, in the rim of the San Fernando basin, is of more than the latter capacity.

Suffice it to say there is no lack of facilities for the storage of water with safety and profit. The first expense, however, is very great; and private enterprise is not ready to undertake it on a large scale except in the most favorable localities. The waters of the San Gabriel River brought out upon the higher hill-lands of the Ayusa or Duarte would suffice to irrigate all the great valley below, the coast plain beyond, and the intervening range of hills to their very tops. The waters of Millard Cañon and the Arroyo Seco, stored in the vicinity of the Giddings ranch, or the lands of the John Brown's sons, or other available places, could be made to flow over the San Rafael hills and those in and adjoining east Los Angeles. So with the San Dimas and the streams of Santa Anita, Eaton, Tejunga, Pacorima, San Fernando, Mormon Creek, Verdugo, and Santiago, whose flow in the aggregate is enough to supply all the lands between them and the ocean many times over. Also over the range in the hitherto regarded irredeemable desert of the Mojave, where most of the land still belongs to the Government, and the soil is as rich as lies under the sun, whole townships of the finest raisin grape, fig, and deciduous fruit land may be irrigated by the waters of the Mojave, Big and Little Rock Creeks, Oak Creek, and some others—most of which show surface water only in the rainy season—if those waters are husbanded, as there are abundant facilities for doing. And in the Newhall region, the Santa Clara, the San Francisquito, and the Castaic may be made to greatly increase the productiveness of the valley and the wealth of the county.

The number of acres of good land which require irrigation are, south of the mountains, according to the State engineer's estimate, 460,900. North of the Sierra Madre range, Los Angeles County shares with Kern and San Bernardino in the great Mojave desert, so called. This desolate region contains many thousand square miles. In these three counties one-half of this is probably arid beyond redemption; one-half of the remainder is too rough and mountainous to be valuable for cultivation, but the remainder is mostly highly fertile soil, lying favorably for the application of water. Of this vast territory, Los Angeles County possesses 250,000 acres which can be made to comfortably sustain a population of 100,000 people.

It is stated that the lowest summer flow of the Mojave River is about 5,000 inches. The average flow for six months in the year, the winter and spring months, is from 20,000 to 30,000 inches, during May, June, and July more than 10,000, and for the rest of the season more than 5,000 inches. Of this the Hesperia Land and Water Company has filed a claim of 5,000 inches. The Hesperia Company irrigates about 300 acres of land, and is flooding 15,000 acres for the purpose of preparing it for cultivation with the use of less water than it would otherwise require. The remainder, properly cared for, will redeem half a million acres of now absolute desert and make it as rich and blooming as the plains of Babylon thirty centuries ago.

SITES FOR STORAGE RESERVOIRS ARE ABUNDANT.

The land is mostly Government land, and the profits thereon would pay for enormous and elaborate works. Big and Little Rock Creeks, which debouch upon the desert plain at higher elevation, west of the Mojave River, are wholly within Los Angeles County. Their flow in winter is thousands of inches, and in summer is sufficient, as at present handled, to irrigate several hundred acres. Facilities for storage on these creeks are as abundant as on the Mojave. The land below is still owned, for the most part, by the Government. The universal testimony is that it is as fertile as the best. It is covered with grass and flowers during several months of the year, and is capable, under irrigation, of producing the most luxuriant and profitable crops. Artesian-well boring has proved successful in places on the desert, but the expense is of course greater than elsewhere. The region is one of the most healthful on the globe. Its hot, dry atmosphere is found congenial to many people. It is especially adapted to the production of certain crops, as the fig and raisin grape. It produces in some places as fine wheat as is raised anywhere, but to become habitable for any more than a few scattered families or small communities, it must have water to save its crops in summer. We have an engineer's report with regard to Little Rock Creek. He finds ample winter flow to furnish irrigation water, if stored, for 270,000 acres, allowing 1 inch to 5 acres. He allows for 30 inches of evaporation, and finds sites and gives estimates for two reservoirs, the larger one having a capacity of 644,000,000 gallons, and to cost $125,000. There is reported from the same locality 800 acres to which water is applied; 200,000 acres irrigable—one-half of which belongs to the Government; 14 miles of ditches. Value of irrigable land, $50 per acre; non-irrigable land, $1.15 per acre; the number of artesian wells in the region, seven, with an average depth of 340 feet and average flow of 12 inches. The counties of Los Angeles and Orange have an area of 4,812 square miles or 3,079,680 acres. Their population is fully 150,000 souls. Without irrigation not one-quarter of this number would be living there; and "this in spite of the fact that those two counties produce more than one-half of the corn of the State almost altogether without irrigation; that there are nearly 90,000 acres of good land that require no irrigation."

The land now irrigated is about 150,000 acres, and this is the basis of maintenance of 113,000 people. Theoretically, no increase of this population is wanted without a corresponding increase of irrigated lands. Factories and mineral developments, travel and transportation by sea and land, and the healthfulness and delightfulness of the climate, would add to the population; but the cost of living would be increased in proportion to growth, the homes of the poor would no longer be those of people who control their own destinies; and this would become a rich man's paradise—a thing not to be desired.

FORMER AND PRESENT POPULATION.

Ten years ago the population of the counties was little over 30,000. Fifteen years ago the land on which Pasadena now stands was held at $7 per acre; in seven years it was valued and sold in large quantities at from $500 to $1,000 per acre. This was for orchards—not city lots—orchards made possible only by a supply of moisture for the roots of the trees during the long arid season of the year. So with the whole of the great foot-hill region along the base of the Sierra Madre range from Tejunga and Crescenda Cañada on the west through Altadena, Sierra Madre, Lamanda Park, Santa Anita, Monrovia, Duarte, Ayusa, Glendora, Alosta, San Dimas, Lordsburg, Cucamonga, Rialto, Redlands, and over the San Gorgonio Pass into the desert at Indio, and again at Riverside and Arlington, and places too numerous to mention. The growth has been proportionate to the extent to which irrigation has been carried. The region mentioned was almost worthless even for grazing purposes, and was as incapable of sustaining a population as the Mojave desert itself. Now visit it and you will find it the most charming region and the most valuable land in all California, or in the United States for that matter.

IRRIGATING CONDUITS FOR THE WATER OBTAINED FROM THE MOUNTAINS

In every direction, either above or below the surface like a spider's web, the ditches, flumes, and pipes are leading the life-giving fluid. It is for the most part above the region of wells, so that the water for all purposes has to be brought in. Where no provision has been made for supplying a locality from running streams, a reservoir is made, or other methods adopted. The mountains are bored and tunneled for seepage and spring water; wet places in the cañons and gulches are underdrained; springs are cleaned out, and reservoirs of various sizes constructed to increase and store the flow. Pipes are laid for long distances into the cañons to bring the trickling streams from their hiding places to the light and usefulness. Ingenuity and experience as well as capital are required to find many of these waters. Much money has been expended to little purpose in such work; but a great many inches of flow have been obtained in this way—much more than enough to compensate for the outlay in this direction.

In the ranges of hills between the mountains and ocean, water has been and is being developed in the same way; but the difference in the soil and the moisture borne on the ocean breeze renders less water necessary, and the same enterprise in obtaining it has not been displayed. The Whittier Colony is a notable exception to this rule as to enterprise, though not as to need of irrigation. There are probably now 1,500 miles of irrigating conduits in those two counties.

The character of these conduits is continually changing. Flumes are being substituted for catch-ditches, and cement or iron pipes for both. There are now quite 400 miles of underground conduits. Every system and character of irrigation is here exemplified—from the ancient methods of the Indians and Mexicans to the most improved modern systems, including subirrigation, flooding the lands, channels and basins, slow streams and deep-wetting, quick, full, and frequent flow, the use of 1 inch to 10 acres, and of an inch to 1 acre (the inch flow giving 12,560 gallons per day, equivalent to 4½ inches rain-fall in the one hundred days of the irrigating season), and so on, *ad infinitum*. All phases of the subject may be found treated here.

In most instances the value of the water-right and the appurtenances is divided into shares, and then are owned by each irrigator in proportion to the number of acres he wishes to irrigate. He pays his share of the expenses, and takes his share of the water in his turn, which is settled by agreement at the beginning of the irrigating season. The amount of water applied to irrigation depends upon contingencies. The water is measured by inches or heads, 1 inch being the amount that will flow through an inch-square orifice under 4-inch pressure. The head nominally is 100 inches; the run is for any number of hours according to agreement, usually from twelve to twenty-four. The irrigating season is ordinarily about three months, July, August, and September. A man is employed to turn the water to each irrigator as his time comes; this man is called a "Zanjero," as the ditch in Spanish is called a "Zanja." He receives from $1 to $1.50 per day for the season. The cost per acre is from 30 cents to $1.50 for the year, which covers all expenses. Many of the open ditches are injured during the rainy season, and a great deal of ditch repairing is required at the beginning of every dry season. The pipe system escapes this and other drawbacks which attend the old, crude methods of the first settlers.

The average rain-fall of the region is about 12 inches, running from a light precipitation near the coast to a copious one in the mountains and foot-hills, though different parts of both localities are more or less differently farmed. There have been no droughts in ten years, but droughts can have no such effect upon the region as formerly. The people know so well how to use and husband the moisture that no material damage could be done to the country by a lack of rain-fall that did not continue for several years. We have no general failure of crops, and every year makes assurance doubly sure that it can never occur again.

The value of land in this section lies in the water. In the San Gabriel Valley water has actually been sold at the price of $15,000 per inch, which price at 1 inch to 10 acres would be $1,500 per acre. The average value of the product of unirrigated land is not more than one-tenth that of irrigated.

The difference in the variety of the crops possible to raise, and in the capacity of the two kinds of land to sustain population, is quite as great. The improvement in the character of the population is as marked as in numbers; intelligence and energy distinguish the new occupants of this country from the old. With regard to the practical knowledge of irrigation, there is probably no field in the world where it is more exhaustive than in these two counties. It has been applied here for more than a hundred years, and has gradually grown from the simple methods of Spanish-American settlers to the most elaborate of modern systems.

XIV.—IRRIGATION IN SAN BERNARDINO COUNTY—STORAGE RESERVOIRS AS AIDS TO IRRIGATING SYSTEMS.

The great value of storage reservoirs is just beginning to be appreciated in southern California since the actual use of water from Bear Valley reservoir has commenced, in connection with the natural flow of the Santa Ana River.

The supply of water from a stream is just the reverse to the demands made upon it for irrigating purposes. The natural stream is large in January, diminishes in size till July or August, and then increases in volume till January again.

The use of water for irrigating purposes is least in January, and increases gradually until August, and then diminishes again till January.

The value of a stream for irrigating purposes is measured by the duty its water will do at that season of the year when the most water is required, or when the stream will irrigate the smallest amount of land.

All surplus water at other seasons of the year is of no value for irrigation purposes, except as it can be stored for future use.

Suppose we have a stream of water that carries 1,000 inches under a 4-inch pressure, or 20 cubic feet of water per second, at the driest time of the season—say August—of each year. This stream of water is sufficient in San Bernardino County to irrigate 5,000 acres of land in good shape, or, if conditions are favorable, perhaps 10,000 acres. The water in the stream is not all called into use until the months of July and August, and then at times every drop must be utilized. During June and September there is enough water for 20,000 acres, and during the balance of the year there is enough to irrigate from 25,000 to 50,000 acres or more. These are rough estimates, but they are practically correct, although in different seasons the irrigating capacity of the stream will differ.

Now the theory of the people should be to furnish an independent supply of water that could be turned into this irrigation system at a time when it will do the most good.

Suppose that it was desirable to make this stream irrigate 50,000 acres of land where it now irrigates but 5,000 acres.

To do this work would require 9,000 inches additional in July and August, perhaps 5,000 inches additional in June and September, 2,000 inches additional in May and October; and, as a rule, the stream would take care of the entire tract during the remainder of the year.

Here we find that a stream of water equal to 30,000 inches for one month would irrigate 40,000 acres of land, whereas if it were not used in connection with a natural stream it would not irrigate one-quarter that amount. This would require a reservoir 1 mile square and about an average of 55 feet deep.

Bear Valley reservoir, in San Bernardino County, was started as an experiment, but it has proved itself more valuable than its founders had hoped it would be, and steps are being taken to make it still more valuable by increasing its capacity and constructing a dam to a height of 120 feet, whereas its present height is but 50 feet. This reservoir is located 6,000 feet above the sea-level, where the evaporation is very light, and where the water can be stored in its natural purity.

This reservoir commands the entire San Bernardino Valley on both sides of the Santa Ana River from the mountains to the chain of hills which separate the interior valley from the coast valleys of Orange County. This great interior valley extends from Pomona on the west to San Gorgonio Pass on the east, a distance of 50 miles, and from the Sierra Madre Mountains on the north to the Temescal Mountains on the south, a maximum width of 25 miles.

In this great valley is to be found Pomona, watered by the waters of San Antonio Creek and artesian wells; Chino with its vast extent of moist land, and its large tract of dry land irrigated by artesian water from the Pomona artesian belt; Ontario irrigated from San Antonio Cañon, and by waters flowing from a tunnel run for half a mile beneath the bed of the San Antonio Creek; Cucamonga irrigated by the waters of Cucamonga Creek and by artesian wells and by tunnels run beneath large cienegas; Etiwanda irrigated by waters from Etiwanda and other cañons, and Rialto watered by Lytle Creek. These form a group of thrifty settlements extending along the foot of the mountains to the west of San Bernardino.

The city of San Bernardino is located in the midst of a large tract of artesian land that that is naturally moist, and that covers over 20 square miles of territory.

Through this artesian belt flows the Santa Ana River, which in summer-time gets its entire available water supply from its tributaries, which take their rise in this moist-land section; for at the mouth of the cañon, where the river debouches from the mountains, the entire stream is taken from the river-bed, one-half to irrigate Highlands on the north, and the other half to irrigate Lugonia, Redlands, and Old San Bernardino on the south.

The mouth of the Santa Ana Cañon, where these waters are taken out, is about 2,000 feet above sea level.

Farther down the stream and on the southeast bank is to be found the Riverside settlement. This valley, or section of the valley, comprises 12,000 acres under the Riverside system of canals, which take their water from the Santa Ana River and from its principal tributary, Warm Creek. Above this lies the Gage tract of 10,000 acres, irrigated from the Gage canals, which take their waters mostly from artesian wells; and still above this is another strip of 5,000 acres, which is being irrigated from a system of wells located to the northeast of San Bernardino, and piped to the land, a distance of about 10 miles. This gives the Riverside section a tract of country amounting to about 27,000 acres.

Still farther down the river, and on the same side, is located South Riverside, with about 8,000 acres on the south side of Temescal wash, and about 3,000 acres on the north side of the wash, the latter tract being known as Auburndale. These tracts are being irrigated by waters from cienegas and artesian wells located in the Temescal Valley, about 6 miles above the upper edge of the tract. These waters are conveyed to the tract in a 32-inch cement pipe, and then distributed in smaller iron and cement pipes.

On the opposite side of the river from Riverside is situated the Jurupa tract of land, comprising about 25,000 acres, over half of which is moist or semi-moist land, while the other half is fine orange land, and is to be irrigated by water developed in the lowlands along the Santa Ana River, and by water from the artesian belt. All ready the canal, with a capacity of 5,000 inches, is nearly completed to the lands, at a cost of $150,000; and about 1,000 inches of water are flowing therein—more water than is yet needed by the 3,000 acres now under the completed portion of the canal.

This review completes the principal irrigated sections of this great valley.

There is probably enough water in sight, to-day, to irrigate one-half of the irrigable, arable land in the San Bernardino Valley; and storage reservoirs must be depended upon largely to complete the work.

To the south and east of this valley is another large valley, the San Jacinto, which is about 25 miles long by 15 miles wide. This is a large body of fine land, at present mostly sparsely settled, principally because of lack of water. In the upper end of the valley is situated the town of San Jacinto, in quite an extensive artesian belt. The San Jacinto River furnishes some water for irrigation purposes, but the supply is limited. Upon the headwaters of this stream, which heads in the mountains bearing the same name, is a small mountain valley very similar to that of Bear Valley, where the Hemet Valley Reservoir Company has taken steps to construct a reservoir that will do for San Jacinto what the Bear Valley reservoir is doing for the San Bernardino Valley. It is a feasible project, however, to irrigate this entire valley from the waters of Bear Valley reservoir, by means of a pipe, 10, or, perhaps, 20 miles long

There are other reservoir sites in the mountain valleys that can yet be utilized. There is one located on the north side of the mountains on a branch of the Mojave River high up in the mountains, so that from the mouth of the reservoir a short tunnel through the mountains would deliver the water out into the San Bernardino Valley, where it will be of greater value than if used on the desert side. This reservoir when constructed will hold water enough to irrigate several thousand acres of land, and can be made to supplement the waters of Lytle Creek to good advantage. The cost of this reservoir and tunnel will not exceed $35,000; and as much more money would probably deliver the water to the Lytle Creek Water Company, which irrigates the lands about Rialto.

The dry mesa lands of the San Bernardino Valley have no value until they are irrigated, except a speculative value. If a water-right can be bought for $100 an acre, and the irrigated land sold for $200 an acre, these facts have an influence on the speculative value of the dry land.

VALUE OF IRRIGATED LAND.

Choice land for orange culture is selling to-day at from $125 per acre—extremely low—to $200, $250, and even $400 and $500 per acre, according to location, and circumstances surrounding the owners. Without the water the value is nominal.

A cubic foot of water per second is equal to 50 inches of water under a 4-inch pressure; and 1 inch of water is a good water-right for 5 acres of land, and a fair water-right for 10 acres under favorable circumstances. Water is being developed in various ways.

Large amounts of water are being obtained from artesian wells; and this supply, when obtained, appears to be permanent.

Tunnels are frequently run under beds of creeks and under cienegas; and the results have been very satisfactory. In one instance, at Cucamonga, a tunnel was run under a cienega covering 5 acres, and furnishing but 6 inches of water. This tunnel was 500 feet in length, and a branch tunnel the same length was also run. The two tunnels dried up the surface of the cienegas entirely, and furnished a permanent flow of 196 inches, or 4 cubic feet per second.

Storage reservoirs will become a necessity in the irrigation of the arid lands of America, as they are in irrigating the plains of India; and the Government should take a hand in reclaiming these lands, either directly or by advancing the funds to do the work, to be repaid back after the lands are made productive.

Riverside has 3,000 acres of orange orchards, a portion of which is yielding good crops, a portion is yielding partial crops, and a portion is not in bearing at all. These 3,000 acres this year produced 1,000 car-loads of oranges and lemons, worth on the track an average of $750 a car, or $750,000—about $250 an acre. This is not picking out sample orchards, but averaging all the orchards, whether in bearing or not.

Budded trees yield the third year in orchard $1.50 per tree; the fourth year, $3 per tree; the fifth year, $4 to $5 per tree—from $300 to $375 per acre; eight-year old buds, $10 per tree; and nine-year old buds, $15 per tree, or $1,125 per acre. From six to seven boxes to the tree have been received from fifteen-year old seedling trees; and this gives a net income of $1,225 an acre, counting the first but $1 a box on the tree.

These are some of the reasons why choice lands have sold at from $250 to $800 and $1,000 an acre in good locations, and why water has been developed and put upon land at a cost of $150 and $200 an acre for the water-right alone. During the past two years there has been an advance in the price of bearing orange orchards, as the trees have grown in size and have increased the amount and value of their crops.

There is no place in the United States where the benefits of irrigation are more fully illustrated than they are in the San Bernardino Valley.

XV.—In San Diego County Irrigation is a Necessity.

The streams of that county, except the Coloradó, which flows along its southern boundary, are not large, nor is the water supply, without using catchment reservoirs, equal to the demand. Within the past few years, much attention has been given to the matter of irrigation in this locality. One great reservoir has been constructed, and others have been surveyed. And thus it will be observed that provisions are being made to store the waste waters of winter for practical uses in summer. This has already given special activity to horticultural and agricultural interests in this county, the possibilities of which have not hitherto been known or appreciated even by those who have lived there many years.

XVI.—THE AMOUNT OF LAND NOW IRRIGATED IN THE SAN JOAQUIN VALLEY.

In Fresno County there are about 100,000 acres of land now irrigated. This estimate is made by Mr. George Manuel, a well-known civil engineer; but he adds:

"It is somewhat difficult to draw the line between irrigated and unirrigated lands, for the reason that the effects of irrigation by filling up the country affect and render fertile to a great extent lands lying contiguous to irrigated lands, but not themselves subjected to irrigation by the usual methods of application. Of this latter class of lands," says he, "there are about 200,000 acres."

Thus it will be seen that the 200,000 acres are an area double in extent of that which is actually irrigated, and is reaping the benefits without being subjected to any of the burdens of irrigation. Irrigation in Fresno County has heretofore been carried on wholly by the private canal system. It is a voluntary matter by this plan with each land-owner whether or not he will contribute anything towards the expense incident to the irrigation of lands. His lands may be surrounded by irrigated lands, and thus in a short time they become sufficiently irrigated by percolation; but he may and does decline to buy water where he can get it by absorption without. By the district plan this iniquity is overcome; and every man who owns land that will be benefited is compelled to contribute his portion of the expense incident to the system, and gets in return all the water he may require.

The following is the estimate made by Mr. Manuel of the amount of lands in Fresno County which is now not irrigated, but which is irrigable:

	Acres.
(1) In Madera irrigation district, about	300,000
(2) Under Chowchilla canal, excluding about 5,000 acres already irrigated.	60,000
(3) Land lying above or east of Madera district, but which can be irrigated by a branch of the main canal of said district (in Fresno County)	87,600
(4) Lands lying above water in main canal of Madera district, but which is susceptible of irrigation by a system of storage reservoirs	38,400
(5) Land lying between San Joaquin and Kings Rivers, excluding about 60,000 acres already irrigated, and which can be irrigated by existing works or their extensions	684,960
(6) Land lying above or east of Enterprise canal, but which can be covered by storage reservoirs or branch canal taken out high up in the mountains	40,000
(7) On west side of Fresno Slough, below Hall survey in Fresno County, which can be covered with extensive irrigation works	113,000
(8) In Sunset irrigation district above Hall survey, proposed to be irrigated by a canal having levees 35 feet high at highest point, and about 15 miles long, and which lie above Hall survey	190,000
(9) Between the 240 and 300 feet contour line on State engineer's map, which can be irrigated by canal taken from Kern River, or by water pumped by water power as proposed by Sunset district in Fresno County	190,000
(10) Land lying above the 300 feet grade line in Fresno County on west side, which can only be irrigated by storage reservoirs on the streams flowing from the Coast Range	293,000
Total	1,996,960

All of the above lands, with the exception of about 200,000 acres lying near and affected by the present irrigation, and possibly 50,000 acres lying near the foot of the Sierras on the east side, are practically useless without irrigation.

Instancing the benefits of irrigation in Fresno County, Mr. Manuel states: As examples of the benefits of irrigation, the following is from the assessor's records of Fresno County, for T. 14 S., R. 20 E., showing the former and present assessed value of property:

In 1870.—Sections 1 to 35 assessed to W. S. Chapman at $1.01 per acre; section 36, at $1.13 per acre.

In 1880.—Bank of California tract, 12 sections at $4 per acre.

Bank of California tract, 240 acres at $5 per acre.

C. A. Towne, section 2 (adjoining Fresno City) at $5 per acre.

C. H. Hoffman, section 12 (near Fresno City) at $5 per acre.

E. Jansen, 6 sections (near Fresno City) at $4 per acre.

In 1888.—A. T. Covell, in Washington Colony, 5 miles from Fresno, 60 acres at $150 per acre.

Sections 1 and 2, and 11 and 12, $250 to $350 per acre—$250 about average for unimproved land.

Sections 30 to 31, unimproved, at $40 per acre.

Sections 6–7 at $100 per acre.

Section 19 at $75 per acre.

Sections 5–8 at $125 and $200 per acre (unimproved and from one-half to 1 mile from city of Fresno).

Sections 17, 18, and 19 average $85 per acre.

Sections 23, 24, 25, and 26 at $75 per acre.

The above valuations from the assessment rolls of Fresno County teach an instructive lesson.

Ten years ago, when the effects of irrigation in Fresno County had been but little felt, the present city of Fresno was but a struggling village of probably from 1,200 to 1,500 souls. Now it is a bustling city of 10,000 inhabitants.

In Tulare County much progress has been made in the work of irrigation. The one criticism to be made on the work in that section is that it is fragmentary and lacks uniformity and systematic methods. Irrigation is consequently patchwork, but enough has been done to demonstrate the miraculous power of irrigation in the San Joaquin Valley.

Mr. P. Y. Baker, civil engineer, for many years devoted to the work, says: "There are about 15,000 acres irrigated in this county, and 950,000 acres not irrigated. There are about 250,000 practically useless without irrigation. Of the above 950,000 there are perhaps 700,000 that produce some crops without irrigation, but very little of it produces fair crops. That is to say, one year with another, the average would be so low that it would be a serious question of making a bare living on most of it. Experience has shown that the proximity of irrigation has added much to the productiveness of non-irrigated lands."

MERCED COUNTY.

In this county provision has been made whereby a considerable area of lands may be irrigated; but the acreage actually subjected to irrigation is small. The famous Crocker canal, which is said to have cost $1,500,000, is situated in this county, and will eventually be applied to a large area. The area of the plain lands which may be profitably irrigated is large.

So far as irrigation has become an accomplished fact in the San Joaquin Valley, it has been done through private enterprise. Under the district irrigation law of 1887 a number of irrigation districts have been organized, and by this means the irrigated area will soon be rapidly extended.

The following districts have been organized in this valley, having the acreage shown:

	Acres.
Modesto irrigation district	108,000
Turlock irrigation district	176,000
West side irrigation district	300,000
Madera irrigation district	330,000
Alta irrigation district	160,000
White River irrigation district	60,000
Poso irrigation district	48,000
Sunset irrigation district (proposed)	285,000
Total area San Joaquin Valley	1,467,000

XVII.—THE NEXT QUESTION IS, WILL IRRIGATION PAY?

For more than seven hundred years irrigation has been successfully practiced in Lombardy, which covers a territory of but 9,000 square miles (an extent of country not half so large as southern California), which to-day supports by means of irrigation a population of about 3,500,000 people, and is the garden spot of Europe and of the world. It has paid these people well, and it has built up a country and sustained a vast population; but for irrigation this territory would not otherwise support 500,000 people. Nor do we find the condition of things different in India. There has been expended for the irrigation canals of India, directly and indirectly, $200,000,000. The system of canals there constructed is the most stupendous ever built within historic times. The great Ganges canal is 10 feet in depth and 175 feet in width. It is simply a vast river, and irrigates to-day a million and a half acres of land in a country where irrigation is not only necessary, but where the evaporation is double what it is in California. By means of this irrigation, that country produces, with certainty, from two to three crops a year; and this certainty and regularity is a characteristic feature of irrigation. There is no such thing as failure, famine is rendered impossible, and a reasonable reward for labor is made sure.

After examining the official reports relating to the price of water in most of the irrigating districts of the world, the average annual expense is from $1.50 to $2.50 per acre. When only garden spots or small tracts are irrigated the expense is greater.

In California the planting can be done in winter. By irrigation there are no crop failures. Farming becomes a certain business. There are no droughts, no dread of the scorching "northers," no parching of the earth. An uncertainty is changed to a certainty.

It has been estimated that, by irrigation, from ten to twenty times the number of people can live and prosper on the same extent of territory, and this even where there are the usual rains, as in Lombardy. Of course, in parts of India, in Arizona, and in Nevada, irrigation is a necessity. It has been noted in California that the price of lands in districts like Fresno, Los Angeles, and San Bernardino has, by reason of irrigation, increased from twenty to fifty times its original value.

XVIII.—THE TEMPERATURE OF THE WEST IS SUITED TO IRRIGATION.

To present the favorable climatic conditions of the Pacific coast, and especially of California, we append the following statistics, showing the mean annual temperature of the different localities in California, and of foreign countries as well. The statistical information as to the mean annual temperature of Washington Territory, Oregon, Montana, Nevada, Arizona, and New Mexico are not in reach, and can not, in the short time allowed, be presented; but it can be truthfully said that many of the favorable conditions as to irrigation in California are applicable to most of the States and Territories referred to, except that in the western parts of Oregon and Washington Territory the rains are so ample that irrigation is quite unnecessary. In Nevada, Arizona, and New Mexico irrigation must be resorted to that the lands may be made productive; and to that end all the water in those sections should be and soon will be utilized.

Table of mean annual temperature of different localities.

Marysville	63.58	Paso Robles	56.00
Woodland	61.00	Gilroy	58.00
Calistoga	59.00	Livermore	58.00
Auburn	58.00	Merced	63.00
Red Bluff	64.00	Monterey	57.40
Chico	65.00	Colton	62.00
Redding	61.58	Yuma	74.00
Truckee	43.00	Indio	73.00
Napa	59.19	Anaheim	67.00
San Mateo	54.00	Mojave	63.00
Stockton	58.00	Caliente	64.00
San José	56.75	Los Angeles	64.75
Tulare	64.00	San Diego	61.00
San Luis Obispo	57.00	Santa Barbara	60.00

Mean temperature of the following foreign localities.

Turin, northern Italy	53.00	Madrid, Spain	57.00
Florence, northern Italy	59.00	Calcutta, India	68.00
Naples	61.00	Madras, India	82.00
Toulouse, southern France	55.00	Azores	65.00
Toulon, southern France	59.00	Madeira	65.84

It will be observed by the foregoing tables that so far as temperature is concerned California is especially adapted to the purposes of irrigation. If the average mean temperature were too high, like that of Madras, India, the evaporation would be so great that it would be most difficult to carry on successful irrigation, and especially during the hot or summer months.

XIX.—WHAT INTEREST HAS THE NATIONAL GOVERNMENT IN IRRIGATION?

The answer is, the whole nation is interested in the subject of irrigation, because the whole nation is interested in making the uninhabitable portion of our country habitable. Most of that part of the United States west of the one hundredth meridian either requires, or would be benefited by, irrigation. Without it crops are not certain. Thus irrigation not only becomes a question of national interest, but a question of national necessity. This is quite as much so in the United States in relation to this part of the Republic as was irrigation in India to Great Britain, or irrigation in Lombardy to Italy. The vast territory in the United States requiring irrigation covers over one-third of the inhabitable part of our country, and if the national Government can wisely expend millions of dollars in keeping the water off from a portion of the inhabited part of the country, can it not, with equal wisdom, expend wisely money to put water upon that portion of the land which most needs it?

It may be noted that the public lands are almost exhausted; that the preparing of a new country for the habitation and support of a large population is the equivalent of the acquisition of a like amount of territory. By these means the national Government will make useful to the American people what before was of no use. To show the extent of the United States where irrigation would be advantageous, and where it is most necessary, we venture to refer to the territorial area of those States and Territories in parts of which the rain-fall is too light to make farming a certainty:

State or Territory.	Acres.	Square miles.
California	100, 992, 640	157, 801
Oregon	60, 975, 360	95, 274
Utah	54, 380, 800	84, 970
Washington	44, 769, 160	69, 994
New Mexico	77, 568, 640	121, 201
Nevada	71, 737, 600	112, 090
Arizona	72, 906, 240	150, 932
Colorado	66, 880, 000	104, 500
Wyoming	62, 645, 120	97, 883
Idaho	55, 228, 160	86, 294
Montana	92, 016, 640	143, 776

Add to this territory the northern and western part of Texas, which covers an area of about 100,000 square miles and an acreage of 64,000,000, and we see what an empire would thus be brought into practical use. We submit that the oft-repeated argument that the national Government can not afford to promote private interests by national means does not apply to this question, for this is one of national, not one of State or local importance.

The population of our country is increasing at a remarkable ratio. As the population increases, the opportunities for young and ambitious men, who live in the older States of the Union, to gain an honest livelihood, is every year becoming less. Labor is necessarily becoming cheaper. If no more unoccupied lands are made fit for use, land-holding will soon be the privilege of the rich, and tenantry the only hope of the poor. The old adage so often quoted by successful men, that "the fittest succeed," may be true; but unless those who are not "fittest" have an opportunity to establish for themselves homes, the poor will soon vastly outnumber those who are able to help themselves; and when there is little hope for the many, and the Government is carried on for the benefit of the few, neither the property of the one nor the labor of the other will be secure. Indeed, the best safety that capital can have, or that labor may receive, is universal ownership in the soil. Place land within the reach of every citizen. The Government is then secure, because the people are happy. Any system that will open up for settlement a new country, that will change from an arid waste to cultivated fields a region as big as half of Europe, necessarily promotes not only the interest of the whole nation, but benefits the whole civilized world.

Before this Republic should seek to acquire new territory, it should wisely utilize the territory it now has; and it is most respectfully submitted that a national system of irrigation, directed by wise and uniform laws, controlling the rights of water and its uses, will be of the most infinite advantage to the whole American people, and especially if so carried out under the wise supervision of the national Government and engineered by its scientific and experienced men. When this is accomplished there will be ample room in the unsettled portion of the United States to find homes for the millions of people who are to come after us.

Added to this we may say that in considering the interest which the people of the United States have in the subject of irrigation throughout the arid regions of the United States, it is obvious that that interest is paramount. The time is within the recollection of men still young when the population of these United States did not exceed 20,000,000. The time is also readily recalled when the aggregate accession of population by European immigration did not exceed 50,000 per annum. To-day, the population of the United States exceeds 60,000,000; and the annual immigration equals, and for the past five years has almost equaled, 1,000,000 per annum. With the natural increase of 60,000,000 people, reenforced by the artificial increase of an incoming foreign immigration, reaching our shores at that period of life when the generations to be born of them are to be born in our own country, we are fast approaching that period in our national history when the condition known to political economists as the pressure of population will be felt here.

Hitherto, the larger possibilities of the common life of our country have been due largely to the opportunities of acquiring fertile land at primitive or undeveloped values, and enjoying the benefits of the increment which has followed settlement.

Up to the line of the one hundredth meridian, by a general classification, our country is fertilized by a natural precipitation of moisture, sufficient to mature annual crops of cereals. West of that line, with the exceptions of small portions of Washington, Oregon, and California, the country is devoid of sufficient rainfall to mature agricultural crops. The soil is not wanting in fertility. The area embraces over one-third and nearly one-half of the territorial area of the United States. We have already shown that, under irrigation, land is more productive, and its cultivation more certain of profit to the cultivator, where the element of moisture is controlled and directed by means of artificial irrigation. It therefore follows that the application of water to the fertile areas lying west of the one hundredth meridian is to confer upon them a productive capacity even in excess of that capacity now inherent in the lands east of that line. Their fertilization by artificial systems of irrigation is therefore equivalent to acquiring a new territory equal if not superior in fertility to that now occupied by the great body of our civilization. It is therefore equivalent to making room for 60,000,000 more industrious citizens. Nor would this great work, if undertaken, or aided, or even encouraged, in the manner now proposed by the Congress of the United States, be work done in the interest of a population already settled in the territory under consideration. Practically, that portion of the United States lying west of the one hundredth meridian is unoccupied. It is a territory 1,600,000 square miles in extent, occupied by less than 2,000,000 inhabitants. An equal area east of the line of the one hundredth meridian, as has already been shown, is occupied by an industrious citizenship of 60,000,000 inhabitants. The undertaking is, therefore, to be in the interest of the posterity of the 60,000,000 people comprising the citizenship of the United States.

The census of 1880 disclosed the fact that the male citizens of the United States between the ages of twenty-one and twenty-four years, including native-born, foreign-born, and colored, aggregated 2,041,000. Of these, 1,556,000 were native. Assuming the present population of the United States to be 65,000,000 inhabitants, and allowing a proportionate number to the number of the census of 1890, would give about 2,000,000 native-born young men between the ages of twenty-one and twenty-four, and 2,500,000 of all classes. From other statistical facts, it is derivable that at least 1,000,000 young men in each year reach their majority. In each year, therefore, 1,000,000 of the young male inhabitants of the United States reach the age which entitles them to the full rights of citizenship and independent action.

It is most obvious that if the territory lying west of the one hundredth meridian to-day possessed fertility equal to that of the fertility lying east of that line, and if the western territory had yet been unacquired by the United States, and was as sparsely settled or as nearly unoccupied as it is to-day, it would be deemed the highest statesmanship to acquire that territory, in order that the two and one-half million young men between the ages of twenty-one and twenty-four might find a proper field for the exercise of those high faculties of energy and enterprise which the American youth possess. If this be true, the fertilization of this field stands for the exact equivalent of its acquisition. The territory is already a portion of the national domain. Its reclamation, if it is reclaimed at all, will be in the interest of the posterity of the people reclaiming it. The attention our Government will bestow upon it will find all the justification which would attend the attention bestowed by a father upon the possible inheritance of his children. We believe any other enlightened and civilized nation of the earth would accept the possession of such a territory as a valuable inheritance, and would give it the attention we are now seeking at the hands of the Government for the territory under consideration.

England expended $200,000,000—not to reclaim an arid and waste country in India, but for the purpose of adding to the resources of that fertile country the increased capacity which irrigation confers.

The overcrowded populations of Europe are seeking our shores encouraged thereto by the enlarged possibilities of the common life in our country.

Our fiscal systems are directed to the maintenance of high wages to our working classes. The cost of transportation between Europe and America, and the time consumed in the passage, has so far diminished, that the difference between the reward of one week's labor in the two countries will fully compensate the loss of time and repay the passage money.

The conditions with reference to the density of population between Europe and America are very rapidly equalizing. If no other new territory is added, either by way of acquisition from adjacent territory or by the increased productiveness of our own, within the lifetime of children now born the fertile portions of the United States will be occupied by a population equal in density to that of England, Belgium, and France.

The reclamation of the sterile valleys lying west of the one hundredth meridian can be achieved at a cost much less than that which would attend the clearing of a forest and the reduction to a state of cultivation of forest lands.

We are not now proposing that the Government of the United States from its treasury shall construct the instrumentalities of irrigation. What we ask, and what we hope will be granted, is that the preliminary cost of ascertaining all the economic facts necessary to induce capital to enter upon the completion of this great work shall be borne by the Government of the United States, and, when the public lands are effected, make such appropriations as may be wise. Let it once be shown by conclusive data that a reasonable reward awaits the investment of capital in the reclamation of the arid lands belonging to this nation, and private capital will not long be wanting to engage in that undertaking. The necessary capital for the prosecution of any reasonably profitable enterprise is not wanting, when the opportunity for such investment is clearly and officially pointed out. We believe, therefore, that the proposed surveys for reservoir sites, and the approximate ascertainment and publication of the possibilities for the reclamation of the sterile portions of our country, to be in consonance with the wisest statesmanship.

The people of California are more deeply interested in this subject than the people of the other States of the Union, only because of the proximity of the territory to be benefited. The development of a fertility in the soils now sterile for want of artificial irrigation in the portions of our State needing the vitalizing influence of artificial moisture, and in the territory lying immediately contiguous to us, would promote our wealth and prosperity, by building up strong neighboring communities, whose purchasing power would add to our wealth, and by adding that volume of population to our own State so necessary to the establishment and maintenance of a higher civilization.

National life generates a surplus energy which in times past has found war a congenial field for its expenditure. Modern statesmanship addresses itself to directing this national energy into channels of public enterprise. The field under consideration is broad and full of promise in the direction of promoting national prosperity and perpetuating peace.

Respectfully submitted.

M. M. Estee, *Chairman*,
W. H. Mills, San Francisco,
E. W. Jones, Los Angeles,
N. P. Chipman, Tehama,
L. M. Holt, San Bernardino,
Jesse D. Carr, Monterey,
C. C. Wright, Stanislaus,
Frank H. Cunningham, San Diego,
Wm. Thompson, Reno, Nevada,
Committee.

Mr. Estee (resuming). Following that, permit me to say that I think I voice the sentiment of the people of San Francisco and of this coast when I say to you that we are gratified to know that you have visited our State and our city. We have telegraphed to different parts of the State, to representative men who are familiar with the subjects you are investigating. We have gentlemen from the north, like Mr. Green, of Colusa; we have Professor Hilgard, of the university, and we have leading surveyors, Mr. Hall and Mr. Manuel—the latter gentleman having given considerable attention to surveying in Fresno district—Mr. Cunningham, and others, from San Diego. While our gathering here to-day is not large, it is a representative one, so far as those present are familiar with the subject-matter of your inquiry.

The Chairman. I would suggest that you call the names in the order in which we would be the more likely to get the information condensed.

Mr. Estee. As the Government has selected an eminent engineer for this coast, Mr. Hall, I think he should be the first to address the committee. He is an engineer of well-known repute, and has occupied a public station.

STATEMENT OF WILLIAM H. HALL, OF THE U. S. GEOLOGICAL SURVEY, SUPERVISING ENGINEER FOR THE PACIFIC COAST, U. S. IRRIGATION SURVEY.

Mr. Chairman and gentlemen, to review this subject of irrigation as it might be done upon the basis of ten or twelve years of work immediately in connection with it would take more of the time of this committee than I would be justified in taking. Therefore, I have come here to present, in so far as they have been printed, the results of my work, and to say that a condensed and tabulated statement will be the most interesting and useful to the committee.

Mr. M. M. MILLS, of the State Board of Trade. State the origin of the effort on the part of California to make the ascertainments which are now exhibited to the committee, and you will then begin the history of this inquiry.

Mr. HALL. Prior to 1876 there had been but little effort made in this State to systematize or regulate irrigation. But there was an endeavor on the part of the owners of the dry lands through, principally, the San Joaquin and southern valleys to irrigate by means of waters diverted from the running streams. At that time there was a conflict as between those who desired to divert the waters and use them for irrigation and those who were at that time known as cattle-men. They were the owners of large tracts of land, and had utilized those streams solely for grazing purposes. Therefore, the legislature was called upon to enact such laws as would enable the proposed irrigators to divert these waters without hindrance, or at any rate to divert them to a sufficient extent for their purposes. But the legislature had been appealed to for several seasons before to enact laws defining and regulating the diversions, and the proposition met with violent opposition. Some of the leading members of the legislature were those who were interested in cattle-growing. They denounced irrigation as a fallacy, and actually declared that it was a humbug; saying that the plains of the San Joaquin Valley would not grow anything but long-horned steers, at the rate of one steer to 25 acres. But the few who had succeeded in diverting little streams out on the bottom lands, where diversion was easy and the soil rich, knew better. They made strenuous efforts to bring about such legislation as would justify them in this diversion. This conflict led to an investigation of the subject of irrigation generally by the State; which investigation it was supposed would furnish the basis for intelligent legislation.

In 1878, as a compromise measure, was passed a law providing for an investigation of the subject of irrigation. There was tacked on to that law a provision requiring the officer holding the position of State engineer, which had been created by law, to inquire into the débris and artesian drainage provisions. The office of State engineer was created in the spring of 1878, and it was my misfortune to be appointed as the first occupant of that position. That office I held up to within a few months when I was appointed a supervising engineer for the irrigation survey under the Government, and that position I now hold.

The work of the State engineering department started out well, but did not continue. The people thought that when they started out they wanted an investigation of this subject. But when they found that it was going to cost some money it seemed that the majority of the people did not want the work. So the work has not been completed. But so far as the irrigation part is concerned I think enough has been done to show at least what it was intended to be, and to show some valuable and useful results. These results, so far as they have been printed and lithographed, I have thought advisable to present to this committee, and then to refer to them very briefly.

Here [exhibiting volume] is a report made by the State engineer in 1880, covering the subject of irrigation, describing it as it then existed in the then principal irrigation districts of the State, and in the conclusion of the report making certain recommendations with respect to legislation. In this report, I think, will be found the recommendation of the district irrigation bill. But there was in addition to that one to the effect that the State should regulate and control the action of the district. So far as the district idea is concerned it has been adopted and enacted into a law.

Here [indicating] is a collection of reports submitted from time to time since, in all about a dozen in number, touching more or less on the subject of irrigation. Then we come to the final report, in so far as it has been printed.

The CHAIRMAN. You will file those reports with the committee?

Mr. HALL. Yes; although I believe some members of the committee have them. Of course, in studying the subject of irrigation as set forth in the report of the Director of the Geological Survey to Congress, which I have seen, and which I think you gentlemen of the committee are familiar with, you ought to have a knowledge of the topography and general physical conditions of the water supply. Such study was commenced in California, and here is a volume of statistics on California, representing a portion of the work of the State engineering department. There will be found in it, for instance, a compilation of rain-fall statistics for about two hundred stations within the State. There will be found in it a set of tables showing the monthly flow of all the streams in the San Joaquin Valley from Kern River on the south to Mokelumne on the north, and also Sacramento River and valley, with the flow of those streams per month and per second. That is the result of a very considerable amount of instrumental observation and systematic recording. I do not think any other State in the Union, unless it is perhaps the State of New York, can show such results.

Beyond those there are the records of evaporation experiments, which of course have a pertinent bearing upon this water supply and utilization of it, and beyond that is a table of drainage areas, made up from maps of the entire State, showing the water-shed area of each particular stream, and most of the tributary streams within the entire State.

To have carried this work out to a full fruition would have involved very much additional labor, because such information can not be had in a short space of time. No amount of observation will gauge the flow of a stream in one year, or even five or six years; such observations must be made through a period of time. These results cover about six years of actual labor, and several years more of reconnaissance.

Then comes the final report which was projected, a volume which was intended to be introductory to the whole subject, commenting upon irrigation in France, Italy, and Spain, the three irrigation countries of Europe, where the subject has been more closely studied than in any other countries of the world. This book reviews the laws, the customs, the regulations, the organizations for the construction of works, the utilization of water, and the political and financial questions connected with irrigation. Of course this very largely is a compilation of existing authorities, and from extensive correspondence with governmental officers in those countries. So that from the time of printing, two or three years ago, I have reason to think that it represents a very fair story of the experience of those countries.

Following that comes volume 2 of the final report of the State engineer, which undertakes to describe the existing works in the three southern counties, San Diego, San Bernardino, and Los Angeles. This volume brings the subject down to last September, and describes minutely every work of any note in those three counties, giving the district in which the work is, the work itself, its operation and maintenance, going into the matter of organization; then the water supply available for the work, the use and application of that water, and the history of its organization. So that I think you will find here a very complete story of irrigation as it existed in those three southern counties up to about August of last year. But there has been little change since that. This volume is illustrated with maps.

The CHAIRMAN. Does it give an account of the dams recently constructed in San Diego?

Mr. HALL. Yes; it describes and gives the cost of construction of those dams, etc. This book is illustrated with cuts and pictures of those dams, and it also contains two maps, one of which illustrates the subject of drainage areas within the entire State, showing the division into great areas and sub-areas, with a tabulated statement of the square miles in each area and sub-area; and the other a rain-fall map made up from observations of rain-fall, which observations were conducted by the Department, the Railway Mail Service, and very many other authorities, which shows the distribution of rain-fall for over 10 inches up to 90 inches, and showing where our country is deficient for purposes of precipitation. Then there are other charts, which it is not necessary to refer to here, plans of dams, etc.

There are in this package a number of lithographic maps. One of them represents the San Joaquin and Sacramento valleys, and has within it the great interior valley of the State. It shows every stream correctly located, the topography of the adjacent foot-hills, the slope, and the fall of the plains to be irrigated, etc.

Another map, and on another scale, shows the San Joaquin Valley alone, going more into detail than the general map does, and covering the whole valley, showing the extent of lands actually irrigated.

Then there are ten irrigation sheets, showing every irrigation canal and ditch up to within about three years ago—because this work in that valley was practically stopped three years ago—in the San Joaquin Valley, and the extent of this irrigation in a separate color, and to some extent the character of that irrigation by the shade of that color. So that the story of irrigation in San Joaquin Valley, as it was to be told three years ago, is in graphic form for the inspection of the committee.

Then there are twelve detailed irrigation sheets relating to San Bernardino and Los Angeles Counties, going more into detail than those relating to the San Joaquin valley. These twelve sheets now for the first time appear before the public, but the other sheets I think the committee have received.

The CHAIRMAN. Has there been any change in the San Joaquin valley in the last four years?

Mr. HALL. Yes. I have just come to that point. These twelve sheets relating to the southern counties are more in detail, as I said, and on a larger scale than in the San Joaquin valley, and they show, down to last August, every bit of land irrigated to that time, and the character of the irrigation.

Now, the tabulation of this data, while it has been for some time in course of preparation, was in a measure checked for want of funds for completion. And I have certain tables, copies of which I shall furnish to the committee. Here [exhibiting] is a table showing the division or district in each river from Kern to Mokelumne, which covers the irrigation portion of the great interior of the State. It shows the data of each county, its length, dimensions, etc.; its claim to water, and equivalent of that claim, the period of flow, the period of time during each season that it ordinarily has water, the greatest average flow for three months during the season of 1885, and the cost of the works so far as such cost can be ascertained or even approximately estimated, and the amount of land irrigated in acres for each cubic foot per second of continuous flow for three months. That tells a very complete story of the irrigation of that valley at that time. In course of preparation I have a supplement to this table which brings the work down to last season, in some cases quite accurately, and in other cases approximately. (See Exhibit A.)

The **CHAIRMAN**. When will that be completed?

Mr. **HALL**. I will have that before the committee before it will be required.

Then there is a table showing the irrigation of each canal in the three southern counties, naming it, and giving the extent of its application, being a synopsis of the data in the second report. That table I will hand to the committee to keep; the other I will have to retain for the present (Exhibit B), but will forward.

The **CHAIRMAN**. Are you through with the State work?

Mr. **HALL**. Yes, so far as presenting this printed data is concerned. Irrigation in this State has advanced not only the marketable value of the land, but the actual value of land from practically nothing up to from $100 to $500 per acre. The marketable value of the land has advanced in some instances to $1,000 and $1,200 per acre. But I say the actual value of the land is from $100 to $500 per acre. In broad terms that is the economic value of irrigation which every one can understand.

The **CHAIRMAN**. Will your reports approximate the average cost per acre in irrigating in the first instance?

Mr. **HALL**. Irrigation has cost, by the crude, home-like methods which the ordinary farmers individually have practiced, from $2 to $5 an acre. By the better methods pursued and by better organized companies, by men commanding capital, with more substantial works constructed, it has cost from $2.50 to $10 per acre.

In the southern part of the State, where water is scarce and where the results of water are measured in oranges and in raising grapes, they have lined the ditches with concrete. Sometimes they line them with wood, sometimes with asphaltum, at other times they line them with brick, and in many cases with stone laid in cement. In other cases ditches have been dispensed with, and pipes have been laid; large concrete pipes, like a sewer in a city, or large iron pipes, such as would astonish some persons engaged in water supply works for cities. In those cases irrigation has cost more to the acre. The cost of such work has amounted to from $15 to even $40 an acre. But there the land has been practically valueless without irrigation, and it has commanded from $250 an acre to $750 an acre when water was put on it. So that, you may say that, according to the work, irrigation has cost from $2.50

an acre to $50 an acre in this State. And, as a matter of course, the cost in every instance presents a peculiar problem. If we start out to irrigate a small bit of bench land, we must expect it to cost very much more to the acre than it would to reclaim a great desert. There have been instances where irrigation works, simple open ditches and the ordinary methods of construction, have cost very much more than the ordinary price. But there are instances where large areas have been reclaimed and have cost less. As in every other business, we may say, when you undertake to irrigate a portion of the Colorado desert by the diversion of the Colorado, or the barren lands of Modoc and Siskiyou Counties by the Pitt River or the Owens, with such work as that and a large capitalization to carry it through, you can bring the cost per acre down, and the Government, if it should move promptly in the matter, might carry out the work at 25 per cent. of its ordinary cost.

The CHAIRMAN. You class the irrigated land at from $100 to $500 per acre?

Mr. HALL. Yes.

The CHAIRMAN. And that you apply to nearly every locality in the State?

Mr. HALL. Yes; those figures will cover every locality in the State.

The CHAIRMAN. What crops do they produce?

Mr. HALL. Grain on some lands, if properly prepared, $200 an acre and $300 an acre can be maintained; but the generality of experience with grain in the State does not justify the cost. It is more trouble and more expense to irrigate land for grain than for any other crop.

The CHAIRMAN. How as to grasses?

Mr. HALL. Alfalfa you can speak of in about the same class as grain, but generally with grasses. If you want to irrigate alfalfa economically you must spend the money on the land, that is on the irrigation works at first, in order to be able to cover that land with the least amount of water.

Senator STANFORD. Is there any acre of land in this State in alfalfa that can be irrigated and made to produce an income of $100?

Mr. HALL. There is no area of fair valley land but will produce fully to that valuation. Of course, there are areas of land which to the eye will look pretty well, but they are not fair lands for irrigation purposes; they are alkali lands, and heavy in the soil. The expert will recognize that at once. But they are the exception. It does not make so much difference if you have alkali on the land, because experience in this State has shown if you have alkali combined with clay, light alkali land, it can be handled very well, but the heavy alkali lands can not be.

The CHAIRMAN. When you have alkali lands do you reclaim them by putting water on to them and paying attention to the drainage?

Mr. HALL. Yes. There must be more attention paid where the land is covered with alkali than where it is not.

The CHAIRMAN. What would be the proper way?

Mr. HALL. It depends on the amount of cultivation, the expense that would justify the return expected. Where you have only general agricultural and not horticultural farming, the method of open ditches, with closed conduits, is the only method that would be justified.

Mr. MILLS. Before Mr. Hall leaves the question of the valuation of land, I would like to ask him a question. What increment of value, as a general proposition, is conferred upon the land by irrigation. That is to say, take the average valuation of irrigable land in the San Joaquin valley. Without irrigation, in its natural state, what would it be worth, and what value would be conferred upon it, or what percentage or increment of value would be conferred upon it—how many times its present value would it be worth with irrigation?

Mr. **HALL**. Of course, in answering that question one would have to predicate his answer of the present value of lands there. But what dry lands are held at in the San Joaquin Valley is not a good criterion. The present value of dry lands down there without water and without the hope of getting water, does not exceed $10 per acre. You can buy them for that. But it does not exceed that. I speak of the Tulare portion, and not San Joaquin.

Senator **STANFORD**. Is not this $10 an acre valuation based upon the possibilities of irrigation?

Mr. **HALL**. No. It is by reason of the neighborhood of irrigated lands. These dry lands are rendered more valuable, actually, because of their proximity to irrigated lands than they would be without the irrigation in the neighborhood. They can be utilized in many ways. But without that irrigation near there, without that population which irrigation sustains—wipe out irrigation in Tulare Valley and set it back thirty or twenty-five or even twenty years, and the land will go down to $1.25 an acre.

Mr. **MILLS**. That is my question. Where irrigation has been projected how many times does the value of the land increase?

Mr. **HALL**. Two hundred fold.

Mr. **ESTEE**. Take Riverside, for instance.

Mr. **HALL**. I am speaking of agricultural lands generally. Riverside is an exception. A horticultural neighborhood must be the exception. We can not expect to practice horticulture on the great body of the arid region. Riverside land, of course, has gone up from $2.25 an acre to $600 an acre, or, perhaps, $1,000 an acre.

The **CHAIRMAN**. How much land would it have required to support one head of cattle, one ox, in the San Joaquin Valley before there was irrigation?

Mr. **HALL**. I have had no experience in that direction; but I remember to have heard in the legislature of the State a discussion in which Hon. Thomas Fowler, a well known cattle man in early times, took part. It was he who was the great opponent of irrigation. I heard him declare, in 1876, that the plains of the San Joaquin Valley were valuable to him and others in the same business with him to the extent of one long-horned Mexican ox to each 25 acres. He was good authority then.

The **CHAIRMAN**. How many horned cattle will an acre of well cultivated alfalfa now support?

Mr. **HALL**. Two or three. There are better witnesses upon that point, however, than I am.

The **CHAIRMAN**. I would like to hear about the Government surveys, whether any good can be accomplished in California by having them go on. You have undertaken these surveys.

Mr. **HALL**. I might be considered a prejudiced and biased witness upon that point, seeing that I am interested in them. But, taking my statement for what it is worth, I think there is a very great necessity for just such an examination as the Government has undertaken. The necessity in California is not confined alone to the valley land, but generally, for purposes of water supply, for domestic purposes, and for the prevention of floods, for the amelioration of the sanitary condition of the country, and for the reclamation of the land—all of these ends will be subserved by such a study as that which has been commenced. For instance, taking the Sacramento Valley, a valley with some hundreds of thousands of overflowed lands in it. Those lands can never be reclaimed unless there be some systematic work in controlling the floods, in controlling the rivers. Such work can not be undertaken without a physical study of the hydrological conditions in that valley. That study must be based upon a knowledge of the topography of the country, of the opportunities for storing water, and, of course, of the water supply, and the manner in which that supply is had. This study undertaken by the Government will furnish the foundation of the reclamation of 1,000,000 acres of land overflowed annually, or for the protection of hundreds of thousands of acres which have been partially reclaimed, but are threatened every few years with inundation.

In the San Joaquin the question of water supply for purposes of irrigation is more especially important, and this study will enable the people of the State, and especially those living in that valley, to know where and how water can be stored and served for purposes of irrigation. The Government owns some arid lands in that valley, especially on the western side and of course the valuation of those lands will be affected, as I have stated, perhaps 100, 200, or 300 per cent. by reason of this work. I have spoken of that portion of the State where irrigation is less needed, unless we take into consideration these coast counties, and the people there are too well off to want any Government aid.

But going back in Siskiyou and Modoc Counties, there are a million or so acres of land, and that land is largely the property of the General Government. That can in a great measure be reclaimed by the storage of water and the diversion of water from the larger streams. Such storage and such diversion, in my judgment, can be carried on only upon the basis of such a study, because the problems there are too much in private enterprise, and unfortunately or fortunately, as you may consider, the laws of our State are in such a condition that private enterprise is afraid of such investments, unless there be some governmental scheme to carry it out. So that, in some sections of our State, private enterprise is at a standstill as to undertaking great irrigation works, and unless the Government should do something in the way of demonstration of the possibility of the inaugration of the great works, new ones in this State will very soon cease. Of course, on the eastern side of the mountain, in what is called the La Hontan division, you can hear from Mr. Bridges, who has charge of that work, what can be accomplished by irrigation. But going south into the Mohave and Colorada Deserts, in the Colorado Desert there is a country 25 miles broad and 50 miles long that can be very largely irrigated by the diversion of water from the Colorado River. That is a scheme which the Government alone should undertake, in my judgment. I do not think any private enterprise should undertake that unless it were by governmental authority. The scheme is a big one, and the chances are too great, the time necessary for carrying it out too long, and the conditions too complicated for private enterprise, at least in our generation.

The **CHAIRMAN**. To what extent for reservoir sites in this State does the Government still own land?

Mr. **HALL**. In the northern part and eastern part of the State—the northern part, that is, exclusively the coast valley and the great interior valley—the Government yet owns very largely the land, and we might say that the opportunities for storing water in those portions, that is in the eastern portions and northern portion, even, than any other section of the State where irrigation is now considered necessary.

The **CHAIRMAN**. Are you familiar with the high mountains that form the water-shed of the Kern and the other rivers from there up to Stockton?

Mr. HALL. I am.

The CHAIRMAN. Are there many lakes in the high mountains along there?

Mr. HALL. In the Kerr Mountain water-shed there are exceptionally good opportunities for water storage. There is one remarkably fine chance there. It is called the Manatechee meadows. It has been surveyed. It was surveyed by the State engineering department in 1880, and it has been since surveyed by private enterprise. It is a mountain meadow, having a very flat surface and broad expanse, where a dam for impounding water to a maximum depth of 80 feet could be built. A dam 400 feet long on the top will retain 6,378,000,000 cubic feet of water, covering an area of 4,420 acres. I do not think there is another available water site in California, unless it be some big natural lake like Lake Biglar, Clear, or Goose Lake, that form similar opportunities.

The tabulated results of storage of water in California, by great hydraulic dams, and dams constructed for municipal purposes for the supply of San Francisco and Oakland, and dams constructed in the southern part of the State for irrigation purposes, with a liberal estimate for this site—the cost for that place will be somewhat less than one-half to the volume of water than any other site surveyed—I propose to hand to this committee, and not consume your time with them now.*

There is one question I find to which, perhaps, justice has not been done; a question about which this committee ought to carefully avoid hearsay, because I know it is after the truth—bottom facts. That question is the duty of water. You will find, for instance, in the San Joaquin Valley that claims are made that a cubic foot of water per second will irrigate 200 or at any rate 160 acres of land. Now, it is not doing it. We have the acreage irrigated platted out definitely on a map, and the name of every man who irrigates every piece of land. We have the canals measured, and have observed through not one season but several of them, and I find that a cubic foot of water in the San Joaquin Valley does not irrigate 160 acres of land. But that is not because a cubic foot of water will not irrigate 160 acres, but because it is wasted. It is wasted because this State has never properly regulated the matter. That is the reason.

Senator JONES. Do you think a cubic foot is sufficient to irrigate 160 acres of land if properly managed?

Mr. HALL. I think that a cubic foot of water properly managed with open ditches carefully constructed can be made to irrigate 160 acres of land in the San Joaquin Valley; but it will take supervision.

Senator JONES. What depth of water, of actual irrigation, will that give?

Mr. HALL. I have not calculated that part of it, but I can easily do so.

The CHAIRMAN. That is a cubic foot during the irrigating season?

Mr. HALL. During the irrigating season—the four or five months of irrigation.

The CHAIRMAN. Does it require more or less water at the beginning of irrigation?

Mr. HALL. Oh, vastly more. In 1876, I think it was, or 1877, I was temporarily in charge of some canals which had been constructed in Fresno, and which, through the failure of one of the large land owners there, had gone into the hands of one of our local banks, and one season, as representing the bank there, I visited that canal and measured over and over again the amount of water which was applied to a 20-acre tract. That 20-acre tract was down at the end of the irrigated area, and it was in a new country surrounded by a broad expanse of absolutely dry plain, and just where this tract was situated the soil was 60 feet below the surface. I have run on to that tract of land enough water to cover it 23 feet deep in one irrigating season. I have run that much on over and over again. Of course, that tract of land was simply a little sponge through which the water sunk. Taking a level cross-section to get a profile of the country, the San Joaquin on the north and Kings River on the south, and then measuring from the surface down, we found that water on the plain with this irrigating water on top sloughing away. Now, irrigation has gone on there for thirteen years more—I am not certain about just that locality, but within 2 or 3 miles of there—the water stands on the surface of the ground, and flags and rushes grow there, and, if no Fresno gentlemen are here, I will say that chills and fever grow there too. That is the effect.

---

* These tables have not come to hand.

The CHAIRMAN. It needs drainage now?

Mr. HALL. Yes.

The CHAIRMAN. You were about to give the duty of water?

Mr. HALL. Going into the southern counties where water is applied for different purposes, horticultural purposes almost entirely, through cemented ditches, wooden flumes, and iron pipes, it is claimed that the inch, which is about one-fiftieth per cent. of a cubic foot per second, will irrigate 10 acres. Of course, that will be 500 acres to the cubic foot per second. But it does not. The inch will irrigate 10 acres of young oranges, where the water is applied around the base of a tree with a hose, or to wet a place two feet square around a young orange tree or grape vine. But experience at Riverside, where irrigation has been carried on longer, shows that the inch irrigates from 2½ to 3 acres.

Mr. N. P. CHIPMAN. State what an inch of water is in this country.

Mr. HALL. The inch in this State is very much like the old lady's piece of butter in her receipt for cake, and so according to local custom the inch varies about 100 per cent. of its minimum value. But measuring water through a 1-inch orifice, under a pressure of 4 inches over the top of that orifice, we will get the equivalent of about one-fiftieth of a cubic foot per second. And so, while not accurate, for convenience, in order to translate the inch into a definite quantity, I have adopted in this State engineering the co-efficient of 50. I divide it by 50, or multiply it by 50, to get the cubic foot, and I think that has been adopted by engineers in the southern part of the State.

But to go back. On page 219 of the second volume of the report of the State engineer, can be found a statement of irrigation at Riverside, showing the capacity of the canals in inches, the low water in miner's inches, and the overflow in miner's inches, and the extent of irrigation. The figures for 1888, the last year of observation, are all marked there, and have approximates, because in that year we did not actually measure the amount of land irrigated, but upon the basis of those which preceded and from returns made by the irrigators in writing, we get very closely to it, and the last figure is not far wrong. You will find then that with an ordinary flow of 3,500 miner's inches in the Riverside canal during the irrigation season, there were 6,500 acres irrigated. There you will see that it is actually less than 2 acres to the inch.

There are a great many ways in which water is lost in irrigation. But you measure water and run it onto a tract of land for a few hours at a time and you will find its duty mounts up comparatively high. But you must remember there is a loss in transmitting water through the main canal; there is a loss in distributing; there is a loss in managing it, and there is a loss in the actual irrigation in the waste off from the tract irrigated. And so, while I do not say as a matter of fact that the extent of the duty of water in Riverside has been reached, or that it has been reached in any other of those colonies down there, still I do say they will never irrigate 10 acres to the inch as is claimed. If they make it 5 or 2½ acres to the inch, the water carried in closed conduits and in the best class of work, they will be doing very well.

The CHAIRMAN. Have you ever made any observations with a view to determining what effect irrigation will have upon the climate?

Mr. HALL. There have been curious climatic changes in this State which we must attribute to irrigation. For instance, I remember to have gone to Bakersfield some years ago when irrigation was first being introduced there. I do not know whether this ought to be recorded, but I was struck with the very curious appearance of shape of the younger ladies or girls in that section. It seems that I could not account for it at the time, but it turned out that they had a little affection of the spine, and there was a rotundity of the trunk which was astonishing in ladies so young. I tell you that to illustrate the fact that before irrigation was regularly introduced, there was a malarial influence which pervaded the population to that extent, and it showed not only upon the countenance of the people, but upon their persons. But now that the slough has been cleaned out, the underbrush cut away, the rank vegetation ploughed off, the surface of the land turned over to the atmosphere, fresh water brought over these sloughs and applied to the land and vegetation, the atmosphere and the climatic conditions appear to have changed to that extent that I believe Bakersfield and that neighborhood is about as healthful a locality as you will find in any portion of this State. And I attribute it to irrigation.

Mr. CHIPMAN. The popular idea all over the world is that irrigation produces malaria, and is so unhealthful that it is discarded in many localities. You can not be too emphatic on that point.

Mr. HALL. I was just coming to that. Here in Bakersfield is one instance where the cultivation of land by irrigation has greatly improved the health of the people. Bakersfield was comparatively a low section. Going up to Fresno we have a high section. At Bakersfield the ground waters were within 10 or 15 or 20 feet of the surface—that is when I saw it—I mean the neighborhood. At Fresno, the ground waters were 60 or 80 feet below the surface before irrigation. That country has been filled up like a sponge, and there has been no adequate drainage. The water enters subterraneously the cellars of Fresno and flags grow upon the formerly dry plains. There is no doubt that Fresno is a much less healthful place than it used to be. But it is not due to irrigation. It is due to the lack of drainage. Fresno can be as healthful a section as it ever was or any other section in that portion of the State.

The CHAIRMAN. Must this drainage be expensive?

Mr. HALL. No, it need not cost any more to the acre than to irrigate.

The CHAIRMAN. Will the drainage cost as much as the original irrigation works—the cost of bringing the water onto the land?

Mr. HALL. A proper drainage of Fresno would not cost as much as the irrigation of it. But it is not irrigated yet, and the full expense of irrigation is not known there. Generally speaking there are instances where irrigation has been practiced in a crude way; where apparently the healthfulness of the climate has been affected, where chills and fever and malarious effects have come with irrigation; but they can be traced to the lack of drainage as we can trace typhoid fever or those low grades of fever which pervade sections of this State to defective sewer drainage in the houses. I know a family in this town that has been driven out of three houses, that is to say, it has gone into three separate houses where it has turned out that the drainage underneath the ground was moistened with sewage matter. You can not have healthful houses on the plains of Fresno with the water standing in your cellar any more than you can with the sewage water in your house in this city.

The CHAIRMAN. How does it affect rain-fall?

Mr. HALL. The experience of this State has been too limited to speak definitely upon that point. You will find a great many intelligent gentlemen here who believe that irrigation has thus far increased the amount of precipitation, and I do not think any of us are prepared to dispute it without facts. But it seems curious. Over a series of years since irrigation was practiced in Los Angeles County, the rain-fall has been greater, and the same can be said of San Joaquin Valley. But what time is necessary we do not know.

Senator JONES. Have there been observations for a sufficient length of time to determine that?

Mr. HALL. No. I file with the committee tables, etc., marked respectively Exhibits A and B.

EXHIBIT A.

The canals of San Joaquin Valley—Irrigation data for 1885.

	Acres.
Kern River, north side:	
Pierce and Barker (no irrigation)	
Barker and Wilson (no irrigation)	
Kern River, south side:	
Barker	100
Kern River, north side:	
Beardsley	1200
McCord	2,000
Calloway	18,000
McCaffrey Slough	300
Emery	80
Jones and Turkey (no irrigation)	
Railroad	360
Wible	
Goose Lake	
Pioneer	4,080
Edwards (no irrigation)	
James and Dixon	960
Johnson	360
Ashe (no irrigation)	
May (no irrigation)	
Joice	640
Kern River, head of Joice canal:	
Dixan	100
Kern River, south side:	
Kern Island	10,170
South Fork	3,675
Farmers	1,780
Castro (no irrigation)	
Stine	7,000
Anderson	1,400
Gates	
Buena Vista	2,480
James	4,800
Plunkett	
Meacham	280
Kern River, south side—Cont'd.	
Wilson	100
Henly (not in use)	
Frazier (not in use)	
Kern Valley Water Company's west-side canal	3,500
Kern Valley Water Company's east-side canal	
Total	63,365
Poso Creek:	
Purcell	400
Creasey (unfinished)	
Deer Creek:	
Wingfield	300
Carothers (no irrigation)	
Deer Creek, consolidated ditch	1,335
Total	1,635
Tule River:	
Great American	50
Pioneer	1,292
Traylor	60
Porter Slough	53
Hockett	314
Wallace	40
McGee, Putnam, and Caldwell	110
Gilliam	120
Hubbs and Miner	405
Fulweiler	152
Hunsaker	160
Platts	10
Thomas	5

EXHIBIT A.—*The canals of San Joaquin Valley, etc.*—Continued.

	Acres.
Tule River—Continued.	
Elrod	31
Brown and Ray	10
M. M. Burnett	40
W. T. Burnett	166
Bacigalupi and Chreighton (no irrigation).	
Bond	80
Klein (not in use).	
Royerr, jr., School-house Branch of Tule River (not in use).	
Royerr, jr., Stadtmiller, (not in use).	
Lamacsna (not in use).	
Bacigalupi	170
Wilcox	80
South Tule River	15
Plano	408
Vandalia	100
Rose	18
Mitchell, Springer, & Rose	44
South side	754
Fine	576
Collisium Slough	634
English	120
Stockton	681
Ball & Harrison	190
Empire	160
Woodville	100
Tipton	254
Janes (no irrigation).	
Lone Oak Slough (no irrigation).	
Hirely (from L. O. Slough)	20
Creech (from L. O. Slough)	40
Rogers (from L. O. Slough) no irrigation.	
Fancher	293
Small	160
Firmly (no irrigation.)	
Gully (no irrigation).	
Small and Woesling	160
Total	8,075

	Acres.
Kaweah River:	
Wutchumna	1,634
Curtis & Lindsley	48
Venice	81
Elbow Creek (no irrigation).	
Matthew	267
Curtis (not in use).	
Weston (not in use).	
Uphill	596
Settlers	4,934
Lakeside	9,167
Upper Pogue (no irrigation).	
Lower Pogue	100
Ogden	80
Hamilton	30
Consol'd't People's Ditch	4,065
Farmers	645
Kaweah	3,121
Tulare	402
Rocky Ford (no irrigation).	
Cameron	1,372
Bacon & Crossmore	2,270
Judd (abandoned 1868).	

	Acres.
Kaweah River—Continued.	
Evans & Turner (not in use).	
Kaweah and Mill Creek	1,425
Chatter (from Kaweah and Mill Creek)	150
Oaks (from Kaweah and Mill Creek)	150
Evans (from Keweah and Mill Creek)	289
Burch (from Kaweah and Mill Creek)	110
Watson (from Kaweah and Mill Creek	315
Mill (from Kaweah and Mill Creek) used only for water-power.	
Jennings	506
Hicks and Weston	50
Royers	55
Modoc	809
Holladay (no irrigation)	
Upper Hayes	700
Lower Hayes	
Channels from St. John's Channel to Kaweah River:	
Long's Canal (no irrigation)	
Ketchum Cut (no irrigation)	
Bostwick Cut (no irrigation)	
Total	33,371

		Acres.
King's River (north side):		
King's River and Fresno		3,935
King's River (branch of Fresno Canal):		
Centerville		
Fresno		25,045
Fowler Switch		4,059
Centerville and Kingsburg		9,116
Emigrant		4,781
Lagmade Tache		9,085
Liberty		1,242
King's River (north side):		
Millrace		390
Reed		160
King's River (south side):		
"'76"		2,200
Kincaid	Small private ditches in Centerville bottom.	200
Morrow		......
Glerm		......
Barton		......
People's		16,545
Mussel Slough		
Last Chance		13,436
Lower King's River		6,622
Rhoads		2,735
Total		99,551

	Acres.
San Joaquin River:	
Upper San Joaquin	600
Chowchilla	6,900
San Joaquin and King's River	23,835
Posey Slough	
Temple Slough	
Santa Rita	400
Total	31,795

EXHIBIT A.—*The canals of San Joaquin Valley, etc.*—Continued.

	Acres.
Fresno River:	
Fresno Dam and Canal Co.'s canal	5,416
Adobe Ranch	350
Total	5,766
Chowchilla River:	
Kohler, West, and Minturn	850
Minturn	40
Total	890
Merced River:	
Merced Falls	198
Murray Hill	165
Snelling	423
Montgomery	153
Ingalsbe Slough	202
Scott	130
Deane	449
Old River	1,142
Old River:	
Grade slough (fr. Old River)	....
Sellman (fr. Old River)	....
Means (fr. Old River)	....
Grade (fr. Old River) not in use.	
Merced	2,000
Feldhams and Reed	407
Griffith and Sharer	550
Hamlin	127
Total	5,946
Tuolumne River:	
Wheaton	50
Stainslaus River:	
San Joaquin County	184
Pentland (not in use 1881)	....
Mokelumne River:	
Barnett	112

SUMMARY.

Supply from—	Name of canals.	Irrigated area.
		Acres.
Kern River	Kern River canals	63,365
Poso Creek	Poso Creek canals	400
Deer Creek	Deer Creek canals	1,635
Tule River	Tule River canals	8,075
Kaweah River	Kaweah River canals	33,371
Kings River	Kings River canals	99,571
San Joaquin River	San Joaquin River canals	31,795
Fresno River	Fresno River canals	5,766
Chowchilla River	Chowchilla River canals	890
Merced River	Merced River canals	5,946
Tuolumne River	Tuolumne River canals	50
Stanislaus River	Stanislaus River canals	184
Mokelumne River	Mokelumne River canals	112
Total	....	251,140

EXHIBIT B.

Actual irrigation. San Diego, San Bernardino, and Los Angeles Counties, 1888.

SAN DIEGO COUNTY.

Group, etc.	Supplied from—	Name of corporation or ditch.	Irrigated area.
			Acres.
San Diego and San Diequito Rivers.	San Diego River	South Fork (old ditch; Indians)	50
	San Diequito River	Bottom Lands (old ditch)	100
	Do	San Pasquel Valley (old ditch)	175
	Do	Santa Ysabel Rancho (old ditch; Indians).	100
	Guejito branch Diequito River.	Guejito Branch of San Isabel (old ditch)	25
San Louis Rey River	....	San Louis Rey Mission (old ditch)	100
		Montserrate Rancho (old ditch)	65
		Vicinity of Pola, 5 or 6 ditches (old ditch)	200
		Aqua Tibia Creek (old ditch)	65
		Panna Creek (old ditch; small patches).	....
		Cuca and Warner's Ranchos (old ditches; Indians).	50

EXHIBIT B.—*Actual irrigation, etc.*—Continued.

SAN DIEGO COUNTY—Continued.

Group, etc.	Supplied from—	Name of corporation or ditch.	Irrigated area.
			Acres.
Santa Margarita River.	....	Santa Margarita Rancho (old farm ditch).	312
San Jacinto River	....	Huiler Ditch	55
		Hewett's Ditch	450
		Estudillo Ditch (abandoned)	....
		Mission Indians Ditch	150
		San Jacinto town ditch (around town)	....
		Webster's Ditch	75
		McAllister's Ditch	75
		Palm Valley Land and Water Company	160

SAN BERNARDINO COUNTY.

Santa Ana River.

Santa Ana Cañon group (1).	Santa Ana River	North Fork Canal:	
	North side	Highland Vineyard Canal	1,400
		Crain, Van Lueven Canal	
	South side	South Fork or Sunnyside Canal	1,535
		Red Lands Ditch	1,200
		J & B Ditch	
	Bear Valley Company	East Red Lands Company Works	150
		West Red Lands Company Works	150
		Riverside Water Company:	
Basin Diversion group (2).	Santa Ana River	R. Lower Canal	6,580
	Warm Creek	R. Old Upper Canal	
		R. Warm Creek Canal	
Riverside mesa sub-group (*a*)	Artesian wells in San Bernardino Basin.	Upper Riverside Enterprise Gauge Canal	1,100
		Highest Riverside Mesa Scheme:	
		Vivienda Water Company (no irirgation).	....
		N. Riverside Land and Water Company (no irrigation).	....
		Jumpa Land and Water Company (no irrigation).	....
Basin Diversion group (2).	....	Camp Carlton Ditch	415
		The Old Hunt Ditch	125
		Old Jansen Ditch	132
		Belarde & Salazar Ditch	55
South side Santa Ana sub-group (*b*).	Hunt's Springs	Hunt's Spring Irrigation	30
	Four artesian wells	Filanc Wells Irrigation	42
Warm Creek and City Creek sub-group (*c*).	Warm Creek	Hawes Ditch	50
	Warren Creek and wells.	Rabel's Dam Ditch	375
	Do	Stout's Dam Ditch	240
	Warm Creek	McKenzie or Lower Dam Ditch	325
	Lower City Creek	Spark's Ditch	20
	Do	Stewart's Ditch	47
	Do	Waterman's Ditch	55
	Do	St. Bernard or Davis Mill Ditch	....
	Heap Springs	Heap's Springs or Beam Ditch	70
	Artesian Springs	Johnson's Swamp Ditch	115
	Artesian	Coburn Swamp Ditch	56
Lytle Creek Springs and Town Springs sub-group (*d*).	Raynor Springs	Rancheria Ditch	180
	Do	Cotton Land and Water Company's Ditch.	204
		Town Creek Ditch (no data)	....
		Beamis Ditch (no data)	....
		Garner Ditch (no data)	....
Basin Diversion group (2).	Santa Ana River	Santa Ana Waste-water Ditch	300
North side Santa Ana sub-group (*e*).	Warm Creek	Meeks and Daley Ditch	385
	Santa Ana River	Jaramillo Ditch	30
	Do	San Salvador Ditch	50
	Do	Aqua Mansa Ditch	116
Jumpa Plains sub-group (*f*).	....	North Riverside Land and Water Company; Vivienda Company; Jumpa Land and Water Company. (Projects only.)	....

EXHIBIT B.—*Actual irrigation, etc.*—Continued.

SAN BERNARDINO COUNTY—Continued.

Group, etc.	Supplied from—	Name of corporation or ditch.	Irrigated area.
			Acres.
Jumpa Valley group (3).	Santa Ana River (west side).	Jumpa or Rubidoux Ditch	557
	Riverside Lower canal.	Trujillo Ditch	250
	Santa Ana River	Linville Ditch	75
	Do	Soucal Ditch	100
	Do	Brickmore or Island Ditch	120
		Hall Ditch	100
Rincon group (4)	Santa Ana Lower Cañon.	Yorba Ditch	485
	Santa Ana River	Fernandez Ditch	279
	Chino Creek	Taylor Ditch	6
	Rincon Mill Creek	Cota Ditch	50
	Do	Spring Valley Ditch	47
	Spring Valley Waste	Fuqua Ditch	66

San Bernardino Valley Works.

South Cañon group (5).	Mill Creek	Old Zanja Crafton Water Company	1,300
	Crafton Main	Red Lands Heights, Main	
	Bear Valley Canal	Crafton, Lugonia and Redlands Domestic Water Company. (No data.)	
	Yucuipa Creek	Yucuipa Ditch, a small ditch in Yucuipa Valley. (No data.)	166
	San Timoteo and Elder Creeks.	Several ditches (small, no data)	
North Cañons group (6).	City Creek Cañon	City Creek Ditch	203
	West Creek	West Twin Creek Ditch	70
	Do	Waterman Hot Springs Irrigation	40
	East Creek	East Twin Creek Ditch (abandoned)	
	Cajon Pass stream	Glen Helen Ditch	200
	Lytle Creek	Rialto Canal	602
	Do	Semi-Tropic Land and Water Company	475

Cucamonga Plains Irrigations.

Cucamonga Plains groups (7).	Day's, Young's, and Middle Cañons.	Etiwand Colony Irrigation	652
	Deer and Alder Cañons.	Hermosa Water Company	368
	Small intermediate cañons.	Sausevain's Ditch (abandoned)	
	Cucamonga Cañon	Iowa Colony Irrigation	301
	Do	Cucamonga Development Company, Cucamonga Water Company's Works.	1,940
	Cucamonga Cañon and Cienegas.	Cucamonga Vineyard Company	350
	San Antonio Cañon	San Antonio Water Company	1,750

LOS ANGELES COUNTY.

Cucanwuga Plains irrigations.

Pomona (1)		Pomona Land and Water company's works:	
		Old settlement ditch	455
		Irrigating Company of Pomona	1,880
		Palomares Irrigating Company	430
		Del Monte Irrigating Company	520
		Cañon Irrigating Company	2,040
		Packard works	(?)
		Fleming & Rohrer	(?)
		Chino	(?)

EXHIBIT B.—*Actual irrigation, etc.*—Continued.

LOS ANGELES COUNTY—Continued.

San Gabriel Valley irrigations.

Group, etc.	Supplied from—	Name of corporation or ditch.	Irrigated area.
			Acres.
Sierra Madre Cañons group (2).	San Dimas Cañon.....	San Dimas Land and Water Company.....	100
		San José Ranch Company.................	125
		San José Land and Water Company........	(?)
San José subgroup....	Dalton Cañon..........	Glendora Water Company (no irrigation).	....
San Gabriel River subgroup.	....	Dalton or Azusa Ditch....................	2,550
		Azusa Water Development and Irrigation Company.	1,500
		Duarete Mutual Irrigation Canal Company.	600
		Beardslee Water Ditch Company	500
Santa Anita subgroup (c).	San Pit Cañon	Bradbury-Monrovia Works	50
	Santa Anita Cañon...	Santa Anita Water Company	(?)
	Little Santa Anita Cañon.	Sierra Madre Water Company	300
Sierre Madre cañons group (2).	Davis' Cañon	Sierra Madre Villa and Vosburg Companies.	105
		Kinnola Ditch..................................	60
San Pasquel subgroup (d).	Eaton Cañon...........	Precipice Cañon Water Company.........	250
	Rubio and Les Flores Cañon.	Rubio Cañon Water Company	200
		Rubio Cañon Land and Water Association	
		Les Flores Water Company................	
Basin group (3)........	San Gabriel and Santa Anita Cienagas.	Santa Anita Rancho........................	150
		Marengo Water Company..................	6,000
		Alhambra..	
		Alhambra Addition Water Company....	
		Old San Gabriel Irrigations...............	
	San José Creek	Phillips Ditch	50
		Fryer's Ditch	100
		Rubottom Ditch...............................	40
		Wright Ditch..................................	60
		Currier Ditch.................................	150
		Rowland and Foster Ditch................	200
		Ybarra Ditch..................................	350
		Quintana Ditch...............................	100
		Monroe Ditch.................................	40
		T. and J. Rowland Ditch...................	250
		Workman Ditch................................	30
		Puente Mill Ditch............................	60
		Pio Pico Ditch................................	160
	Middle San Gabriel Cañon and springs supply.	Peck Ditch.....................................	(?)
San Gabriel and San Fernando group (4).		Millard Cañon Water Company	50
		North Pasadena Irrigation Works	(?)
		Arroyo Seco Springs Works................	500
		Pasadena Lake Vineyard Land and Water Company.	1,000
		Highland Park Water Co. (domestic).....	....
		Crystal Springs Water Co. (domestic)....	....

San Fernando Valley irrigations.

San Fernando Valley group (5); Cañada subgroup (h).	....	Cresenta Cañada Colony Works..........	1,900
		Pickens' Cañon Works......................	200
		Hall Cañon Works	230
		Earl Cañon Works	100
		Shields Cañon Works	....
		Verdugo Cañon Springs Works............	1,[illegible]00
	Lejunga and Paicoma Cañon.	Monte Vista Colony Works................	[illegible]00
		Phillips' Ditch	17
		Johnson's Ditch..............................	5
	San Fernando Cañon..	Porter Land and Water Company's Works.	543
	Mormon Cañon.......	San Fernando Valley Improvement Company.	80

EXHIBIT B.—*Actual irrigation, etc.*—Continued.

LOS ANGELES COUNTY—Continued.

Los Angeles Valley and coast plains irrigations.

			Inside city.	Outside city.	
Los Angeles group (6) The Los Angeles city system.	Los Angeles River	Zanja:			
		6—1	50		50
		1	178	500	678
		2	328	1,500	1,828
		3	532	800	1,332
		4	300	500	800
		5	168	1,500	1,668
		7	398	1,000	1,398
		8	4		4
		8—R	148	2,000	2,148
		C and R	159	100	259
		Nichols	5		5
		9—E	254		254
		9—R	204		204
		Feliz Chavez	200	150	350
	Total		2,937	8,050	10,987
Irrigated by city sewage					3,000
					13,987

Coast plains irrigations.

Group.	Supplied from.	Name of corporation or ditch.	Irrigated area.
			Acres.
Cahmuga, Ballona group (7).	Ballona Creek	North side Ditch	735
		South side Ditch	800
Lower San Gabriel group (8)	New San Gabriel River	Temple Ditch	350
		Workman Ditch	375
		Rincon Ditch	400
		Cate Ditch	1,300
		Standifer Ditch	1,300
		Banta Ditch	715
		Los Nietos Ditch	950
		Little Lake Ditch	1,000
		Section Line Ditch	500
		Agricultural Ditch	1,000
		New River Ditch	1,000
		Clear Water Colony Ditch (no data)	
	Old San Gabriel River.	Arrogo Ditch, four branches:	
		Sandridge Stockton Taylor Cochran	3,800
		Repetto Ditch	100
		Foster Ditch	480
		San Antonio Ditch	800
		Cerritos Colony Ditch	1,200
Lower Santa Ana River group (9).	North side	Ryan	430
		Anaheim Union Water Company, three canals:	
		Cajou New Anaheim Old Anaheim	4,000
		Yorba Ditch	600
	South side	Santa Ana Valley Irrigating Company Canal.	15,500
Santiago Creek group (10).		Serrano and Carpenter Companies:	
		Serrano Water Company	1,300
		Carpenter Water Company	800
San Juan Capistrano group (11).		Old Mexican Ditches:	
		Mission Viejo Ditch	383
		Lower Trabuco Ditch	327
		Upper Trabuco Ditch	40
		Boca de la Playa Ditch	50

EXHIBIT B.—*Actual irrigation, etc.*—Continued.

SUMMARY.

Area irrigated in San Diego County, 1888.

	Acres.
San Diego and San Dieguito Rivers	360
San Luis Rey River	480
San Margurita River	312
San Jacinto River	965
Total	2,117

SUMMARY.

Area irrigated in San Bernardino County, 1888.

	Acres.
Santa Ana River irrigations:	
Santa Ana Cañon:	
Group (1)	4,435
Basin diversion:	
Group (2) Riverside Mesa subgroup (*a*)	7,688
South side Santa Ana subgroup (*b*)	799
Warm Creek subgroup (*c*)	1,363
Lytle Creek and City Creek subgroup (*d*)	384
North side Santa Ana subgroup (*e*)	881
Jurupa Valley group (3)	1,202
Rincon group (4)	933
San Bernardino Valley irrigations:	
South Cañons group (5)	1,468
North Cañons group (6)	1,500
Cucamonga Plains irrigations:	
Cucamonga Plains group (7)	5,361
Total for all groups	26,070

SUMMARY.

Area irrigated in Los Angeles County, 1888.

	Acres.
Cucamonga Plains irrigations:	
Pomona group (1)	5,375
San Gabriel Valley irrigations:	
Sierra Madre Cañons group (2)	
San José subgroup (*a*)	225
San Gabriel River subgroup (*b*)	5,150
Santa Anita River subgroup (*c*)	350
San Pasquel subgroup (*d*)	765
Basin Group (3)	7,590
San Gabriel and San Fernando group (4)	1,550
San Fernando Valley irrigations:	
San Fernando group (5)	4,875
Los Angeles Valley and Coast. Plains irrigations:	
Los Angeles group (6)	13,987
Coast Plains irrigations:	
Cahuenga-Ballona group (7)	1,535
Lower San Gabriel group (8)	15,600
Lower Santa Anita River group (9)	21,000
Santiago Creek group (10)	2,100
San Juan Capistrano group (11)	800
Total for all groups	80,902

FINAL SUMMARY.

Area irrigated in the three lower counties, 1888.

	Acres.
San Diego County	2,117
San Bernardino County	26,070
Los Angeles County	80,902
Grand total	109,089

STATEMENT OF W. S. GREEN, OF COLUSA.

Mr. Chairman and gentlemen, I come from a region of country that will produce 2 per cent. of the wheat of the United States. Therefore, we do not claim to have any arid land in that region. We think, however, that irrigation will benefit us to the extent that we have farmed four districts under the Wright law, and propose to irrigate 300,000 acres of land in that county. And that would be our opinion of irrigating arid lands. After discussion among the people there they have voted in those districts, some four or five to one, in favor of irrigation. Of course, it is their opinion and my opinion that the arid lands can be irrigated to a great benefit. They have no arid lands in that district; but they have voted bonds there to the extent of some million and a half of dollars for the purpose of irrigation, and some of the bonds have been sold. The central district was the first to sell the bonds, the first to have contracts to do work under the law of two years ago, the session of the legislature before the last. After hearing Mr. Hall and after seeing his report, I should say that he has gathered facts to which I can add nothing.

But I should like to say a word on the subject of sanitary conditions of irrigation. I have investigated that question for a great many years, and I believe there is no such thing as malaria in the atmosphere of California; that it is entirely in the water we drink. Where irrigation has made the locality unhealthful, it is because irrigation has simply changed the condition of the water. The atmosphere is all the time in motion, and you can not poison it any more than you can poison the ocean or a stream of running water. It takes too great an amount of poison, and from actual observation—and I have been in the State twenty-five years—I can say that with the same atmosphere and drinking different water some persons will have malaria and some will not. I find that malaria exists in spots. When I commenced to investigate the subject I took several portions of the State and I found that to be true—that malaria exists in spots. But it is not due to irrigation or the want of it. It is in the water that is drank, and those who are careful of the water they drink need not ever have malaria; that is, in this State. I could give a good many instances of that.

The CHAIRMAN. I understand you have given some attention to the subject of the effect on the water supply of cutting timber on the water-shed.

Mr. GREEN. I have not given the matter such attention that I could give to this committee any facts. I think this timber should be protected. That is the result of my observation. But I can not give you any figures. The result of my observation has been that the cutting of timber decreases the rain-fall, and the assembling of timber will make it more precipitous in the valleys. But I am not prepared to give any figures. In fact I was not expected to meet this committee until yesterday, and, therefore, have no figures to present.

I should like to call the attention of this committee to the importance of Congress regulating the taking of water from the navigable streams and their tributaries. There will be some trouble to grow out of that unless it is regulated by Congress. If everybody can say that navigation is affected by it, and can bring suits for taking the water from the streams and tributaries, there will be trouble to grow out of it. That subject is being discussed in our county, and I think it is an important thing for the committee to take into consideration. There should be some authority to say how much water shall be taken away.

STATEMENT OF GEORGE MANUEL, OF FRESNO.

Mr. Chairman and gentlemen, my connection with irrigation was confined to Fresno, Kern, Stanislaus, and San Joaquin Valleys for ten years, and during that time I was continually engaged in letting out the headwaters of the Fresno. The question has been raised as to the economic value of irrigation. I had occasion to investigate that subject a little, and I went to the Board of Trade of Fresno. That board gathered statistics on the subject from the assessor of that county.

In 1870, in township 14 south, range 20 east, sections 1 to 5, assessed to W. S. Chapman, at $1.01 per acre; section 36, at $1.13 per acre; that made an assessed valuation of that township, in 1870, of a little over $25,500 in round figures. In 1880 the Bank of California tract, a portion of these twelve sections, at $4 an acre, and Bank of California tract, 240 acres, at $5 per acre. C. A. Towne, section 2, adjoining Fresno City, at $5 per acre. C. H. Hoffman, section 12, near Fresno, at $5 per acre. E. Jansen, six sections near Fresno City, at $4 per acre. In 1888, A. T. Covell, in Washington Colony, 5 miles from Fresno, 60 acres, at $150 per acre. Sections 1 and 2 and 11 and 12 at $250 to $300 per acre, $250 per acre being about the average for unimproved land. And this increase in the value of land is due to irrigation. It is the same land exactly, only in different years, as irrigation has progressed.

Sections 6 and 7, at $100 per acre; section 19, at $75 per acre; sections 5 to 8, unimproved, and from one-half to 1 mile from the city of Fresno, at $125 and $200 per acre; sections 17, 18, and 19, averaging $85 an acre, and sections 23, 24, 25, and 26, at $75 per acre. That is the valuation of that township. The first assessment was $25,500 in round numbers, and the last assessment of the city, $6,800,000. And the total valuation of that township is probably in the neighborhood of $9,000,000.

The CHAIRMAN. That is the assessed value of the land?

Mr. MANUEL. Yes; of course the town property is in that township.

The CHAIRMAN. Would there be any town there if it were not for irrigation?

Mr. MANUEL. We will compare it with Berendo, which was started about the same time, and now consists of a shop and one hotel. Fresno has 12,000 inhabitants. The assessed value of the property in Berendo is a few thousand dollars, and it has no irrigation. The value of the property in Fresno County is due to three or four canals coming out of the north side of the Kings River. And so it is at Hanford.

The CHAIRMAN. What is the result at Hanford?

Mr. MANUEL. Hanford has increased largely. I do not know that it has increased as fast as Fresno, but the values are somewhat in proportion. Concerning the value of irrigation, I know of one canal that was said to cost in the neighborhood of $50,000. The first year after its inception the increased value of the real estate along the line of the canal was $640,000—land that could before have been bought at $2.50 per acre had increased in value sufficient to make that valuation. So I could give other instances, but I suppose that would be sufficient.

Now, concerning the value of this governmental investigation, what interest will it be? I am the engineer of this Fresno canal, and I was the engineer of the Madora district, lying immediately north of the San Joaquin River, also the West Side district, which comprises a long strip of country in some five counties from Fresno to San Joaquin, and containing about 260,000 acres of land; and of the Turlock district, lying in Stanislaus County. The people in that section voted $850,000 of bonds, and one item of that $850,000 was $140,000 for purpose of making storage reservoirs. Any work that this committee or the Government may see fit to do in that direction will be utilized by these parties. So in these other districts, they will probably avail themselves of any surveys that are made, and will proceed immediately as soon as they can place their bonds to carry the work to completion.

The **CHAIRMAN.** Are the places in that district for reservoirs in the hands of private parties, or are they public lands?

Mr. **MANUEL.** I think they are public lands.

The **CHAIRMAN.** Then the reservation of those sites would be an advantage?

Mr. **MANUEL.** I think so.

Mr. **MILLS.** How much would it cost per acre to get the water onto the land?

Mr. **MANUEL.** Probably that question can be answered by saying that we sell our water now for $5 per acre—we give a water right for that.

Senator **JONES.** Does the user have an annual payment to make after that?

Mr. **MANUEL.** One hundred dollars. But the water right, the taking of that water onto the land, leaving a marginal profit to the ditch company, is $5 per acre. We are irrigating 40,000 to 50,000 acres of land, and yet we are filling up as much more without pay.

As to the duty of water. Of course Fresno is peculiarly situated in some respects, and we have a large quantity of water which we use very liberally, and we do not consider it lost. The liberal way in which we use water benefits a population 10 miles away, on whose land big wheat crops are produced.

Senator **JONES.** Land which was not productive until this water was turned onto it?

Mr. **MANUEL.** Yes. They could not raise a bean. That is the result of irrigation, not due to direct contact with the ditches; but the filling up of the country. We have adopted the policy of encouraging irrigators to use all the water they can. When there is a shortage of water, of course it is different; but when there is 10,000 feet of water going to waste and benefiting no one, we encourage them to use it.

The **CHAIRMAN.** Is there water enough in the San Joaquin Valley to irrigate all the land in the valley if it were properly stored?

Mr. **MANUEL.** That is a large question. I will state that from Kings River north the water coming down is ample to irrigate all those lands; but from Kings River south it is impossible to irrigate all the land. You will find that as you go north, say from Kern River, the precipitation and the amount of water running in the streams gradually increases in a certain ratio, so that the northern part of the State is much better supplied than the southern part. Take the Kern River. There is a larger body of land attached to it than anywhere in the valley; but it has not the body of water that other rivers have. To illustrate that. We think that the Kern River has a drainage of 2,300 miles, and the Mokelumne has a drainage of 2,600 and the Mokelumne has a greater flow. But if you go farther north, a river of 600 miles of drainage supplies more water than the one of 2,300. It increases in that proportion. So that the most crying need for saving water is in the southern portion of the valley, and the farther you go south the greater the need. In Fresno Valley we have between the San Joaquin and Kings rivers 1,260 square miles.

Senator **STANFORD**. Did you ever make any estimate of what it would cost to irrigate by pumping on a large scale?

Mr. **MANUEL**. Yes. Probably these district will furnish a basis. For instance, the Turlock district. For the area of that district, a little over 200,000 acres, $600,000 of bonds were voted. In other words, nearly $3 per acre. That is according to the best estimate that we have made. That would be ample to construct every branch ditch and to carry water to every alternate section. That is the cost. The Madeira district, with 300,000 acres, the bonds voted were $850,000, nearly the same proportion. Of that $850,000, $140,000 were intended for storage reservoirs. The west side is not in a condition that will permit of figures; but it is somewhere in the neighborhood of $5 or $6 an acre.

The **CHAIRMAN**. Was the voting of bonds based on mere estimates or the actual cost?

Mr. **MANUEL**. Mere estimates.

The **CHAIRMAN**. You have stated that you have investigated the question of pumping.

Mr. **MANUEL**. I could give you some figures on that subject; but of course that is a scheme which we do not much employ in our country. Our water supply is abundant, and we have not gone into that.

The **CHAIRMAN**. You think you can get water enough without it?

Mr. **MANUEL**. We could get it; but we depend on the gravity supply. What we want is a storage system to help out our low water. For instance, about six or seven months of the year the rivers flow large quantities of water, enough to supply all the canals; but commencing about July or August, until the first of December, the supply is short; that is to say, the rivers run down. While we can get along without that help, while it is not a necessity, yet it would be a convenience. I think water during that period would be a convenience, and it is a necessity for young orchards, but not a necessity for anything else.

Now about malaria at Fresno. When I went there I weighed 150 pounds, and people told me that I would die if I went there. But I have been there surveying ditches, and you see the result.

Mr. **CHIPMAN**. What is your present weight?

Mr. **MANUEL**. Two hundred and twenty pounds. I attribute it to malaria in the system! But, seriously, I would say that I have a report on the subject of irrigation and its tendency to produce malaria. The British Government in India appointed a commission to visit Italy and investigate the subject there; and that commission labored for five years. That commission reported that proper irrigation did not produce malaria, but improper irrigation would. They also made some proposition about the construction of canals and works which they stated would be effectual to prevent malaria; and experience has shown them to be effectual.

The **CHAIRMAN**. Did that relate to drainage or the formation of the canal?

Mr. **MANUEL**. Both. In making canals you should not leave holes for stagnant water to accumulate. That commission came to the conclusion that running water in canals did not produce malaria, but that improper irrigation, where the water was permitted to run into ponds and swamps, did. There was also a British commission that came to this country and took the testimony of the people of Fresno and of those lower counties. That was a royal commission, sent from Victoria. But all I know is from personal experience, and all I say is that proper irrigation will not produce malaria.

And in regard to the subject of increase of rain-fall on account of irrigation, all I know of that subject is from precipitation tables in Fresno and the surrounding country. I see that the rain-fall there has increased from a half to a third, that is to say, from 6 inches up to 8 and 12 inches. That is, in the last four or five years. But whether that is due to irrigation or simply a coincidence, I do not know.

Then about crops at Fresno. The time was when a certain country lying east of the canals produced only about one crop in three or four. Now, it produces nearly every crop; it is seldom that any crop fails. The amount of crops produced certainly has been increased, and the failures have been reduced one-half. That is not due to irrigation direct, but from the fact that the land is in the track of the wind from the irrigated country around.

The CHAIRMAN. You think it is due to the wind in a moist country as it does not dry up so much.

Mr. MANUEL. That seems to be the general impression, and I think the correct one.

STATEMENT OF L. M. HOLT, OF SAN BERNARDINO.

Mr. Chairman and gentlemen, there are many points to be referred to in connection with this subject; but there was one suggestion made by Mr. Hall which, while practically true, tends to mislead the committee, and that is with regard to the duty of water at Riverside and other southern counties. I have lived at Riverside for ten years until last year. Now I am living at San Bernardino, close by there. I have kept watch of the water at Riverside with a view to studying it in connection with the new canals. It is true, when we take into consideration the amount of water that runs into the canal and compare it with the number of acres of land irrigated, Mr. Hall's statement is practically correct. But when we take into consideration the amount of water that is sold by the company or dealt out by the canals to the land owners, we find a different state of affairs. I took one of the Riverside companies from its formation up to 1870 and compared the number of inches sold by that company and paid for by the users with the number of acres of land under cultivation, and up to that time there had been no year where the consumer had used to exceed an inch of water to 5 acres of land.

But there is a waste of water in the main canals, and the hundreds of distributing ditches. For instance, take the ditch on which my orchard is located. They turn off 60 inches of water from the main canal and get 20 inches to my orchard. This shows a waste of water in the system of distribution, and not the amount of water that was actually needed to put on the orchard. When it comes to the use of water in other sections of California, I will state that a great deal depends on the location of the water system—its proximity to the coast. For instance, at Pasadena they started with a system of an inch to 160 acres, and the supply was increased to an inch of water to 60 acres.

Riverside is different from any other section down there so far as water is concerned. The Gage system about Riverside is founded on 1 inch of water to 5 acres, and it does not matter how much they may want, that is all they are going to get. At Fresno it is an inch of water to 8 acres. This was afterwards increased so that they could get an inch of water to 4 acres. The Pomona system was an inch of water to 10 acres. Whether that is enough or not, they have been successful there; but that is all they can get. The Ontario system is 1 inch of water to 10 acres, and that is all they can get unless they can get another supply of water; but they have been successful There is land in the irrigation system which is entitled to water, but it can not get it. In the Etiwanda system they have 1 inch of water to 8 acres. If I was rightly informed, Etiwanda furnishes some of the largest raisins in California—the largest grapes, so far as raisins are concerned. And I was told that they did not need the water that they had. I have given these facts just as I got them. I may be misinformed about some; but I guess I am pretty nearly right. Some require more irrigation than others. Those back from the coast require more than they do down by the coast. While Pasadena has very little water, there is a vast difference between an inch to 60 acres and an inch to 160 acres; but a large number of their crops do not need irrigation at all.

The CHAIRMAN. Can you tell to what extent the people of those districts have taken up the water supply?

Mr. HOLT. Pasadena is pumping its water. They lift it somewhere in the neighborhood of 100 feet. The other systems, with the exception of Redland, I do not think have increased their water supply. They have increased the supply of water with a view to spreading the acreage.

The CHAIRMAN. How do they do that?

Mr. HOLT. By means of artesian wells, by tunnels, and by reservoirs. The Ontario system runs a tunnel up the bed of the cañon, under the water supply, and I think the tunnel is in the neighborhood of 80 feet below the surface of the stream. But the results of that tunnel have not been very satisfactory as yet. They have now struck bed rock, and they expect when they cross cut to get a large supply of water. It has not been satisfactory as yet, though they have had as high as 75 or 80 inches of water in their tunnel at times. But it has less now.

With regard to the value of the land without irrigation, I would say that the tract of land on which Riverside is located twenty years ago was assessed at 75 cents an acre, and the owner appeared before the State board of equalization to have that estimate reduced. I do not know that I could give the assessed value per acre all the way through of that land at the present time, but the 6,000 acres is valued at a little over $4,000,000, including the town site. The actual value of the orchards and vineyards in Riverside will to-day stand at about $1,000 or $1,500 per acre. The production of that 6,000 acres at Riverside last year was 1,000 car-loads of oranges and 200,000 boxes of raisins, the two items covering 4,000 acres of land—3,000 of oranges and 1,000 of grapes—20 pounds in a box. The other 2,000 acres of the settlement was devoted to other fruits, and I could not give the figures with regard to them. The oranges on the tree sold for from $1.50 to $3 per box, and there were 300,000 boxes. The highest that we have received there on any acre up to the present time has been $1,100. Some of our orange trees as yet are not bearing.

The CHAIRMAN. Was that $1,100 for one crop?

Mr. HOLT. Yes; the highest received for any one orchard in San Bernardino County has been $1,750 for one crop on an acre and a quarter. The population of Riverside on the 6,000 acres to-day is about 7,000.

Mr. ESTEE. What was the population of Riverside before irrigation was practiced there?

Mr. HOLT. We had one sheep herder before that.

Mr. CHIPMAN. Does irrigation affect the healthfulness of the community?

Mr. HOLT. It does not, so far as malaria is concerned. I agree with some that the quality of water may not have been so good, on account of ditching their water. Since they have piped their water the healthfulness of the community has been good. The question has been asked whether this country filled up as it did in Fresno. There is no place in California where they have gotten the same results. It was 40 or 50 feet to surface water when it was established, and it is the same now.

The CHAIRMAN. Is it on a sub-soil?

Mr. HOLT. No; it is on a meadow, and the meadow is below. All the surplus water goes down into the river and does not fill up at all. One of the main sources of supply there is the artesian well.

We have a peculiar formation around San Bernardino which we would like to point out. There is a dike, and above that dike is the artesian basin, and you can sink a well to almost any distance and you would hardly get surface water, and it is only about 2 rods from the artesian belt that you can not get artesian water. From that artesian belt we are getting our water supply for our Gage system. He has two hundred wells there on an average of 200 feet in depth, and they give 200 inches of water. He has one well there that gives 200 inches of water single flow. It is the largest well in the valley.

The CHAIRMAN. Has the supply of the wells been reduced by multiplying them in number?

Mr. HOLT. It does not appear to have that effect, or has not yet. The flow at this season of the year on the outer edge of the stream has decreased, and in some places entirely ceased, and has heretofore during the summer season. But when the winter comes on again they flow. I do not know that we have any permanent decrease in the flow of water in those wells since they were sunk. Mr. Gage in his system has in the neighborhood of 1,700 inches of water.

Senator JONES. Miner's inches?

Mr. HOLT. Yes; fifty of these inches make a cubic foot per second. So far as artesian wells in the southern portion of California are concerned—the other sections I can not speak of—there has been no permanent reduction in the flow. There is a variation every year; there will be less water in the summer time and more in the winter.

Senator JONES. How far is the artesian district in California?

Mr. HOLT. We have several. The San Bernardino district will cover about a township—thirty-six sections.

Senator JONES. How many wells are in that township?

Mr. HOLT. Five hundred wells. I think fully that many.

Senator JONES. Is the flow now as good as it was when the first well was sunk? Has there been any decrease in the flow of the first well on account of the sinking of the other wells?

Mr. HOLT. No; unless it may be in the summer time. But in the winter it will go up to the standard again.

Senator JONES. Do you know from where the water comes?

Mr. HOLT. Some have the theory that it comes from the mountains or the Mohjave Desert.

The CHAIRMAN. What district is covered by the reservoir?

Mr. HOLT. It includes Redland, Highlands, Riverside, and even west through to Rialto. It has not been taken through there.

The CHAIRMAN. Can you describe the work and its success?

Mr. HOLT. I will state that the company has made an arrangement to put in a new dam 120 feet high instead of the present one, which is only 24 feet high. When they do that they will have a supply of water that will give them 20,000 inches of water during the season.

There are other sites there. I went over to San Bernardino, over the ridge, to see a reservoir site. The reservoir when made will irrigate 10,000 acres of land, and it will cost in the neighborhood of $75,000 to complete the reservoir and take the water through the land to be irrigated. The man who applied for a reduction of the assessment on his land from 75 cents an acre ought to have had this land. The theory is that they can run stock on that land, but it will be a very precarious business. There is no value to the land except it may be a speculative value, and the speculative value is how much is it worth to buy it and put water on to it. You can not raise barley there to make it pay except it may be on moist lands.

There are 250,000 acres of land in San Jacinto Valley, in San Diego County. The Hemet Valley is another valley similar to the Bear Valley. They have all their surveys made and are ready to dam in. They estimate that when the dam shall have been completed they can irrigate 100,000 acres of land in that valley.

The **Chairman**. Will surveys by the Government and the reservation of the public land be of any service to you in carrying out these projects?

Mr. **Holt**. I think the reservoir sites in southern California, so far as irrigating between the mountains and the sea is concerned, are all taken up.

STATEMENT OF WILLIAM COLLIER.

Mr. Chairman and gentlemen, I have not had enough experience in the States, but I have always had a belief that timber ought to be protected in order to protect the rain-fall. I made a trip on the mountains the other day, and I saw large tracts of timber where the timber had been cut away. New timber is a better protection to rain-fall than the old growth, and the ground was covered with a thicket from 12 to 50 feet high. But whether all timber lands send up the new growth in that way or not I do not know. If they do not, I say keep the timber there.

STATEMENT OF R. B. BLOWERS.

Mr. Chairman and gentlemen, I live under an irrigating system of about 30,000 acres under the Moor Ditch. Clear Lake covers about 300,000 acres of land, but only a small portion of that has been used. In the early days we paid for water on our wheat land, but at the present time it is used for alfalfa and agricultural purposes. In my neighborhood we consider that one-half a cubic foot per acre put on during the whole season (1 cubic foot is the maximum) is sufficient for a vineyard, and is sufficient for a variety of horticultural products. Our system is a charge of $4 for every cubic foot of water.

The **Chairman**. A cubic foot per second.

Dr. **Blowers**. We get probably from 1½ to 2. It is not measured. We get a liberal supply because we have a liberal supply to draw from in the ordinary irrigating part of the season. In the summer and in the drier seasons our supply fails, because there are underground streams that take it from our system and distribute it all over the country. If we had Clear Lake during the summer and sufficient drainage for all these 300,000 acres under the Moor Ditch and between Clear Lake and Cache Creek and Putah Creek, a large area of land in Cashe County and land on the top of the mountains more favorably situated on account of their natural grade than any other land in the world, could be reclaimed. If we had plenty of water we would probably use on alfalfa a foot per acre; or, in other words, we would pay $3 an acre for three or four irrigations. With that result in water and the proper amount of irrigation to keep the gophers off, we could insure 10 tons of alfalfa hay to the acre for ten years from the seeding, each of those tons representing 100 pounds of neat flesh put on to cattle.

In regard to climatic conditions. If all the upper part of the Sacramento Valley which includes Tehama, Colusa, Yolo, and Solano Counties were irrigated it would have its effect on the climate. It would reduce the evaporation of this vast amount of water, would reduce the temperature, and consequently raise the dew point to a higher degree. And it would deprive the hot desiccating north winds with which we are troubled of their effect, and would change the climate materially to our benefit in that manner.

With regard to our country being arid I will say that it is arid as compared with the condition in which we can place it by intelligent irrigation. We are now pumping water from Cache and Putah Creeks, and there are suits for damages that have been instituted against several parties for pumping water from Putah Creek. But, speaking of the temperature, I will say that there is much more rain in the San Joaquin Valley now than there was twenty years ago, and it will continue to increase so long as the area of irrigation is increased.

Mr. MILLS: What interest will the hay pay?

Dr. BLOWERS. That depends. If a party should raise it for beef-cattle alone 1 ton of that hay would be equivalent to 120 pounds of beef. Beef is 5 cents a pound. Therefore the gross amount of produce from each ton would be $6 per ton, and the gross amount of the product that would go into the products of the country would be $60 an acre.

Mr. MILLS. That would be 10 per cent. on $600.

Dr. BLOWERS. Of course the element of labor would have to come out of that. Irrigation allows us to raise any kind of product that we are desirous of producing. We can raise any product that can be raised in the temperate zone.

The CHAIRMAN. What would be a fair-sized farm of irrigated land for a farmer to irrigate himself?

Dr. BLOWERS. That would depend on the number of children he had. I have a neighbor who has one child. That child married and has children. He had 10 acres of land and 5 acres were bearing. He was a bricklayer and he hired help, and kept an account of the net proceeds of those 5 acres in raising grain, and they amounted to $1,000 a year for several years. That is to say, he made a clear profit of $200 per acre. I suppose his last success of that kind was three or four years ago. Every square section of land in Yolo County under irrigation could support a population of 1,000 souls.

The CHAIRMAN. With an ordinary family would 40 acres be enough?

Dr. BLOWERS. They would have to hire about $2,000 worth of labor to get along. I have paid on 25 acres, a raisin vineyard, $5,000 for unskilled labor. I paid in freight on the product of a single acre of irrigated land $1,000, and I have shipped 10 tons of raisins from 1 acre. We have to run our risk. We do not always know how our fruit is going to get to market.

Mr. CHIPMAN. The committee may not be aware of the desiccating effects of the north wind, which results, sometimes, in making the grain fields dry in two or three days, and in the destruction of the wheat crop. That north wind originates in the desert east of the Sierras. I would like the doctor to tell whether irigation would destroy the effect of that north wind.

Dr. **Blowers**. The returning polar wind, the wind that once went upward from the torrid region, sucks its way back to where it starts, that is to the torrid zone. Whenever the wind is sufficient to send a large body of air to the south, it has a tendency to bring toward the earth this polar current; and my idea is that if the arid region of Arizona and California—the whole surface of that country—were covered with vegetation, the effect of these intensely hot winds would disappear. The temperature would be reduced to such a degree and the moisture increased to such a degree that they would not have the desiccating effect of which so much complaint has been made.

STATEMENT OF E. B. PERRIN.

Mr. Chairman and gentlemen, I have been connected with irrigation for fifteen years, and I have given it a good deal of thought, as a physician. Here I have a Government report, the census report of 1870, published by act of Congress, and it is about as impartial and as perfect a report as can be gotten. It is better than individual estimates. Now, I think Mr. Hall fell into a mistake that is calculated to do harm.

Take our Fresno country—and all California can take a shot at it—and we have done there what the world has never done before in the way of getting productions from the ground. While Los Angeles has given 5 and 6 tons of grapes, and Napa 5 and 6 tons, in Fresno we make 20 and more; but we will stop at 20.

Mr. **Estee**. Not as a regular thing.

Mr. **Perrin**. No, not as a regular thing. I say what we will do. I have been told by my friends that they have sold 28 tons to the acre. On the question of health, you will find that Sacramento Valley has three out of five of malaria, San Francisco one out of five, Los Angeles one out of five, and this terrible Fresno one out of five. That was in 1870.

Senator **Jones**. Before irrigation?

Mr. **Perrin**. Before very much irrigation had been practiced there. Now, since irrigation we claim that it has made that country far more healthful, and it is more healthful for the animal than the man, for this reason: They have better water to drink. They have artesian water now and good drainage. In regard to consumption, which our western friends ought to know, and which the people of the United States ought to know, there are the reports on consumption. They show Boston 5, Chicago 4, San Francisco 4, Mobile 5, Los Angeles 3, San Diego 1, and Fresno none.

Mr. **Estee**. That was in 1870.

Mr. **Perrin**. Yes; but you must remember Fresno had a population in those days. Take the bowel affections and typhus fever. We have a wonderfully healthful country. While San Francisco has more trouble with the lungs, it is free from malaria.

Mr. **Estee**. I wish you would show the effect that irrigation has on the human system anywhere. State what its effect is so far as causing malaria is concerned.

Mr. **Perrin**. I would not have made these remarks but for what my friend, Mr. Hall, said, which is calculated to do harm. Of course, if you put water on the land and the people drink the water from the ditches, it will have a bad effect, but if you have good drinking water and proper drainage, not only the men but the animals will be healthy.

It is not only that. To show Mr. Estee that I am right in this I will say that if he will go to certain portions of Fresno County, where cattle have died for years, he will find that the people can show him a simple way of stopping cattle from dying—that is to give them good water. Mr. Carr, of Kern County, who is largely interested in irrigation there, told me that he would not give his cattle any water after this that he would not drink himself. As soon as people understand that cattle as well as people must have pure water to drink we will solve a good many difficulties.

Mr. ESTEE. Professor Hilgard, of the University of California, is here, and would like to be heard.

The CHAIRMAN. We shall be glad to hear Mr. Hilgard.

STATEMENT OF E. W. HILGARD, PROFESSOR IN THE UNIVERSITY OF CALIFORNIA.

The CHAIRMAN. The committee will be glad to hear anything that you may have to say on the subject of irrigation in California or elsewhere.

Mr. HILGARD. Our experience in irrigation in California is precisely in the line of the gentleman who has spoken before me. As professor of agriculture in the State university, and now in charge of the experimental stations of the State, I have come in contact largely with irrigation, and so far as experiences have gone, in regard to the effects of irrigation, I can only say that I am fully and entirely in accord with everything that has been stated with regard to the increased value and the wonderful effects which the water produces, even in regions which have rain-fall. I have naturally been led to study rather the natures of soils and their origin than the economic questions involved. In regard to the nature of soils which can be irrigated in this State, I would say that I have yet to meet the soil that can not be reclaimed by irrigation.

At one time, by the courtesy of the Central Pacific road, I had a complete set of samples of soils from the places along the road, all the way through its line. I have examined all the soils, from an agricultural stand-point, and, with a single exception, there was not one that could not be cultivated by irrigation. As a desert, the Mojave may be said hardly to exist. It is purely a question of water. The part of the desert that has been irrigated amply proves that fact.

In regard to the water supply, I have made some study which impresses me most strongly with the great importance of this topic of reservoirs. In the first place, the water supply, undoubtedly, in most portions of the State, is hardly adequate to give a supply for irrigation in the dry season. In the second place, a great many lands will be benefited by irrigation which are now cultivated by other means.

Senator JONES. When you state that the water supply was not sufficient, do you mean that it is not sufficient without storage, or that it is not sufficient with storage?

Mr. HILGARD. I meant that it is not sufficient without storage. In the foot-hills this state of things exists: A large portion of the land can be cultivated without irrigation, but in a large portion of it a good deal of the soil is shallow, although in other respects it is first-class. With irrigation it can be settled; without it the crops will not be certain, and therefore the lands will not be settled so soon.

There is one point of importance I should mention, and that is the quality of the water for irrigation. In regard to storage reservoirs, which are naturally available, perhaps one of the earliest that has been spoken of has been Tulare Lake. When this enterprise of irrigating the San Joaquin Valley with the waters of Tulare Lake was first broached, I learned (having been then only a short time in the State) that the water was likely not to be suitable for irrigation. I had a sample of the water procured and found that it was strongly alkaline. I have since continued that study, and I believe that the water at the present time would not only be unsuitable for irrigation, but would be detrimental to any land on which it was placed. Three enterprises have been successively started in utilizing land in that neighborhood. I was instrumental in calling attention to them. From the study I have made I am strongly inclined to think that the water is not even adapted for storage. At present the very bed of the lake, I believe, is charged with evaporated strata of alkaline salts, which would make it entirely unadapted for irrigation unless the alkali were washed out. This question is of great importance to the country. Similar studies should be made in other directions. You have heard that artesian wells would give water for irrigation. A very large portion of these wells would give very good water for that purpose. Another portion would give water entirely unfit for that purpose, and the Government alone has the ability and the means of making that study complete.

I know of one series of wells in San Joaquin Valley that have done considerable damage in the irrigation of lands, and I think it highly expedient that this study should be undertaken for the purpose not only of finding the waters which can be used for storage, and the storage reservoirs themselves which can be utilized, but also those which can not be utilized for reasons not generally understood by the people.

There is another branch of the subject which I have studied. That is the connection of irrigation with the alkali. Of course you know that alkali, that is, soluble salts, are to some extent in the arid regions, including in that term the country west of the one hundredth meridian. The presence of this natural alkali is the natural result of the deficiency of the rain-fall—enough rain not falling to take away the alkali, which is a natural deposit, you may say, of the soil. In Tulare and Kern Counties, the rain-fall being from 6 to 4 inches, not enough water falls at one time to wet the soil more than to the depth of 3 or 4 inches. The evaporations from the surface afterward will bring up all the soluble salts. Those salts will rise to the surface, and will tend to kill the vegetation that might accumulate there. It is a curious result of irrigation in some places that those salts have been brought to the surface. It is necessary that some means of preventing this should be devised, and also some means to stop the further use of alkaline waters in irrigation.

I have in my studies tried to perform some of the duties which will now fall to the Geological Survey to perform. I can only say that the task which is before it in the way of work to be done is of the greatest importance. The means at the command of the State University, or of the experimental stations, are altogether too limited to permit of all these important studies being carried on properly here.

I have set forth these studies in the publication which forms part of my annual report, and of which I present a copy with an abstract to the committee. (See Exhibit C.)

I have also made a study in part of the question of water supply, particularly in the southern region.

The chairman asked a while ago of one of the other gentlemen (Mr. Holt) a question as to where the supply of artesian water came from.

I think the simple reply to that question is that the storage of that water is in an enormous gravel-bed at probably the depth of a thousand feet or more, and that this gravel bed is annually charged with the winter waters of the Santa Ana and other rivers, and if these rivers flow in at the height of 700 or 1,000 feet above the level of the valleys below, of course sufficient pressure accumulates.

With regard to the diminution of supply by boring more wells, this state of facts exists in that region that wells bored quite closely together fail to influence each other to any perceptible extent. In the places I have studied, it is found that the artesian supply is so great that the limits are hard to estimate, except perhaps by the area of the basin, which is about 10 miles by 14 miles, the gravel-bed reaching to an unknown depth. Of course that valley must contain an enormous mass of water.

Mr. MILLS. The artesian system, which constitutes the source of supply there, is peculiar to that region?

Mr. HILGARD. Yes.

Mr. ESTEE. The same influences do not operate upon Santa Clara at all, do they?

Mr. HILGARD. No.

Mr. MILLS. They do not apply to any other region of the State. Artesian water is not to be relied on, in the experience of this country, for irrigation. Storage is the only thing that will add to our water for that purpose.

The CHAIRMAN. Except in this locality.

Mr. MILLS. Yes.

Mr. HILGARD. I was going to say that the communication between the wells in Santa Clara County is freer than in San Barnardino County. In the last few years in which the wells have been specially studied the supply has been getting low, and contiguous wells have unquestionably influenced others very considerably. The supply also has been comparatively limited, and for irrigation purposes have hardly come into consideration at all. Storage would be the only means available.

The CHAIRMAN. You were not there when they first commenced boring wells, were you?

Mr. HILGARD. No, but I know how the wells have run. It is quite peculiar to San Barnardino County.

Mr. MILLS. As to the diversity of agriculture and horticulture, how would they be affected in this State by the artificial application of water?

Mr. HILGARD. The introduction of irrigation in certain districts has simply changed the face of the country from that of a single industry to that of a garden. That is the case more prominently, perhaps, in the San Barnardino Valley. The diversity I consider as one of the prime conditions of prosperity of a community. Any community which pursues one single industry will be likely to be caught in some unpleasant condition at some time. I was speaking with a gentleman once who told me how very abundant cotton was in the South, but said he, "At that very time we had nothing to eat." That same thing is apt to occur and has occurred here in respect to other products.

Mr. MILLS. As to the regularity of production, one crop with another, year by year, what have you to say as to the effects of irrigation?

Mr. HILGARD. Of course irrigation makes a crop a certainty. It does something that it is very hard to estimate the value of, except by a detailed examination of every water, and that is another one of the duties which I think the Government should perform. It relieves the cultivator to a certain extent of the necessity of fertilizing. A great deal of our irrigation water contains so much potash that the bringing of it from somewhere else is out of the question. In the waters of Riverside the annual supply of one-fifth of an inch to the acre, or 1 inch to 5 acres, is ample for wheat, which takes a great deal. In the San Joaquin Valley, waters are flowing which contain not only much potash, but acid, which becomes a complete fertilizer, and makes any other fertilizer unnecessary. The influence of this item it is impossible to estimate without a detailed examination of the waters; but it certainly is an exceedingly important thing.

The **Chairman.** What is the effect of the sediment which comes down in suspension in the waters?

Mr. **Hilgard.** The sediment almost always contains the finest ingredients of the water. All the deposits brought down by irrigation waters are extremely desirable and add very much to the fertility of the soil; in fact they help it almost indefinitely.

The **Chairman.** What do you say as to the fertility of water stored in reservoirs? Is there not organic matter in that that will be a benefit to plant life?

Mr. **Hilgard.** What accumulates in reservoirs beyond what the water brings into them is hardly worth considering, but the storage will help us to collect what now runs into the sea, not only the water, but, as well, the different materials for fertilizing that it may bring along.

I should like to say a word about the irrigation at Fresno; that is, as to the percolation of the water. It appears to me that it is absolutely essential that some restriction should be imposed from some source in regard to the seepage of the ditches. There is an enormous loss of irrigation water caused by imperfectly constructed ditches. That is one of the points that has not received sufficient consideration. In the case of Fresno it caused almost the ruin of the early settlers, now drowned out by the high-line ditches. Of course, however healthy the climate may be, as soon as water oozes out around every vine, as in the lower portions of the Fresno region, it is impossible that the country should be healthful. What power should regulate these matters I do not know, but the enormous seepage now taking place in the Fresno region is serious.

The estimates made farther south are more reliable. I was surprised to hear Dr. Blowers say that it required 50 miner's inches to the acre to irrigate. A cubic foot per second is equal to 50 miner's inches. That is so much in excess of what is used elsewhere that I should not like to have it stand on record without some qualification.

Dr. **Blowers.** I did not say that. I said that one-half of a cubic foot, running for twenty-four hours, is equivalent to the entire irrigation necessary for the year. That was simply the equivalent of 1 cubic foot per acre for the year; and that was the most successful irrigation performed there.

Senator **Jones.** I certainly understood the remark as Professor Hilgard did. I do not now understand what is meant by half a cubic foot running for a length of time.

Dr. **Blowers.** Half a cubic foot to the second of time running for twenty-four hours.

Mr. **Mills.** They irrigate there but one day in the year. What Dr. Blowers means is that half a cubic foot per second for twenty-four hours answers for a whole year; but they irrigate once in the winter and a little in the spring.

Mr. **Estee.** That is about 4 or 5 inches, professor, is it not?

Mr. Hilgard. Yes. I noticed that some others understood it in the way I understood it, and I desired to have the doctor's statement corrected, if I understood it correctly. Such a quantity of water is, of course, entirely in excess.

Mr. Mills. They misunderstood it because the ordinary conception of irrigation is that it is a constant and perpetual flow. As matter of fact, people only irrigate once in the winter and a little in the spring. That is all the irrigation needed for a year.

Mr. Hilgard. It has been frequently stated that fruit grown with irrigation is not as good as fruit grown without irrigation. I think that statement is calculated to do damage. I will state this, as a general proposition, that with proper irrigation fruit is improved in the arid regions; with improper irrigation, on the other hand, fruit is ruined and so is the land. There are very few regions of the country that are not benefited by irrigation.

Mr. Estee. Have you not found irrigated districts in California where they made raisins a specialty, and is it not true that the raisin grape raised there carries quite as much sugar as any raisin in the world?

Mr. Hilgard. Certainly.

Mr. Estee. And is not that the test of the raisin?

Mr. Hilgard. Certainly. If the irrigation is properly done it does not decrease the sugar; if improperly done it may bring it down to a very low degree. In Fresno, where irrigation has been overdone a little, in some places it is known that upon the old irrigated vineyards a ditch 7 feet deep is a very successful corrective of excessive irrigation.

EXHIBIT C.

ABSTRACT OF THE PAMPHLETS FURNISHED BY PROF. E. W. HILGARD, DIRECTOR OF THE UNITED STATES EXPERIMENTAL STATION, CALIFORNIA.

The pamphlet report on "Alkali Lands—Irrigation and Drainage in their Mutual Relations," published as part of the report of the College of Agriculture of the University of California for 1886, by Prof. E. W. Hilgard, treats of the occurrence of lands surcharged with alkali salts in the State of California, of the remedies that may be used in order to insure immunity from the effects of the corrosive salts on growing crops, and especially of the effects of irrigation on alkali lands.

After showing that deficient rain-fall, by failing to leach out the soluble salts formed by atmospheric action in *all* soils, is the necessary cause of "alkali;" that it is the accumulation of the salts on the surface by evaporation of the soil moisture holding them in solution that does the damage to crops, by corrosion of the root crowns, and not the direct action of soil water upon the roots themselves, Professor Hilgard discusses and illustrates by analytical examples, the unfavorable effects produced by alkaline carbonates upon the tillableness of clay soils, which in some cases are rendered wholly incapable of tilth by the presence of carbonate of soda. The dissolution of the humus of the soil by the same substances is an additional injury, causing appearances which have given rise to the popular designation of "black alkali," the most injurious of all. "White alkali," on the other hand, consists of neutral sulphates and chlorodes of the alkalies, and is injurious only when very abundant.

The general remedy for all alkali is leaching of the soil by flooding and underdrainage, thus supplementing the effect of a deficient rain-fall. Deep and frequent tillage, by restraining evaporation, also diminishes the effect of alkali; as also does the shading of the soil. Chemical antidotes can be used in some cases; these must be varied according to the nature of the alkali salts. Gypsum is one of the most important, as it converts the noxious "black" alkali into the relatively bland "white" or neutral compounds, and likewise renders insoluble, and thus causes the retention in the soil, of the humus and soluble phosphates, which are very important to plant nutrition. The action of these antidotes is dependent upon the abundant presence of water, and therefore practically upon irrigation.

A table of analyses, showing the composition of alkali salts from twenty different points, is given, showing great variations, and also the fact that the injurious salts are commonly associated with a large supply of valuable fertilizing materials, so that alkali lands when reclaimed are usually of extraordinary and durable fertility. They also are very retentive of moisture and require less irrigation than non-alkaline ones of the same character.

The effects of irrigation on alkali soils is then discussed, showing that surface irrigation without corresponding drainage is injurious in causing a "rise of the alkali" on lands not previously known to be thus afflicted. In many cases the rise of the bottom water, caused by extended irrigation, has brought alkali to the surface from great depths, and has in California, as in India, rendered large tracts uncultivatable by the increase of the injurious salts. Subirrigation produces this effect to a less degree; but the depths at which water may be applied without actually rising to the surface, so as to be subject to active evaporation, vary in different soils, being least in sandy, greatest in clay soils. Since the prevention of surface evaporation is of fundamental importance, the crops grown on alkali soils should never be broadcast, but always such as admit of cultivation between the rows so as to keep the surface loose; or else, such crops as alfalfa, which by shading the soil and causing evaporation to take place only through their leaves, supplied by their deep-lying roots, also diminish surface evaporation to a minimum. Cereal crops are in general the least suitable; deep-rooted hoed crops, such as roots, castor-bean, and other oil crops, also hemp, ramie, and especially cotton, are recommended for the San Joaquin Valley.

The second part of the report treats of the "Lake and river waters of the great valley (of California) and their quality for irrigation purposes." It is shown by analysis that the lake waters of the valley are much too heavily charged with soluble salts to be applicable to irrigation purposes, and that even their basins would not be suitable as reservoirs for irrigation water on account of the large deposits of alkali salts known to exist in their substrata. As irrigation of the valley lands increases, whatever water drains into these lakes will carry more and more salts into them.

The river waters of the valley are then passed in review and analyses of the same given, showing that they differ considerably in the purity in their summer flow, the Mokelumne and King's Rivers being the purest, while Kern River shows in its composition the origin of the salts now tainting the waters of the lakes fed by it.

The artesian waters of the valley are then discussed, and the fact that in some regions they are altogether unsuitable for irrigation, being too strongly charged with alkali salts, which, however, differ widely in composition; hence detailed investigation of the same is absolutely necessary, as in some cases land irrigated with them would be severely injured.

A third division of the report discusses the experience had in northwest India in respect to the rise of the alkali caused by the establishment of high-lying irrigation canals. The report of a government committee on this subject is presented in abstract, showing that the evils now beginning to be felt in California have their exact counterpart in the experience of India irrigators, only that in the latter case the evils have become so great as to suggest even so extreme a remedy as the lowering of the entire system of irrigation canals, constructed at enormous cost; the alternative being, apparently, their entire abandonment, so far as a corresponding system of drainage can not be applied. Had the latter been kept in view from the outset, a vast amount of costly construction and heavy damage to lands would have been saved. The conclusion reached is that in arid climates *all* irrigation works must provide for drainage, under penalty of causing the sterilization of the irrigated land by alkali; and that the utmost care should be taken to have the irrigation water as free as possible from saline ingredients which, when superadded to the supply already in the soil, will steadily add to the injury.

Another report, issued by the experiment station of the University of California, deals with "examinations of waters, water supply, and related subjects made during the years 1886–'89."

In the first portion of this report are given numerous analyses of well, spring, and artesian waters from various portions of the State of California; also the waters of Carmel and Owen's Rivers used in irrigation. The latter, although flowing through a region heavily charged with alkali, is found not to be overcharged with mineral salts, and perfectly suitable for irrigation purposes.

A somewhat extended treatise on "The water supply of the San Bernardino Valley" gives some data of special interest in respect to possible storage of winter waters apart from reservoirs artificially constructed. A detailed examination of a series of relatively shallow artesian wells bored in the flood plain of the Santa Ana River, a few miles above San Bernardino City, shows the existence of an unusually abundant store of artesian water in that region, and a remarkable absence of that interdependence of discharge which elsewhere characterizes groups of artesian wells located in close proximity to each other. Searching for the cause of this state of things, it is found that one of the largest streams in the valley—Warm Creek, supplying the irrigation works of the town of Riverside—originates in the level valley, as do a number of copious springs from which the water gushes with an apparently artesian rise, indicating a common source for all these waters within the valley itself, since they issue from unmistakable valley deposits.

An investigation of the geological and hypsometrical features of the San Bernardino Valley, as shown in the wells and in the breaks of the country, proves that the upper portion of the valley trough is filled to great depths and over an area of about 140 square miles with more or less stratified deposits of gravel and bowlders, such as are now discharged from the cañons of the San Bernardino range, and especially from those of the Santa Ana River and Mill Creek. These loosely bedded gravels, interrupted more or less by irregularly disposed water-tight beds, are filled with water under heavy pressure, the difference in altitude from the head of the valley to San Bernardino city being over 1,000 feet in a distance of about 17 miles, while the average thickness of the gravel mass is shown by deep borings to be in the neighborhoood of 1,000 feet.

Observation shows that an enormous amount of water must be absorbed during the winter floods, particularly in the upper portion of this great gravel mass, where it is uncovered and composed mostly of large bowlders. Shafts and tunnels excavated near the mouth of the cañons for the purpose of finding unappropriated water have shown the gravel-beds to be dripping with water everywhere; and the suggestion that it would be easy to increase greatly the absorption by loosening the gravel with the aid of lines of blasts judiciously placed, is very forcible. At present an enormous volume of water runs to waste during winter through the channel of the Santa Ana River. If this were diverted upon the gravel surfaces, loosened by blasting, the artesian reserve could doubtless be materially increased, and the flow of the wells in the valley rendered more copious during the dry season. This would be of wider importance than for the San Bernardino Valley alone, for it is almost certain that the original drainage of that valley was toward Los Angeles conjointly with the San Gabriel River, and that the water-bearing gravel-beds extend in that direction, and not along the present course of the Santa Ana River, which passes to seaward through a shallow cañon, in which the bed-rock is exposed. Any addition to or maintenance of the artesian storage at the head of the San Bernardino Valley is therefore of interest to the entire valley of southern California, as it can probably be tapped at proper depths anywhere between the head of the valley and the city of Los Angeles.

The report also gives analyses of the irrigation waters of the San Bernardino Valley, showing that they contain an unusually large proportion of fertilizing mineral ingredients, and that their use will relieve irrigators from the necessity of supplying at least one of the chiefly important crop ingredients—potash—by the purchase of fertilizers, unless production should be very much intensified. Some of the other "cienega" lands of the region are also briefly discussed.

"The Lakes of the San Joaquin Valley" form the subject of discussion in another chapter of the report. The rapid contraction of these lakes by evaporation since the water of the tributary rivers has been largely diverted for irrigation purposes is discussed, and is illustrated by analyses of the waters of these lakes made at successive periods, showing these waters to be utterly unfit for irrigation, although ditches for that purpose have repeatedly been excavated. An examination of the condition of Tulare Lake in winter 1888-'89 shows that an extraordinary recession of the lake waters has occurred during the preceding year, being one of three of deficient rain-fall; the alkali salts having now accumulated so far that mussels and certain kinds of fish can not live in them any more, and other species show signs of distress. In respect to the future of the lake the question is raised whether it had better be drained so as to lay bare the extremely fertile lands now covered by its waters, reserving only a water-way that may be made navigable, or whether under certain conditions it might be utilized as a reservoir for irrigation waters. It is feared that the latter use is impracticable on account of the alkaline drainage that must come toward the lake from the higher-lying irrigated lands, when, as must soon be done, these shall be properly drained in order to prevent the "rise of the alkali" before referred to. In any case the necessity of the removal of the strongly saline water now contained in the lake basin is insisted on.

A fourth chapter discusses, from the stand-point of the chemist, the changes brought about in the composition of alkali salts by the action of carbonic acid, under different conditions of dilution. It is found that by such action, which constantly occurs in soils to a greater or less extent, the bland sulphates and chlorides can be transformed into corrosive carbonates, and that this action must be taken into account in considering the reclamation of alkali lands by the use of gypsum. Attention is called to the fact that this reaction, heretofore almost overlooked, is of the widest importance in the chemistry of geological formations.

Mr. MILLS. Mr. Marks desires to address the committee briefly.

Mr. MARKS. My specialty is colonization, and as your time is limited I would rather others should speak.

Mr. **Mills**. I would like to have brought before the committee some testimony with regard to the colonization and settlement of the State. Your experience as a colonizing agent might be serviceable in that respect.

STATEMENT OF BERNHARD MARKS.

The **Chairman**. We would like to hear what you have to say upon the subject of irrigation, especially in this State.

Mr. **Marks**. I do not intend to furnish the committee with any cumulative evidence on the advantages of irrigation. I had another point to present altogether, but inasmuch as Mr. Mills has called on me, I will say that my specialty is colonization. That is, I take into consideration those circumstances which will enable an intelligent family to live on irrigated land and use as small a piece of land as they can conveniently and properly cultivate. Perhaps the quickest way to get at my point would be to tell what has been done at Fresno.

Fifteen years ago, when the railroad was built through there, the town of Fresno was a mere hamlet. Any one could stand near that hamlet and sweep the horizon with a field-glass, and absolutely nothing would obstruct the view, not a shanty or even a tree. The whole expanse was a brown, bare, barren, repulsive desert waste of sand, and nothing else.

After having studied the soil and country, and after having made up my mind that it was a land specially adapted to the raisin and the vine, I laid off a piece of land 3 miles long and 2 miles wide, about 2½ miles from town; built 40 miles of ditch and 14 miles of canal; planted some miles of trees in order to make it fit for a family, and commenced the colonization of that country. That colony was a complete success. Now there are twenty-two colonies like that, surrounding the town of Fresno.

The great value of California to civilization, in my opinion, does not consist in its capacity to furnish a large profit to capital, or the raising of wine, raisins, oranges, or any one product. In my opinion the great value of California to civilization is that the combination of soil and climate is such that within its area an intelligent family accustomed to the amenities of civilization can acquire a better living and live in greater affluence with 10 acres of land than they can in any other country that I have ever read of.

At Fresno, if this committee goes there, they will see the result of irrigation. You may go through miles of avenues there, and every 660 feet you will meet with a handsome little cottage surrounded by its outbuildings, its orchard, its vineyard, its vegetable garden, its nursery, its alfalfa patch, its cow, staked out on the alfalfa, and its happy and prosperous inhabitants. You can go there and see all those things, every 660 feet—every eighth of a mile—and yet these people are taking their water almost literally at the muzzle of a gun. That is why I have come before you.

The United States Land Commissioner has issued to the various land officers instructions intended to prevent all acquisition of legal title to lands that may be selected for sites for reservoirs and canals, and lands susceptible to irrigation.

Inasmuch as these instructions show that this committee is taking cognizance of the legal feature of the irrigation matter, I beg most respectfully and most earnestly to express the opinion that the laudable efforts of the Land Commissioner to forestall legal complication will be most likely to fail of accomplishment unless some way be found whereby other irrigable States and Territories may be protected from the legal calamities which now severely afflict California.

If I am making a mistake in assuming from the action of the Land Commissioner that this committee regards the legal aspect of irrigation as coming within the scope of its mission, it may eventually transpire that the important results of its labors will be nullified by unnecessary legal impediments. If, however, I am correct in the foregoing assumption, then will this committee ascertain that the settlement for the Territories by Congressional or other action of the legal difficulties which beset irrigation in this State is by far the most important, as it may be the most difficult, part of its work.

Assuming that a study of and a report by this honorable committee on this feature of the irrigation matter will result directly in such Federal and indirectly in such State legislation as will forever settle the title to the water of the natural water-courses in other States and Territories, I bespeak your earnest attention to the lamentable condition of water titles in California.

The physical, historical, legislative. and industrial conditions which dominated the State of California were such as should have abundantly secured it, if such security were possible, from such State supreme court decisions as have been rendered in this State; decisions which have paralyzed the State in all those enterprises which demand the use of running water, which have kept back in Fresno County alone an advance in population and property to the extent of 10,000 inhabitants and ten millions of capital in the last ten years; and which, if they had been rendered in the early days of California, would have either made mining impossible or would have compelled the miners to do what the farmers of California are doing to-day, viz, to use water in contravention of law and in defiance of the decrees of the courts.

The supreme court of California has always compared and does now compare, favorably in probity, ability, and legal learning with the similar tribunals of ultimate resort in other and older States; and yet, in spite of the favorable conditions I have alluded to, this honest and able supreme court has struck the State a blow more staggering in its effects than could have been dealt it by alien foe or hostile power.

That this committee may see the urgent necessity of endeavoring to protect other States and Territories from the calamitous decisions which now so severely injure California I will briefly set forth, with your permission, those favorable conditions which have failed to protect this State and which other States and Territories may not have the advantage of to so eminent a degree.

The San Joaquin Valley, the great valley of California, capable of sustaining in affluence a population of five millions, is a perfect model of a country specially suited to irrigation. In fact, it is not otherwise habitable to an agricultural people. The land has a general slope, which at the same time fits it for the economic application of water and affords ample opportunity for drainage. The nature of the soil is admirably adapted to surface irrigation. The rain-fall is insufficient for the production of the more valuable vegetation, but the rivers afford abundant water to supplement its scarcity. The water which in other countries is distributed over the entire surface of the land during the summer months is here accumulated in the form of snow upon the Sierras during the winter. The nature of the river-beds of this plain are admirably fitted to perform the peculiar service required of them. Instead of the rocky bottoms of eastern rivers, which favor the quick escape of superabundant waters from land to sea, the rivers that water this plain have beds of absorbing sand which detain the well-gauged waters of the region and prevent their too rapid flow to the ocean. There are no bottom lands worth mentioning along these rivers, but the whole vast plain sustains to them the relation which entitles it to their fructifying influence. The climate of the region is not dependent upon latitude but upon altitude. Starting from any given point in the elliptical basin which constitutes the valley an isothermal line will describe a very eccentric ellipse and will return to the starting point. In brief, there is no other part of our country in which the physical conditions point so directly to the necessity of the kind of legislation and judicial decisions which obtain in irrigated countries.

Historically in favor of judicial decisions friendly to irrigation, California had the great advantage of the provisions of the treaty of Guadaloupe Hidalgo, which insured to the granted part of her territory the sensible and equitable Mexican laws concerning the distribution of water as against the wholly absurd and impracticable English common law of riparian rights.

In legislation the State was extremely fortunate. The legislation of the State affecting the use and distribution of its waters reflects credit on the intelligence of the pioneers of California. As in the case of other newly-constructed States, the legislature enacted that the English common law should be, not the law of the land, but the rule of decision in its courts; and, foreseeing just such contingencies as the disastrous application of the riparian part of the common law to the physical conditions of the State, it enacted that the English common law should not be applied in cases in which it should be repugnant to or inconsistent with the laws of Congress or of the State.

At successive sessions of the legislature laws were enacted to regulate the acquisition of the right to use water for beneficial purposes.

The foundation of these laws was the right of prior appropriation as opposed to the English law of riparian rights. Under these laws it was utterly impossible for any natural or artificial person to acquire title to a single drop of water. Title could be acquired only to the use of water, and only to the quantity of water actually used. No person or corporation could acquire the right to run a drop of water to willful or heedless waste, or to prevent any other person from using water not actually in beneficial use by a prior appropriator. No vested right could accrue to any person or corporation by which water not in use could be kept from others desirous of using it. The water law of California is the perfection of equity and wisdom, and yet it was wholly set aside by the State supreme court and the English common law of riparian rights substituted in its stead.

The industrial conditions which California was in position to rely upon for protection against decisions adverse to her irrigation interests were comprised in the fact that during the whole time of the operation of her water law, which included almost the whole life of the State, all the mining, milling, and irrigation enterprises were established; untold and almost untellable millions of capital were invested and property developed; and upon the stability of these properties depended almost the entire taxable value of the State.

It is difficult to see how a State or Territory could be better equipped to resist the destructive application of the English common law of riparian rights to a physical condition wholly at variance with its principles. Nevertheless the decisions of the supreme court of California have fastened upon the State the following destructive principles:

The English common law prevails in California not only as it stood at the time when the United States separated from England, but as it has since been changed from time to time in England to suit the exigencies of English affairs.

All the water in the State that falls from the clouds or results from the melting snow is the absolute private property of the few persons who own the strips of land bordering on the natural river-courses of the State.

The rigid riparian rule that the water must flow past its riparian owners undiminished in quantity and unimpaired in quality may be modified so far as to recognize the right of the riparian owners themselves to divert water upon their own riparian lands subject only to each others' rights.

The California supreme court rejects the modification of the rule by which English judges, in accordance with the same English common law, suspend its disastrous operation in cases to which it is not properly applicable, as in Australia and India.

There is no way to acquire the right to use any of the water of the State for any purpose except to purchase it by private agreement or through the operation of the law of eminent domain.

Inasmuch as the law of eminent domain may be invoked only for a public use, it follows that no person or corporation, nor any number of persons or corporations, can acquire the right to water for their own use, no matter how necessary or beneficial that use may be. They must invest sufficient capital to buy water for the general public in addition to what they may need for their own use, even though they may never be able to sell what they buy for that purpose.

The foregoing propositions having been settled by the decisions of the majority of the supreme court, the legislature of California enacted a law known as the Wright bill, which is intended to enable those who may desire to operate under its provisions to construct canals and purchase water by taxing lands susceptible to irrigation for the purpose of selling said water to the general public.

The reasons why the Wright bill is impracticable and unnecessary are too many to be here presented; but it will suffice to say that the people of California, outside of the cities, want water in but small measure for a public, but in a great measure for a private use; that, as no legislation can be of an *ex post facto* character, the damage inflicted by riparian decisions can never be repaired by legislation; and that so long as a majority of the State supreme court entertains English riparian opinions the prosperity of the State dependent upon the use of flowing water can not advance and must recede.

If the States and Territories in which the operations of this committee are intended to stimulate the adoption and establishment of systems of irrigation are destined to be covered by supreme court riparian decisions founded on the recognition of the English common law of riparian rights, then will the irrigation that will be practiced be very small in comparison with the litigation that will be developed.

The experience of California makes manifest the following propositions:

A system of irrigation founded on the principle of prior appropriation is the only one that is practicable under a non-paternal government. Under such a system there is no such thing as property in water. Those who wish to use water for mining, milling, or irrigation may acquire the right to use it and will be prevented from monopolizing any water not actually in use.

The element of speculation in the water of the State is wholly eliminated. Its public use may be as effectively subserved by the appropriation under the law of free public water as by condemnation and purchase of private rights.

Appropriation and condemnation are inconsistent with and antagonistic to each other.

There is neither equity nor sound public policy in allowing private individuals to acquire title to water-courses which they did not create and to the results of the forces of nature which they do not control.

In the early days of California most of the land was the property of the Federal Government. The running waters were deemed public property and were considered as dedicated to the use of the people.

Congress expressly sanctioned the appropriation of water on the public domain and authorized it by enactment in 1866. That enactment seemed to be insufficient to deter the California supreme court from applying the English common law of riparian rights to the destruction of irrigation, mining, and milling in California. If, through the action of this committee, Congress shall be led to enact such further laws as will effectually protect the Government land in the Territories from the application to them of the English common law, then will this committee have done infinitely more for irrigation than it could possibly do in making preliminary surveys for reservoirs and canals.

Mr. **ESTEE.** If the committee please, so far as this report is concerned, it is an able one, but I wish the committee to understand that the State board of trade has no quarrel with the supreme court, whatever the opinion of that court may be. We are not here to present any fight against the supreme court of our State.

So far as concerns the effect of the decision referred to by Mr. Marks on the free use of water, the article may be generally right or wrong as the case may be, but this board does not assume the position of criticising the court. We are here to present facts and not arguments against our supreme court. I do not suppose any power can control the waters of this State, except the navigable waters.

Mr. **MARKS.** I do not represent the State board of trade, but the people of Fresno whose homes are in danger. It is for this committee to say whether they will consider it worth while to report to Congress in reference to enacting such laws as will be a guide not only to the supreme court of California but to those of other Territories to be erected into States.

SAN FRANCISCO, *August* 26.

STATEMENT OF N. P. CHIPMAN, OF RED BLUFF.

The **CHAIRMAN.** We should be glad to hear any views you may desire to present to the committee on the subject of irrigation.

Mr. **CHIPMAN.** I have just one word that I desire to say tending to emphasize the value of irrigation in California. I live in the northern portion of the State—the best portion of the State so far as nature has bestowed her gifts. Notwithstanding that we have a climate equal in all respects to the climate so highly prized in the southern part of the State by health-seekers; notwithstanding that we have a rich soil, an ample rain-fall, and the banner wheat county of the world—notwithstanding all that, a year and a half ago when I was called on to make an agricultural address and wanted to get at some practical point and to develop some possible remedy for the lack of emigration into northern California, I found two things existing: First, that a gradual increase of the assessment roll, the gradual and rapid enchancement of values in this State, was taking place in the southern portion of California. The filling up of the State, the increased population, was occurring in the southern part; and I found that but for irrigation the lands down there, which were filling up and were enhancing so rapidly in value, were really valueless, while ours, with the water which nature has bestowed upon us—with an equally splendid climate and everything to make homes attractive, were not getting a share of the population. I came to the conclusion that it was a simple question of irrigation, even in northern California. So have the people of northern California come to that conclusion. Therefore in Colusa County they are now burdening themselves with a million and a half dollars of debt in order to bring water into the banner county of the world.

Mr. ESTEE. Mr. Wright is present; he has been the author of all our leading legislation on irrigation. Perhaps you would like to hear him for a few minutes; I know he can interest you.

The CHAIRMAN. We shall be glad to hear Mr. Wright.

STATEMENT OF C. C. WRIGHT.

The CHAIRMAN. Anything that you desire to say on the general subject that we are investigating we shall be glad to hear. Anything of special interest to irrigation in California will instruct the committee.

Mr. WRIGHT. I do not desire to detain the committee with any extended remarks, but perhaps I could do no better than to simply call the attention of the committee to the irrigation law of 1887—the law which it seems has been so severely criticised here. The criticism I shall not advert to further than to say that the judgment of the gentleman is at variance with that of about nine-tenths of the people in the irrigable portion of California.

That act has for its object the irrigation of all the territory in California which may be easily accessible to a common source of supply, and so that all the people may by common effort irrigate the land. Under that act about twenty districts have been organized in this State. The people who have organized those districts look to this Senatorial committee with some hope that they may get some material aid from the Government for the purpose of irrigating their land.

It is a well-known fact that there would not be sufficient water to water all this land in California that required irrigation without a storage system. That is indispensable. A storage system must be created, and inasmuch as this committee has that particular subject in hand, has for its object, as I understand, the selection of reservoir sites——

The CHAIRMAN. The committee has simply in hand the investigation of facts. It is not to commit Congress to any special course.

Mr. WRIGHT. That is what I understand. The facts being obtained, if the Government should engage in the work of constructing reservoirs or creating a water supply it would be an incalculable advantage to the people of this State. I do not know to what extent the Government would agree to go in this matter, but these districts, if they lack anything at all, simply lack a supply of water with which to water their lands. If the Government will give attention and aid in that particular, it will give aid that no other power can do so well.

The CHAIRMAN. Would surveys be of service and the ascertainment of the facts as to the amount of money necessary to complete a thorough system of irrigation; would those aid the people?

Mr. WRIGHT. Very materially. The engineer who was present here to-day, and who knows more, perhaps, than any other man in this State, remarked to me to-day that it would be a very material aid. So with the reservoir sites.

Senator JONES. What powers are conveyed by the law of 1887, to which you referred, on these districts?

Mr. WRIGHT. The first power is that of organization; then the power to provide for the creation of indebtedness sufficient to construct the works; then the power to condemn wherever that may be necessary—in other words, the exercise of the right of eminent domain; and the acquisition of the necessary rights for the condemnation of existing works, whenever that may be found advisable; also the power to hold elections, and to assess and collect a revenue for the purpose of defraying expenses, and the general powers of a municipal corporation.

Mr. ESTEE. Also that they are to distribute the waters equitably and by general rules.

Mr. WRIGHT. Yes.

Senator JONES. By what names are those organizations known—as irrigation districts?

Mr. WRIGHT. Yes. The law provides that five directors shall be elected for each district, who shall have the power to control the distribution of the water and all matters connected with the conduct of the district.

Senator JONES. Do they have the power to collect money and expend it?

Mr. WRIGHT. Yes. They exercise some duties kindred to those of the supervisors of the county.

Mr. ESTEE. There is a gentlemen here from Los Angeles who will not detain the committee more than a moment.

Senator JONES. Before he begins I would like to ask Mr. Wright one question more. In the practical working of this law, has there been any difficulty in defining the limits of those irrigation districts?

Mr. WRIGHT. None whatever.

Senator JONES. Has that been regulated by the water commissioners?

Mr. WRIGHT. Yes; they include in one district all the land that can be easily watered from one source.

Senator JONES. The intention, then, is to embrace in the system only such lands as can be irrigated?

Mr. WRIGHT. Yes.

Senator JONES. Suppose a valley has to be surrounded by a lot of hills—the hill-sides that are above the line of irrigation are not included in those irrigation districts, are they?

Mr. WRIGHT. No; only such lands as may be actually reached by the water.

Mr. MILLS. And the bonds that are issued are a mortgage on those lands?

The CHAIRMAN. You only include in your district land that may be irrigated, but, to obtain water, you may have to go outside of the land to be irrigated?

Mr. WRIGHT. Yes; that is the idea. I desire to make one further suggestion, and that is, that we have pamphlet copies of this irrigation law, and will supply the committee with a copy. (See Exhibit D.)

Exhibit D.

Wright Irrigation Bill and Amendments, 1889.

Chapter XXXIV. An Act to provide for the organization and government of irrigation districts and to provide for the acquisition of water and other property, and for the distribution of water thereby for irrigation purposes.

The people of the State of California, represented in senate and assembly, do enact as follows:

Section 1. Whenever fifty or a majority of freeholders owning lands susceptible of one mode of irrigation from a common source, and by the same system of works, desire to provide for the irrigation of the same, they may propose the organization of an irrigation district under the provisions of this act, and when so organized such district shall have the powers conferred or that may hereafter be conferred by law upon such irrigation district.

Sec. 2. A petition shall first be presented to the board of supervisors of the county in which the lands or the greatest portion thereof is situated, signed by the required number of freeholders of such proposed district, which petition shall set forth and particularly describe the proposed boundaries of such district, and shall pray that the same may be organized under the provisions of this act. The petitioners must accompany the petition with a good and sufficient bond, to be approved by the said board of supervisors, in double the amount of the probable cost of organizing such district, conditioned that the bondsmen will pay all said cost in case said organization shall not be effected. Such petition shall be presented at a regular meeting of the said board, and shall be published for at least two weeks before the time at which the same is to be presented, in some newspaper printed and published in the county where said petition is presented, together with a notice stating the time of the meeting at which the same will be presented. When such petition is presented, the said board of supervisors shall hear the same, and may adjourn such hearing from time to time, not exceeding four weeks in all; and on the final hearing may make such changes in the proposed boundaries as they may find to be proper, and shall establish and define such boundaries: *Provided*, That said board shall not modify said boundaries so as to except from the operation of this act any territory within the boundaries of the district proposed by said petitioners, which is susceptible of irrigation by the same system of works applicable to the other lands in such proposed district, nor shall any lands which will not, in the judgment of the said board, be benefited by irrigation by said system be included within such district: *Provided*, That any person whose lands are susceptible of irrigation from the same source shall, upon application of the owner to said board, be entitled to have such lands included in said district. Said board shall also make an order dividing said district into five divisions, as nearly equal in size as may be practicable, which shall be numbered First, Second, Third, Fourth, and Fifth, and one director shall be elected from each district. Said board of supervisors shall then give notice of an election to be held in such proposed district, for the purpose of determining whether or not the same shall be organized under the provisions of this act. Such notice shall describe boundaries so established, and shall designate a name for such proposed district, and said notice shall be published for at least three weeks prior to such election in a newspaper published within said county; and if any portion of such proposed district lie within another county or counties, then said notice shall be published in a newspaper published within each of said counties. Such notice shall require the electors to cast ballots which shall contain the words, "Irrigation district—Yes;" or, "Irrigation district—No," or words equivalent thereto; and also the names of persons to be voted for to fill the various elective offices hereinafter prescribed. No person shall be entitled to vote at any election held under the provisions of this act unless he shall possess all the qualifications required of electors under the general election laws of this State.

Sec. 3. Such election shall be conducted in accordance with the general election laws of the State, provided that no particular form of ballot shall be required. The said board of supervisors shall meet on the second Monday next succeeding such election, and proceed to canvass the votes thereat; and if upon such canvass it appear that at least two-thirds of all the votes cast are "Irrigation district—Yes," the said Board shall, by an order entered on their minutes, declare such territory duly organized as an irrigation district, under the name and style theretofore designated, and shall declare the persons receiving, respectively, the highest number of votes for such several offices to be duly elected to such offices. Said board shall cause a copy of such order, duly certified, to be immediately filed for record in the office of the county recorder of each county in which any portion of such lands are situated, and must also immediately forward a copy thereof to the clerk of the board of supervisors of each of the counties in which any portion of the district may lie; and no board of supervisors of any county, including any portion of such district, shall, after the date of the organization of such district, allow another district to be formed including any of the lands in such district, without the consent of the board of directors thereof; and from and after the date of such filing, the organization of such district shall be complete, and the officers thereof shall be entitled to enter immediately upon the duties of their respective offices, upon qualifying in accordance with law, and shall hold such offices respectively, until their successors are elected and qualified. For the purposes of the election above provided for, the said board of supervisors must establish a convenient number of election precincts in said proposed district, and define the boundaries thereof, which said precincts may thereafter be changed by the board of directors of such district.

SEC. 4. An election shall be held in such district on the first Wednesday in April, eighteen hundred and eighty-eight, and on the first Wednesday in April in each second year thereafter, at which an assessor, a collector, and a treasurer, and a board of five directors for the district shall be elected. The person receiving the highest number of votes for any office to be filled at such election is elected thereto. Within ten days after receiving their certificates of election, hereinafter provided for, said officers shall take and subscribe the official oath and file the same in the office of the board of directors. The assessor shall execute an official bond in the sum of ten thousand dollars, and the collector an official bond in the sum of twenty thousand dollars, and the district treasurer an official bond in the sum of fifty thousand dollars; each of said bonds to be approved by the board of directors; and each member of said board of directors shall execute an official bond in the sum of twenty-five thousand dollars, which said bonds shall be approved by the judge of the superior court of said county where such organization was effected and shall be recorded in the office of the county recorder thereof, and filed with the secretary of said board. All official bonds herein provided for shall be in form prescribed by law for the official bonds of county officers.

SEC. 5. Fifteen days before any election held under this act, subsequent to the organization of any district, the secretary of the board of directors shall cause notice to be posted in three public places in each election precinct, of the time and place of holding the election, and shall also post a general notice of the same in the office of said board, which shall be established and kept at some fixed place to be determined by said board, specifying the polling places of each precinct. Prior to the time for posting the notices, the board must appoint for each precinct, from the electors thereof, one inspector and two judges, who shall constitute a board of election for such precinct. If the board fail to appoint a board of election, or the members appointed do not attend at the opening of the polls on the morning of election, the electors of the precinct present at that hour may appoint the board, or supply the place of an absent member thereof. The board of directors must, in its order appointing the board of election, designate the house or place within the precinct where the election must be held.

SEC. 6. The inspector is chairman of the election board, and may:

First. Administer all oaths required in the progress of an election.

Second. Appoint judges and clerks, if during the progress of the election any judge or clerk cease to act. Any member of the board of election, or any clerk thereof, may administer and certify oaths required to be administered during the progress of an election. The board of election for each precinct must, before opening the polls, appoint two persons to act as clerks of the election. Before opening the polls, each member of the board and each clerk must take and subscribe an oath to faithfully perform the duties imposed upon them by law. Any elector of the precinct may administer and certify such oath. The polls must be opened one hour after sunrise on the morning of the election, and be kept open until sunset, when the same must be closed. The provisions of the Political Code concerning the form of ballots to be used shall not apply to elections held under this act.

SEC. 7. Voting may commence as soon as the polls are opened, and may be continued during all the time the polls remain opened, and shall be conducted as nearly as practicable in accordance with the provisions of chapter nine of title two of part three of the Political Code of this State. As soon as the polls are closed, the judges shall open the ballot-box and commence counting the votes; and in no case shall the ballot-box be removed from the room in which the election is held until all the ballots have been counted. The counting of ballots shall in all cases be public. The ballots shall be taken out, one by one, by the inspector or one of the judges, who shall open them and read aloud the names of each person contained therein, and the office for which every such person is voted for. Each clerk shall write down each office to be filled, and the name of each person voted for for such office, and shall keep the number of votes by tallies as they are read aloud by the inspector or judge. The counting of votes shall be continued without adjournment until all have been counted.

SEC. 8. As soon as all the votes are read off and counted, a certificate shall be drawn up on each of the papers containing the poll list and tallies, or attached thereto, stating the number of votes each one voted for has received, and designating the office to fill which he was voted for, which number shall be written in figures and in words at full length. Each certificate shall be signed by the clerk, judge, and the inspector. One of said certificates, with the poll list and the tally paper to which it is attached, shall be retained by the inspector, and preserved by him at least six months. The ballots shall be strung upon a cord or thread by the inspector, during the counting thereof, in the order in which they are entered upon the tally list by the clerks; and said ballots, together with the other of said certificates, with the poll list and tally paper to which it is attached, shall be sealed by the inspector in the presence of the judges and clerks, and indorsed "Election returns of (naming the precinct) precinct," and be directed to the secretary of the board of directors, and shall be immediately delivered by the inspector, or by some other safe and responsible carrier designated by said inspector, to said secretary, and the ballots shall be kept unopened for at least six months, and if any person be of the opinion that the vote of any precinct has not been correctly counted, he may appear on the day appointed for the board of directors to open and canvass the returns, and demand a recount of the vote of the precinct that is so claimed to have been incorrectly counted.

SEC. 9. No list, tally paper, or certificate returned from any election shall be set aside or rejected for want of form if it can be satisfactorily understood. The board of directors must meet at its usual place of meeting on the first Monday after each election to canvass the returns. If at the time of meeting the returns from each precinct in the district in which the polls were opened have been received, the board of directors must then and there proceed to canvass the returns; but if all the returns have not been received the canvass must be postponed from day to day until all the returns have been received, or until six postponements have been had. The canvass must be made in public and by opening the returns and estimating the vote of the district for each person voted for and declaring the result thereof.

SEC. 10. The secretary of the board of directors must, as soon as the result is declared, enter in the records of such board a statement of such result, which statement must show:

First. The whole number of votes cast in the district.

Second. The names of the persons voted for.

Third. The office to fill which each person was voted for.

Fourth. The number of votes given in each precinct to each of such persons.

Fifth. The number of votes given in the district to each of such persons.

The board of directors must declare elected the person having the highest number of votes given for each office to be filled by the votes of the district. The secretary must immediately make out and deliver to such person a certificate of election signed by him and authenticated with the seal of the board. In case of a vacancy in the office of assessor, tax collector, or treasurer, the vacancy shall be filled by appointment by the board of directors. In case of a vacancy in the office of member of the board of directors, the vacancy shall be filled by appointment by the board of supervisors of the county where the office of such board is situated. An officer appointed as above provided shall hold his office until the next regular election for said district, and until his successor is elected and qualified.

SEC. 11. On the first Wednesday in May next following their election the board of directors shall meet and organize as a board, elect a president from their number, and appoint a secretary. The board shall have the power, and it shall be their duty, to manage and conduct the business and affairs of the district, make and execute all necessary contracts, employ and appoint such agents, officers, and employés as may be required, and prescribe their duties, establish equitable by-laws, rules, and regulations for the distribution and use of water among the owners of said lands, and generally to perform all such acts as shall be necessary to fully carry out the purposes of this act. The said by-laws, rules, and regulations must be printed in convenient form for distribution in the district. And it is hereby expressly provided that all waters distributed for irrigation purposes shall be apportioned rateably to each land owner upon the basis of the ratio which the last assessment of such owner for district purposes within said district bears to the whole sum assessed upon the district: *Provided*, That any land owner may assign the right to the whole or any portion of the waters so apportioned to him.

SEC. 12. The board of directors shall hold a regular monthly meeting in their office on the first Tuesday in every month, and such special meetings as may be required for the proper transaction of business: *Provided*, That all special meetings must be ordered by a majority of the board; the order must be entered of record, and five days' notice thereof must, by the secretary, be given to each member not joining in the order. The order must specify the business to be transacted, and none other than that specified must be transacted at such special meeting. All meetings of the board must be public, and three members shall constitute a quorum for the transaction of business, but on all questions requiring a vote there shall be a concurrence of at least three members of said board. All records of the board shall be open to the inspection of any elector during business hours. The board and its agents and employés shall have the right to enter upon any land in the district to make surveys, and may locate the line for any canal or canals, and the necessary branches for the same, on any of said lands which may be deemed best for such location. Said board shall also have the right to acquire, either by purchase or condemnation, all lands and waters and other property necessary for the construction, use, supply, maintenance, repair, and improvement of said canal or canals and works, including canals and works constructed and being constructed by private owners, lands for reservoirs, for the storage of needful waters, and all necessary appurtenances. In case of purchase the bonds of the district, hereinafter provided for, may be used at their par value in payment; and in case of condemnation the board shall proceed in the name of the district under the provisions of title seven of part three of the code of civil procedure. Said board may also construct the necessary dams, reservoirs, and works for the collection of water for said district, and do any and every lawful act necessary to be done, that sufficient water may be furnished to each land owner in said district for irrigation purposes. The use of all water required for the irrigation of the lands of any district formed under the provisions of this act, together with rights of way for canals and ditches, sites for reservoirs, and all other property required in fully carrying out the provisions of this act, is hereby declared to be a public use, subject to the regulation and control of the State in the manner prescribed by law.

SEC. 13. The legal title to all property acquired under the provisions of this act shall immediately and by operation of law vest in such irrigation district, and shall be held by such district in trust for and is hereby dedicated and set apart to the uses and purposes set forth in this act. And said board is hereby authorized and empowered to hold, use, acquire, manage, occupy, and possess said property as herein provided.

SEC. 14. The said board is hereby authorized and empowered to take conveyances or other assurances for all property acquired by it under the provisions of this act, in the name of such irrigation district, to and for the uses and purposes herein expressed, and to institute and maintain any and all actions and proceedings, suits at law or in equity, necessary or proper in order to fully carry out the provisions of this act, or to enforce, maintain, protect, or preserve any and all rights, privileges, and immunities created by this act or acquired in pursuance thereof. And in all courts, actions, suits, or proceedings the said board may sue, appear, and defend, in person or by attorneys, and in the name of such irrigation district.

SEC. 15. For the purpose of constructing necessary irrigating canals and works and acquiring the necessary property and rights therefor, and otherwise carrying out the provisions of this act, the board of directors of any such district must, as soon after such district has been organized as may be practicable, estimate and determine the amount of money necessary to be raised, and shall immediately thereupon call a special election, at which shall be submitted to the electors of such district possessing the qualifications prescribed by this act the question whether or not the bonds of said district shall be issued in the amount so determined. Notice of such election must be given by posting notices in three public places in each election precinct in said district for at least twenty days, and also by publication of such notice in some newspaper published in the county where the office of the board of directors of such district is required to be kept once a week for at least three successive weeks. Such notices must specify the time of holding the election, the amount of bonds proposed to be issued, and said election must be held and the result thereof determined and declared in all respects as nearly as practicable in conformity with the provisions of this act governing the election of officers: *Provided*, That no informalities in conducting such an election shall invalidate the same if the election shall have been otherwise fairly conducted. At such election the ballots shall contain the words, "Bonds—Yes," or "Bonds—No," or words equivalent thereto. If a majority of the votes cast are "Bonds—Yes," the board of directors shall immediately cause bonds in said amount to be issued; said bonds shall be payable in gold coin of the United States in installments as follows, to wit: At the expiration of eleven years not less than five per cent. of said bonds; at the expiration of twelve years not less than six per cent.; at the expiration of thirteen years not less than seven per cent.; at the expiration of fourteen years not less than eight per cent.; at the expiration of fifteen years not less than nine per cent.; at the expiration of sixteen years not less than ten per cent.; at the expiration of seventeen years not less than eleven per cent.; at the expiration of eighteen years not less than thirteen per cent.; at the expiration of nineteen years not less than fifteen per cent.; and for the twentieth year a percentage sufficient to pay off said bonds; and shall bear interest at the rate of six per cent. per annum, payable semiannually on the first day of January and July of each year. The principal and interest shall be payable at the office of the treasurer of the district. Said bonds shall be each of the denomination of not less than one hundred dollars, nor more than five hundred dollars, shall be negotiable in form, signed by the president and secretary, and the seal of the board of directors shall be affixed thereto. They shall be numbered consecutively as issued, and bear date at the time of their issue. Coupons for the interest shall be attached to each bond signed by the secretary. Said bonds shall express on their face that they were issued by authority of this act, stating its title and date of approval. The secretary shall keep a record of the bonds sold, their number, the date of sale, the price received, and the name of the purchaser.

SEC. 16. The board may sell said bonds from time to time in such quantities as may be necessary and most advantageous to raise money for the construction of said canals and works, the acquisition of said property and rights, and otherwise to fully carry out the objects and purposes of this act. Before making any sale the board shall, at a meeting, by resolution, declare its intention to sell a specified amount of the bonds and the day and hour and place of such sale, and shall cause such resolution to be entered in the minutes, and notice of the sale to be given by publication thereof at least twenty days in a daily newspaper published in each of the cities of San Francisco, Sacramento, and Los Angeles, and in any other newspaper, at their discretion. The notice shall state that sealed proposals will be received by the board at their office for the purchase of the bonds till the day and hour named in the resolution. At the time appointed the board shall open the proposals and award the purchase of the bonds to the highest responsible bidder, and may reject all bids; but said board shall in no event sell any of the said bonds for less than ninety per cent. of the face value thereof.

SEC. 17. Said bonds, and the interest thereon, shall be paid by revenue derived from an annual assessment upon the real property of the district; and all the real property in the district shall be and remain liable to be assessed for such payments as hereinafter provided.

SEC. 18. The assessor must, between the first Monday in March and the first Monday in June in each year, assess all real property in the district, to the persons who own, claim, have the possession or control thereof, at its full cash value. He must prepare an assessment book with appropriate headings, in which must be listed all such property within the district, in which must be specified in separate columns under the appropriate head:

First. The name of the person to whom the property is assessed. If the name is not known to the assessor, the property shall be assessed to "unknown owners."

Second. Land by township, range, section, or fractional section, and when such land is not a Congressional division or subdivision, by metes and bounds, or other description sufficient to identify it, giving an estimate of the number of acres, locality, and the improvements thereon.

Third. City and town lots, naming the city or town, and the number and block according to the system of numbering in such city or town, and the improvements thereon.

Fourth. The cash value of real estate, other than city or town lots.

Fifth. The cash value of improvements on such real estate.

Sixth. The cash value of city and town lots.

Seventh. The cash value of improvements on city and town lots.

Eighth. The cash value of improvements on real estate assessed to persons other than the owners of the real estate.

Ninth. The total value of all property assessed.

Tenth. The total value of all property after equalization by the board of directors.

Eleventh. Such other things as the board of directors may require.

SEC. 19. The board of directors must allow the assessor as many deputies, to be appointed by him, as will, in the judgment of the board, enable him to complete the assessment within the time herein prescribed. The board must fix the compensation of such deputies, which shall be paid out of the treasury of the district. The compensation must not exceed five dollars per day for each deputy, for the time actually engaged, nor must any allowance be made but for work done between the first Monday in March and the first Monday in August in each year.

SEC. 20. On or before the first Monday in August in each year the assessor must complete his assessment book, and deliver it to the secretary of the board, who must immediately give notice thereof, and of the time the board of directors, acting as a board of equalization, will meet to equalize assessments, by publication in a newspaper published in each of the counties comprising the district. The time fixed for the meeting shall not be less than twenty nor more than thirty days from the first publication of the notice; and in the meantime the assessment book must remain in the office of the secretary for the inspection of all persons interested.

SEC. 21. Upon the day specified in the notice required by the preceding section for the meeting, the board of directors, which is hereby constituted a board of equalization for that purpose, shall meet and continue in session from day to day, as long as may be necessary, not to exceed ten days, exclusive of Sundays, to hear and determine such objections to the valuation and assessment as may come before them;

and the board may change the valuation as may be just. The secretary of the board shall be present during its sessions, and note all changes made in the valuation of property, and in the names of the persons whose property is assessed; and within ten days after the close of the session he shall have the total values, as finally equalized by the board, extended into columns and added.

SEC. 22. The board of directors shall then levy an assessment sufficient to raise the annual interest on the outstanding bonds; and at the expiration of ten years after the issuing of bonds by the board, must increase said assessment for the ensuing ten years, in the following percentage of the principal of the whole amount of bonds then outstanding, to wit: For the eleventh year, five per cent.; for the twelfth year, six per cent.; for the thirteenth year, seven per cent.; for the fourteenth year, eight per cent.; for the fifteenth year, nine per cent.; for the sixteenth year, ten per cent.; for the seventeenth year, eleven per cent.; for the eighteenth year, thirteen per cent.; for the nineteenth year, fifteen per cent.; and for the twentieth year, a percentage sufficient to pay off said bonds. The secretary of the board must compute and enter in a separate column of the assessment book the respective sums in dollars and cents to be paid as an assessment on the property therein enumerated. When collected the assessment shall be paid into the district treasury, and shall constitute a special fund, to be called the "bond fund of [naming the district] irrigation district."

SEC. 23. The assessment upon real property is a lien against the property assessed from and after the first Monday in March for any year; and such lien is not removed until the assessments are paid or the property sold for the payment thereof.

SEC. 24. On or before the first day of November the secretary must deliver the assessment book to the collector of the district, who shall, within twenty days, publish a notice in a newspaper published in each of the counties comprising the district, if there be lands situated in more than one county in such district, that said assessments are due and payable and will become delinquent at 6 o'clock p. m. on the last Monday of December next thereafter; and that unless paid prior thereto five per cent. will be added to the amount thereof, and also the time and place at which payment of assessments may be made. The notice shall also specify a time and place within each election precinct of the district when and where the collector will attend to receive payment of assessments, and shall be published for fifteen days, and a printed copy of said notice shall be posted for the same time in some public place in each precinct. The collector must attend at the time and place specified in the notice to receive assessments, which must be paid in gold and silver coin. He must mark the date of payment of any assessment in the assessment book opposite the name of the person paying, and give a receipt to such person, specifying the amount of the assessment and the amount paid, with a description of the property assessed. On the thirty-first day of December of each year all unpaid assessments are delinquent, and thereafter the collector must collect thereon, for the use of the district, an addition of five per cent.

SEC. 25. On or before the first day of February, the collector must publish the delinquent list, which must contain the names of the persons and a description of the property delinquent, and the amount of the assessments and costs due opposite each name and description. He must append to and publish with the delinquent list a notice, that unless the assessments delinquent, together with cost and percentage, are paid, the real property upon which such assessments are a lien will be sold at public auction. The publication must be made once a week for three successive weeks in a newspaper published in each of the counties comprised in the district. The publication must designate the time and place of sale. The time of sale must not be less than twenty-one nor more than twenty-eight days from the first publication, and the place must be at some point designated by the collector.

SEC. 26. The collector must collect, in addition to the assessments due on the delinquent list and five per cent. added, fifty cents on each lot, piece, or tract of land separately assessed, one-half of which must go to the district and the other to the collector for preparing the list. On the day fixed for the sale, or some subsequent day to which he may have postponed it, of which he must give notice, the collector, between the hours of ten o'clock a. m. and three o'clock p. m., must commence the sale of the property advertised, commencing at the head of the list and continuing alphabetically, or in the numerical order of the lots or blocks, until completed. He may postpone the day of commencing the sales, or the sale, from day to day, but the sale must be completed within three weeks from the day first fixed.

SEC. 27. The owner or person in possession of any real estate offered for sale for assessments due thereon may designate in writing to the collector, prior to the sale, what portion of the property he wishes sold, if less than the whole; but if the owner or possessor does not, then the collector may designate it, and the person who will take the least quantity of the land, or in case an undivided interest is assessed, then the smallest portion of the interest, and pay the assessments and costs due, including two dollars to the collector for the duplicate certificate of sale, is the purchaser. If the purchaser does not pay the assessments and costs before ten o'clock a. m. the following day, the property, on next sale day, before the regular sale, must be resold for the assessments and costs. After receiving the amount of assessments and costs, the collector must make out in duplicate a certificate, dated on the day of sale, stating (when known) the name of the person assessed, a description of the land sold, the amount paid therefor, that it was sold for assessments, giving the amount and the year of the assessment, and specifying the time when the purchaser will be entitled to a deed. The certificate must be signed by the collector, and one copy delivered to the purchaser, and the other filed in the office of the county recorder of the county in which the land sold is situated.

SEC. 28. The collector, before delivering any certificate, must in a book enter a description of the land sold, corresponding with the description in the certificate, the date of the sale, purchasers' names, and amount paid, regularly number the description on the margin of the book and put a corresponding number on each certificate. Such book must be open to public inspection, without fee, during office hours, when not in actual use. On filing the certificates with such county recorder the lien of the assessments vests with the purchaser, and is only divested by the payment to him, or to the collector for his use, of the purchase money and two per cent. per month from the day of sale until redemption.

SEC. 29. A redemption of the property sold may be made by the owner, or any party in interest, within twelve months from the date of purchase. Redemption must be made in gold or silver coin, as provided for the collection of State and county taxes, and when made to the collector he must credit the amount paid to the person named in the certificate, and pay it, on demand, to the person or his assignees. In each report the collector makes to the board of directors he must name the person entitled to redemption money, and the amount due to each. On receiving the certificate of sale, the county recorder must file it and make an entry in a book similar to that required of the collector. On the presentation of the receipt of the person named in the certificate, or of the collector for his use, of the total amount of redemption money, the recorder must mark the word "redeemed," the date, and by whom redeemed, on the certificate and on the margin of the book where the entry of the certificate is made. If the property is not redeemed within twelve months from the sale, the collector, or his successor in office, must make to the purchaser or his assignee a deed of the property, reciting in the deed substantially the matters contained in the certificate, and that no person redeemed the property during the time allowed by law for its redemption. The collector shall receive from the purchaser, for the use of the district, two dollars for making such deed.

SEC. 30. The matter recited in the certificate of sale must be recited in the deed, and such deed duly acknowledged or proved is prima facie evidence that—

First.—The property was assessed as required by law.

Second.—The property was equalized as required by law.

Third.—That the assessments were levied in accordance with law.

Fourth.—The assessments were not paid.

Fifth.—At a proper time and place the property was sold as prescribed by law and by the proper officer.

Sixth.—The property was not redeemed.

Seventh.—The person who executed the deed was the proper officer.

Such deed, duly acknowledged or proved, is (except as against actual fraud) conclusive evidence of the regularity of all the proceedings from the assessment by the assessor, inclusive, up to the execution of the deed. The deed conveys to the grantee the absolute title to the lands described therein, free of all incumbrances, except when the land is owned by the United States or this State, in which case it is prima facie evidence of the right of possession.

SEC. 31. The assessment book or delinquent list, or a copy thereof, certified by the collector, showing unpaid assessments against any person or property, is prima facie evidence of the assessment, the property assessed, the delinquency, the amount of assessments due and unpaid, and that all the forms of the law in relation to the assessment and levy of such assessments have been complied with.

SEC. 32. When land is sold for assessments correctly imposed, as the property of a particular person, no misnomer of the owner or supposed owner, or other mistake relating to the ownership thereof, affects the sale or renders it void or voidable.

SEC. 33. On the first Monday in each month the collector must settle with the secretary of the board for all moneys collected for assessments, and pay the same over to the treasurer; and within six days thereafter he must deliver to and file in the office of the secretary a statement under oath, showing:

First. An account of all his transactions and receipts since his last settlement.

Second. That all money collected by him as collector has been paid.

The collector shall also file in the office of the secretary on said first Monday in each month the receipt of the treasurer for the money so paid.

SEC. 34. Upon the presentation of the coupons due to the treasurer, he shall pay the same from said bond fund. Whenever after ten years from the issuance of said bonds, said fund shall amount to the sum of ten thousand dollars, the board of directors may direct the treasurer to pay such an amount of said bonds not due as the money in said fund will redeem, at the lowest value at which they may be offered for liquidation, after advertising for at least four weeks in some daily newspaper in each of the cities hereinbefore named, and in any other newspaper which said board may deem advisable, for sealed proposals for the redemption of said bonds. Said proposals shall be opened by the board in open meeting, at a time to be named in the notice, and the lowest bid for said bonds must be accepted: *Provided*, That no bond shall be redeemed at a rate above par. In case the bids are equal, the lowest numbered bond shall have the preference. In case none of the holders of said bonds shall desire to have the same redeemed, as herein provided for, said money shall be invested by the treasurer, under the direction of the board, in United States gold-bearing bonds, or the bonds of the State, which shall be kept in said "bond fund," and may be used to redeem said district bonds whenever the holders thereof may desire.

SEC. 35. After adopting a plan of said canal or canals, storage, reservoirs, and works, the board of directors shall give notice, by publication thereof not less than twenty days in one newspaper published in each of the counties composing the district, provided a newspaper is published therein, and in such other newspapers as they may deem advisable, calling for bids for the construction of said work, or of any portion thereof; if less than the whole work is advertised, then the portion so advertised must be particularly described in such notice; said notice shall set forth that plans and specifications can be seen at the office of the board, and that the board will receive sealed proposals therefor, and that the contract will be let to the lowest responsible bidder, stating the time and place for opening said proposals, which at the time and place appointed shall be opened in public, and as soon as convenient thereafter the board shall let said work, either in portions or as a whole, to the lowest responsible bidder, or they may reject any or all bids and readvertise for proposals, or may proceed to construct the work under their own superintendence with the labor of the residents of the district. Contracts for the purchase of material shall be awarded to the lowest responsible bidder. Any person or persons to whom a contract may be awarded shall enter into a bond, with good and sufficient sureties, to be approved by the board, payable to said district for its use, for double the amount of the contract price, conditional for the faithful performance of said contract. The work shall be done under the direction and to the satisfaction of the engineer, and be approved by the board.

SEC. 36. No claim shall be paid by the treasurer until allowed by the board, and only upon a warrant signed by the president, and countersigned by the secretary: *Provided*, That the board may draw from time to time from the construction fund and deposit in the county treasury of the county where the office of the board is situated, any sum in excess of the sum of twenty-five thousand dollars. The county treasurer of said county is hereby authorized and required to receive and receipt for the same, and place the same to the credit of said district, and he shall be responsible upon his official bond for the safe-keeping and disbursement of the same, as in this act provided. He shall pay out the same, or any portion thereof, to the treasurer of the district only, and only upon the order of the board, signed by the president and attested by the secretary. The said county treasurer shall report in writing on the second Monday in each month the amount of money in the county treasury, the amount of receipts for the month preceding, and the amount or amounts paid out; said report shall be verified and filed with the secretary of the board. The district treasurer shall also report to the board, in writing, on the first Monday in each month, the amount of money in the district treasury, the amount of receipts for the month preceding, and the amount and items of expenditures, and said report shall be verified and filed with the secretary of the board.

SEC. 37. The cost and expense of purchasing and acquiring property and constructing the works and improvements herein provided for, shall be wholly paid out of the construction fund. For the purpose of defraying the expenses of the organization of the district, and of the care, operation, management, repair, and improvement of such portions of said canal and works as are completed and in use, including salaries of officers and employés, the board may either fix rates of tolls and charges, and collect the same from all persons using said canal for irrigation and other purposes, or they may provide for the payment of said expenditures by a levy of assessments therefor, or by both said tolls and assessments; if by the latter method, such levy shall be made on the completion and equalization of the assessment roll, and the board shall have the same powers and functions for the purposes of said levy as are now possessed by boards of supervisors in this State. The procedure for the collection of assessments by such levy shall in all respects conform to the provisions of this act relating to the payment of principal and interest of bonds herein provided for.

SEC. 38. The board of directors shall have power to construct the said works across any stream of water, water-course, street, avenue, highway, railway, canal, ditch, or flume which the route of said canal or canals may intersect or cross, in such manner as to afford security for life and property; but said board shall restore the same, when so crossed or intersected, to its former state as near as may be, or in a sufficient manner not to have impaired unnecessarily its usefulness; and every company whose railroad shall be intersected or crossed by said works, shall unite with said board in forming said intersections and crossings, and grant the privileges aforesaid; and if such railroad company and said board, or the owners and controllers of the said property, thing, or franchise so to be crossed, can not agree upon the amount to be paid therefor, or the points or the manner of said crossings or intersections, the same shall be ascertained and determined in all respects as is herein provided in respect to the taking of land. The right of way is hereby given, dedicated, and set apart, to locate, construct, and maintain said works over and through any of the lands which are now, or may be, the property of this State; and also there is given, dedicated and set apart, for the uses and purposes aforesaid, all waters and water rights belonging to this State within the district.

SEC. 39. The board of directors shall each receive four dollars per day, and mileage at the rate of twenty cents per mile, in attending meetings, and actual and necessary expenses paid while engaged in official business under the order of the board. The board shall fix the compensation to be paid to the other officers named in the act, to be paid out of the treasury of the district: *Provided*, That said board shall, upon the the petition of at least fifty, or a majority of the freeholders within such district therefor, submit to the electors at any general election a schedule of salaries and fees to be paid hereunder. Such petition must be presented to the board twenty days prior to a general election, and the result of such election shall be determined and declared in all respects as other elections are determined and declared under this act.

SEC. 40. No director or any other officer named in this act shall in any manner be interested, directly or indirectly, in any contract awarded or to be awarded by the board, or in the profits to be derived therefrom; and for any violation of this provision, such officer shall be deemed guilty of a misdemeanor, and such conviction shall work a forfeiture of his office, and he shall be punished by a fine not exceeding five hundred dollars, or by imprisonment in the county jail not exceeding six months, or by both such fine and imprisonment.

SEC. 41. The board of directors may, at any time, when in their judgment it may be advisable, call a special election, and submit to the qualified electors of the district the question whether or not a special assessment shall be levied for the purpose of raising money to be applied to any of the purposes provided in this act. Such election must be called upon the notice prescribed, and the same shall be held, and the result thereof determined and declared in all respects in conformity with the provisions of section fifteen of this act. The notice must specify the amount of money proposed to be raised, and the purpose for which it is intended to be used. At such elections the ballots shall contain the words, "Assessment—yes," or "Assessment—no." If two-thirds or more of the votes cast are "Assessment—yes," the board shall, at the time of the annual levy hereunder, levy an assessment sufficient to raise the amount voted. The rate of assessment shall be ascertained by deducting fifteen per cent. for anticipated delinquencies from the aggregate assessed value of the property in the district as it appears on the assessment roll for the current year, and then dividing the sum voted by the remainder of such aggregate assessed value. The assessments so levied shall be computed and entered on the assessment roll by the secretary of the board, and collected at the same time and in the same manner as other assessments provided for herein; and when collected shall be paid into the district treasury for the purposes specified in the notice of such special election.

SEC. 42. The board of directors, or other officers of the district, shall have no power to incur any debt or liability whatever, either by issuing bonds, or otherwise, in excess of the express provisions of this act, and any debt or liability incurred, in excess of such express provisions, shall be and remain absolutely void.

SEC. 43. In case the volume of water in any stream or river shall not be sufficient to supply the continual wants of the entire country through which it passes, and susceptible of irrigation therefrom, then it shall be the duty of the water commissioners, constituted as hereinafter provided, to apportion, in a just and equitable proportion, a certain amount of said water upon certain or alternate weekly days to different localities, as they may, in their judgment, think best for the interest of all parties concerned, and with due regard to the legal and equitable rights of all. Said water commissioners shall consist of the chairman of the board of directors of each of the districts affected.

SEC. 44. It shall be the duty of the board of directors to keep the water flowing through the ditches under their control to the full capacity of such ditches in times of high water.

SEC. 45. Navigation shall never in anywise be impaired by the operation of this act, nor shall any vested interest in or to any mining water rights or ditches, or in or to any water or water rights, or reservoirs or dams now used by the owners or possessors thereof in connection with any mining industry, or by persons purchasing or renting the use thereof, or in or to any other property now used directly or indirectly in carrying on or promoting the mining industry, ever be affected by or taken under its provisions save and except that rights of way may be acquired over the same.

SEC. 46. None of the provisions of this act shall be construed as repealing or in anywise modifying the provisions of any other act relating to the subject of irrigation or water commissioners. Nothing herein contained shall be deemed to authorize any person or persons to divert the waters of any river, creek, stream, canal, or ditch from its channel to the detriment of any person or persons having any interest in such river, creek, stream, canal, or ditch, or the waters therein, unless previous compensation be ascertained and paid therefor under the laws of this State authorizing the taking of private property for public uses.

SEC. 47. This act shall take effect immediately.

Approved March 7, 1887.

CHAPTER XIX. An act to amend sections ten, twenty-two, and twenty-seven of an act entitled "An act to provide for the organization and government of irrigation districts, and to provide for the acquisition of water and other property, and for the distribution of water thereby for irrigation purposes," approved March 7, 1887, relating to appointments to office in case of vacancies, and to assessments of real property, and to the collection of such assessments.

The people of the State of California, represented in senate and assembly, do enact as follows:

SECTION 1. Section ten of said act is hereby amended to read as follows:

Section 10. The secretary of the board of directors must, as soon as the result is declared, enter in the records of such board a statement of such result, which statement must show—

First. The whole number of votes cast in the district and in each division of the district.

Second. The names of the persons voted for.

Third. The office to fill which each person was voted for.

Fourth. The number of votes given in each precinct to each of such persons.

Fifth. The number of votes given in each division for the office of director, and the number of votes given in the district for the offices of assessor, collector, and treasurer.

The board of directors must declare elected the persons having the highest number of votes given for each office. The secretary must immediately make out and deliver to such person a certificate of election, signed by him and authenticated with the seal of the board. In case of the vacancy in the office of assessor, collector, or treasurer the vacancy shall be filled by appointment of the board of directors. In case of a vacancy in the office of director the vacancy shall be filled by appointment by the board of supervisors of the county where the office of such board of directors is situated from the division in which the vacancy occurred. An officer appointed as above provided shall hold his office until the next regular election for said district, and until his successor is elected and qualified.

SEC. 2. Section twenty-two of said act is hereby amended to read as follows:

Section 22. The board of directors shall then levy an assessment sufficient to raise the annual interest on the outstanding bonds, and at the expiration of ten years after the issuing of bonds by the board must increase said assessment for the ensuing ten years in the following percentage of the principal of the whole amount of bonds then outstanding, to wit: For the eleventh year, five per cent.; for the twelfth year, six per cent.; for the thirteenth year, seven per cent.; for the fourteenth year eight per cent.; for the fifteenth year, nine per cent.; for the sixteenth year, ten percent.; for the seventeenth year, eleven per cent.; for the eighteenth year, thirteen per cent.; for the nineteenth year, fifteen per cent.; and for the twentieth year, a percentage sufficient to pay off said bonds. The secretary of the board must compute and enter in a separate column of the assessment book the respective sums in dollars and cents to be paid as an assessment on the property therein enumerated. When collected the assessment shall be paid into the district treasury, and shall constitute a special fund, to be called the "bond fund of —— irrigation district." In case of the neglect or refusal of the board of directors to cause such assessment and levy to be made as in this act provided, then the assessment of property made by the county assessor and the State board of equalization shall be adopted and shall be the basis of assessments for the district, and the board of supervisors of the county in which the office of the board of directors is situated shall cause an assessment roll for said district to be prepared, and shall make the levy required by this act in the same manner and with like effect as if the same had been made by said board of directors, and all expenses incident thereto shall be borne by such district. In case of the neglect or refusal of the collector or treasurer of the district to perform the duties imposed by law, then the tax collector and treasurer of the county in which the office of the board of directors is situated must, respectively, perform such duties, and shall be accountable therefor upon their official bonds as in other cases.

SEC. 3. Section twenty-seven of said act is hereby amended to read as follows:

Section 27. The owner or person in possession of any real estate offered for sale for assessments due thereon may designate in writing to the collector, prior to the sale, what portion of the property he wishes sold, if less than the whole; but if the owner or possessor does not, then the collector may designate it, and the person who will take the least quantity of the land, or in case an undivided interest is assessed then the smallest portion of the interest, and pay the assessments and costs due, including two dollars to the collector for the duplicate certificate of sale, is the purchaser. If the purchaser does not pay the assessments and costs before ten o'clock a. m. the following day the property on the next sale day must be resold for the assessments and costs. But in case there is no purchaser in good faith for the same on the first day that the property is offered for sale, then, when the property is offered thereafter for sale and there is no purchaser in good faith for the same, the whole amount of the property assessed shall be struck off to the irrigation district within which such lands are situated as the purchaser, and the duplicate certificate delivered to the treasurer of the district and filed by him in his office. No charge shall be made for the duplicate certificate where the district is the purchaser, and, in such case, the collector shall make an entry, "sold to the district," and he shall be credited with the amount thereof in his settlement. An irrigation district, as a purchaser at such sale, shall be entitled to the same rights as a private purchaser, and the title so acquired by the district, subject to the right of redemption herein provided, may be conveyed by deed, executed and acknowledged by the president and secretary of said board: *Provided*, That authority to so convey must be conferred by resolution of the board, entered on its minutes, fixing the price at which such sale may be made, and such conveyance shall not be made for a less sum than the reasonable market value of such property. After receiving the amount of assessments and costs the collector must make out in duplicate a certificate, dated on the day of sale, stating (when known) the names of the person assessed, a description of the land sold, the amount paid therefor, that it was sold for assessments, giving the amount and year of the assessment, and specifying the time when the purchaser will be entitled to a deed. The certificate must be signed by the collector, and one copy delivered to the purchaser and the other filed in the office of the county recorder of the county in which the land is situated.

SEC. 4. This act shall take effect from and after its passage.

Approved February 16, 1889.

CHAPTER XX. An act amendatory of and supplemental to an act entitled "An act to provide for the organization and government of irrigation districts, and to provide for the acquisition of water and other property, and for the distribution of water thereby for irrigation purposes," approved March 7, 1887, and providing for a change of the boundaries of irrigation districts, by including other lands therein.

The people of the State of California, represented in senate and assembly, do enact as follows:

SECTION 1. The boundaries of any irrigation district now or hereafter organized under the provisions of an act, entitled "An act to provide for the organization and government of irrigation districts, and to provide for the acquisition of water and other property, and for the distribution of water thereby for irrigation purposes," approved March 7, 1887, may be changed in the manner herein prescribed; but such change of the boundaries of the district shall not impair or affect its organization, or its rights in or to property, or any of its rights or privileges of whatsoever kind or nature; nor shall it affect, impair, or discharge any contract, obligation, lien, or charge for or upon which it was or might become liable or chargeable had such change of its boundaries not been made.

SEC. 2. The holder or holders of title, or evidence of title, representing one-half or more of any body of lands adjacent to the boundary of an irrigation district, which are contiguous, and which, taken together, constitute one tract of land, may file with the board of directors of said district a petition in writing, praying that the boundaries of said district may be so changed as to include therein said lands. The petition shall describe the boundaries of said parcel or tract of land, and shall also describe the boundaries of the several parcels owned by the petitioners, if the petitioners be the owners, respectively, of distinct parcels, but such descriptions need not be more particular than they are required to be when such lands are entered by the county assessor in the assessment book. Such petition must contain the assent of the petitioners to the inclusion within said district of the parcels or tracts of land described in the petition, and of which said petition alleges they are respectively the owners; and it must be acknowledged in the same manner that conveyances of land are required to be acknowledged.

SEC. 3. The secretary of the board of directors shall cause a notice of the filing of such petition to be given and published in the same manner and for the same time that notices of special elections for the issue of bonds are required by said act to be published. The notice shall state the filing of such petition and the names of the petitioners, a description of the lands mentioned in said petition, and the prayer of said petition; and it shall notify all persons interested in or that may be affected by such change of the boundaries of the district to appear at the office of said board at a time named in said notice and show cause in writing, if any they have, why the change in the boundaries of said district, as proposed in said petition, should not be made. The time to be specified in the notice at which they shall be required to show cause shall be the regular meeting of the board next after the expiration of the time for the publication of the notice. The petitioners shall advance to the secretary sufficient money to pay the estimated costs of all proceedings under this act.

SEC. 4. The board of directors, at the time and place mentioned in the said notice, or at such other time or times to which the hearing of said petition may be adjourned, shall proceed to hear the petition, and all the objections thereto, presented in writing by any person showing cause as aforesaid why said proposed change of the boundaries of the district should not be made. The failure by any person interested in said district, or in the matter of the proposed change of its boundaries, to show cause, in writing, as aforesaid, shall be deemed and taken as an assent on his part to a change of the boundaries of the district as prayed for in said petition, or to such a change thereof as will include a part of said lands. And the filing of such petition with said board, as aforesaid, shall be deemed and taken as an assent on the part of each and all of such petitioners to such a change of said boundaries that they may include the whole or any portion of the lands described in said petition.

SEC. 5. The board of directors, to whom such petition is presented, may require as a condition precedent to the granting of the same, that the petitioners shall severally pay to such district such respective sums, as nearly as the same can be estimated (the several amounts to be determined by the board), as said petitioners or their grantors would have been required to pay to such district as assessments had such lands been included in such district at the time the same was originally formed.

SEC. 6. The board of directors, if they deem it not for the best interests of the district that a change of its boundaries be so made as to include therein the lands mentioned in the petition, shall order that the petition be rejected. But if they deem it for the best interests of the district that the boundaries of said district be changed, and if no person interested in said district or the proposed change of its boundaries shows cause in writing why the proposed change should not be made, or if, having shown cause, withdraws the same, the board may order that the boundaries of the district be so changed as to include therein the lands mentioned in said petition, or some part thereof. The order shall describe the boundaries as changed, and shall also describe the entire boundaries of the district as they will be after the change thereof as aforesaid is made; and for that purpose the board may cause a survey to be made of such portions of such boundary as is deemed necessary.

SEC. 7. If any person interested in said district, or the proposed change of its boundaries, shall show cause, as aforesaid, why such boundaries should not be changed, and shall not withdraw the same, and if the board of directors deem it for the best interest of the district that the boundaries thereof be so changed as to include therein the lands mentioned in the petition, or some part thereof, the board shall adopt a resolution to that effect. The resolution shall describe the exterior boundaries of the lands which the board are of the opinion should be included within the boundaries of the district when changed.

SEC. 8. Upon the adoption of the resolution mentioned in the last preceding section, the board shall order that an election be held within said district to determine whether the boundaries of the district shall be changed as mentioned in said resolution; and shall fix the time at which such election shall be held, and cause notice thereof to be given and published. Such notice shall be given and published, and such election shall be held and conducted, the returns thereof shall be made and canvassed, and the result of the election ascertained and declared, and all things pertaining thereto conducted in the manner prescribed by said act in case of a special election to determine whether bonds of an irrigation district shall be issued. The ballots cast at said election shall contain the words "For change of boundary," or "Against change of boundary," or words equivalent thereto. The notice of election shall describe the proposed change of the boundaries in such manner and terms that it can readily be traced.

SEC. 9. If at such election a majority of all the votes cast at said election shall be against such change of the boundaries of the district, the board shall order that said petition be denied, and shall proceed no further in that matter. But if a majority of such votes be in favor of such change of the boundaries of the district, the board shall thereupon order that the boundaries be changed in accordance with said resolution adopted by the board. The said order shall describe the entire boundaries of said district, and for that purpose the board may cause a survey of such portions thereof to be made as the board may deem necessary.

SEC. 10. Upon a change of the boundaries of a district being made, a copy of the order of the board of directors ordering such change, certified by the president and secretary of the board, shall be filed for record in the recorder's office of each county within which are situated any of the lands of the district, and thereupon the district shall be and remain an irrigation district, as fully and to every intent and purpose as if the lands which are included in the district by the change of the boundaries, as aforesaid, had been included therein at the original organization of the district.

SEC. 11. Upon the filing of the copies of the order, as in the last preceding section mentioned, the secretary shall record in the minutes of the board the petition aforesaid; and the said minutes, or a certified copy thereof, shall be admissible in evidence with the same effect as the petition.

SEC. 12. A guardian, an executor, or an administrator of an estate, who is appointed as such under the laws of this state, and who, as such guardian, executor, or administrator, is entitled to the possession of the lands belonging to the estate which he represents, may, on behalf of his ward or the estate which he represents, upon being thereunto authorized by the proper court, sign and acknowledge the petition in this act mentioned, and may show cause, as in this act mentioned, why the boundaries of the district should not be changed.

SEC. 13. In case of the inclusion of any land within any district by proceedings under this act, the board of directors must, at least thirty days prior to the next succeeding general election, make an order redividing such district into five divisions, as nearly equal in size as may be practicable, which shall be numbered First, Second, Third, Fourth, and Fifth, and one director shall thereafter be elected by each division. For the purposes of elections the board of directors must establish a convenient number of election precincts in said districts, and define the boundaries thereof, which said precincts may be changed from time to time, as the board may deem necessary.

SEC. 14. This act shall take effect from and after is passsage.

Approved February 16, 1889.

CHAPTER XXI. An act amendatory of and supplemental to an act entitled "An act to provide for the organization and government of irrigation districts, and to provide for the acquisition of water and other property, and for the distribution of water thereby for irrigation purposes," approved March seventh, one thousand eight hundred and eighty-seven, providing for the exclusion of certain lands within any such district.

The People of the State of California, represented in Senate and Assembly, do enact as follows:

SECTION 1. The boundaries of any irrigation district, now or hereafter organized under the provisions of an act entitled "An act to provide for the organization and government of irrigation districts, and to provide for the acquisition of water and other property, and for the distribution of water thereby for irrigation purposes," approved March seventh, one thousand eight hundred and eighty-seven, may be changed, and tracts of land which were included within the boundaries of such district, at or after its organization under the provisions of said act, may be excluded therefrom, in the manner herein prescribed; but neither such change of the boundaries of the district, nor such exclusion of lands from the district, shall impair or affect its organization, or its right in or to property, or any of its rights or privileges, of whatever kind or nature; nor shall it affect, impair, or discharge any contract, obligation, lien, or charge for or upon which it was or might become liable or chargeable had such change of its boundaries not been made, or had not any land been excluded from the district.

SEC. 2. The owner or owners in fee of one or more tracts of land which constitute a portion of an irrigation district, may file with the board of directors of the district a petition, praying that such tracts and any other tracts contiguous thereto may be excluded and taken from said district. The petition shall describe the boundaries of the land which the petitioners desire to have excluded from the district, and also the lands of each of such petitioners, which are included within such boundaries; but the description of such lands need not be more particular or certain than is required when the lands are entered in the assessment book by the county assessor. Such petition must be acknowledged in the same manner and form as is required in case of a conveyance of land, and the acknowledgment shall have the same force and effect as evidence as the acknowledgment of such conveyance.

SEC. 3. The secretary of the board of directors shall cause a notice of the filing of such petition to be published for at least two weeks in some newspaper published in the county where the office of the board of directors is situated, and if any portion of such territory to be excluded lie within another county or counties, then said notice shall be so published in a newspaper published within each of said counties; or if no newspaper be published therein, then by posting such notice for the same time in at least three public places in said district, and, in case of the posting of said notices, one of said notices must be so posted on the lands proposed to be excluded. The notice shall state the filing of such petition; the names of the petitioners; a description of the lands mentioned in said petition, and the prayer of said petition; and it shall notify all persons interested in or that may be affected by such change of the boundaries of the district, to appear at the office of said board at a time named in said notice, and show cause in writing, if any they have, why the change of the boundaries of said district, as proposed in said petition, should not be made. The time to be specified in the notice at which they shall be required to show cause shall be the regular meeting of the board next after the expiration of the time for the publication of the notice.

SEC. 4. The board of directors, at the time and place mentioned in the notice, or at the time or times to which the hearing of said petition may be adjourned, shall proceed to hear the petition and all objections thereto presented in writing by any person showing cause as aforesaid why the prayer of said petition should not be granted. The failure of any person interested in said district to show cause in writing why the tract or tracts of land mentioned in said petition should not be excluded from said district, shall be deemed and taken as an assent by him to the exclusion of such tract or tracts of land, or any part thereof, from said district; and the filing of such petition with such board, as aforesaid, shall be deemed and taken as an assent by each and all of such petitioners to the exclusion from such district of the lands mentioned in the petition, or any part thereof.

SEC. 5. The board of directors, if they deem it not for the best interest of the district that the lands mentioned in the petition, or some portion thereof, should be excluded from said district, shall order that said petition be denied: but if they deem it for the best interests of the district that the lands mentioned in the petition, or some portion thereof, be excluded from the district, and if no person interested in the district show cause in writing why the said lands, or some portion thereof, should not be excluded from the district, or if, having shown cause, withdraws the same, and also, if there be no outstanding bonds of the district, then the board may order that the lands mentioned in the petition, or some defined portion thereof, be excluded from the district.

SEC. 6. If there be outstanding bonds of the district, then the board may adopt a resolution to the effect that the board deems it to the best interest of the district that the lands mentioned in the petition, or some portion thereof, should be excluded from the district. The resolution shall describe such lands so that the boundaries thereof can readily be traced. The holders of such outstanding bonds may give their assent in writing to the effect that they severally consent that the board may make an order by which the lands mentioned in the resolution may be excluded from the district. The assent must be acknowledged by the several holders of such bonds in the same manner and form as is required in case of a conveyance of land, and the acknowledgment shall have the same force and effect as evidence as the acknowledgment of such conveyance. The assent shall be filed with the board, and must be recorded in the minutes of the board; and said minutes, or a certified copy thereof, shall be admissible in evidence with the same effect as the said assent; but if such assent be not filed, the board shall deny and dismiss said petition.

SEC. 7. If the assent aforesaid of the holders of said bonds be filed and entered of record as aforesaid, and if there be objections presented by any person showing cause as aforesaid, which have not been withdrawn, then the board may order an election to be held in said district to determine whether an order shall be made excluding said land from the district as mentioned in said resolution. The notice of such election shall describe the boundary of all lands which it is proposed to exclude, and such notice shall be published for at least two weeks prior to such election in a newspaper published within the county where the office of the board of directors is situated; and if any portion of such territory to be excluded lie within another county or counties, then said notice shall be so published in a newspaper published within each of such counties. Such notice shall require the electors to cast ballots which shall contain the words "For Exclusion," or "Against Exclusion," or words equivalent thereto. Such election shall be conducted in accordance with the general election laws of the State: *Provided*, That no particular form of ballot shall be required.

SEC. 8. If at such election a majority of all the votes cast shall be against the exclusion of said lands from the district, the board shall deny and dismiss said petition and proceed no further in said matter; but if a majority of such votes be in favor of the exclusion of said lands from the district the board shall thereupon order that the said lands mentioned in said resolution be excluded from the district. The said order shall describe the boundaries of the district should the exclusion of the said lands from said district change the boundaries of the district, and for that purpose the board may cause a survey to be made of such portions of the boundaries as the board may deem necessary.

SEC. 9. Upon the entry in the minutes of the board of any of the orders hereinbefore mentioned a copy thereof, certified by the president and the secretary of the board, shall be filed for record in the recorder's office of each county within which are situated any of the lands of the district, and thereupon said district shall be and remain an irrigation district as fully, to every intent and purpose, as it would be had no change been made in the boundaries of the district, or had the lands excluded therefrom never constituted a portion of the district.

SEC. 10. If the lands excluded from any district under this act shall embrace the greater portion of any division or divisions of such district, then the office of director for such division or divisions shall become and be vacant at the expiration of ten days from the final order of the board, under section eight of this act, excluding said lands, and such vacancies shall be filled by appointment by the board of supervisors of the county where the office of such board is situated from the district at large. A director appointed as above provided shall hold his office until the next regular election for said district and until his successor is elected and qualified.

SEC. 11. At least thirty days before the next general election of such district the board of directors thereof shall make an order dividing said district into five divisions, as nearly equal in size as may be practicable, which shall be numbered first, second, third, fourth, and fifth, and one director shall be elected by each division. For the purposes of elections in such district the said board of directors must establish a convenient number of election precincts, and define the boundaries thereof, which said precincts may be changed from time to time, as the board of directors may deem necessary.

SEC. 12. A guardian, an executor, or an administrator of an estate, who is appointed as such under the laws of this State, and who, as such guardian, executor, or administrator, is entitled to the possession of the lands belonging to the estate which he represents, may, on behalf of his ward or the estate which he represents, upon being thereto properly authorized by the proper court, sign and acknowledge the petition in this act mentioned, and may show cause, as in this act provided, why the boundaries of the district should not be changed.

SEC. 13. In case of the exclusion of any lands under the provisions of this act, there shall be refunded to any and all persons who have paid any assessment or assessments to such district, or any lands so excluded, any sum or sums so paid. Such payments shall be made in the same manner as other claims against such district, and from such fund or funds as the board of directors may designate.

SEC. 14. This act shall take effect from and after its passage.

Approved February 16, 1889.

CHAPTER CLXXVIII. An act supplemental to an act entitled "An act to provide for the organization and government of irrigation districts, and to provide for the acquisition of water and other property, and for the distribution of water thereby for irrigation purposes," approved March seventh, eighteen hundred and eighty-seven, and to provide for the examination, approval, and confirmation of proceedings for the issue and sale of bonds issued under the provisions of said act.

The people of the State of California, represented in senate and assembly, do enact as follows:

SECTION 1. The board of directors of an irrigation district now or hereafter organized under the provisions of the act entitled "An act to provide for the organization and government of irrigation districts, and to provide for the acquisition of water and other property, and for the distribution of water thereby for irrigation purposes," approved March seventh, eighteen hundred and eighty-seven, may commence a special proceeding, in and by which the proceedings of said board and of said district providing for and authorizing the issue and sale of the bonds of said district, whether said bonds or any of them have or have not then been sold, may be judicially examined, approved, and confirmed.

SEC. 2. The board of directors of the irrigation district shall file in the superior court of the county in which the lands of the district or some portion thereof are situated a petition praying, in effect, that the proceedings aforesaid may be examined, approved, and confirmed by the court. The petition shall state the facts showing the proceedings had for the issue and sale of said bonds, and shall state generally that the irrigation district was duly organized, and that the first board of directors was duly elected; but the petition need not state the facts showing such organization of the district, or the election of said first board of directors.

SEC. 3. The court shall fix the time for the hearing of said petition, and shall order the clerk of the court to give and publish a notice of the filing of said petition. The notice shall be given and published in the same manner and for the same length of time that the notice of a special election provided for by said act to determine whether the bonds of said district shall be issued is required to be given and published. The notice shall state the time and place fixed for the hearing of the petition and the prayer of the petition, and that any person interested in the organization of said district, or in the proceedings for the issue or sale of said bonds, may, on or before the day fixed for the hearing of said petition, demur to or answer said petition. The petition may be referred to and described in said notice as the petition of the board of directors of —— irrigation district (giving its name), praying that the proceedings for the issue and sale of the bonds of said district may be examined, approved, and confirmed by said court.

SEC. 4. Any person interested in said district, or in the issue or sale of said bonds, may demur to or answer said petition. The provisions of the code of civil procedure respecting the demurrer and the answer to a verified complaint shall be applicable to a demurrer and answer to said petition. The persons so demurring to or answering said petition shall be the defendants to said special proceeding, and the board of directors shall be the plaintiff. Every material statement of the petition not specifically controverted by the answer must, for the purpose of said special proceeding, be taken as true, and each person failing to answer the petition shall be deemed to admit as true all the material statements of the petition. The rules of pleading and practice provided by the code of civil procedure which are not inconsistent with the provisions of this act are applicable to the special proceeding herein provided for. A motion for a new trial must be made upon the minutes of the court. The order granting a new trial must specify the issues to be re-examined on such new trial, and the findings of the court upon the other issues shall not be affected by such order granting a new trial.

SEC. 5. Upon the hearing of such special proceeding the court shall have power and jurisdiction to examine and determine the legality and validity of, and approve and confirm, each and all of the proceedings for the organization of said district under the provisions of the said act, from and including the petition for the organization of the district, and all other proceedings which may affect the legality or validity of said bonds, and the order for the sale, and the sale thereof. The court, in inquiring into the regularity, legality, or correctness of said proceedings, must disregard any error, irregularity, or omission which does not affect the substantial rights of the parties to said special proceeding; and it may approve and confirm such proceedings in part, and disapprove and declare illegal or invalid other and subsequent parts of the proceedings. The court shall find and determine whether the notice of the filing of said petition has been duly given and published for the time and in the manner in this act prescribed. The costs of the special proceedings may be allowed and apportioned between all the parties, in the discretion of the court.

SEC. 6. An appeal from an order granting or refusing a new trial, or from the judgment, must be taken by the party aggrieved within ten days after the entry of said order or said judgment.

SEC. 7. This act shall take effect and be in force from and after its passage.

Approved March 16, 1889.

STATEMENT OF A. C. FISH.

The CHAIRMAN. The committee will be glad to hear anything you desire to say bearing on the subject of irrigation.

Mr. FISH. I would be wholly unwilling to keep this committee a moment longer than would be necessary except to call your attention to the fact that when you get over the Tehachapi Mountains we will show you in Los Angeles County a region of 250,000 acres of irrigable land—150,000 acres already irrigated—sustaining a population of 113,000 persons, which ten years ago sustained a population of only 30,000. We will show you irrigating ditches 1,500 miles in length.

The CHAIRMAN. You mean ditches aggregating that in mileage?

Mr. FISH. Yes; we will show you all sorts of ditches, from the old Mexican kind up to iron pipe under ground, of which we have about 400 miles, and we will show you a region of country which presents an object lesson in irrigation, and which I think will be a very convincing argument in favor of the grand project which the Government is now investigating.

Something has been stated here of the necessary duty of water in southern California. I have an instance in point. In 1887 I bought of the Precipice Water Company, in the San Gabriel Valley, 68 shares of water, the whole number of shares being 12,500. Mr. William Hammond Hall, in his late report, states that they have 40 miner's inches of water. The market price of those shares was $50 each. Only a little was for sale. It was owned by four individuals. I will not give their names. As I say, but a little of it was for sale at $50 a share. Soon it went up. I had purchased the land and I must have water for it. The land was not worth one-half the sum I paid for it unless I could get water, although it is worth $1,000 an acre to-day. The total of water was 18,750 miner's inches. The people of that whole valley from Pasadena to Colton and Riverside are thirsting for water. My friend, Mr. Holt here, states that the valuable reservoirs are all taken up.

Mr. **Holt**. I said the main reservoir sites were on private land, not on public land.

Mr. **Fish**. Yes. The field for surveys which will point out the practical sites for reservoirs, is one that you will find a very interesting one in that valley. I have taken the statements of twenty-one persons, who have furnished their names for publication, in San Bernardino and Los Angeles Counties, as to the products of their orange orchards. I asked them: "What does your orange orchard produce on three-year-old cuttings, one year grafted?" Eleven replied that they had averaged at the end of four years $419 per acre each.

The **Chairman**. Per annum?

Mr. **Fish**. Yes; per annum. Those statements can be verified under oath. If you want an object lesson which will give you a view of irrigable land go to one of those orange farms and you will see that from within the orange farm you can throw a stone into a cactus patch that is not worth a dollar an acre, while the orange orchard is cheap at $1,000 an acre.

When you consider the statements made by this State Board of Trade that west of the one hundredth meridian we have a quantity of land that is sufficient to support a population of 60,000,000, you can realize that the responsibilities of this committee are very great. You are charged with an important mission, and we ask you not only to see Fresno, but to go over the Tehachapi Mountains down into the south-land and see what talismanic effect the water has had upon what is otherwise a desert.

If that writer is correct who states that he is a public benefactor who makes two blades of grass to grow where only one grew before, you have it in your power, gentlemen, to become public benefactors in the grandest sense.

Mr. **Estee**. The State Board of Trade represents all the industrial interests of California. Its committee has now presented to you their printed report and such witnesses as they have brought here. They have endeavored to present for your consideration facts in their report which they think will upon examination prove instructive. They have brought before you many leading representatives of the several industries—gentlemen who have come from all parts of the State to give you their reasons why they are in favor of irrigation in California. If you gentlemen do not desire to hear any others, we will submit what we have already done. For myself, I am content to say to you that we are more than grateful for the attention you have given to the people of this State on this most important question.

The CHAIRMAN. We are much obliged to the State Board of Trade for the pains they have taken to gather together the gentlemen who have given us the valuable information which we have had to-day. There are a few other gentlemen who are here who have come to be heard, and we will now hear them.

STATEMENT OF WILLIAM CARTER, OF SAN DIEGO.

The CHAIRMAN. We shall be glad to hear anything that you desire to say to the committee with regard to irrigation in your section.

Mr. CARTER. With other gentlemen now present I have come here on short notice. We have come as the representatives of the Chamber of Commerce of San Diego, for the purpose of meeting this committee on the inception of its work in this State. We are not prepared to submit any special feature of the subject, but to interest the committee in the work of irrigation, and to extend in connection with our friends from Los Angeles County the thanks of the people of southern California for the work the committee is doing. We hope to be able to show you gentlemen what has been done throughout the counties of San Bernardino and Los Angeles. We can show you a storage reservoir 90 feet high, and can show you all that has been done in our county.

Senator JONES. How large is the reservoir of which you speak?

Mr. CARTER. It covers 700 acres in area. The dam is 90 feet high.

Senator JONES. What is the depth?

Mr. CARTER. I am not prepared to say what the average depth is, but at the dam it is 90 feet high.

Senator JONES. They used water from it during the irrigating season of last year?

Senator JONES. Do you know what it cost?

Mr. CARTER. I think about $200,000, or over.

STATEMENT OF F. H. CUNNINGHAM, OF SAN DIEGO.

The CHAIRMAN. What have you to say in regard to irrigation?

Mr. CUNNINGHAM. I would say that the water in the reservoir, which has just been referred to by Mr. Carter, is 70 feet high, and that when the water is up to the level of the 70-foot mark the reservoir holds 6,000,000,000 gallons of water. The dam itself cost something over $200,000, and the pipe line leading from it cost $750,000, making a total expenditure of about $1,000,000. The land which it is to cover comprises about 20,000 acres of mesa, which before the work was attempted, was utterly worthless for horticulture or any use whatever. The land is now being sold for $350; that price being somewhat influenced by the fact of the proximity of the city of San Diego.

We have also another work there which brings the water from a distance of 20 miles from the mountains to the city of San Diego. This water is brought in a wooden flume, which is somewhat unique for that purpose in that part of the State. This flume may, by those who wish, be traversed in a boat. The may ride on the surface of the water 36 miles on that conduit. Those two systems I think are systems that you will not see anywhere else—a great storage dam in the form of a segment of a circle and a great wooden flume used for the purpose of irrigation.

Senator JONES. Does that flume supply water to the city of San Diego?

Mr. CUNNINGHAM. Yes.

Senator JONES. The city takes no water from the dam?

Mr. CUNNINGHAM. No.

Senator JONES. The reservoir is used for irrigation alone?

Mr. CUNNINGHAM. Yes. This wooden flume is supplied with water from a reservoir located 60 miles from the city; that has a dam 25 feet high.

Senator JONES. The reservoir of which you speak then does not supply water to the city at all?

Mr. CUNNINGHAM. Not to the city of San Diego, but it does to National City.

Senator JONES. Do the projectors of this work own the 20,000 acres of land that you say are reclaimed?

Mr. CUNNINGHAM. They own a large part of it. It was given to the Santa Fé Railroad as an inducement to bring the road to San Diego.

STATEMENT OF JOHN ROTH, OF TULARE CITY.

The CHAIRMAN. What have you to say with regard to irrigation in your section?

Mr. ROTH. My colleague and myself have been sent up here to represent the people of one or two of, I think, the driest counties in the State. I have not prepared any statement. My colleague, who is with me, has some statistics to present, and the record would probably be more interesting to you than any oral statement I might make. I will, however, simply say that we have an extremely slight rain-fall. We think this committee should stop on its way south to give us an opportunity to show what we have done with the little rain-fall we get. There is considerable water in that country, but it is absolutely necessary that we build up some kind of storage system in order to develop that country.

STATEMENT OF JOHN TUOHY, OF VISALIA, TULARE COUNTY.

The CHAIRMAN. State to the committee your views regarding irrigation in your section.

Mr. TUOHY. I have no statistics to give you here, but the place we represent has prepared an address, giving the catchment area of Tulare County and the necessity of reservoirs. On the part of the board of trade and all our county, we desire you to visit the town or county of Tulare, and see this for yourselves. We will endeavor to show you the amount of fertile land we have there and the large number of people it will sustain over and above those there who could be supported without it. We can assure the committee that the people will be glad to see you. They are extremely pleased to know that this inquiry has been set on foot. We earnestly ask you to call upon us there, and let us know when you will be there, so we can invite our people to meet you and show you what they have.

STATEMENT OF J. H. WALLACE, OF SAN FRANCISCO.

In the two great valleys of California—the San Joaquin and Sacramento—water is obtained from wells usually from 75 feet to 200 feet in depth. In most parts of these valleys a supply of from 2,000 to 3,000 gallons per hour can be obtained from a bored well 7 inches in diameter.

In crossing the Sierra Nevadas on the Central Pacific Railroad water is obtained from the many streams which are fed by the melting snows, and thus have water running in them throughout the year.

Advantage has been taken of the numerous ditches and canals built in earlier times to supply the mines with water, and which are now being largely used to supply water for irrigation. There being many of these canals close to the line of the road, and at elevations sufficient to run water to our tanks by gravity, we have arranged with the owners of them to furnish us with the water needed. This is the case at all our water stations between Rocklin, which is the foot of the mountains, and Alta, at an elevation of 3,607 feet. Between this point and Truckee, on the eastern side of the mountains, the company has appropriated the flow of springs and small streams. A small lake, known as Crystal Lake, is drawn on for a supply at a station of the same name. And at Summit Station water is obtained from another small lake.

Between Truckee and Wadsworth the road follows the Truckee River, which furnishes the water used between these two points. The Truckee River is left at Wadsworth, and between that station and Lovelock's, at which point the Humboldt River is reached, we have been unable to get any water.

A well was put down several years ago at White Plains, a station close to what is known as the Sink of the Humboldt; this well was bored to a depth of 2,300 feet without striking any water, and was then abandoned.

Between Lovelock's and Ogden the country has been very thoroughly prospected for springs large enough to supply the road with water, and wherever such have been found they have been appropriated for that use, the water being conveyed to the railroad by pipe-lines from 1 to 9 miles in length. Where water could not be obtained in this manner it has been pumped from wells. One of these is at Battle Mountain, where the supply was formerly obtained from a small spring about 3 miles distant; but about two years ago, this spring not supplying enough water, a well was bored at the station, and at a depth of 180 feet a vein of water was struck which flowed over the pipe at the surface of the ground. This well is 7 inches in diameter, and flows about 11,000 gallons in twenty-four hours. A steam-pump, pumping at the rate of 3,600 gallons an hour, lowers the water only 10 feet.

The last three seasons have been very dry, and but a very small amount of snow has fallen in Utah and Nevada; the result is, that springs which three or four years ago yielded an abundance of water all through the summer have this year been extremely low.

On the Southern Pacific Railroad, crossing the Tehachapi Mountains, between San Francisco and Los Angeles, springs have been developed which yield all the water needed for railroad purposes. East of Los Angeles water is obtained in the same way; there being, however, a few wells from which water is pumped at points where springs could not be found at convenient distances from the road.

At Indio and Walters, two stations on the edge of the Colorado Desert, at elevations respectively of 20 feet and 195 feet below sea-level, an excellent quality of water is found at a depth of from 75 feet to 100 feet below the surface.

Between Walters and Yuma, a distance of 107 miles, we have been unable to get any water fit for locomotive boilers. At one station, known as Flowing Well, a well was bored to a depth of about 400 feet, and an artesian flow of salt water was struck. Other attempts to obtain water in this neighborhood have been unsuccessful.

East of Yuma the railroad follows the valley of the Gila River to Gila Bend, a distance of 119 miles; and at three stations, viz, Tacna, Texas Hill, and Gila Bend, water is pumped from the river into the tanks at the stations.

At Sentinel, the road being a long distance from the river, a well was bored to a depth of 1,029 feet. At this depth water was struck which rose to 185 feet above the surface. It yields a supply of about 3,000 gallons an hour, although the lower part of the well is only 5 inches in diameter.

Between Gila Bend and El Paso water is obtained altogether by pumping from wells, the wells varying from 100 to 600 feet deep. We have recently completed a well at Lanark which is 950 feet deep. At this depth we believe we have found a good supply of water.

The California and Oregon Railroad, after passing through the Sacramento Valley, enters the cañon of the Sacramento at Redding, and an abundant supply of water is obtained from the numerous small streams flowing into the river.

Passing out of the Sacramento Cañon, around the base of Mount Shasta, the road enters the Shasta Valley, and at Montague water is obtained from a well. At Hornbrook, a station a few miles from the crossing of the Klamath River, water is also pumped from a well. At other points, as far north as Ashland, springs in the neighboring hills have been appropriated by the company or purchased from the original proprietors, and a supply of water got from them.

No attempts have ever been made by this company to store water, though there are, doubtless, several places where it would be advantageous to do so.

STATISTICS OF COUNTIES USING IRRIGATION.

Number of ditch systems, mileage thereof, valuation for taxation, acres cultivated in grains, etc., in vines, and fruit-trees growing.

[Compiled from reports of State board of equalization, 1880 to 1888.]

Counties.	No. of systems.	Mileage of ditches.	Average value per mile.	Total valuation.	No. of acres in cultivation, not fruit.	Acres in vines.	No. of fruit-trees.
Alameda	1	5	$200.00	$1,000	79,005	3,521	420,560
Alpine	6	14	261.00	3,660	1,600	......	1,250
Amador	7	107	1,355.00	145,000	30,705	1,075	120,911
Butte	6	171	219.00	37,450	18,754	444	149,412
Calaveras	......	2	*1,000.00	2,000	31,575	1,440	825,500
Colusa	......	2	*1,000.00	2,000	432,954	225	126,276
Del Norte	2	13	446.00	5,800	2,679	......	9,642
El Dorado	......	27	1,089.00	30,095	13,655	1,715	299,770
Fresno	11	136	1,726.00	234,750	174,908	11,558	351,888
Inyo	2	15	123.00	1,850	10,154	25	23,864
Kern	32	297	6,734.00	†2,000,000	42,000	74	78,000
Lake	......	2	......	......	18,234	1,327	83,448
Lassen	......	6	1,120.00	6,715	†13,000	......	......
Los Angeles†	......	345	152.00	52,515	119,900	†27,000	‡1,073,510
Mariposa	......	33	50.00	1,670	†1,500	67	11,265
Merced	3	86	2,104.50	180,988	322,010	626	81,390
Placer	......	49	1,089.00	53,699	31,157	2,527	§429,055
Plumas§	......	55	*103.00	5,715	......	......	12,000
Sacramento	4	54	40.00	21,200	158,132	6,528	503,180
San Bernardino†	7	67	6,323.00	423,650	143,526	11,415	1,847,945
Santa Cruz	......	10	*1,089.00	10,890	1,989	1,326	282,211
San Diego ‖	19	......	......	†1,500,000	28,480	3,781	191,526
San Mateo ¶	......	......	......	†706,066	20,381	778	31,679
Shasta	2	6	1,000.00	6,100	21,818	......	82,000
Sierra	......	2½	1,089.00	2,700	13,710	4	4,820
Siskiyou	......	370	1,089.00	402,930	48,168	2,360	73,293
Stanislaus	3	13½	2,170.00	29,500	282,983	516	40,000
Tehama	......	51	386.00	19,680	135,872	2,197	254,696
Trinity	......	120	68.00	8,175	21,200	200	20,000
Tulare	15	177	323.00	57,650	286,206	3,701	344,102
Tuolumne	4	281	215.00	60,450	5,460	900	15,250
Ventura	5	20	702.00	14,038	83,830	377	382,303
Yolo	4	90	322.00	29,000	157,600	3,600	132,644
Yuba	......	120	100.00	11,850	128,433	277	74,970
Total	133	2,767	1,089.00	6,077,990	4,777,237	85,623	8,778,360

In the lower foot-hills mining counties a considerable proportion of the mining ditches are also used for irrigating the small farms of that section; probably one-third of the total mining mileage is so used.

The mileage and valuation of the mining ditches of California, as shown by the report of 1887-'88, were as follows: Values, $1,381,831; mileage, $1,591. At least one-fourth of this mileage, taking the mining counties through, do service also for irrigation uses.

* Based on averages shown in other counties.

† Estimated.

† The values of irrigation works and appliances in the counties of Los Angeles and San Bernardino are greatly underestimated, as a glance at the evidence will show. At least $2,000,000 should be added for the reservoir (Bear River, etc.), the Ontario piping system, and the artesian wells, which fill so important a place in the economy of California reclamation.

‡ The number of trees in Los Angeles County is taken from the report of 1886.

§ For Plumas County the report of 1887 is used.

‖ San Diego, no return is made of the value for taxable purposes; the estimate given, including valuable reservoirs, flumes, and pipe-systems, is obtained from other sources.

¶ The San Mateo values include the Spring Valley Water Company's plant and works which supply the city of San Francisco.

STATEMENT OF THOMAS HUGHES, OF FRESNO, IN RELATION TO RISE IN REAL ESTATE VALUES.

Having been familiar with the productions of several of the coast counties where no irrigation was needed, and with the prices lands were selling at where the same were planted to vines and tree-fruits, which were from $150 to $300 per acre and even as high as $500, on my arrival ten years since in Fresno I opened a real-estate office for the selling and renting of lands for others. After examining the immense crops of fruits and grapes produced on the irrigated lands, which were fully double that produced in any other county, while in many cases the quality of the production was far superior, I came to the conclusion that the irrigated portion of our county would become very valuable, or as much so as lands producing similar crops in other counties, and as I had no money to buy lands with, I began to look around for some tract on which I could get a contract to purchase without the payment of any cash.

I obtained such a contract on 12,000 acres for six months, the purchase price to be $2 per acre. It was near the railroad station called Fowler, 12 miles south of the town of Fresno, and was to have a commission of 5 per cent. for selling. I spent two months traveling from place to place, urging my friends to look at this tract of land, but failed to get any one to buy. But one man came to look at the land. While we were on the land he stood up in the buggy and looked around and could not even see a sheep cabin. Dropping back into his seat, he made the remark, "Hughes, this is too big a country to ever be settled up." This same man four years after invested over $200,000 in some of the same land, at from $12 to $20 per acre. Since then similar land has been sold as high as $400 per acre. This year, cultivated in raisin-grapes, some of it has paid the owners from $100 to $200 net per acre.

In 1881 I purchased 7,000 acres of land adjoining the town of Fresno, agreeing to pay $40,000, and having 6 months to make the first payment of $5,000. I immediately had circulars printed, offering to sell land, with water for irrigation, to parties who would move on the land and improve in trees and vines, without any cash payment. In this way I soon sold the most of this tract, and would borrow on my note with these mortgage notes as collateral security, getting about 50 cents advance on the dollar. I sold the land at prices ranging from $40 to $75 per acre. This gave me a surplus of money to pay what I was owing on the land, and money to make a small payment on the purchase of other lands, which I continued to do from year to year, until I was myself $350,000 in debt, and had mortgage notes due me to the amount of nearly $500,000 for lands in most cases sold on a credit of one, two, and three years, with interest at 10 per cent., payable half yearly. The settlers have all made their places worth to-day from $200 to $1,000 per acre, and all have paid me in full. I have sold thousands of acres of land on these terms, and I have never been compelled to foreclose a mortgage in Fresno County. Men who will work can settle on irrigated land, pay their 10 per cent. interest, improve the land, and pay for their land at prices ranging from $50 to $125 per acre inside of four years. And that, too, on land that before the irrigation system was started could not be sold for more than from $1 to $5 per acre, according to location.

When I came to this county, in 1878 the Central California Colony, which was first started in 1876 by B. Marks, for W. S. Chapman, was irrigated by water from the Fresno Canal and Irrigation Company. At that time only about 1,000 acres of the colony was under irrigation. Although there was nearly as much water in the canal at that time as at the present, there was a scarcity of water, and Mr. Eisen, who had a vineyard of some 250 acres on the canal, 4 miles above the colony, would tell the intending settlers that there was not water sufficient in King's River to give him all he wanted for his place, to say nothing about water for all the colonies the real-estate agents were laying out.

At that time, in boring wells for family use, it was from 50 to 60 feet to the first water. The constant irrigation, the extent of the land irrigated increasing every year, has brought the water now up to within 6 to 8 feet of the surface. We claim that instead of 1,250 acres that we had to irrigate in order to mature our crops in 1878, over 60,000 acres have become subirrigated and need no irrigation whatever. The vineyards which the sub-committee rode through have never been irrigated since the first year they were planted. It has in hundreds of instances been demonstrated that 10 acres are sufficient for a comfortable support of a family on our irrigated lands. By the expenditure of $10,000,000 in the reservoiring of water in the mountains, and piping a portion to what we call the west side of the San Joaquin Valley, a desert land sufficient to support not less than 5,000,000 people would be reclaimed. It has been demonstrated that no other portion of the world can produce as many pounds of grapes per acre as we can in Fresno County. In fact, everything that is grown from the soil which needs moisture and sunshine grow and produce so abundantly that men do not believe our statements until they see them.

Adjourned.

STATEMENT OF M. C. KING, OF FRESNO COUNTY.

In my opinion 100,000 acres, otherwise irreclaimable, in Fresno County may be brought under use by reaching the underground water supply and bringing the same by appropriate pumps to the surface, thence distributing the same. Average depth of water would be about 75 feet. Fuel costs: Wood, $7 per cord; coal, from $6 to $12 per ton, mined by the farmers themselves. Its market value is from $3 to $3.50 per ton.

Adjourned.

TULARE, CAL., *August* 30, 1889.

The committee met pursuant to the call of the chairman.

Present: Messrs. Stewart (chairman) and Reagan; also, Director Powell.

STATEMENT OF JOHN TOUHY, OF TULARE.

Mr. Chairman and gentlemen, through its committee, Tulare Grange, No. 198, Patrons of Husbandry, California, respectfully desire to address you on the subject of your mission, and ask your particular attention to Tulare County, its adaptability to irrigation, its possible productiveness by means thereof, the sources from which water can be obtained, the means which can be adopted for increasing the supply, the great necessity for systematic work in securing, distributing, and using water for irrigation.

Tulare County is in the southern portion of Tulare Valley. It has an area of 3,835 square miles, or 2,454,400 acres, of mountain and hill land, and 1,775 square miles, or 1,136,000 acres, of valley land. Of the valley land one-third, or about 380,000 acres, as being lake, alkali, river-bed, and such like, may be assumed to be unfit for cultivation, but the remaining 750,000 acres are as rich, fertile, and, under a proper system of irrigation and cultivation, as productive as any equal body of land in the United States.

We believe your honorable committee will have ample statistics and evidence furnished you, and that your own observation will confirm them, as to the great benefit of irrigation in increased production, in increased value of products, in capabilities of sustaining increased population, as also increased wealth to the community and increased security, if not absolute certainty, of regular annual crops. On such points we deem it superfluous and unnecessary for us to dwell, but believing in your investigations you desire to satisfy yourselves not alone on the benefits of irrigation, but also where and why it can be made most efficient, where facilities for obtaining water are best, and quality of soil and atmospheric conditions are such as will conduce to the production of most remunerative and varied crops; in short, where best results can with least expenditure of labor and means be obtained, we ask your favorable consideration to the fertility of our soil, to the variety and value of its products, to the necessities of making them more valuable, to the facilities for obtaining and storing water, to the necessity of aid and system therein, and to our climatic conditions which insure the production and perfection of the most remunerative crops.

Every variety of vegetable, in size, quality, and quantity equal to any part of California, are grown in Tulare County. In fruits, apricots, peaches, raisin grapes, nectarines, figs, pears, prunes, plums (in the mountains, apples), oranges, and lemons are grown to perfection.

These crops, to be produced in their greatest abundance and perfection, must be irrigated. When irrigated, nothing the husbandman can get from his soil is so remunerative.

At the present time the staple product of Tulare County is wheat, for export to Europe, in our county at the present time worth, sacked and delivered at the railroad, $1.05 per 100 pounds. On our dry land, where wheat is cultivated, 320 acres, in consequence of the uncertainty and irregularity of the seasons, is insufficient to support a small American family; whereas, with irrigation, in vegetables and fruits as before mentioned the same family could have all the comforts of a home, in a most liberal acceptation of the word, on 20 acres, and many of those whose experience has enabled them to know assert on 10 acres.

In Tulare County water for irrigation is obtained from White River with, in six years' observation, a mean annual discharge of 90 cubic feet per second; from Deer Creek with a mean annual discharge of 110 cubic feet per second; from Tule River with a mean annual discharge of 451 cubic feet per second; from Kaweah River with a mean annual discharge of 724 cubic feet per second. Kings River, flowing through Fresno County, and in places between Fresno and Tulare Counties, has a mean annual discharge of 2,584 cubic feet per second, the greater portion of which is appropriated and used in Fresno County; still considerable of it is appropriated and used in Tulare County, and 800 cubic feet per second might be appropriated with propriety for Tulare County. This will give in all 2,064 cubic feet per second as a mean annual discharge which can be utilized for irrigation in Tulare County, added to which there are about one hundred and fifty flowing wells in the county capable of irrigating on an average 40 acres to the well. For the above estimates of flow of rivers we are indebted and refer you to ex-State Engineer William Ham Hall's carefully compiled volume of Physical Data and Statistics.

To the foregoing supply of water may be added what may be saved by storage reservoirs, for which purpose State Engineer William Hall reported to the legislature in 1881 that he located one site on Tule River covering 7,164 acres, capable of storing 2,675,000,000 cubic feet; three sites on Kaweah River, 3,885 acres, capable of storing 7,162,000,000 cubic feet, and seven sites on Kings River, covering 1,134 acres, capable of storing 1,665,000,000 cubic feet, the surveying of Kings River in consequence of the lateness of the season having to be abandoned before completion.

The foregoing estimates of water supply being for the whole year, we may say, practically, irrigation is carried on from the 1st of March to 1st of July; before and after those dates but little irrigation is or need be done; still, estimating on the annual discharge of 2,064 cubic feet per second and allowing a duty of water of 1 cubic foot per second per acre per twenty-four hours, which makes allowance of 15 per cent. for percolation and evaporation, we find the 2,064 cubic feet per second is capable of irrigating that number of acres per twenty-four hours, or 241,680 acres in a season of one hundred and twenty days. We hesitate not to say not one-fifth part of that amount is irrigated. Still, if all of it was irrigated this is not all the duty which the water discharge in our county is capable of performing, for we find on reference to Physical Data and Statistics that for the months of March, April, May, and June, and the years 1879, 1880, 1881, 1882, 1883 and 1884, the mean discharge of Kings River was 18,336 cubic feet per second; of Kaweah River 5,958 cubic feet per second; of Tule River 3,500 cubic feet per second; of Deer Creek 537 cubic feet per second, and of White River 325 cubic feet per second, and allowing 6,000 cubic feet per second as Tulare's portion of the flow from Kings River, we have, in all, a flow of 16,330 cubic feet per second, or about eight times the mean annual discharge, and as a matter of sequence capable of irrigating eight times the present amount of land.

Lest your honorable committee should infer from the foregoing that the water is here and we have only to apply it to our lands, in all earnestness we say to you nothing can be more misleading. 'Tis true the water is here, but the system of distribution and use is lacking, and for explanation of cause we refer you to State Engineer William Ham Hall's report to the legislature of 1880.

Without irrigation the best results of agriculture are impossible. Without system of use and distribution the best results of irrigation are impossible.

With a systematic irrigation and with the atmosphere of Tulare and the natural fertility of its soil the possibilities of agriculture in Tulare and in the future can scarcely be imagined.

The drying of fruit and making of raisins have developed into the most successful branch of agriculture, and many successful experiments in that line in Tulare County have proven our soil and climate to be particularly adapted to carrying it on to its greatest perfection, the one great drawback being lack of water to irrigate.

We declare the present system of agriculture pursued in this county, and the only one practicable without irrigation, is vicious. It is injurious alike to present and future generations. Legislation should discourage it where provision can be made for a better system, or at least should by all laudable means encourage the better system.

We find from tables in Physical Data and Statistics, State engineer's report, that from records kept at five different points in Tulare County the mean annual rain-fall at Goshen for five years was 8.04 inches; at Lemoore, six years, 7.70 inches; at Tulare, ten years, 6.62 inches; at Visalia, five years, 9.14 inches, and at Lewis Valley, five years, 12.39 inches—Lemoore being near the lake and west side of the valley, Lewis Valley being on the east side of the valley in the edge of the foothills—showing a mean annual rain-fall for the county of 8.80 inches.

When we assure you experience has taught us an annual rain-fall of 10 inches, coming at proper intervals, is necessary for a crop you can judge for yourselves how necessary it is to encourage a better system of agriculture and a better class of agricultural products.

We have said the cultivation of vegetables, fruits, and raising grapes are the most profitable branches of agriculture, capable of sustaining the largest amount of population on the smallest amount of land. We have said Tulare County is particularly well adapted to the cultivation and curing of these products, for whilst other counties, particularly along the coast, can grow fruit as well as Tulare, yet from the humidity of the atmosphere in the coast counties and the absence of moisture and the evaporation in the atmosphere of Tulare we can claim it among the best counties in the State for growing and drying fruit.

We believe, then, considering the facilities for perfecting a system of irrigation; considering that in no place can a system of irrigation be adopted and introduced more readily, more cheaply, or more efficiently, that in no way can the General Government better assist the prosperity of the present and future generations than to devise, adopt, and perfect a system of water storage and irrigation for Tulare County, for in no place is it more requisite, more desired, or can be more useful.

In the impartial consideration of this appeal to you, and in considering the claims we make, there is one more factor to which we wish to call your attention. Whilst the General Government is with a lavish hand annually dispensing large sums for the improvement of bays and rivers adjacent to the coast, and to which we necessarily contribute and from which we derive small practical benefit, we, residing 250 miles from the sea-board, solely dependent on a single line of railroad for the transaction of our business and at its mercy as to terms, can not help believing—we do believe—it is right and just that the General Government should take into consideration our location, our situation, and our claims for assistance in a matter in which, we regret to say, we have found we can not so well assist ourselves.

In conclusion we ask you to believe that in making this appeal we do not desire to be obtrusive, but make it because we believe your committee and Congress desire to be informed where good can be done and how it can be accomplished; because we believe your committee and Congress in seeking to build up and benefit the whole community desire to be fair and impartial; because on the line we propose can you best assist this community and promote its best and most material interests, thereby benefiting and building up the whole country of which we are an integral part.

STATEMENT OF JOHN URTON, OF HANFORD, TULARE COUNTY.

The CHAIRMAN. What is your profession?

Mr. URTON. I am a farmer and civil engineer.

The CHAIRMAN. The settlement of Hanford has a very interesting history. Were you among the beginners?

Mr. URTON. I was among the earlier settlers.

The CHAIRMAN. Tell us how they did in Hanford?

Mr. URTON. When we started there we had a dry arid plain, and we were very much discouraged by the stock-raisers. They told us that the water supply was insufficient to accomplish anything by irrigation, and there was a question whether the soil was of that character that it would be benefited by irrigation.

The CHAIRMAN. What time was that?

Mr. URTON. That was in 1873-'74; the earlier settling of the country. We were there and a good many of us had nothing to get away on. As a result we took hold to see what we could accomplish. The situation was such that if we made a failure we would not be hurt much. We made an examination of the Kaweah and Kings Rivers to see where we could best get the water. The people were poor and any engineering plan for them had to be within their reach. There was no use talking about anything which required much money. We had a few beans and some mustangs. With what means we had we made a survey and we found that it was within our reach to introduce water.

The first canal I was connected with was a small ditch from the Kaweah River carrying 75 cubic feet of water per second. That was the original size. We introduced that water and we found that things grew, that we could produce vegetables of all kinds, and we were encouraged to build ditches. The Lakeside ditch was the next ditch built.

The CHAIRMAN. Where was that taken from?

Mr. URTON. From the Kaweah. After we had taken that out there was a ditch started from Kings River called the People's Ditch. These ditches all commenced to distribute their water at the same time. The subject was new to us all, but we grappled with it the best we could.

The CHAIRMAN. Were you farmers?

Mr. URTON. Yes; mostly. We, of course, had to find out what kind of grades our earth would stand, as the soil was porous. We found out how to irrigate, and after that we enlarged these three ditches, and after we had introduced water our population began to increase.

In the course of four or five years from the beginning we irrigated with this water. The People's Ditch had 100 feet; that was the original size. The Settler's Ditch was 75 feet, the Lakeside Ditch was 100 feet. Then there was the Mussel Slough Ditch, the last one taken out, 125 feet per second. The lower Kings River Ditch was of the same size, and in the course of five years or six after we started in we gathered the data of what we had accomplished with the water, the variety of crops we produced, and all that sort of thing, which data is embodied in the State engineer's report. We found that we irrigated 50,000 or 60,000 acres of land when we had a full season, and during our short season 44,000 or 50,000 acres. I can say that we made some mistakes in the construction of our ditches. Our rivers were not hard to approach, and we succeeded in cutting our ditches; but we did not make our distributing ditches large enough. We found when we came to apply the water that we wanted larger sized ditches. We found that the main canals should be the same size from beginning to end, because if there is plenty of water in the river and you want to bring in a large head of water into your ditch, you have the benefit of the whole ditch.

The **Chairman**. You say you got 60,000 acres under cultivation within five years.

Mr. **Urton**. Yes.

The **Chairman**. How much land have you under cultivation now?

Mr. **Urton**. I am not prepared to say. I have not the figures—actual data; but I suppose 75,000 or 80,000 acres.

The **Chairman**. From where did you come originally?

Mr. **Urton**. I am from Kentucky.

The **Chairman**. You had never seen any irrigation before you came to California?

Mr. **Urton**. Never saw an irrigating canal until I came to this country, except perhaps it was on the car coming through.

The **Chairman**. There was none here?

Mr. **Urton**. There were about 3,000 persons in the county when I came.

The **Chairman**. They were not irrigating?

Mr. **Urton**. Very little.

The **Chairman**. What was the land worth when you came on to it?

Mr. **Urton**. It was sage brush land, some places alkali. It was not a soil on which you could grow wheat, for the reason that if there is much alkali and short rain-fall it parches out.

The **Chairman**. Did you raise crops on that alkali land?

Mr. **Urton**. No.

The **Chairman**. Had it ever been done?

Mr. **Urton**. They had sowed some and raised hay, but it had not been a success.

The **Chairman**. Since you have irrigated, has it been a success?

Mr. **Urton**. Yes; we raise as large crops as anywhere in the State.

The **Chairman**. What was the land worth before it was irrigated?

Mr. **Urton**. What grazing land would be worth—$1.50 an acre.

The **Chairman**. What is it worth now?

Mr. **Urton**. From $40 to $125 an acre, according to location.

The **Chairman**. How much land would a farmer require to support himself if he should do the work himself?

Mr. **Urton**. If they do the work themselves some of them require very little. But one man could take care of 5 or 6 acres if he be industrious.

The **Chairman**. What would be a fair sized farm in this valley for a home for a family?

Mr. **Urton**. If the man did not calculate to hire much labor, but calculated to do the work himself, he could get the best results on from 20 to 40 acres. That would make a very good little farm.

The **Chairman**. Not to exceed 40 acres?

Mr. **Urton**. Of course, the more stock he could raise the better it would be. With alfalfa he could have a larger ranch. But if he confined it to fruits and vegetables, 20 to 40 acres would make a home.

There is another thing which I desire to call to your attention, and that is our water supply and its use. We have a wasteful system here. These ditches which we have in Mussel Slough are calculated to irrigate more territory than they are irrigating. That is my conclusion. These are the things which I wish to call to your attention, so that you may have the benefit of our observation and experience.

The **Chairman**. Are there any public lands on which reservoirs could be built?

Mr. URTON. Do you mean in the mountains?

The CHAIRMAN. Yes.

Mr. URTON. I suppose there are.

The CHAIRMAN. Have you examined the mountains to see whether there are lakes at the heads of these streams?

Mr. URTON. I suppose there are; I have never been over these streams. We depend a great deal on seepage in these ditches. If we had more ditches to apply the water more quickly we would do away with the labor.

The CHAIRMAN. Of what use would Government surveys be to you?

Mr. URTON. The State has made a good many surveys, and we have a good many statistics compiled.

The CHAIRMAN. You have gotten along pretty well in that direction.

Mr. URTON. Yes. So far as the reservoirs are concerned, I do not know what the last reports are. I do not know whether they have given that a thorough examination or not, but I suppose they have, moderately.

The CHAIRMAN. The reservoir sites are now reserved so that nobody can take them. That has been done by Congress. If those sites are on public lands they may be of use to you.

Mr. URTON. Yes.

STATEMENT OF T. J. McQUIDDY, OF HANFORD, TULARE COUNTY.

The CHAIRMAN. Were you one of the colony that came across the plains and undertook this enterprise at Hanford?

Mr. McQUIDDY. I am one of that colony. I came through from the State of Tennessee to Mussel Slough. I brought five families with me.

The CHAIRMAN. I asked for information about Hanford because I think it is an illustration of what may be done in a great many places over which we have traveled. Do not make your statement a lengthy one, but give your experience at Hanford.

Mr. McQUIDDY. In the year 1873, as many of you who are familiar with the history of the United States know, we had something of a financial panic. The result of that panic was that I found myself in California hunting a home for myself and others. I, by accident more than otherwise, drove my stakes down in Mussel Slough. Contrary, however, to the judgment of a few friends whom I had in Tulare County, acquaintances who had preceded me to this country, my judgment was that the soil was here. Arriving here in the month of October I found that the heat was here, and consequently came to the conclusion that but one thing was lacking, and that was moisture. I then went to the Kaweah River and found it flowing and unappropriated. The question then was, could we make the application of the water to the land. In my own judgment I thought we could, and, getting a civil engineer, demonstrated it by running a line of levels from Kings River.

Then the question was, how about getting that water out? There were two small ditches lower down on the Kings River, which were being operated to some extent and irrigating a small area of land. The result of that irrigation was satisfactory to me, it being the first I had ever seen.

Early in 1874 I left with my family and, as I stated, four other families, and made what was then known as and called the Tennessee settlement in Mussel Slough. In a few days we organized what was known as the Settlers' Ditch Company. I think eighteen or twenty of us joined in that organization. I think there were two men in the company who had means enough to lay in six months' provisions. The remaining sixteen members of the company did not have anything. We realized that there was an undertaking ahead of us. It was a big undertaking to take out the water and irrigate the land. But, as Mr. Urton stated, we were there and could not get away. So we went to work and succeeded in getting the water from the Kaweah, from what is known as the Cross Creek Tunnel. We built the Settler's Ditch in two years. We succeeded in irrigating an area of land there covering our homes, with the happy results of big yields.

It is not necessary to go into detail and tell you how we did it; but we did it. We had yields of wheat and barley running from 20 to 60 bushels to the acre. We had fine melons, large squashes, and an abundance of everything that we wanted that would grow on the land. Of course, our fruits did not come on; our orchards were planted since. But you see what can be done by irrigation. [Pointing to an exhibit of fruit and vegetables in front of the committee.]

The **CHAIRMAN**. Is a portion of that fruit from Hanford?

Mr. **MCQUIDDY**. A portion of it from Hanford and vicinity, and a portion is from Visalia and the neighborhood of Tulare—all the result of irrigation. That is the history in brief.

The **CHAIRMAN**. Did you have any accumulated capital to aid you in any way until after you got your land irrigated? Did anybody come in to assist you with capital, or did you do it yourselves?

Mr. **MCQUIDDY**. That will draw out a statement. After one year's work on the ditch we found ourselves without means. We went out in harvest time and accumulated enough to buy a few sacks of flour, and went to work again. The ditch was not completed, and the question was, what could be done to go on with the work. We could not live without water, and we could not prosecute the work without some means. It was suggested that if we would incorporate a company and make it responsible for any debts that might be contracted, we could find some one who could loan us money. We said, we have done so much; we have demonstrated to every thinking man that we can accomplish everything that we have started out to do, and if we issue scrip and pay ourselves off in that scrip for our work we can find men to furnish us supplies. We did that, and it worked handsomely. The scrip was issued to us, we pledged it as security to Mr. Jacobs, of Visalia, and others, and we raised money and provisions that enabled us to complete our ditches. The ditches being completed, we went to work and cultivated our lands, raised crops, harvested them, paid our debts, and we are now a happy people.

The **CHAIRMAN**. How long was the ditch that you constructed?

Mr. **MCQUIDDY**. It was 14 miles when first constructed, and it is some 18 miles now. About the same time Settler's Ditch was built Lakeside Ditch was built, which went through the same ordeal, except a little more capital was invested. The People's Ditch was gotten through at the same time and upon the same plan, and the Lower King's River Ditch was constructed in the same way.

The **CHAIRMAN**. Then, with these three ditches, you irrigate 75,000 acres of land.

Mr. **MCQUIDDY**. Yes. It was said by some people that we lived on bean and crow until we got those ditches constructed. The land in Mussel Slough is worth from $25 to $125 per acre.

The **CHAIRMAN**. What was it worth when you began?

Mr. McQuiddy. I would have to say that Mr. Sullivand, an old stockholder in the company, stated on oath that he would not pay 25 cents an acre for it. It was a dry, sandy plain. But it was rich land—some of it too strongly impregnated with alkali.

STATEMENT OF TIPTON LINDSAY, OF VISALIA, TULARE COUNTY.

The Chairman. Give us any information that you may have on the subject of irrigation of arid lands and the use of water, and state what use, if any, Government surveys would be to you, if you have considered the matter.

Mr. Lindsay. I will very briefly and more particularly speak in reference to the United States land district. For thirty years I have been a resident of this district. It is situated between the third and eighth standard, ranges 13 and 38 east from Mount Diablo, and embraces three hundred Government townships. According to our State engineer, one hundred and twenty-five of those townships are susceptible of irrigation, and about twenty-five do not require irrigation to produce ordinary agricultural crops. Hence, about one-half, not quite 7,000,000 acres, is agricultural land of the best quality.

As I stated, I have resided here thirty years, and my occupation has been so varied that I have visited on horseback almost every township in the valley, and have visited all the regions in the mountain country where horsemen can go, and I have assisted to some extent in making the canals which now irrigate a portion of this district.

Irrigation commenced here in 1871. Prior to that time only a few gardens had been irrigated by stock-raisers. Since 1871 we have irrigated within this land district, which embraces more than half of Fresno, all of Tulare and half of Kern Counties, twenty-two townships. The White River, the Tule, Deer Creek, and Kings River afford ample water to irrigate our one hundred and twenty-five townships, which our engineer tells us are susceptible of irrigation. We have Mount Whitney, which is the highest mountain in the United States, and we have the largest trees discovered on the continent.

The Chairman. State the size of your trees.

Mr. Lindsay. The General Grant is 41 feet in diameter, and all the other trees are almost of that size.

The Chairman. What is the highest? Has it been measured?

Mr. Lindsay. Not to my certain knowledge. I measured it as well as I could when I visited there, and I call it something over 300 feet. A little part of the trunk is broken away. In this land district the mountains are so situated that on the north side in shady spots we have perpetual snow. In this valley where you are now, and you are about in the center of the United States land district, the gardens bloom every month in the year, and while we are misrepresented in reference to climate, I say to you, Senators and Representatives, that I have lived here and raised a family, have been here for thirty years, and have never missed a meal, and my family has been as healthy as I could wish to see.

Now, we have one hundred townships to irrigate, and the water that we have been using in our wasteful way has been pretty well consumed or buried in the sand. We are at this time only supporting about eight persons to the square mile, while we are capable of supporting eighty, and not supporting them as European paupers but as American citizens. But I promised to be brief.

The people whom I represent do not expect or believe that the Congress of the United States has arrived at that stage of liberality or that intelligence in reference to irrigation that King James did in the twelfth century, when he drove all the Moors out of Spain and found there an irrigation system not dissimilar from ours of to-day. But we do ask you, as Representatives, to report back that we ask to have reserved the lands which the Government now owns on the ridges of our mountains and at the heads of our rivers, that we may have reservoirs to hold a sufficiency of water for purposes of irrigation. We ask that the growth there shall not be burned off annually by foreigners and sheep-herders, leaving our hills bare and thus allowing our waters to be gone in April when they should be there in June.

I have from observation and from information obtained from others familiar with that locality prepared a small plat of the townships, thinking that the land there should be reserved.

The **CHAIRMAN**. What is your opinion about the propriety of repealing all laws for the sale of timber land and having the Government deal the timber out to those who may require it, under regulations that shall preserve the undergrowth—allowing everybody to have as much timber as they may need for their use? Do you think that would help to stop this destruction of timber?

Mr. **LINDSAY**. In this land district with which I am entirely familiar it ought to be stopped, and should have been stopped five years ago.

The **CHAIRMAN**. Have the speculators to any considerable extent in this district purchased the timber?

Mr. **LINDSAY**. It is difficult to judge whether they are speculators or not. Of course, only one individual can take a quarter section. That is all that has been taken. Still a number of sections have fallen into one company's hands. There is still a part of it owned by our citizens —one-quarter section. That is all that has been taken in the last three years.

The **CHAIRMAN**. Have you observed what effect the denuding of the hills has had upon the streams?

Mr. **LINDSAY**. Certainly; in my judgment, in the last decade the water supply has been less late in the season than in preceding years.

The **CHAIRMAN**. The snow keeps back the moisture until late in the season?

Mr. **LINDSAY**. Yes; particularly in the mountains where this timber belt was so dense that the snow remained until July. But they have burned it off to get their stock through, especially the sheep, and large forests and bodies of timber have been destroyed.

The **CHAIRMAN**. If the growth were allowed to remain, would it reproduce quickly?

Mr. **LINDSAY**. Yes, if let alone.

The **CHAIRMAN**. Have you paid attention to the duty of water in this section? How much is required to irrigate an acre of land?

Mr. **LINDSAY**. I can not give you any certain figures on that head. I can only say that 10 inches of rain-fall properly distributed will raise an ordinary agricultural crop.

The **CHAIRMAN**. You spoke of the water being very wastefully used now.

Mr. **LINDSAY**. That is owing to strife between the different companies, and the fact that we run the water for miles over beds of sand when it should be in the proper channel.

STATEMENT OF M. E. DE WITT, OF TULARE.

The **CHAIRMAN.** Make any statement which you may desire to make in regard to irrigation.

Mr. **DEWITT.** If there is any point upon which you particularly wish information, I wish you would ask questions.

The **CHAIRMAN.** How long have you resided in Tulare County?

Mr. **DEWITT.** Twelve years.

The **CHAIRMAN.** What is your occupation?

Mr. **DEWITT.** Farmer.

The **CHAIRMAN.** Have you farmed by irrigation?

Mr. **DEWITT.** Yes.

The **CHAIRMAN.** What kind of crops do you raise?

Mr. **DEWITT.** Principally alfalfa—some fruit and grapes.

The **CHAIRMAN.** How much alfalfa do you raise to the acre; how much can you get in a year?

Mr. **DEWITT.** I have cut as high as 8 tons to the acre.

The **CHAIRMAN.** How much is an average crop when well attended?

Mr. **DEWITT.** Two or three tons to the acre for a cutting.

The **CHAIRMAN.** How many cuttings in a year?

Mr. **DEWITT.** From three to four; that is with plenty of water.

The **CHAIRMAN.** Then the average crop would be 6 tons to the year?

Mr. **DEWITT.** Upon the average, yes. It would run from 6 to 8 tons; probably 6 tons would be an average.

The **CHAIRMAN.** Have you been up in the mountains here, and are you familiar with Mount Whitney?

Mr. **DEWITT.** No, I am not familiar with Mount Whitney. I am not that far back.

The **CHAIRMAN.** You have not examined them with the view to finding places for the storage of water?

Mr. **DEWITT.** No, I have not.

The **CHAIRMAN.** Is there now plenty of water for all the land in this county?

Mr. **DEWITT.** Oh, no.

The **CHAIRMAN.** What proportion of it has water?

Mr. **DEWITT.** I would say that probably there is, under the present system, water enough for one-tenth of it.

The **CHAIRMAN.** You think it could be very much improved?

Mr. **DEWITT.** It could be, indeed.

The **CHAIRMAN.** By storing it and saving it in proper reservoirs?

Mr. **DEWITT.** Yes; by taking the water all out before it reaches the sand-beds in the valley and putting it into the main canal on each side of the river, even before it leaves the mountains or foot-hills. In that way there could be one-half or two-thirds of the water saved.

The **CHAIRMAN.** Is there anything further that you wish to say?

Mr. **DEWITT.** There is one point I would like to say a word about, and that is with regard to the sinking of water into the sand-beds. Here we have a granite and sand formation. On the Tule River some years ago there was an artesian well, and while the water flowed in that river that well flowed an inch and a half over the casing, and when the water receded in the Tule River, it receded in the well—went down 3 or 4 feet below the surface. The first flow was struck at 300 feet.

The **CHAIRMAN.** I think it is obvious that the water sinks in the gravel. There is gravel up above, and the water sinks in that and gets into the clay strata. When you tap it below you bring it up. That is an artesian supply, and when the supply is dried up the well will be dry.

Mr. **DeWitt.** That water will not reach the surface except by tapping the artesian supply. The waste is very great. We only get a small portion of the water. Our ditches come out from the foot-hills almost to the lake, and the system is very crude. But the storage of water and the taking of water out in main canals on each side of the channel would increase the supply sufficiently to irrigate the entire country.

This fruit which you see here, a good portion of it, is raised on land which, when I came to this county twelve years ago, was absolutely desert land. No man could make a living, raise grain or wheat or any other kind of crop. I know that myself, and I was superintendent of the canal when the water was first brought into this section of the country.

STATEMENT OF J. M. MOORE.

Mr. Chairman and gentlemen, I will state that I have been in this country for fourteen years, engaged in farming, with and without irrigation, principally with it, raising wheat; and in that time there has been out of fourteen crops planted without irrigation but seven reaped. Anything that was irrigated, of course, succeeded, and as a rule the crops that are raised even in good years without irrigation will not yield as heavy as those that are irrigated. This year I had a piece of ground, and the water came down in January, before I plowed. I turned some on one evening and in a short time flooded about 20 acres. As soon as I could go on to it I plowed the whole piece. There were 130 acres that I sowed in grain. Where the water was run onto the land the yield was 25 bushels to the acre, and where it did not, the yield was 7; and it was put in at the same time.

The **Chairman.** This was winter irrigation?

Mr. **Moore.** This was winter irrigation. My experience has been this year as well as other years—and I have been engaged in harvesting and running thrashing machines in this county, and I have been over a great portion of it—that where they had water or the benefit of it they had a crop that paid; but where they did not, the yield was very light, not sufficient to pay expenses. There is no use in taking land in this county to farm without water to depend on, because you can not make a living out of it for ten years, and support a family; and probably the more acres a man has the worse off he will be. But with water and a fair amount of land, 160 acres, he would have no trouble in making a living, and at much less expense.

But in relation to land in alfalfa. I find that wheat impoverishes our land; it becomes poorer with every crop we take off, whether we irrigate it or not. But we can put it in alfalfa, and it will pay a large revenue where they have water, and will pay interest on a valuation of $100 per acre, and it will be better land in ten years than it was before it was put in alfalfa; that is to say, it will produce more grain after it has been in alfalfa for ten years with water, and after it has been plowed up.

The **Chairman.** Is there anything in the water which you speak of in producing continuous crops of wheat?

Mr. **Moore.** I do not know that there is. I did not notice any particular difference. Of course, water impregnated with alkali would not be as good as water in a purer state. That is my experience with it.

I think from my experience in this county that the only hope for the county, and the only way that the people can make a living here, is through a system of irrigation. With that the county is capable of supporting a very large population; but without irrigation the population must be limited, and the land of very little value; because if you take away entirely the influence of water the land will not produce a crop, on an average, every other year.

The **CHAIRMAN**. Will it produce all-around crops?

Mr. **MOORE**. No; it will not.

The **CHAIRMAN**. A farmer can not go on and produce all-around crops and support a family without water?

Mr. **MOORE**. No; he would only raise small grain; something that he could put in in the winter.

STATEMENT OF A. O. ERWIN, OF TULARE.

The **CHAIRMAN**. What is your profession?

Mr. **ERWIN**. I am a farmer.

The **CHAIRMAN**. Do you farm in this county?

Mr. **ERWIN**. Yes.

The **CHAIRMAN**. By what means do you farm?

Mr. **ERWIN**. By irrigation.

The **CHAIRMAN**. State anything that you think would be of interest to the committee.

Mr. **ERWIN**. My experience has been only of recent date, and I do not know that I could add anything to what has been said about the means of procuring water. My knowledge is after the water is upon the land. As to the sources of supply and the amount to be obtained, I do not know anything. I raise alfalfa, stock, and fruits, and as I have said, I have been here but a short time, and our fruit trees are not bearing, so that I would not be able to give any idea of the returns we expect to receive. Alfalfa being a crop realized very soon, I know the value of our land for that purpose. We have hopes in the direction of fruit, because we have seen what has been done by those who came here earlier, and who have trees and vines that are bearing.

The **CHAIRMAN**. You require irrigation to produce trees and vines?

Mr. **ERWIN**. Yes.

The **CHAIRMAN**. Then you have had no experience that would justify you in saying anything further?

Mr. **ERWIN**. In alfalfa we find a very remunerative crop. We expect usually five to six tons per acre every growing season.

The **CHAIRMAN**. What do you do with alfalfa?

Mr. **ERWIN**. Sell it.

The **CHAIRMAN**. How much per ton do you receive for it?

Mr. **ERWIN**. From $5.50 to $7.50 per ton at the stack. Aside from the amount we get for our hay we usually get from $12 to $15 per acre for winter pasturage, as alfalfa affords pasturage the entire year. During the winter we take in outside stock and our own stock, and it affords us that much per acre. We have a young vineyard started, and a young orchard started. The trees are growing in a thrifty manner, and this season we harvested the first crop. Of course it is small—it is not a fair showing. There are others who can give you an idea of what it will do. By a proper mode of irrigation we can do well. We can get too much as well as too little water, you know. Our alfalfa we water once a year; our trees and vines of certain kinds of fruit we water less than that. An orchard well started, well rooted, in a good healthy condition, will do watered once every other year. We water by flooding, by bringing the water onto the land and covering the entire surface, and the ground retains the moisture. A crop we had charge of we raised what would be 80 bushels of Egyptian corn per acre. We cut that. That shows that with a proper amount of irrigation our soil will produce everything in abundance.

STATEMENT OF E. A. BROILER.

The **Chairman**. Are you familiar with the mountains? We want a description of the mountains. Tell us how they retain the snows, what there is up in them, and what is necessary to be done to preserve the moisture.

Mr. **Broiler**. I have been back in the Sierra Nevadas for two seasons on fishing excursions. We went up to the foot of Mount Whitney. We talked with the sheep men who go in there in the summer and get what grass they can. They also burn up dead timber and everything in their way, and, as a matter of course, since the burning down of the timber and the destruction of young trees, young forests, the snow melts off a great deal more rapidly than it did a few years ago, when it was covered with underbrush. That is what they tell me back there.

The **Chairman**. Is that true all along the Sierra Nevada Mountains?

Mr. **Broiler**. It is, so far as I have gone.

The **Chairman**. What remedy would you suggest for that?

Mr. **Broiler**. I believe there should be some way to keep the Government lands from being run over by people who pay nothing for them, by foreigners, not even voters—men who go out there in the summer time with herds of sheep and destroy our forests. There should be something done to stop them. The timber is as far back as Mount Whitney, too far back to bring it out as lumber. It is 60 or 70 miles back there. There are fine chances there for reservoirs. There are two lakes on Kern River, one a mile long and a half mile wide, and it is quite level land around them, with a gulch at the lower end, where a dam 150 or 200 feet would run water back 2 or 3 miles.

The **Chairman**. Are there any flats there that discharge through a narrow gorge?

Mr. **Broiler**. Yes, some small and some large.

The **Chairman**. How is it on these other rivers—Kings River and White River?

Mr. **Broiler**. Kings River is as large a river as the Kern River, but I have had very little experience up on Kings River.

The **Chairman**. How is the White River?

Mr. **Broiler**. I understand there are some flats there; and on Tule River there are some flats. On Kern River there have been some surveys where there are some places for reservoirs—down near the Kaweah.

The **Chairman**. That is for this county.

Mr. **Broiler**. Yes; that is for this county. And I wish to say in connection with the Kaweah River that we do not use a quarter or a fifth of the water that comes out of that river.

The **Chairman**. Even during the season that you are irrigating?

Mr. **Broiler**. Yes. The water that comes out of the mountains goes into a hard flat. Turn down a thousand feet of water at the head of the stream, and before it comes out, drawing 200 or 300 feet of water, and about two-fifths or three-fourths would be wasted in the flats. We should have some system of irrigation. Water could be brought out of the Kaweah where it comes out of the mountains with a canal on each side of the river on solid firm ground. If that were done, we would have water enough to irrigate this whole county. As it is now, there is not enough. On the headwaters of the Kern there is a scope of country 50 miles wide, as fine as a park. We are anxious that that should be set aside as a Government reservation, and if you will do it, I think the people of this county will build a wagon road up to Mount Whitney and give the people a chance to go there.

The committee adjourned to meet on call of the chairman.

STATEMENT OF SAMUEL FOWLER, OF TULARE.

The CHAIRMAN. The committee will hear your views.

Mr. FOWLER. When we first brought water to irrigate the land around Tulare the old settlers said that we could not bring the water on the dry plains. The water had left the old channels and had made a new channel, known by the name of St. John. We knew if we turned the water back into the old channels where it ran before the flood of 1862 we would have a hard job, for the streams that were filled with sand had grown full of willows, which would have to be grubbed out and then the sand scraped out. The land was very rich on the old channels, and the best of the land could be bought from $4 to $6 per acre. We knew the value of water on the west side in Merced County, which made us undertake the enterprise. We got a little water on the land in 1875. In 1876 the barley grew 4 feet high on land that was made wet in 1875.

The land by the side of that irrigated land, and which only had the benefit of the rains, grew 1 foot high and dried up and made no grain. We knew the land was well adapted for irrigation and that under such a system it would increase in value at least twofold. A few of us kept at work to bring the water into this neighborhood until we succeeded. A new life began for Tulare. Orchards, vineyards, and alfalfa fields were planted. The horses in place of being turned out on the plains to be "locoed"* and become useless were turned into the alfalfa and got fat. Hogs got on the alfalfa, and then we got hogs with short noses and sold the ones that had noses a yard long that had to go to the lake and run them down to the mussel shells to make a living. We began then to see the wilderness blossom as the rose. Men who had money came into the country and bought land. One firm bought 10,000 acres of land and planted it in fruit and vines (raisin grapes). They recently told me that it would take one thousand hands next year to harvest and take care of the fruit, etc. With water we can raise two crops; first a wheat crop, irrigate the land, and when the wheat is harvested plow and plant corn, which will keep the weeds from growing.

That is two crops with one irrigation. We thought we were happy.

Water is the salvation of this region. While we learned the value of the water the men on the old channels learned the same. As we had turned the water in part into the old channel we took the water out by ditches as needed. For the lack of sufficient money to keep out of these old channels we got into trouble. Men living on them below where our water was taken out brought suits against us, such as riprarian claims, etc. What water they did not want to use they permitted to go to the lake, and a great deal of money has been spent in lawsuits and much hard feeling had been engendered, which has stopped the growth of this part of the country. We have made a move to remedy this trouble, and we have organized an irrigation district under the "Wright law." We now feel encouraged by the fact that there are some men in Congress that are taking interest in the men that feed the hungry of the United States.

---

*A poisonous weed which destroys animals that feed upon it.

Adjourned.

BAKERSFIELD, CAL., *August* 31, 1889.

The committee met pursuant to the call of the chairman.

Present: Messrs. Stewart (chairman) and Reagan; also Director Powell.

STATEMENT OF O. BROWN, OF BAKERSFIELD.

The CHAIRMAN. What is your occupation?

Mr. BROWN. A farmer.

The CHAIRMAN. How long have you been farming?

Mr. BROWN. Eight years.

The CHAIRMAN. What crops do you raise?

Mr. BROWN. Alfalfa, corn, and some other things. I also attempted to raise some wheat. What I wish to talk about is with regard to the people who have staid on these arid lands. I have 160 acres. We are obliged to abandon the land for the reason that we have no water. We have perfected our ditches and paid for our land, but we have been obliged to abandon it because of lack of water. We are now living on rented land in Bakersfield.

The CHAIRMAN. Is there any unappropriated water supply that could be gotten?

Mr. BROWN. That is what I wish to talk about. The Kern River here is appropriated to a great extent by a large water monopoly, a water company. That is to say, the natural flow of the Kern River is taken up. But there is a flood flow that I do not think is appropriated by anybody. That is the point which the people on these plains wish the committee to understand. There is water that could be properly stored, enough to irrigate the whole country.

The CHAIRMAN. What do you know of the facilities for storing water? Have you examined to see if there are places that could be used for that purpose?

Mr. BROWN. I have not examined; but I know many persons who have been around the headwaters of the Kern River.

The CHAIRMAN. Where are those places situated? Are they on the public lands?

Mr. BROWN. I do not know, but I believe there are places on public lands where these flood waters could be stored. But what I was going to say is this: the company that has appropriated the natural flow of the river purposes to build a reservoir down at the mouth of the river near Buena Vista Slough. That is a bad idea, and for this reason: When the water is run off millions of gallons would run to waste that could be brought here for irrigation purposes. If the water should be stored in Buena Vista Slough it would only irrigate one man's land, while if it were stored in the mountains and taken in ditches after it comes on the plains it would irrigate every acre of land within a radius of 40 miles from where it comes out of the mountains to where it gets on the plains.

The CHAIRMAN. Would public surveys determine some of the questions that now perplex you?

Mr. BROWN. It would determine some of these matters. There was a survey made by an engineer of California; and I saw a report of that survey. That report stated that there was sufficient water if it were properly stored.

The CHAIRMAN. Do you regard a survey of these reservoir sites as important?

Mr. BROWN. It is very important. But I wish to say that inasmuch as there are more or less places suitable for reservoirs that have been already taken up, you want to see to it that California passes a condemnation law so that the land on those places can be condemned and taken. I suppose there is a law already in existence that is sufficient for that purpose. But if the Government would make the reservoirs, there is law in California to protect the people who make the ditches.

The CHAIRMAN. We will not discuss what the Government will do; what we wish to understand is whether this land is worth reclaiming. Now, persons crossing the continent look upon this land as a desert.

Mr. BROWN. It is not a desert; it is one of the finest spots in the country.

The CHAIRMAN. What can you raise here?

Mr. BROWN. With irrigation you can raise anything that grows under the sun.

The CHAIRMAN. Can farming be carried on without irrigation?

Mr. BROWN. Nothing can be done without irrigation. Without the water the land is entirely valueless. That is why I say that every drop of water should be stored in the mountains and brought here on the public land. It is probably one of the best places for irrigation in California or in the United States.

The CHAIRMAN. Why so?

Mr. BROWN. Because the land responds to irrigation better than any other place in California. My idea is that no cold country is fit for irrigation; we must have a hot country.

The CHAIRMAN. How much alfalfa can you raise to the acre?

Mr. BROWN. From 7 to 9 or 10 tons per acre per year. That number of tons I have myself raised here.

The CHAIRMAN. How with regard to potatoes?

Mr. BROWN. Of potatoes about 200 sacks per acre.

The CHAIRMAN. How many in a sack?

Mr. BROWN. From 120 to 125 pounds. It is probably not as fine a potato as that grown in some other places.

The CHAIRMAN. How much of barley?

Mr. BROWN. From 50 to 75 bushels per acre.

The CHAIRMAN. How with regard to oats?

Mr. BROWN. Oats, not so well; from 40 to 60 bushels per acre.

The CHAIRMAN. How much of wheat?

Mr. BROWN. Wheat will run from 30 to 60 bushels to the acre.

The CHAIRMAN. Is this a good fruit country?

Mr. BROWN. Yes.

The CHAIRMAN. What kind of fruit can you raise here?

Mr. BROWN. Most of the fruits—peaches, apricots, prunes, oranges, lemons, figs, bananas—all kinds of fruits that are raised in any other country. We have the best peach orchard here that is in the United States, cultivated by irrigation.

Mr. **HINTON**. What is the value of land without water?

Mr. **BROWN**. I consider my land worth 10 cents an acre without water; with water from $100 to $500 an acre.

STATEMENT OF J. A. BLODGETT, OF BAKERSFIELD.

The **CHAIRMAN**. Have you recently visited the headwaters of the Kern River?

Mr. **BLODGETT**. Yes.

The **CHAIRMAN**. Describe what you saw on your trip there.

Mr. **BLODGETT**. In reference to irrigation the main thing was the natural reservoir sites in the mountains and valleys.

The **CHAIRMAN**. Did you go there for the purpose of investigating those things?

Mr. **BLODGETT**. No, for pleasure, for my health. But, of course, being interested in land in Kern County, being a farmer and in other enterprises, I took a good deal of interest in the matter, and I particularly noticed the adaptability of these mountains and valleys for reservoirs. The south fork of the Kern River is almost a succession of valleys and basins from the summit of Mount Whitney to the plains. There are, perhaps, from six to eight or ten valleys and natural basins commencing almost from the summit of Mount Whitney. Most of those meadows are nearly level. The river flows on a fall of about 7 feet to the mile.

The **CHAIRMAN**. Does it discharge through narrow gorges?

Mr. **BLODGETT**. Yes, through narrow gorges 7 or 8 miles long. There will be a level of 4 or 5 miles, and then another valley, and so on. There are valuable meadows on Whitney Creek, the Bradshaw, the Templeton and Walker Meadows, and the Manache, within the valleys in the south fork.

The **CHAIRMAN**. Are these meadows private property?

Mr. **BLODGETT**. Some of them. Some of them were taken up under the swamp-land act. The meadows are where there are springy bodies of land, where water oozes out of the mountains, and where during the winter months the valleys are full of snow. In many places you can not ride across them. They are pasturage lands.

The **CHAIRMAN**. Has there been no money spent to reclaim them?

Mr. **BLODGETT**. There does not appear to have been. The impression that a person would get of the land is that it has no value except for pasturage, and in a few months of the year it can not be tilled. They have frosts there, and the crops grown would be few and of no value.

The **CHAIRMAN**. In your judgment how much water runs to waste there during the year?

Mr. **BLODGETT**. I have no technical information on the subject. In many seasons, the rainy seasons, there is a large volume of water that runs to waste. I might say off-hand that a third of the flow of the river runs to waste. I am certain, however, that there is an immense quantity of water sufficient to fill reservoirs in a short time.

The **CHAIRMAN**. You say you are a farmer?

Mr. **BLODGETT**. Yes, and interested in other kinds of business as well.

The **CHAIRMAN**. What crops do you raise?

Mr. **BLODGETT**. Alfalfa.

The **CHAIRMAN**. How much alfalfa can you produce to the acre? What do you consider a good crop of alfalfa?

Mr. **BLODGETT**. From 6 to 9 tons.

The **CHAIRMAN**. Have they in this country gone extensively into the fruit business?

Mr. **BLODGETT**. Not extensively. But few persons have gone into it extensively.

The **CHAIRMAN**. With what success have they met?

Mr. **BLODGETT**. They have been very successful. They have raised a quality and quantity unsurpassed anywhere.

The **CHAIRMAN**. Do you raise good oranges here?

Mr. **BLODGETT**. Very few. There have been few experiments in that line. In the bottoms they can grow them successfully, as experiments have shown. Of course, the orange belt as a rule is above the irrigation belt; it is thermal; there has been no water with which to irrigate.

The **CHAIRMAN**. Take land here that is not under water, or upon which it is not possible to get water, and state what it is worth.

Mr. **BLODGETT**. Two dollars and a half per acre, for grazing purposes.

The **CHAIRMAN**. Will it sell for that?

Mr. **BLODGETT**. It will not sell for more than that.

The **CHAIRMAN**. Would it bring that price?

Mr. **BLODGETT**. It would bring about that for sheep pasturage.

The **CHAIRMAN**. Can you farm here without irrigation?

Mr. **BLODGETT**. No, not in this country.

The **CHAIRMAN**. You can not raise regular crops without irrigation?

Mr. **BLODGETT**. No.

The **CHAIRMAN**. If you raised crops without irrigation it would be an accident?

Mr. **BLODGETT**. Purely.

STATEMENT OF W. CANFIELD, OF KERN COUNTY.

The **CHAIRMAN**. In what part of Kern county do you reside?

Mr. **CANFIELD**. About 13 miles southwest from Bakersfield.

The **CHAIRMAN**. Are you farming there?

Mr. **CANFIELD**. Yes.

The **CHAIRMAN**. From where do you get your water?

Mr. **CANFIELD**. From the Kern River.

The **CHAIRMAN**. Are you on the east or west side of the river?

Mr. **CANFIELD**. About 6 miles south of the river.

The **CHAIRMAN**. How long have you been farming there?

Mr. **CANFIELD**. Since 1873.

The **CHAIRMAN**. What crops have you been raising?

Mr. **CANFIELD**. We have not been raising any line of crops but cattle and horses; occasionally a crop of corn in the latter part of the season. Alfalfa has been the principal crop we have raised.

The **CHAIRMAN**. How much alfalfa can you raise to the acre?

Mr. **CANFIELD**. From 5 to 7 tons to the acre.

The **CHAIRMAN**. Have you some fields in alfalfa?

Mr. **CANFIELD**. Our business is mostly pasturing instead of growing hay.

The **CHAIRMAN**. Without a water right what is good alfalfa land worth?

Mr. CANFIELD. I presume a fair price would be $2.50 an acre.

The CHAIRMAN. With a water right what would it be worth?

Mr. CANFIELD. With a water right probably $50 an acre. I speak of the water right as something very definite. For instance, land situated near the source of supply would be worth a good deal more than if it were at the end of the canal. That is according to my experience.

The CHAIRMAN. Is there anything further that you wish to state about farming here?

Mr. CANFIELD. I wish to state that I believe in this committee and in the value of these surveys. So far as the facts are concerned I am satisfied that when measures shall have been taken for a just and equitable distribution of the water it will be a blessing to this country. But I believe more depends upon an economical use of the water after it is on the land than anything else.

The CHAIRMAN. State how much water you require to irrigate.

Mr. CANFIELD. That is a difficult question for me to answer. It depends almost entirely upon the nature of the soil.

STATEMENTS AND INCLOSURES OF WILLIAM B. CARR, OF BAKERSFIELD AND SAN FRANCISCO.

GENTLEMEN: Relative to your investigation of the subject of the selection and reservation of Government lands for reservoir sites in our mountain ranges, to serve for storage of the surplus waters of the streams having their sources in the vicinity of such sites, and relative to the subject of irrigation in general, which necessarily is inseparably united with its oftentimes necessary forerunner, and at all times able coadjutor—storage—I have been invited to give to your committee the result of my experience for the past fifteen years in the cultivation of arid lands by irrigation.

As a means of introducing the various topics of plans of irrigation, practice of irrigation, and results of irrigation, I submit herewith inclosures as follows:

Inclosure No. 1.—Map of a portion of Kern County, Cal., showing lands in which J. B. Haggin and his associates are interested, between Kern River and the north line of the county, and also main canals and distributing ditches, demonstrating system of irrigation there in operation, and also explanation of the same.

Inclosure No. 2.—August 29, 1889. Plan showing system of irrigation in Kern County, Cal., and bird's-eye view of one system of irrigation as operated in Kern County, Cal., and explanations thereof.

Inclosure No. 3.—Clipping from the Resources of California (a monthly newspaper published in San Francisco, Cal., October 1888), descriptive of the water supply and irrigating system of Kern County, Cal., embracing description of its canals, amount of water owned by each, length and manner of handling the water, and explanatory of beneficial results derived therefrom.

Inclosure No. 4.—August 26, 1889. Estimations of cost to ditch and check lands in Kern County, Cal., by W. L. Dixon, engineer, referring to sections 9, 16, 21, and 22, township 28 south, range 26 east, Mount Diablo base and meridian.

Inclosure No. 5.—August 14, 1889. Letter from W. L. Dixon, giving estimation of cost to ditch and check sections 15 and 23, township 28 south, range 26 east, Kern County, Cal.

Inclosure No. 6.—August 24, 1889. Statement of lands ditched and checked season of 1887 and 1888 on District No. 4, Kern County, Cal., showing total cost and average cost per acre of this work.

Inclosure No. 7.—August 24, 1889. Statement of lands ditched and checked season of 1888 and 1889, on Buena Vista Ranch, showing total cost and average cost per acre of this work, Kern County, Cal.

Inclosure No. 8.—August 26, 1889. Statement of lands ditched and checked season of 1888 and 1889 on District No. 4, Kern County, Cal., showing total cost and average cost per acre of this work.

Inclosure No. 9.—October 29, 1889. Description of irrigation as conducted in Kern County, Cal.

Inclosure No. 10.—October 28, 1889. Memorandum of lands seeded to corn and alfalfa, Poso District, season of 1888 and 1889 (as per R. P. O. 1246), together with a few remarks on the irrigation works of Kern County, and the change which has been effected through them in a formerly arid and worthless country.

Inclosure No. 11.—October 30, 1889. Map showing location of haystacks at Poso, Kern County, Cal., 1889, with explanation relative thereto.

Inclosure No. 12.—October 28, 1889. Memorandum of hay cut season of 1889 on Kern County property, with particular explanations as connected with the hay production in the Poso District, on lands seeded during the previous winter and spring, supplemented by remarks on irrigation.

Inclosure No. 13.—List of photographs taken in Kern County, Cal., sent to Maj. John W. Powell, United States Geological Survey, Washington, D. C.

Inclosure No. 14.—August 26, 1889. Memorandum relative to products raised at various times in Kern County, Cal., with remarks upon same.

Inclosure No. 15.—R. P. 1271, August 7, 1889. Copy of newspaper notice, showing comparisons between years 1867 and 1888 relative to number of voters, population, and assessed value of property.

Before referring further to these inclosures let me say that I have given fifteen years close study to the subject of irrigation in all its branches and details. I and my associates have at all times employed able and skillful civil engineers, the best obtainable for the purpose. The results which we have accomplished and the systems of irrigation which we now commend have been developed by large expenditures in experimenting, numerous mistakes, and indefatigable energy. When our irrigation works in Kern County were first commenced, the subject was comparatively new in the United States. Upon our first entrance into this project we had no idea that our irrigation operations would attain their present gigantic proportions. Most of the practical farmers of California considered the project a foolish one, which would never yield a return upon the investment.

To-day there is not another district in California possessing irrigation works as extensive and as efficient as those of Kern County; there is not a property in California having a larger body of cultivated land than has our property in Kern County. There are properties of larger areas, perhaps, but none other with as much land which has been broken with the plow.

Without irrigation Kern Valley would still be as it was fifteen years ago, and as its unirrigated portions are to-day, wholly unfit for anything save the precarious pasturing of a very limited number of stock, which, in any season save of most favorable conditions, would starve to death on lands now heavy with their burden of life-sustaining irrigated vegetation.

The absolute necessity for irrigation in Kern County has been proven by experiments repeated during the last fifteen years, made oftentimes on a scale of a thousand or more acres, by those who, at the time, thought irrigation unnecessary, unless, possibly, to procure a showing of green in the spring of a favorable year, in order to effect a sale of land to one unacquainted with Kern County. No one at all acquainted with its physical conditions would any more attempt to raise a crop without irrigation than without seed.

Of the great interior valley of the southern portion of California, known as the San Joaquin Valley, the southern extremity or pocket is known as Kern Valley, for which latter the waters of Kern River are the principal source of water supply. The waters of this river have been diverted through canals, and have reclaimed thousands upon thousands of acres of land, and now the question arises as to the further utility of those waters for the reclamation of arid lands, whether owned by the Government or by individuals, and which I hold can not be accomplished, to any great extent, without reservoir storage. The projects now entertained by your committee have been in my mind, as a provision for the future, for many years. Such a scheme is entirely feasible and practicable in Kern County, and its benefits can not be measured.

Shall the Government's domain be given, rent free, to the wandering, marauding sheep-herder, who, paying no taxes, serves but to consume the scant feed on an immense territory, set fire to Government and private forests with his camp-fires, aggravating the lack of rain-fall, and come in competition with the stock-raiser who spends his money in the reclamation of worthless domain, the increasing of taxable property? Shall the Government's possessions, such as those in Kern County, Cal., that were offered for sale at $1.25 per acre, in the Buchanan administration, without finding a purchaser, be practically withheld from the farmer, who, on account of his limited means, is unable to construct the necessary irrigation works? Or will the Government, by assistance to its people in respect to storage reservoirs, and by enactment of liberal laws for the sale and reclamation of these arid lands, allow the settlers to cooperate in the construction of the necessary irrigation works, resulting in general benefit to the Government, to the State, and to the people?

Irrigation is made necessary from the fact of an insufficiency of rain, and in a district where irrigation is practically possible on a scale of any magnitude, the supplying stream most generally, if not always, has its source in the snow deposit of some mountain range. It is true that, occasionally, a flood of water is supplied to the river from a possibly unusually heavy rain-fall, but the occurrence of such contributions are so erratic as to be unworthy of dependence. Ninety-nine per cent. of the flow of such rivers generally comes, not by rain-fall, but from the melting of almost perpetual snow in lofty mountains; so that, whilst the necessity for irrigation arises from the climatic conditions of the valleys, the water supply of such rivers is almost exclusively dependent upon the climatic conditions existing at the river sources. It is well known to all that the climate of the higher altitudes is similar to that of the frigid zones. The annual seasons are long and cold winters and short summers. As the hot rays of the summer's sun will melt the snow more readily than the mild days of spring or autumn, it follows that the down-pour of the irrigating river occurs in midsummer, with a smaller flowage in spring and fall, and to a great degree a cessation in winter. These conditions are general in their character, and Kern County is included in their embrace.

Whereas Kern River often affords ample water in March and September, the season of plentiful supply is more often restricted to the months from April to August, both inclusive, with the large floods occurring in the months of April, May, June, and July, and the most limited supply of the year prevailing generally from October to February, both inclusive. It is during this period of comparative drought, beginning with the month of November and extending through February and possibly March, that the farmer needs moist earth through which to plow, needs moisture to sprout his planted seed, and being sprouted, the irrigator needs moisture to keep it alive until the down-coming of the melted snow allows him to irrigate; and in the early spring his pasture land, if it could be irrigated, would soon be green, whereas otherwise it is unproductive until the down-coming of the river.

It can be readily imagined that where irrigation is practiced and is a necessity these varying conditions of the water supply must control and limit the amount of land which can be successfully cultivated. The cultivation of land by irrigation being a purely artificial method, depends for its highest success upon its absolute independence of natural causes. In these arid countries, while the occasional and uncertain rain-fall is of advantage to the farmer, it can not and must not be relied upon; and it may be stated here that lands in these arid regions can not be cultivated by irrigation utilized only during the flood months of the year. It is therefore evident that the limited water supply of spring, autumn, and winter restricts the area possible to be irrigated to a point far below that which the summer's flood would wet, at the same time being inadequate possibly to guaranty the farmer against the loss of his most profitable crop, that sown in the winter.

At the same time it is easily apparent that it is quite impossible to in any way utilize the immense floods of water, for which in the midsummer the entire canal capacity of any irrigating district can not possibly provide, and which, with but a small portion of its volume, serves to wash and break the canals, leaving its greater volume to flow to waste. This waste either goes finally to the sea or sinks into the desert sands, or if spread out into lakes in the valleys is lower in level than the major portions of those valleys, and thus inaccessible for irrigation, and in the generality of such latter cases evaporates with almost incredible rapidity under the burning sun.

If the water which annually goes to waste, as I have described, could be utilized for irrigation, it would multiply, many times, the area which can be irrigated by the amount of water now capable of being utilized. If, taking from the more than abundant flowage of summer, and adding to the insufficiency of spring, autumn, and winter, all of the water which is formed by the melting of the snows in the mountains could be so utilized that the farmers would not be dependent for success upon any natural and uncertain supply, the great problem of the settlement and development of those portions of the country, which ninety-nine men out of every one hundred now deem uninhabitable, would be solved. I think that your committee, in the progress of its investigations, must have become satisfied that I am right in this, and I have no doubt that I am in accord with the committee in believing that this can be accomplished in no other way than by the construction of artificial reservoirs, and the utilization of natural reservoirs, in the Rocky Mountains and in the Sierra Nevadas.

The question now under investigation by your committee, the storage of surplus waters, must be formulated into a shape for permanency and operation. There has been, for many years, no question raised for discussion in Congress, which, properly and intelligently handled, can be productive of greater good to the nation at large than can this subject of irrigation. One of the chief sources of our nation's wealth and thrift is its agricultural capabilities, and any grand expanding of those capabilities can but be a most powerful factor in the Union's history.

In my three topics of Plans of Irrigation, Practice of Irrigation, and Results of Irrigation, as mentioned in the fore part of this statement, I take pleasure in referring you to the inclosures herein made, as enumerated in the commencement:

PLANS OF IRRIGATION.

Inclosure No. 2, as more fully explained in inclosure No. 9, shows the system of irrigation which has been most generally adopted in Kern County, together with explanations regarding the same.

Inclosure No. 3, clipping from the "Resources of California," descriptive of water supply and irrigation system of Kern County, Cal., is very accurate data, with the exception of what is stated relative to the flow of Kern River, which is in excess of the actual amount obtainable from that source. This inclosure, from its accuracy in other respects, will give you a very comprehensive idea as to the irrigating systems there in operation, and as to the capabilities of the same.

Inclosure No. 1, taken in connection with inclosure No. 3, as demonstrating the extent of the irrigation works in one district of Kern County, will convey a conception of what works are required for successful irrigation.

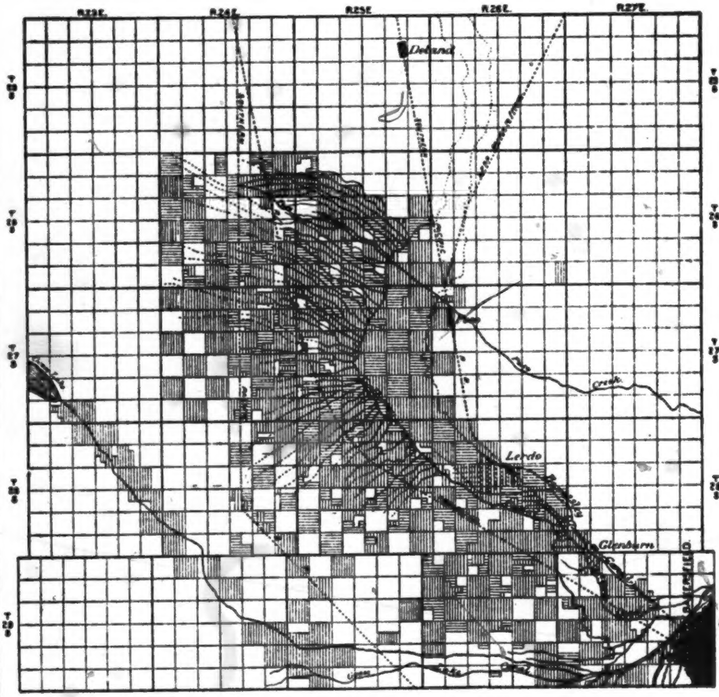
Inclosures Nos. 4 and 5 are furnished to show the estimated cost, as furnished by one of our engineers as indicative of the cost of reclamation works, on lands which we now have in contemplation of irrigation; and inclosures 6, 7, and 8 show similar authenticated figures on lands already ditched and checked, the average cost of this work ranging, as you will note, from $9.78 to $14.37 an acre, the lower average costs, as shown in inclosure No. 6, representing the cost of work done in 1888 on land on which a portion of the constructions were made prior to 1888. The final average cost of $10.95 an acre, as shown on page 4 of inclosure No. 8, is about the cost for which this work can be done, varied somewhat by the topography of the land to be reclaimed.

PRACTICE OF IRRIGATION.

Inclosure No. 10, showing again the cost of these irrigation works and the application of the same to the cost of our crops, as well as the practicability and efficiency of such works, indicates the present history of our work, while Inclosure No. 11, showing the volume of products of irrigation, and Inclosure No. 12, showing what returns we are obtaining from our expenditures in this direction, tell the daily repeated history of irrigation, as we have proven and are proving its profitable and satisfactory results.

RESULTS OF IRRIGATION.

The photographs, taken in Kern County, Cal., sent to Maj. John W. Powell, of the U. S. Geological Survey, Washington, D. C., and as


R23E.
R24E.
R25E
R26E.
R27E.
T 25 S
T 26 S
T 27 S
T 28 S
T 29 S
Delano
Creek
Lerdo
Glenburn

MAP OF A PORTION OF KERN CO. CALA.
SHOWING LANDS IN WHICH J.B.HIGGIN AND HIS ASSOCIATES ARE INTERESTED
BETWEEN KERN RIVER AND THE NORTH LINE OF THE COUNTY AND ALSO MAIN
CANALS AND DISTRIBUTING DITCHES DEMONSTRATING SYSTEM OF IRRIGATION IN
OPERATION OCTOBER 1889

Report on Irrigation.

enumerated in Inclosure No. 13, indicate more clearly than words can tell the story what results have arisen from irrigation in the lower portion of the San Joaquin Valley The barren, arid lands, lacking irrigation and devoid of vegetation, are shown; the water is seen running its way through the many ditches to perform its labors, and the irrigated fields are shown heavy with their growth from unity of sun, soil, and water; the thousand occupations arising from irrigation are made to appear as in the life; and after examining these photographs, if any one doubts the results of irrigation in a country valueless without it, he will have to come to Kern County, examine the reality, and abide by the result of his observations.

Inclosure No. 14, enumerating the various products which we have been able to raise through irrigation, and Inclosure No. 15, showing a comparison of. taxable property, population, etc., in Kern County, as between 1867, prior to irrigation, and 1888, during its progress, also serve to show the results therefrom.

And now, in conclusion, gentlemen, let me say that what I have stated here in reference to the advantages and necessities of irrigation, the storage of surplus waters, and the construction of reservoirs, applies equally not only to Kern County but to the whole of California, and also to all of the now arid country lying tributary to the rivers having their sources in the Sierra Nevada and Rocky Mountains. The climatic conditions are the same, both in the valleys where irrigation is necessary and in the mountains where the sources of the water supply lie.

I can not in too forcible terms laud the object that your committee has in view. The most telling results as regards the future of the nation's agriculture can but ensue. I believe that Congress can not be too liberal in the appropriation of money to be used in ascertaining and selecting the best sites for such reservoirs or other storage works, and for the construction of the same. It is certain that whatever is expended will be returned to the Government a hundred fold, and to the nation a thousand fold.

The results of irrigation in Kern County, as here explained, are not by any means the only examples apparent in southern California, and I await with pleasurable anxiety the reports to your committee of the similar experiences of Tulare County, Merced County, Fresno County, San Diego and Los Angeles Counties, and other irrigating districts of California, which can but multiply the brightness of my predictions.

The results thus anticipated can not be accomplished in a year, or a decade, but will demand careful, continuous, and intelligent application, and a mighty Government's helping hand. Therefore, with congratulations to your committee and ourselves on the prospect of a long continuance of your labors so auspiciously begun, let me join my voice to the common sentiment of California that our records, experiences, and results are at your command, and that our best wishes and support attend your labors.

MEMORANDUM CONCERNING MAP OF A PORTION OF KERN COUNTY.

[Inclosure No. 1.]

This map shows that portion of the property in Kern County, Cal., lying to the north of Kern River and to the west of the Southern Pacific Railroad, which J. B. Haggin and his associates have already reclaimed, and are now in process of reclaiming, from an arid, unproductive state, by means of irrigation.

The shaded lines indicate the lands owned by the parties directly interested in this work of reclamation and irrigation, and who also own the net-work of ditches through which such results have been and are to be effected.

An idea of the magnitude of these operations can be obtained from this map, keeping in view that the length already constructed of the Calloway Canal amounts to 32 miles, and that an extension is in contemplation of 11 additional miles to be of the same size as the present canal, namely 80 feet wide on the bottom and 120 feet wide from bank to bank.

The Beardsley and McCord Canals also supply water to this same district of country, and it is proposed to extend the former 22 miles and the latter 27 miles, as shown by the dotted extensions of the heavy lines indicating the canals, thus largely increasing the extent of the irrigable lands, increasing the area suitable for cultivation and homes, and multiplying the output and taxable property of Kern county.

The interests of these associates are not alone represented by the lands portrayed on this map. They possess an equal amount of property on the south of Kern River, and on all of this vast estate the science of irrigation has been studied in all its branches for over fifteen years, resulting in the Kern Valley of to-day.

On the west bank of the Calloway Canal is constructed, at an altitude, a roadway which serves as an observation point, commanding miles of the sloping plains.

Upon it, with the waters of the canal dancing in the summer sun, one can look far to the westward over fields of waving alfalfa, whose verdant green is a most beautiful carpet with its 3 feet of thickness to the moistened earth. A thousand cattle are in the radius of the eye's circle; a dozen hay stacks oppose their thousand tons of bulk to shut off the view from further fields of green; everything speaks of thrift, of success, of life.

Looking to the eastward above the canal, and on the arid lands not yet reclaimed, one can at once realize the absolute necessity of irrigation, and the results derivable therefrom. In the spring one would see perhaps a patch of short-lived wild flowers, some scant alfilleoria, and perchance some at that time passable grain which some experimenter had planted above the line of irrigation, and which had been sprouted by the light rain-fall. But in the summer the flowers would be withered, the alfilleoria dead, and but a patch of rusty blackened straw, with drooping hollow heads, would tell of the failure of the grain, resulting from want of irrigation. Everything dry and barren, with possibly a few stunted sage-brush, populated only by a passing jack-rabbit, by lizards, and horned toads, would tell the story of Kern County fifteen years ago, and when brought into comparison with the irrigated plenty, would make one conclude that water is king, and that Kern County needs such beneficent kingly rule.

MEMORANDUM CONCERNING PLAN SHOWING SYSTEM OF IRRIGATION, AND BIRD'S-EYE VIEW OF ONE SYSTEM OF IRRIGATING AS OPERATED IN KERN COUNTY.

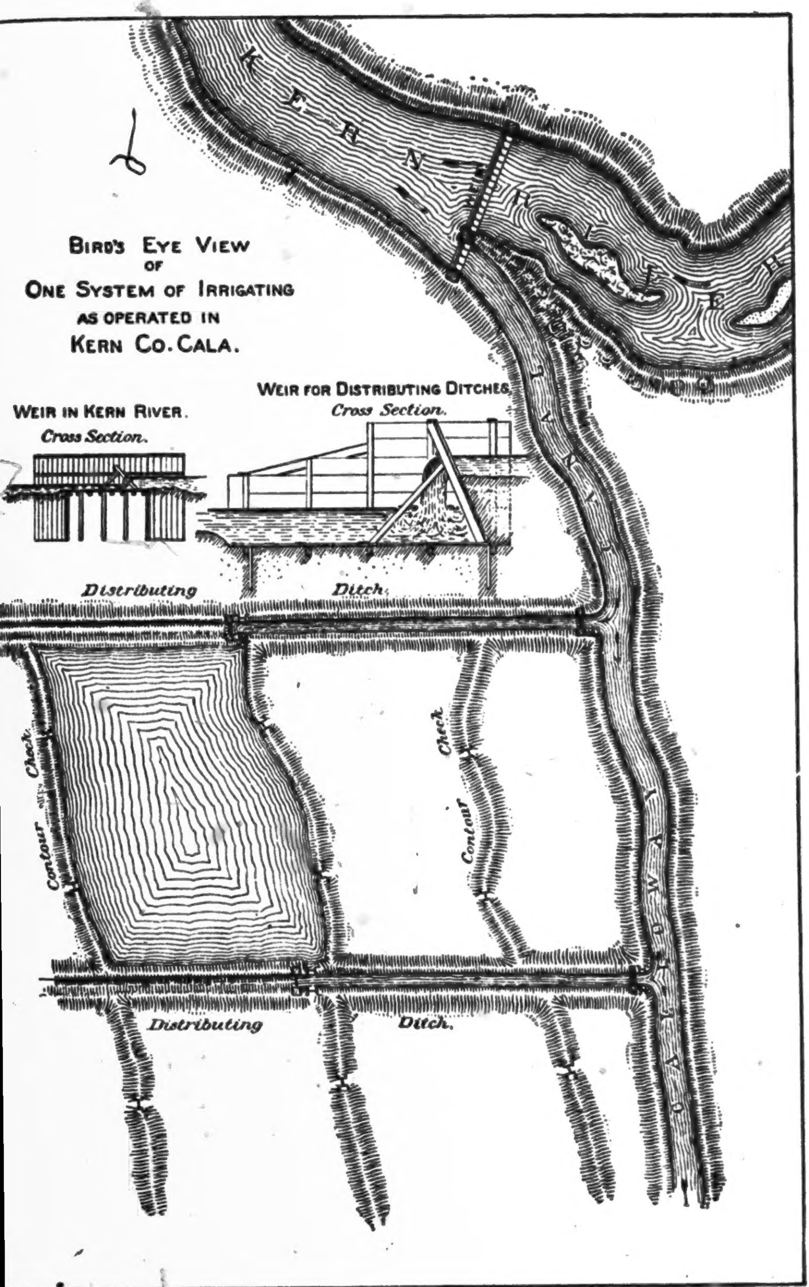
[Inclosure No. 2.]

In the "bird's-eye view" are shown the river, a portion of the Calloway Canal, two distributing ditches, and several contour checks. As indicated by the arrows, the water in the river, arrested by the weir, enters the Calloway Canal through its head-gate and from thence passes into the distributing ditches. In the latter are shown the "drops," acting similarly to the river weir, and forcing the water out of the distributing ditches through the "side gates" of those ditches onto the land inclosed by the contour checks, thus accomplishing the actual irrigation.

In the "plan of irrigation" are similarly shown a portion of the Calloway Canal, distributing ditches, and checks, together with cross-sections of the Calloway distributing ditch and of land in process of irrigation.

The checks are run on a level, and thus at regular intervals of 6, 9, 12, 18, or 24 inches, as desired, act as dams to back the water over the space intervening between the check so constituting the dam and the next check above, as appearing in the cross-section. When the irrigation in one check is completed the surplus water from that check is drained into the next check below, the balance of the water required being supplied from the distributing ditch.

Such is the system of irrigation most general in Kern County, and from its cheapness of construction as compared with other systems and their results, its extreme cheapness of operation, its most satisfactory results in the even and thorough distribution of the water, resulting in thorough irrigation and profitable returns, it commends itself for


BIRD'S EYE VIEW
OF
ONE SYSTEM OF IRRIGATING
AS OPERATED IN
KERN CO. CALA.
KERN RIVER
WEIR IN KERN RIVER.
Cross Section.
WEIR FOR DISTRIBUTING DITCHES.
Cross Section.
CALLOWAY CANAL
Distributing Ditch.
Check
Contour
Check
Contour
Distributing Ditch.

Report on Irrigation.

simultaneous irrigation of large areas most strongly as worthy of a foremost place in irrigation systems.

For a more complete explanation of the same subject, see Inclosure No. 9, constituting "description of irrigation as conducted in Kern County, Cal."

DESCRIPTION AND STATISTICS OF THE KERN COUNTY CANAL SYSTEM.

[Inclosure No. 3.]

It is an indisputable fact, and no one need attempt to deny it, that the San Joaquin Valley is a "dry country,' especially the southern portion of it. The rain-fall from Goshen to Caliente, a distance of 100 miles, is very light. Kern Valley lies in this district. The annual rain-fall at Bakersfield has been as low as 4 inches. There would be small hope for successful agricultural and horticultural pursuits were there no artificial means of obtaining water.

Kern Valley is fortunately located within a magnificent artesian belt; its limits as yet undefined, but it is of great extent. From the northern border of the county, especially on and south of the southern border of Tulare Lake, it extends through the entire alluvial section of Kern Valley. This artesian district covers the entire country for 15 to 20 miles east and north of Tulare Lake, in Tulare County. But here we have only to do with the artesian district of Kern Valley as far as developed. It covers a distance of nearly or quite 50 miles north and south, with a width of 10 to 15 miles. A fair flow is obtained at a depth of 200 feet, and other flows are obtained at short intervals in going down farther, so that any reasonable quantity of water can be obtained by going deep enough. One of these wells will usually irrigate a section of land; and if the water is collected and stored in reservoirs, some will supply water for 3,000 to 4,000 acres.

In many instances the flow is too great for the farmer, and he has to cap his well to prevent a superabundance of water. Just south of Tulare Lake, in the northern part of Kern Valley, there are more than three dozen of these wells within a radius of 10 miles. Here is the flow of a dozen of these wells in gallons every twenty-four hours, all yielding over 1,000,000 each:

Gallons.	Gallons.	Gallons.
2,500,000	2,200,000	1,600,000
2,500,000	2,200,000	1,500,000
2,400,000	2.000,000	1,500,000
2,400,000	1,600,000	1,200,000

The water discharging from artesian wells, of which there are several on Kern Island, within a distance of about 6 miles from the lakes, maintains a uniform temperature of 71° Fah. summer and winter. This uniform high temperature renders artesian water valuable for winter irrigation. These wells just north of the little lakes of Kern Valley are from 250 to 460 feet deep.

Nature has also placed within reach a water supply for Kern Valley much more ample and economical. The annual local rain-fall is light, yet in the summit of the Sierra, from 35 to 40 miles distant from the eastern border of the valley, it is about 100 inches, from the great fall of snow and precipitation of rain. The altitude of this lofty mountain range is nearly or quite 2,000 feet greater in Kern, Tulare, and Fresno Counties than in the central and northern counties. Here, in this range, rising to an average altitude of 8,000 to 10,000 feet, with Mount Whitney the highest mountain in the United States 15,056 feet, and many other peaks but little less, an immense amount of snow is stored in winter, which does not melt till late in spring and early summer. Fortunately Kern Valley lies right at the base of this immense water-shed of the Sierra.

Kern River is the third largest in the San Joaquin Valley, only exceeded in size by the San Joaquin and King's Rivers in this order. It has two branches in the upper Sierra. The northern branch, which is the longer, with its numerous tributaries, rises right at the base of Mount Whitney, and is fed by the snows of that lofty peak. Its source is in the northeastern part of Tulare County, and it flows 60 or 65 miles in that county in a southwesterly direction, past several lofty peaks, and receives the western drainage of the backbone of the Sierra. After reaching Kern County and flowing 25 or 30 miles below the line the southern branch unites with it, and from there to the plains of Kern Valley the course is southwest. From the source of the North Fork of the river to the mouth of the cañon the distance is 115 miles, in which it falls 10,000 to 12,000 feet in a series of cascades through wild, rocky cañons, alternating with short, level reaches in park-like valleys. From the point where it leaves the mountains proper it flows for 18 miles between high, gravelly banks, then in entering the plains it meanders a little north and south of west 14 miles, where the Southern Pacific Railroad crosses it about 1 mile north of Bakersfield. Continuing southwesterly a few miles, its course is westerly, after which it takes a northwesterly direction through Goose Lake to Tulare. This is known as New River. Formerly its course from near Bakersfield was nearly south to Kern Lake, then westerly to Buena Vista Lake, then following the slough in a northwesterly direction to Tulare Lake. This is known in Kern Valley as the Old River. Kern, Buena Vista, and Goose Lakes were formed by the overflow of the river. The delta south and southwest of Bakersfield between Old and New Rivers is known as Kern Island.

This river drains a water-shed or catchment area of 2,382 square miles. Caliente Creek and other small streams, which are really tributary to the Kern, Tehachapi, San Emigdio, and Tejon, with other water-sheds, make a total catchment area or water-shed for Kern Valley of 3,445 square miles.

The average discharge of Kern River is 2,700 cubic feet per second. The maximum discharge during the rainy season, and during the melting of the mountain snow, is 19,041 cubic feet per second. There are eight months of the maximum flow or high water from December to July, inclusive. The actual discharge of Kern River the last of May, 1883, by calculations made, was found to be equal to a depth of 1¼ inches per month from the whole area or catchment of 3,445 square miles. This gives a depth of 3 inches per month for irrigation over 1,200 square miles, or 768,000 acres, which affords a grand scope and promise of magnificent results to the efforts of a vast population in the valley. The discharge is doubtless much larger from the middle of February to April, when water is most needed for irrigation.

By close calculation it is found that 1 cubic foot per second will irrigate 160 acres. So that from the waters of Kern River alone, properly stored and utilized, can be irrigated all the lands of Kern Valley.

No portion of our country of equal extent can be irrigated at a less expense than Kern Valley, and the soil is of the best and most easily worked character. Right here in Kern Valley, and mainly on Kern Island, we find more than thirty canals, some of them with branches, and all with distributing ditches and several with many, the main canals aggregating some 300 miles in length and covering nearly 475,000 acres, which can be irrigated. About 150,000 acres are now irrigated, producing as fine crops as ever grew. On these irrigated lands, with good care, alfalfa gives four and five crops a year, yielding at least 2 tons to the acre each crop, making an annual yield of 8 to 10 tons to the acre besides affording some pasture. As a rule it is cut every six weeks for eight months in the year. Several years ago, when this irrigating system was first inaugurated, it cost 50 cents per acre to irrigate land. Science and art, with much study and labor, have so far perfected this system of irrigation that now the cost varies from 2 to 10 cents per acre, as a rule, averaging from 2 cents or 3 cents to 5 cents under favorable conditions.

The canal of the Kern River Water and Irrigating Company, known as the Beardsley Canal, the highest on the river, being the most northeasterly of this great system, is taken from the northerly bank in the southeast quarter of section 3, T. 29 S., R. 28 E. It is 8 miles in length, 15 feet wide on the bottom, and 2½ feet deep. It has 10 miles of distributing ditches. It appropriates 47,030 miner's inches under a 4-inch pressure, equivalent to 938 cubic feet per second. This location was made December 2, 1873.

The McCord Canal is taken from the northerly bank of the river in the northeast quarter of section 18, T. 29 S., R. 28 E. The main canal is 4½ miles long, with three branches, having a total length of 10 miles and 15 miles of distributing ditches. The main canal is 20 feet wide on the bottom and 2 and 3 feet deep. This, with the Beardsley, is the means of supply for that portion of the district above the Calloway Canal. It appropriates 5,000 inches, equivalent to 100 cubic feet per second. This location was made March 20, 1875.

The Calloway Canal belongs to the Kern River Land and Canal Company, and is the largest and most important in the system. It comes out of the northerly bank of the river a short distance above the Southern Pacific Railroad Company's bridge, in the southeast quarter, section 13, T. 29 S., R. 27 E. It is 32 miles long, 80 feet wide on the bottom, and 120 on the surface, with banks 7 feet high and 10 to 16 feet wide on top, with inside slope of 4 to 1, and outside 2 to 1. On the west bank there is a delightful driveway the full length. It has a depth of about 6 feet. The grade is eight-tenths of a foot per mile. In 30 miles it crosses Poso Creek by means of a weir 150 feet in length, built in the bed of the creek, and connecting at either end with the lower bank of the canal. This arrangement admits of the use of the winter waters of Poso Creek by diverting them into the canal. It has some 65 distributing ditches, from 8 to 20 feet wide on the bottom, averaging 16 feet, and from 1 to 9 miles long, the aggregate length being about 150 miles. These branches have banks 3½ feet high, intended for 3 feet of water, with slopes 3 to 1, and a grade of $1\frac{6}{10}$ feet per mile, giving to each a capacity of $196\frac{6}{10}$ cubic feet per second. The importance of this canal is seen when we state that it covers about 200,000 acres of land. The head-gate at the point of diversion from the river is 100 feet long, built of redwood lumber, 6 by 6 struts, 4 by 6 side posts, and 2-inch flooring. The foundation is 20 feet wide up and down the stream, and has three rows of sheet piling, 4 by 8 Oregon pine, driven to a depth of from 12 to 16 feet, with intermediate or anchor piles of the same dimensions and material to which the sills, 4 by 8, redwood are spiked. There are 25 bays, and the gate-boards are 2 by 6 redwood. The top of the gate is 8 feet from the floor. The gate extends from the right bank out into the stream, and is connected with the weir by an artificial abutment. The weir extends from this abutment southerly across the river, and is 400 feet long, being of similar construction to the head-gate, the only difference being that the gate-boards are twice as long, reaching across the bays. By means of the gate-boards, which are movable, the water is under complete control, and can be regulated at will. The Calloway appropriates 74,000 inches of water, equivalent to 1,476 cubic feet per second. The location was made May 4, 1875.

The McCaffrey Ditch, sharing the head-gate of the Calloway Canal, is 3 miles long, 7 to 8 feet wide on the bottom and is 2½ feet deep. It irrigates the land between the Calloway and the river. The appropriation is 1,296 inches, equivalent to 26 cubic feet per second. The date of location is October 31, 1874.

The head-gate of the Emery Ditch is in the northeast quarter of section 22, T. 29 S., R. 27 E. It is 3 miles long, 6 to 8 feet wide on the bottom, and 2 feet deep. It appropriates 2,000 inches, equivalent to 40 cubic feet per second. Located December 2, 1876.

The Jones and Tuckey Ditch begins in the northeast quarter of section 32, T. 29 S., R. 27 E. It is 4 miles in length, 10 feet wide on the bottom, and 2 feet deep. The appropriation is 1,000 inches, equivalent to 20 cubic feet per second. Located June 24, 1876.

The Railroad Canal, commencing near the corner of southwest quarter of section 31, T. 29 S., R. 27 E., is 3,000 feet long. It is 40 feet wide on the bottom, and 2 feet deep. It empties into Goose Lake slough. It appropriates 31,075 inches, equivalent to 620 cubic feet per second. Its location dates July 24, 1874.

The head-gate of the Wible Canal is in the northwest quarter of section 6, T. 30 S., R. 27 E., and running about 1,000 feet, it discharges into Goose Lake canal, and by means of this canal and Goose Lake slough, its waters are conveyed to the lands to be irrigated. It is 40 feet wide on the bottom, and 2 feet deep. Its appropriation is 5,040 inches, and its capacity 300 cubic feet per second. Located May 1, 1875.

The property of the Goose Lake Canal Company is taken from the northerly bank of Kern River, in the northeast quarter of section 1, T. 30 S., R. 26 E., and runs thence northwesterly 4½ miles, emptying into Goose Lake slough. Flowing through this slough the water is taken out at different points along the slough in ditches. It is 140 feet wide on the bottom and 3 feet deep. It appropriates 90,000 inches, equivalent to 1,795 cubic feet per second. It was located July 13, 1875. The Railroad, Wible, and Goose Lake Canals all empty into the Goose Lake slough, and use it as a common channel to carry their waters to the adjoining lands as far down as Goose Lake, a distance of 22 miles.

The Pioneer Canal, owned by the Pioneer Canal Company, has its head-gate in the northeast quarter of section 1, T. 30 S., R. 26 E. It has a length westerly of 11¼ miles, being 60 feet wide on the bottom and 3 feet deep. This canal flows through the entire length of the McClung ranch, which is wholly irrigated by it, and its principal distributing branch, the Pottinger Ditch, 16 feet wide. It also passes through the Buena Vista ranch, furnishing mainly its irrigating waters. Its appropriation is 20,074 inches, equivalent to 400 cubic feet per second. This canal was located April 26, 1873.

The head-gate of the Edwards Ditch is in the northwest quarter of section 1, T. 30 S., R. 26 E. It is 2 miles long, 10 to 12 feet wide on the bottom, and 1 foot deep. It appropriates 1,440 inches, equivalent to 20 cubic feet per second, and was located December 21, 1874.

The James and Dixon Canal is owned by the James and Dixon Canal Company. It commences in the southeast quarter of section 3, T. 30 S., R. 26 E., and runs in a westerly direction about 12 miles. It is 30 feet wide on the bottom and 3 feet deep. Its appropriation is 14,000 inches, equivalent to 279 cubic feet per second. Its location dates April 19, 1873.

The Johnson Ditch is owned by the Lower New Kern River Irrigating Company, and begins in the southeast quarter of section 3, T. 30 S., R. 26 E., a few feet below the James and Dixon Canal, with which its waters join in a shallow slough, a few hundred feet below. Its course is southwesterly about 4 miles. It is 30 feet wide on the bottom and 3 feet deep. It appropriates 8,640 inches, equivalent to 172 cubic feet per second. It was located June 12, 1873.

The Ash Ditch is near the Johnson, and is taken from the river in southeast quarter of section 3, T. 30 S., R. 26 E., and is 1 mile in length, 3 feet wide on the bottom, and 2 feet deep. It has a discharging capacity of 24 cubic feet per second.

The May Ditch leaves a short arm of the river in the northwest corner of the southwest quarter of section 18, T. 30 S., R. 26 E. It is 2 miles long, 8 feet wide on the bottom, and 2 feet deep. Its appropriation is 4,000 inches, equivalent to 80 cubic feet per second. Its location was made November 29, 1873.

The Joice Canal is taken from the river in the northeast corner of the southwest quarter of section 23, T. 30 S., R. 25 E. It is nearly 4 miles long, 12 feet on the bottom, and 2 feet deep. It appropriates 6,250 inches of water, equivalent to 129 cubic feet per second. Its location was made May 26, 1873.

The Dixon Canal is a branch of the Joice Canal, diverting the water from the latter for about 2½ miles, and then it branches out to the northward, irrigating lands on the borders of the reclaimed swamp-land district. It is 8 feet wide on the bottom and 4 feet deep. The appropriation is 3,456 inches, equivalent to 69 cubic feet per second. Its location dates April 13, 1875.

The foregoing canals and ditches are all on the north side of the New Kern River, or now Kern River proper. Those on the south side, about the same number, are located on both sides of Old River. The first one in order on the river, locating at the highest point on the left bank of the stream, is the property of the Kern Island Irrigating Canal Company, called the Kern Island Canal.

It is taken from Kern River near the southeast corner of the southwest quarter of section 9, T. 29 S., R. 28 E., about 2½ miles northeast of Bakersfield, through which town it passes. It is 18 miles long, with a width at the head-gate of 48½ feet on the bottom and a depth of 4 feet. It terminates at Kern Lake. At Bakersfield the canal makes a vertical fall of nearly 20 feet, furnishing water power for a large flouring mill. This important canal has two main branches, the town branch, supplying Bakersfield and vicinity, having a length of 2 miles, and a central branch, diverging from the canal south of the town, and running nearly parallel to it, varying from one-half to 2 miles distant, for a distance of 10 miles in a southerly direction. This branch has a width of 20 feet on the bottom, and a depth of 3 feet, with slopes of 3 to 1. The central branch is one of the best irrigating canals in the valley. It has nineteen drops in the distance of 10 miles, placed at intervals of half a mile. The Kern Island and its branches have thirty-one lateral ditches, besides a connecting ditch with the Stine Canal, having a total length of over 80 miles. The Kern Island Canal appropriates 20,000 inches, equivalent to 400 cubic feet per second. Its location dates from the latter part of 1870.

Next below the Kern Island is the Old South Fork Canal. It is taken from the river in the central northern part of the northeast quarter of section 17, T. 29 S., R. 28 E., about three-fourths of a mile below the head-gate of the Kern Island canal. It runs 3 miles southwesterly into the bed of the Old South Fork of Kern River, in which its waters are conveyed to Kern Lake in a nearly southerly direction. The canal has a width of 26 feet on the bottom, and is from 2 to 3 feet deep. Its distributing ditches aggregate 7 miles, one of the principal of which is the Cotton Ranch Ditch, irrigating 1,100 acres of alluvial bottom lands, north of and adjoining Bakersfield. Most of the water diverted into the Old South Fork is turned into the Panama Slough, and again diverted below by the Panama Ditch. This canal is also used at times as a feeder for the Kern Island Canal. The appropriation is 3,800 inches, equivalent to 75 cubic feet per second.

The Farmers' Canal, owned by the Farmers' Canal Company, takes its water from the river in the northeast quarter of section 24, T. 29 S., R. 27 E., about 200 feet above the Southern Pacific Railroad bridge across Kern River with a 48 feet opening, fronting parallel with the river, the water entering the canal at right angles with the stream. The first artificial channel to the Panama Slough is about three-quarters of a mile in length. The total length of the main channel is about 15 miles, consisting wholly of natural sloughs. It has four miles of branch constructions, varying from 10 to 20 feet in width. It has 30 miles of distributing ditches. The artificial channel is 50 feet wide on the bottom and 3 feet deep, and the natural channel varies from 20 to 50 feet in width, with a depth of 6 to 10 feet, having nearly vertical banks. The soil through which it passes is generally a firm, clayey loam, and permits natural irrigation of adjacent lands by percolation. A great deal of this land along the old channel is thus kept constantly moist and requires no irrigation. It appropriates 14,400 inches, equivalent to 287 feet per second. Its location was made April 29, 1873.

The Castro Ditch derives its water at the junction of Old and Kern Rivers, in the northeast quarter of section 26, T. 29 S., R. 27 E. It is 16 feet wide on the bottom, 2 feet deep, and 5 miles long. It crosses Panama Slough, and irrigates a small amount of land east of that channel. The appropriation is 1,000 inches, equivalent to 20 cubic feet per second.

The Stine Canal, belonging to the Stine Canal Company, has its head-gate also at the junction of Old and Kern Rivers, adjoining that of Castro, in the northeast quarter of section 26, T. 29 S., R. 27 E. It occupies the bed of Old River for the distance of half a mile. This canal is 80 feet wide on the bottom, 3 feet deep, and 15 miles long. It has two main branches, with numerous forks, varying in width from 12 to 20 feet on the bottom, and having an aggregate length of 34½ miles, and 41½ miles of distributing ditches. It is next in importance, in this system, to the Kern Island Canal, and shares with the Farmers' Canal in irrigating T. 30 and 31 S., R. 27 E., besides supplying water for other lands west and south. Its appropriation is 55,980 inches, equivalent to 1,117 cubic feet per second. It was located December 12, 1872.

The Anderson Canal heads also in the northeast quarter of section 26, T. 29 S., R. 27 E., at the junction of Old and Kern Rivers. Its head-gate connects with those of the Stine and Castro, and the same system of wing-dams serves for all. The canal runs southwesterly 4 miles, is 15 feet wide on the bottom, and 2½ feet deep. This canal is used exclusively for irrigating Stockdale ranch, located about 5½ miles southwest of Bakersfield. Its appropriation is 5,057 inches, equivalent to 101 cubic feet per second. The location was made October 9, 1872.

The Gates Canal, owned by the Gates Canal Company, is taken out of Kern River, in the southwest quarter of section 26, T. 29 S., R. 27 E., and runs in a southwesterly direction 2½ miles. It is 12 feet wide on the bottom and 2½ feet deep. It also is used exclusively in irrigating Stockdale ranch. Its appropriation is 5,057 inches, equivalent to 101 cubic feet per second. This canal was located originally without record early in 1872, and relocated October 7, 1878.

The Buena Vista Canal belongs to the Buena Vista Canal Company. Its head-gate is in the northeast quarter of section 33, T. 29 S., R. 27 E., and runs southwesterly through Bellevue ranch, located about 8 miles west of Bakersfield. It is 13½ miles long, 30 feet wide on the bottom, and 3 feet deep. It has numerous ditches of various dimensions. Its appropriation is 14,000 inches, equivalent to 279 cubic feet per second. Its location was July 15, 1870.

The James Canal, which is the property of the James Canal Company, heads in the northeast quarter of section 33, T. 29 S., R. 27 E. It runs southwesterly 17½ miles, is 60 feet wide on the bottom the first 3 miles and 40 feet the remaining distance, and is 3 feet deep. This canal also flows through Bellevue ranch, supplying water for this ranch and all lands still further south and west. The amount of appropriation is 19,730 inches, equivalent to 394 cubic fee per second. Date of location October 15, 1871.

The Plunkett Canal, belonging to the Plunkett Canal Company, commences in the northwest quarter of section 33, T. 29 S., R. 27 E. It runs southwesterly through Bellevue ranch, and is used exclusively for it. Amount of appropriation is 5,057 inches, equivalent to 101 cubic feet per second. Date of location, December 31, 1872. It is 3½ miles long, 12 feet wide on the bottom, and 2½ feet deep.

The Meacham Canal is the property of the Meacham Canal Company, commencing in the northwest quarter of section 6, T. 30 S., R. 27 E., and flows through Bellevue ranch southwesterly about 4 miles. It is 12 feet wide on the bottom and 3 feet deep. Its appropriation of water is 1,500 inches, equivalent to 30 cubic feet per second. It was located April 15, 1873.

The Wilson Canal commences at a point on Kern River, near the head-gate of the Meacham Canal, in the northwest quarter of section 6, T. 30S., R. 27 E., and also flows through Bellevue ranch 2½ miles in a southwesterly direction, and is 5 feet wide on the bottom and 2 feet deep. It appropriates 500 inches, equivalent to 10 cubic feet per second, and was located August 15, 1874.

The Henley Canal begins in the southeast quarter of section 9, T. 30 S., R. 26 E., and runs southwesterly 2½ miles. It is 3 feet wide on the bottom and 2 feet deep. The amount of the appropriation is 2,880 inches, equivalent to 57 cubic feet per second. Its location dates January 29, 1874.

The Frazer Canal takes its waters out of Kern River, in the northeast quarter of section 16, T. 39 S., R. 26 E. It flows southwesterly 2½ miles, and is 5 feet wide on the bottom, with a depth of 1½ feet. It appropriates 2,600 inches, equivalent to 52 cubic feet per second. It was located April 15, 1873.

The Kern Valley Water Company has two main canals for the reclamation of swamp land in district No. 21, in Buena Vista slough, and a distributing canal. The principal canal is that on the west side of the district, following, generally, the border of the swamp lands for a distance of 24 miles. At its head it is 125 feet wide on the bottom, 7 feet deep, with sides sloping from 3 to 1 and from 7 to 1, and a grade of nine-tenths of a foot per mile. The grade is very irregular, and we give it in detail. For one-half mile the grade is nine-tenths of a foot; 9 miles, it is 2 feet; one-half mile, 2 8/10 feet; and 1½ miles, level; vertical drop, 1 8/10 feet; 1 mile, 8 feet; 2 miles, level.

Below this main channel, a parallel distributing canal, 30 feet wide on the bottom and 2 feet deep, was constructed about 10 miles long. On the east side of the swamp a canal about 6 miles long was constructed for irrigation purposes, having a width on the bottom of 25 feet, a depth of 3 to 5 feet, and side slopes of 3 to 1. The appropriation of water of the Kern Valley Water Company is 100,000 inches, equivalent to 1,995 cubic feet per second, and its location dates April 7, 1877. The appropriation of the Kern Valley, east side, is 30,000 inches, equivalent to 599 cubic feet per second, and the location dates April 9, 1877.

Résumé of the canal system of Kern Valley.

Name of canal.	Length.	Appropriation.	
	Miles.	*Miner's inch.*	*Cubic feet.*
Beardsley	8	47,230	938
McCord	14¼	5,000	100
Calloway	32	74,000	1,478
McCaffry	3	1,296	26
Emery	3	2,000	40
Jones Tuckey	4	1,000	20
Railroad	⅞	31,075	620
Wible	⅞	5,040	100
Goose Lake	4⅛	90,000	1,795
Pioneer	11⅝	20,074	400
Edwards	2	1,440	29
James and Dixon	3	14,000	279
Johnson	4	8,640	172
Ashe	1	1,200	24
May	2	4,000	80
Joice	4	6,250	125
Dixon	2¼	3,456	69
Total	99⅘	315,701	6,293
Kern Island	30	20,000	400
Old South Fork	3	3,800	75
Farmers	19½	14,400	287
Castro	5	1,300	26
Stine	47⅛	55,980	1,117
Anderson	4	5,057	101
Gates	2⅛	5,057	101
Buena Vista	18¾	14,000	279
James	17¾	19,730	394
Plunket	3⅝	5,057	101
Meacham	4	1,500	30
Wilson	2⅛	500	10
Henley	2⅛	2,880	57
Traver	2¾	2,600	52
Kern Valley Water Company	40	130,000	2,594
Total	197½	281,561	5,618
Grand total	297 3/10	597,262	11,911

The first division of the above table represents the canals on the northern bank of Kern River. The second division those taken out of the southern bank of the Kern.

GENERAL REMARKS.

The first and most important consideration, in a section where agricultural success is wholly dependent upon irrigation, as in Kern Valley, is that of the amount and permanence of the water supply, for upon these depend the prosperity of the community. Fortunately Kern River, which is virtually the sole source of supply for all this valley, is a stream of large volume, whose waters can be entirely diverted without injury to any public interest and whose discharge, though variable, is unfailing.

The river heads, as we have shown, among the loftiest peaks of the Sierra Nevada, whose ice-fields and beds of snow only yield to the heat of midsummer, furnishes an immense volume of water long after the winter rains of the foot-hills and valley are lost sight of. The rains of winter and the melting snows of summer on the upper Sierra thus maintain a full flow in Kern River for about two-thirds of the year, the period covering the greatest demand for irrigation. Kern River has a slope through the valley of 6 to 8 feet per mile, and lies in a shallow, sandy bed, with banks of sandy soil 3 to 6 feet high. These are favorable conditions, and enable water to be taken out at almost any point at comparatively small cost. Few permanent, costly dams, or very expensive head-works have been found necessary; a simple wing-dam of sand and brush, running out into the channel of the river at an acute angle up the stream, serves every purpose, in most cases, for diverting water into the canals, there being only five weir extensions across the river in the whole system.

Then, again, the slope of the irrigable lands of the valley is so great there is no difficulty in running canals in almost any direction over them, nor in distributing water in the smaller ditches, or in draining it off. It is therefore peculiarly favorable for irrigation, yet the soil is too friable to permit of canals of any considerable size taking the natural slope of the ground without serious erosion and damage.

WORKS IN THESE CANALS.

The grade over these sloping plains is regulated by "drops," or weirs, placed at proper intervals, with movable weir-boards, which are also convenient and necessary for raising water to enter distributing ditches. These drops are constructed similarly to the canal head-works, and are characterized by an absence of ponderous gates for regulating the water and extreme lightness of timber used, studying the greatest economy in material. Head-gates are a necessity when the water is taken out of the river to control the admission of water to the canal. They are made entirely of wood, there being no stone readily accessible in this vicinity. The better class of these head-gates are constructed upon a foundation of anchor-piles driven into the sand as far as possible, with sheet-piling of 2-inch planks at the upper and lower sides of the structure.

Weirs, as before indicated, are constructed not only for drops, but for raising water for entering distributing ditches. Side gates are at the head of distributing ditches for the purpose of admitting water from the canal into such ditches. They are constructed upon the same principle as head-gates.

The canal flume is the usually constructed flume for carrying one stream of water over another across a gulch or ravine.

Wing-dams are built of brush and in the river, from the lower side of the mouth of the canal up the stream, at an acute angle with the current, to turn the waters of the river into the canal.

Waste-gates are built at the heads of canals and also along their course to let off any oversupply of water. Inverted siphons are put into canals for the purpose of carrying their waters under another canal.

A module is put into a gate or other structure for the measurement of water.

EFFECT ON SOILS IN KERN COUNTY.

It has been positively demonstrated that upon all the sandy soils, at least, which form the principal area of land in this valley under cultivation, the effect of years of irrigation has been a marked increase in their fertility and an apparent change for the better in their composition. The mountains drained by Kern River are composed of friable granite, which is very rapidly disintegrating. Great quantities of this, as well as vast quantities of gypsum from the gypsum beds over which this river flows, are transported by the river to the plains below. Water and cultivation disintegrate the coarser particles, and these fertilizing elements become dissolved and prepared for plant-growth. In filtering through this porous soil all this sediment and fertilizing matter contained in the water is detained and a perpetual restoration is furnished. Some of the richest fields in Kern Island, producing large annual crops and of some productions two crops, were barren wastes of sand before being fertilized and reclaimed by irrigation.

IRRIGATION IMPROVES CLIMATE.

The change for the better in the climate of Kern Valley since the general introduction of irrigation has been as marked as the improvement in the soil. This is more noticeable, in fact, because it affects the physical condition of every one. While it is admitted that formerly there was a good deal of malaria in Kern Valley, we now say with positiveness that there is scarcely any at all. The healthfulness of Kern Valley will compare favorably with any others in our sanatory State. Malarious fevers were quite prevalent in the valley formerly, but have been almost wholly abated mainly, it is claimed, by these measures.

Old sloughs containing stagnant water have been purified by the introduction of pure mountain water running through them. Jungles of miasma-breeding willows have been cleared, swamps drained and dried out, and decaying vegetation on every hand destroyed. Besides, it may as well be understood first as last, that the miasmatic influences prevailing here in the early settlement of Kern Valley were largely owing to the people drinking surface water. Since artesian and deep-well water is used a radical sanitary change is seen.

OTHER RESULTS OF IRRIGATION.

Prior to fourteen or fifteen years ago there were not in this valley more than a dozen families outside of Bakersfield and vicinity, and almost all the entire valley was a barren, desolate, sandy waste or desert, except the immediate environs of Bakersfield. Now about 150,000 acres of this land is made to "blossom as the rose," yielding as fine crops as grow, and capable of sustaining a population of 100,000 people, while not more than one-fourth of the irrigable lands of the valley are under direct cultivation.

ESTIMATIONS OF COST TO DITCH AND CHECK LANDS, MADE BY W. L. DIXON, ENGINEER.

[Inclosure No. 4.]

Section 9, T. 28 S., R. 26 E., 260 acres, below Beardsley:		
Building 1½ miles 12-foot ditch, at $387.10		$483.87
Putting in ten 12-foot gates, including material		777.00
		1,260.87
Ditching	per acre..	6.30
Checking	do....	3.75
		10.05
Section 16, T. 28 S., R. 26 E., 640 acres:		
Building 4 miles 12-foot ditch, at $387.10		1,548.40
Putting in thirty 12-foot gates, including material		2,331.00
		3,879.40
Ditching	per acre..	6.06
Checking	do....	3.75
		9.81
Section 21, T. 28 S., R. 26 E., 420 acres:		
Building 2.6 miles 12-foot ditch, at $387.10		1,006.46
Putting in twenty gates, including material		1,554.00
		2,560.46
Ditching	per acre..	6.09
Checking	do....	3.75
		9.84
Section 22, T. 28 S., R. 26 E., 622 acres:		
Building 3.87 miles 12-foot ditch		1,498.07
Putting in twenty-nine 12-foot gates, including material		2,253.30
		3,751.37
Ditching	per acre..	6.03
Checking	do....	3.75
		9.78

LETTER FROM W. L. DIXON, ENGINEER.

[Inclosure No. 5.]

BAKERSFIELD, *August* 14, 1889.

DEAR SIR: I herewith submit a report of the cost of the work of ditching and checking section 23, T. 28 S., R. 26 E.:

Ditches, section 23, T. 28 S., R. 26 E.:		
Earth-work on 5 miles of ditches		$1,935.53
Labor on gates	606.04	
Lumber and nails	948.39	
		1,554.43
Cost per mile, including gates $697.99		3,489.96
Checking 640 acres on section 23, T. 28 S., R. 26 E		2,395.72
Cost per acre, $3.04 to check.		5,885.68
Total cost per acre to ditch and check, $9.20.		
Total cost per acre to ditch, $5.46.		
Section 15, T. 28 S., R. 26 E.:		
Ditching 4.35 miles, at $387.10 per mile for earth-work		1,683.88
Thirty-one sets of 12 inch gates, at $77.70 each		2,408.70
Cost per acre to ditch, $6.60; cost per acre to check, $3.74, 620 acres..		2,318.80
Total cost per acre to ditch and check, $10.34.		6,411.38

Statement of lands ditched and checked, season of 1887 *and* 1888, *on District No.* 4, *Kern County, Cal., in townships south, ranges east, Mount Diablo base and meridian (the different lands being described in left-hand margin of sections, townships, and ranges, the figures appearing in this order):*

[Inclosure No. 6.]

Location.	Ditched and checked prior to 1888.	Ditched and checked in 1888.	Total ditched and checked.	Cost of ditches and checks built in 1888.	Rate per acre of total cost of ditches and checks built in 1888.
	Acres.	*Acres.*	*Acres.*		
Sec. 20, T. 26, S., R. 25, E	500	800	1,300	$3,901.20	$4.88
Sec. 20, T. 26, S., R. 25, E					
Sec. 21, T. 26, S., R. 25, E					
Sec. 9, T. 26, S., R. 25, E	340	1,260	1,600	7,445.10	5.90
Sec. 16, T. 26, S., R. 25, E					
Sec. 15, T. 26, S., R. 25, E					
Sec. 22, T. 26, S., R. 25, E					
Sec. 17, T. 26, S., R. 26, E	500	....	500	....	....
Sec. 23, T. 26, S., R. 25, E	....	640	640	4,388.90	6.86
Sec. 5, T. 26, S., R. 25, E	(*)	250	250	2,076.58	....
Sec. 5, T. 27, S., R. 25, E	(†)	200	200	1,660.00	8.30
Sec. 6, T. 27, S., R. 25, E	300	180	480	3,608.03	....
Sec. 7, T. 27, S., R. 25, E	....	40	40	533.47	19.23
Sec. 33, T. 26, S., R. 25, E	....	212	212	789.38	3.72
Total	1,640	3,582	5,222	24,402.75	....

* Alfalfa. † Egyptian corn.

Statement of lands ditched and checked, season of 1888 *and* 1889, *on Buena Vista Ranch, Kern County, Cal., T.* 30 *S., R.* 25 *E., Mount Diablo base and meridian.*

[Inclosure No. 7.]

Sections.	Rate per acre of total cost.	Ditched and checked.	Cost of ditching.	Cost of checking.	Cost of gates.	Proportion of surveys.	Total cost of ditches and checks
		Acres.					
4	....	283	$399.20	$754.44	$195.06	$84.54	$1,433.24
3	$5.53	38	236.26	....	105.28	....	341.54
11	13.84	184	1,132.27	579.99	678.85	155.87	2,546.98
9	12.18	620	3,219.79	1,785.61	2,086.47	460.35	7,552.22
10	9.22	366	1,064.87	1,461.81	620.84	225.63	3,373.15
6 and 8	9.58	917	3,461.52	2,417.68	2,395.44	511.25	8,785.89
Total	....	2,408	9,513.91	6,999.53	6,081.94	1,437.64	24,033.02

Statement of lands ditched and checked, season of* 1888 *and* 1889, *on District No.* 4, *Kern County, Cal., in townships south, range east, Mount Diablo base and meridian (the different lands being described on left-hand margin by sections, townships, and ranges, the figures appearing in this order):

[Inclosure No. 8.]

Location.	Ditched and checked.	Cost of ditches and checks in 1888.	Cost of ditches and checks in 1889.	Total cost of ditches and checks.	Rate per acre of total cost.
	Acres.				
Sec. 7, T. 26 S., R. 25 E	670	$9,402.00	$226.16	$9,628.16	$14.37
Sec. 8, T. 26 S., R. 25 E	560	5,058.12	1,313.39	6,371.51	11.38
Sec. 9, T. 26 S., R. 25 E	....	....	263.15	263.15	....
Sec. 17, T. 26 S., R. 25 E	300	1,881.63	510.21	2,391.84	7.97
Sec. 18, T. 26 S., R. 25 E	520	5,154.21	245.23	5,399.44	10.38
Sec. 19, T. 26 S., R. 25 E	....	....	42.15	42.15	....
Sec. 21, T. 26 S., R. 25 E	....	....	35.40	35.40	....
Sec. 22, T. 26 S., R. 25 E	160	....	72.04	72.04	....
Sec. 22, T. 26 S., R. 25 E	160	....	129.03	129.03	....
Sec. 23, T. 26 S., R. 25 E	80	....	136.10	136.10	....
Sec. 27, T. 26 S., R. 25 E	156	....	158.80	158.80	....
Sec. 29, T. 26 S., R. 25 E	257	....	39.56	39.56	....
Sec. 32, T. 26 S., R. 25 E	....	....	6.00	6.00	....
Sec. 10, T. 26 S., R. 24 E	160	1,650.82	22.46	1,673.28	10.47
Sec. 11, T. 26 S., R. 24 E	480	5,267.79	185.03	5,452.82	11.36
Sec. 12, T. 26 S., R. 24 E	640	7,465.21	141.23	7,606.44	11.88
Sec. 13, T. 26 S., R. 24 E	560	3,402.47	163.87	3,566.34	6.37
Sec. 24, T. 26 S., R. 24 E	320	3,144.85	253.80	3,398.65	10.62
Sec. 1, T. 27 S., R. 24 E	500	5,965.83	130.76	6,096.59	12.19
Sec. 5, T. 27 S., R. 25 E	....	....	186.53	186.53	....
Sec. 6, T. 27 S., R. 25 E	....	....	196.17	196.17	....
Sec. 8, T. 27 S., R. 25 E	....	365.40	....	365.40	....
Sec. 13, T. 28 S., R. 25 E	560	283.39	4,158.36	4,441.75	7.93
Sec. 14	640	335.99	5,250.05	5,586.04	8.73
Sec. 15	640	3,644.06	108.01	3,752.07	5.86
Sec. 5, T. 29 S., R. 27 E	629	....	6,979.44	6,979.44	11.09
Sec. 9, T. 29 S., R, 27 E	200	....	2,684,22	2,684,22	13.42
Sec. 10, T. 28 S., R. 27 E	104	....	1,965.31	1,965.31	18.90
Sec, 31, T. 28 S., R. 27 E	534	....	6,640.09	6,640.09	12.44
Sec. 32, T. 28 S., R. 27 E	....	....	....	....	....
Sec. 15, T. 28 S., R. 26 E	Surveys.	....	62.98	62.98	....
Sec. 16, T. 28 S., R. 26 E	...do	....	176.04	176.04	....
Sec. 23, T. 28 S., R. 26 E	640	....	2,485.33	3,485.33	3.89
Sec. 24, T. 28 S., R. 26 E	Surveys.	....	306.09	306.09	....
Sec. 25, T. 28 S., R. 26 E	380	....	4,607.62	4,607.62	12.12
Sec. 36, T. 28 S., R. 26 E	426	....	2,625.67	2,625.67	6.16
Total	10,276	53,021.77	42,506.28	95,528.05	....

RESULTS SHOWN BY FOREGOING STATEMENT.

Acres ditched and checked	10,276 4,710
Cost	$95,528.05 51,575.07
Average per acre:	
Finished and unfinished	9.30
Finished sections only	10.95

DESCRIPTIVE OF IRRIGATION AS CONDUCTED IN KERN COUNTY.

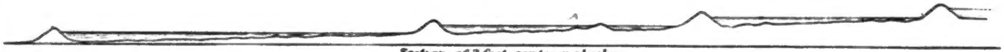
[Inclosure No. 9.]

There are four general classes of irrigation as conducted in California.

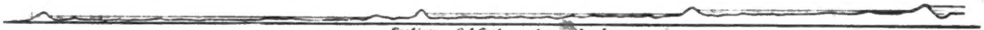
FIRST METHOD.

Constituting irrigation of vines and trees, as practiced in some portions of Los Angeles and San Diego counties, under which the water is conducted through pipes having openings at each different vine or tree to be irrigated, all of these small distributing pipes being supplied from one large pipe. This of course is a highly expensive mode of irrigation, and one which can not be practiced except where an exceedingly small amount of water must be utilized to the greatest degree possible and where the results as derived therefrom are of great benefit.

. PLAN SHOWING SYSTEM OF IRRIGATION.

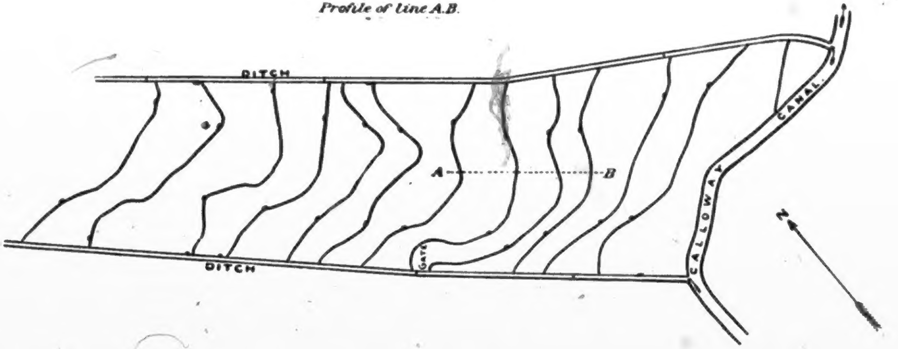


Section of 2 foot contour checks.



Section of 1 foot contour checks

Profile of line A.B.



DITCH
DITCH
GATE
A
B
CALLOWAY
CANAL
N

Cross section of canal

Cross section of ditch.

SECOND METHOD.

By building ditches at stated distances apart, the land being irrigated by the seepage or percolation of water through the soil, from one ditch to another. This method is applicable only in districts having a loose soil, through which the water can easily pass, and is not to any extent valuable for use in Kern County, where such conditions do not exist.

THIRD METHOD.

By building the ditches on the ridges or highest ground in the land to be irrigated, and from them running the water downhill and holding it back by means of small temporary checks, or, in cases of vines or trees, running the water downhill through plow furrows. This method of irrigating is well adapted to the irrigation of orchards and vineyards, thereby utilizing the water to good advantage; but in the irrigation of grass or alfalfa land, or in other cases where it is desirable to cover simultaneously a large area of land, it has been found to be more expensive than, and in the irrigation history of Kern county, has generally been supplanted by, the fourth method.

FOURTH METHOD.

By building ditches at stated distances apart, running downhill with the slope of the country, and between them building permanent levees on contour lines, the latter being distributed with the grade at varying distances of fall, as desired, of 6, 9, 12, 18, or 24 inches. This is the cheapest method of irrigating where there is an abundance of water, and where the area owned, controlled, or irrigated by any one man, is large.

The above descriptions under the first, second, and third modes of irrigation clearly indicate the manner in which the water is handled, and to the uninitiated no explanation is therefore needed, except as connected with the fourth mode, which has most generally been adopted in Kern County. In the second, third, and fourth modes of irrigating the diversion of the water from the river, creek, spring, reservoir, or other general source of supply where large areas are to be irrigated is required to be made into one general conducting ditch, from which the smaller distributing ditches diverge, conducting the water to the lands to be irrigated.

In order to clearly understand the mode of controlling and diverting the water from the river, attention is called to the "bird's-eye view of one system of irrigating as operated in Kern County, Cal.," mentioned in the list of Kern County photographs sent to Maj. John W. Powell, United States Geological Survey, Washington, D. C., as photograph No. 3, which shows Kern River, the Calloway Canal proceeding therefrom, the Calloway in turn supplying a couple of distributing ditches, which latter make delivery of the water within the restraining checks, thus accomplishing irrigation under, what is termed as above, the fourth method.

In the river, at the head of the Calloway Canal, as shown in photograph No. 13, as described in the above-mentioned list, is located what is known as the Calloway Weir, crossing the river from bank to bank and offering, when desired, an effectual barrier against the water flowing further down the river bed, which is accomplished by dropping what are known as weir boards into grooves provided in the upright standards of the weir, thus making a solid dam of 2-inch planking.

At times of abundant water it is unnecessary to employ the weir, for from the vast flood of waters, filling the river banks nearly to overflowing, sufficient water is swept through the canal headgate to supply the quota which should there be diverted. But when the flood lessens, as is the case in most if not all irrigating rivers, then without man's control the waters would be retained in the river bed, leaving the canal quite dry.

At such times it was formerly the practice in Kern County to construct what were termed wing-dams, made of sand and brush, and running out into the channel of the river at an acute angle up the stream, which served to turn into the canal its portion of the down-coming waters. But at best these weirs were but temporary affairs, often broken or washed away, until of late years it has been the policy to construct lasting weirs across the river, which can be regulated with ease and rapidity.

When the flow of water in the river lessens, requiring such action, the weir boards are placed in position in the river weir, "backing up" (or raising the level of) the water above the weir and causing it to enter the head-gate of the canal.

In the same manner there are oftentimes, when necessary, weirs in the canal, which after the same fashion turn the water into the distributing ditches, there being three such weirs in the Calloway Canal.

Where necessary on account of the "fall" of the country, and in order to preserve an even grade in the ditches, the distributing ditches are provided with "drops," allowing the water to make its descent to the new grade. These drops are provided with a superstructure above the line of the water, as shown in the cross section in photograph No. 3, provided with weir boards similar to the other weirs; thus these drops serve to divert the water from the distributing ditches through the "side gates" of the ditches, above those drops, on to the land inclosed by the contour checks, thus accomplishing the actual irrigation.

As a further explanation in this same connection reference is made to inclosure No. 2, "Plan showing system of irrigation in Kern County, Cal.," on which appear cross sections of the main canal and the distributing ditches, and also cross-sections of land in process of irrigation under a system of "1-foot contour checks" and under a system of "2-foot contour checks," in which latter the inequalities of the ground are made to appear, with the blue shading representing the water. A portion of the main canal, a couple of distributing ditches, and the various contour checks are likewise shown. The checks are run on a level and thus, at regular intervals, act as dams to back the water over the space intervening between the check so constituting the dam and the next check above. When the irrigation in one check is completed the surplus water from that check is conveyed to the next check below, the balance of the water required being supplied from the distributing ditch.

Such is an explanation of the system of irrigation most general in Kern County, Cal. It is slightly varied in some respects on different ranches, but the general system is in every case the same, resulting in complete control of the water, from the time it approaches the canal head-gate in the river until it is drawn off in surplus from some irrigated check.

In "Memorandum of lands seeded to corn and alfalfa," under date of August 28, 1889, it it shown that the cost of the ditching and checking of the lands embraced in that statement amounts to an average cost of $10.95 an acre, and as explained in the same statement, these lands are situated about 25 miles from Kern River, and that average cost of $10.95 an acre does not embrace the cost of the main canal, carrying the water from the river for use in distribution amongst the various distributing ditches.

The average cost per acre as against lands irrigable from such a main canal as the Calloway, would be from $2 to $4 an acre, including cost of river weir, head-gates, canal weirs, etc., thus raising the average cost per acre of the irrigating works to a total of from $12 to $15 per acre. Thus it is seen that, whereas the expenditure of that amount is insignificant as compared with the value of the land with its then created productiveness, from the fact that the expenditures on the main canal are distributed amongst vast areas, on the other hand, were any one irrigator compelled to construct such a main ditch from the river to his small quantity of land, it would be impossible for him to limit his expenditures within any bounds of possible profit.

In connection with this same subject, see inclosure No. 2, with explanations concerning the same.

ACRES OF LAND SEEDED TO CORN AND ALFALFA, POSO DISTRICT, KERN COUNTY; SEASON OF 1888-'89.

[Inclosure No. 10.]

	Acres.	Average cost per acre.	Total cost.
Ditched and checked	16,276	$10.95	$178,222.20
Plowed	11,085	1.50	16,682.70
Seeded to wheat and alfalfa	5,536	6.05	33,625.77
Seeded to alfalfa alone	1,016	4.82	4,903.53
Seeded to Egyptian corn	4,513	1.85	8,370.53
Clearing on ground not seeded	11,085		633.22
Total			42,437.95
Of above—			
Clearing on ground not seeded			633.22
Ditched and checked and not seeded	5,191	10.95	56,841.45
Ditched and checked on land seeded to wheat, alfalfa, and corn	11,085	10.95	121,380.75
On ground seeded, cost of all work except ditching and checking	11,085	5.74	63,582.60
			$242,438.22

From the above figures will be noted the expensive irrigation works that are required before a crop can be obtained, which figures are applicable to operations on virgin soil that in one season was furnished with supplying and distributing ditches, was checked, irrigated, reclaimed from its former arid state, and made productive and profitable.

The same figures demonstrate, however, that on the land ditched, checked, and cultivated, out of a total expenditure in accomplishing these results of $184,963.55 the cost of the reclamation works amounted to $121,380.75, or, in other words, and in round numbers, for every dollar spent in putting in the crop it was necessary to spend $2 to construct the irrigating works. This proportion is figured on the totals, including the varying crops of alfalfa seeded with wheat, alfalfa seeded alone, and Egyptian corn seeded alone, and, as the cost of the alfalfa seed is high, and to show the proportion between cost of ditching and checking and the cost of planting of each different crop, the following figures are brought into comparison:

	Wheat and alfalfa.	Alfalfa alone.	Egyptian corn.
Cost per acre for ditching and checking	$10.95	$10.95	$10.95
Cost per acre for planting crop	6.05	4.82	1.85
For each dollar expended in planting crop an expenditure for ditching and checking of	1.81	2.27	5.92

This thorough and complete though expensive class of irrigation works has been found quite necessary, for on the thirsty plains of the lower San Joaquin Valley water must be thoroughly distributed, even like nature's irrigation distributes the falling rain drops. It is also necessary to be able to rapidly flood and as rapidly drain the various checks, or otherwise the crop will be parboiled and killed from the unity of the water and the torrid sun. Hence embankments (or checks) for retaining the water, ditches to distribute and carry it away, and many flood-gates, drops, weirs, and other similar structures to control its flow are of necessity required.

The lands of which the above figures show the cost of ditching and checking are situated about 25 miles from Kern River, the fountain head of Kern County irrigation, and the figures do not embrace the cost of the main canal, which carries its flood of water for distribution amongst them in excess of a hundred smaller distributing ditches. The cost of carrying the water over many miles, if applied to any limited area of land, would be so excessively heavy as to preclude any possibility of profit; hence the reclamation of these arid tracts, distant from a water supply, can be effected only by some such means as are employed in Kern County, Cal., where the many miles of ditches are all under one intelligent management, to which the various lands supplied with water pay their tribute in most moderate water charges.

The expenditures thus made in the construction of the main canals, together with the other reclamation works, as heretofore explained, constitute the farmer's capital, on which, though heavy at first, irrigation multiplies adequate profits, with which come increased population, civilization, and homes, with all other changes consequent upon the transformation scene from desert to garden, from arid thirst to bending grain fields, sweet-scented hay, and heavy-laden orchards.

On the other hand, when the enduring, substantial nature of these works is considered, and when it is considered what a small percentage of additional cost is applicable to any one crop produced through such means, and on the other hand with an assurance of adequate water at the particular period when necessary to the proper nurture of the crops, and with absolute reliance against an oversupply, with a most productive soil compelled by irrigation to obey man's every wish, the original cost of the irrigation works as compared with the profits to be derived therefrom can be compared with the first crop which a husbandman would lose elsewhere through an insufficiency of rain, except that the one assures profit and the other loss.

MEMORANDUM CONCERNING PLAT SHOWING LOCATION OF HAY-STACKS AT POSO, 1889.

[Inclosure No. 11].

The plat represents a portion of what is known as the Poso district, in Kern County, and shows the locations of the various hay-stacks, the result of the cutting of hay made in the summer of 1889 on lands which, during the previous winter and spring, were, by J. B. Haggin and his associates, ditched, checked, and planted in wheat and alfalfa, and transformed, through irrigation, from an arid, unproductive, unprofitable condition to a verdant field of alfalfa.

The total acreage seeded to wheat and alfalfa, as shown by this map, amounts to	acres	5,556
From which grain hay was cut and stacked, in the locations as shown on the map, to amount of	tons	14,919
Therefore giving an average to the acre of hay to amount of	tons	268,100
Out of 6,572 acres seeded to wheat and alfalfa, and alfalfa alone, a good stand of alfalfa was obtained on	acres	6,083

Giving a percentage of crop lost of only 7 per cent., the season being one of the worst known for ten years.

This plat was made for use in the office of the Kern County property, to show the numbers of the stacks, as a reference to their tonnage as spread upon the hay records, and also as an index for office use, indicating the foremen who put up the various stacks. At the same time, as connected with the productiveness of irrigated lands, it is interesting from the fact of indicating, from the proximity of the stack locations one to the other representing a total of nearly 15,000 tons of hay, the wonderful quantity of hay obtainable under proper irrigation.

The reclamation and irrigation of the arid lands of Kern County, which lands up to the present time have been principally devoted to the raising of stock on alfalfa, has been most immediately made profitable through the hay production, demonstrating the productiveness of the soil and proving the correctness of the irrigation methods.

For a more thorough explanation in this same connection see inclosure No. 12, headed "Memorandum of hay cut, season of 1889, on Kern County property," etc.

MEMORANDUM OF HAY CUT SEASON OF 1889 ON KERN COUNTY PROPERTY AND REMARKS ON IRRIGATION.

[Inclosure No. 12.]

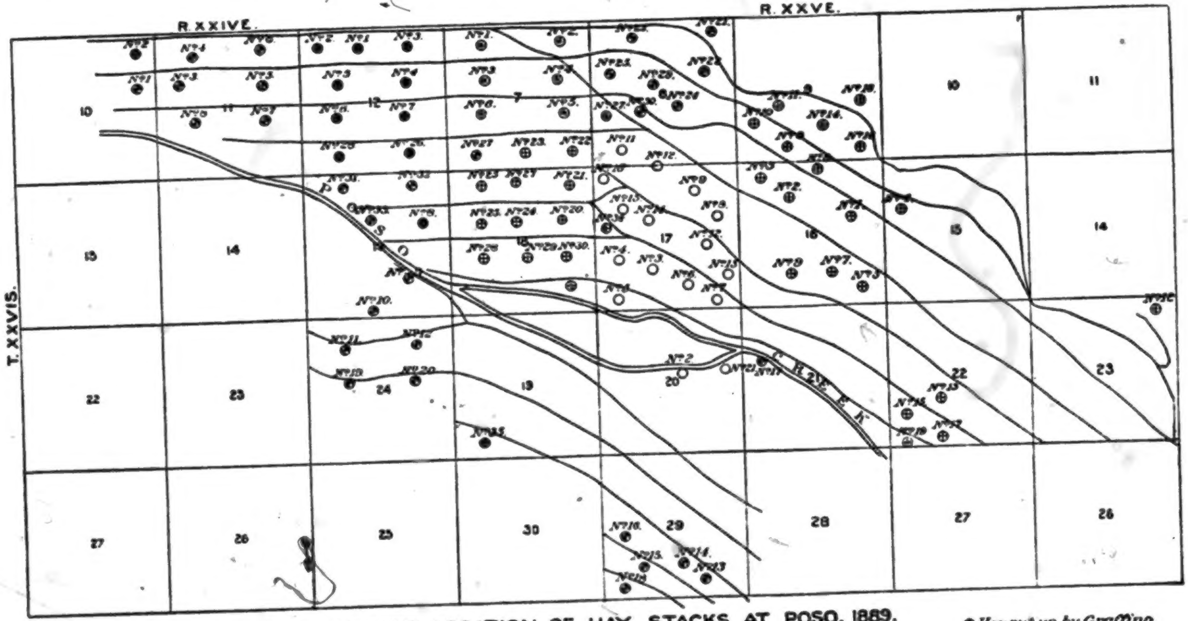
Memorandum of all hay produced.

	Alfalfa hay.	Grain hay.
	Tons.	*Tons.*
Stockdale ranch	611	
Cotton ranch	392	43
Anderson ranch	612½	
Cuyama ranch	183	
Mountain View dairy	675½	
San Emigdio ranch	60	
Bellevue ranch	1,658	
Hop ranch	228	
Rosedale ranch	604	
Greenfield's ranch	2,606	
Lakeside ranch	1,613	108
McClung ranch	782½	
Poso district	1,118	14,919
Buena Vista ranch	993	446
Total	12,136½	15,516 12,136½
Total tons produced		27,652½

As per hay statement, August 29, 1889.

As regards the lands in the Poso district, the records show that for the season of 1888-'89, and subsequent to the completion of the hay cutting, the pasturing of the same lands by cattle was commenced between the 6th and 16th of July, 1889, on which same lands the ditching and checking were done in September, October, November, and December, 1888; the clearing and plowing were done in November and December, 1888, and the harrowing, cultivating, and seeding were done mostly in December, 1888.

Poso District.—The total acreage seeded to wheat and alfalfa, as shown by statement inclosed, amounts to 5,556 acres; from which, as shown above, cut grain hay to amount of 14,919 tons, therefore giving an average to the acre of hay to amount of 2.68 tons. Out of 6,572 acres, total seeded, a good stand of alfalfa was obtained on 6,083 acres, giving a percentage of crop lost of only 7 per cent., the season being one of the worst known for ten years.


R. XXIV E.
R. XXV E.
T. XXVI S.
CREEK
10
11
12
7
8
9
10
11
15
14
13
18
17
16
15
14
22
23
24
19
20
21
22
23
27
26
25
30
29
28
27
26

MAP SHOWING LOCATION OF HAY STACKS AT POSO, 1889.

● Hay put up by Graffino.
● " " " " Moncure
● " " " " Woods.
⊕ " " " " Berry & Fry.
○ " " " " Creasy.

A statement (R. P. O. 1247) showing all debits and credits against the land seeded to wheat and alfalfa, demonstrates the following:

Ditching and checking 6,572 acres at $10.95		$10.95
Putting in crop—		
Wheat and alfalfa, 5,556 acres at $6.05		6.05
Alfalfa alone, 1,016 acres at $4.82.		
Getting off crop, 5,556 acres at $4.31		4.31
Total debit		21.31
Credits:		
Yield of hay, 2.68 tons, at $6	$16.08	
Value of pasturage, say six months, at 25 cents per acre	1.50	
Total credit		17.58
Debit balance representing net cost of ditches and checks and of stand of alfalfa		3.73
Add one year's interest on net amount invested at 10 per cent		.37
Total cost at end of first year of 1 acre alfalfa land		4.10

On the same land the second year's operations could easily be made to show the following:

Debits:		
Net cost ditches and checks and alfalfa on 1 acre alfalfa land		$4.10
Add one year's interest at 10 per cent		.41
Three irrigations (two or even one would probably be sufficient) at 3 cents		.09
Cost of cutting 4 tons alfalfa hay, at $1.50		6.00
Total debit		10.60
Credits:		
Value 4 tons hay, at $5	$20.00	
Value eight months' pasturage, at 25 cents	4.00	
Total credit		24.00
Net credit balance at end of second year		13.40
The profits of the second year, $13.40, representing at 10 per cent. interest on a valuation of the property of	per acre	134.00
Estimated valuation	do	100.00
Leaving balance of amount invested on which interest can be earned as above to represent value of dwelling, barns, outhouses, fences, wells, cattle, sheep, horses, poultry, etc. (the live stock earning interest on their own valuation)		34.00

On a farm of 160 acres this additional investment of $34 per acre would amount to $5,440, a sum more than sufficient for such requirements.

Thus it is seen that under such a system of irrigation it is more than possible to receive, within the first and second years, return of the original investment and interest on a valuable estate.

The cutting of a total of more than 27,000 tons of hay in a district of country which fifteen years ago would not produce 27 tons, the miles upon miles of verdant green, thousands upon thousands of cattle, horses, sheep, hogs, fat and contented as they crop the waving grass, the avenues of tall and stately trees bending their refreshing shade as against the noonday sun, the orchards of deciduous and citrus fruits, vineyards of bright-hued grapes, the immense stacks of hay, warehouses full of grain telling of reserve forces for man and beast, the whirring mills grinding that grain for home use and shipment, the dairies with their heavy laden trucks of sweetest butter, their shelves upon shelves of new-made cheese, the thriving towns busy with an empire's trade, the homes of happy faces, happy children telling the story of thrift and plenty, contentment and prosperity, the every possibility, every inducement for a thousand such homes where there is now one, for a kingdom where there is now a county, all and each of these proceed from one common cause, but one lever moved them all into being and that was water—water proceeding from Whitney's snow-clad peaks, running its noisy, wandering course over many a mountain mile, restrained and made the servant of irrigation, has evolved the present Kern County from the wild, barren waste which possessed the same soil, same water facilities, but knew naught of irrigation.

In connection with this same subject, see inclosure No. 11, map headed "Map showing location of hay-stacks at Poso, 1889."

LIST OF PHOTOGRAPHS, TAKEN IN KERN COUNTY, SENT TO MAJ. JOHN W. POWELL, U. S. GEOLOGICAL SURVEY.

[Inclosure No. 12.]

No. 1, map of a portion of Kern County, showing river, irrigating canals, distributing ditches, and territory between Kern and Buena Vista Lakes to the north line of the county, and showing the locations of the various ranches, also locations of the towns of Bakersfield, Lerdo, Poso, and Delano.

No. 2, map of a portion of Kern County, on a scale larger than that of No. 1, showing most of the same features.

No. 3, bird's-eye view of irrigating as operated in Kern County, showing the river, the main canal (the Calloway), and distributing ditches, checks to restrain the water, and cross-section of distributing ditch, weir, and river weir, together with locations of weirs and side-gates and distributing ditches and flood-gates in contour checks, demonstrating mode of handling the water.

No. 4, view on the Calloway Canal near Poso, showing the volume of water required for the irrigation practiced in that district.

No. 5, view on the Calloway Canal near Poso, showing an irrigated alfalfa field on the left-hand side of the picture, together with the many cattle that it supports and stacks of hay produced therefrom, and in the distance to the right showing the unirrigated land, with its lack of all verdure; also showing the large canal and volume of water required for irrigating.

No. 6, view on Calloway Canal near Poso, showing on the right-hand side an irrigated alfalfa field with its many cattle, and on the right near the foreground an unirrigated patch of land with its few stunted trees, supported by the seepage of the canal, and on the left-hand side the unreclaimed arid lands, which, lacking irrigation, are devoid of vegetation, wholly unproductive, and unprofitable.

No. 7, view down Kern River from bluffs near Bakersfield, showing in the foreground a canal taking its water from Kern River and to the right of that the river itself, and further on in the distance a body of unirrigated, unreclaimed, and arid land.

No. 8, view up Kern River near the mouth of its cañon, with waterfall to the left, tumbling into the main body of the river—the source of all of the productiveness of Kern County.

No. 9, view of Pioneer bridge and weir, Kern River, Kern County. This picture is taken at a time when the Kern River contains an ample volume of water, most of the boards in the weir being withdrawn, allowing a full flood of water to pass the weir and flow down the river to supply the various irrigating ditches below.

An idea can thus be obtained as to the volume of the river from the water pouring over the weir. It will also be remembered that many ditches divert water from the river above this point; but before this system of irrigating was introduced the water of this river ran finally into Tulare Lake, breeding nothing but miasma and leaving the vast body of Kern Valley arid and unproductive.

No. 10, view of Pioneer bridge and weir. This picture is taken at a time when there is a smaller flowage of water in the river, and consequently the weir-boards in the weir are raised to a greater height, thus backing the water up and into the Pioneer Canal, and allowing a smaller quantity to pass below the Pioneer weir.

No. 11, Pioneer head-gate and bridge, Kern County. The same bridge is shown that appears in pictures 9 and 10, and besides is shown the Pioneer head-gate, which is under the bridge on the left-hand side of the picture. The water in the Kern River, being backed up by the river weir to the right hand of the large bridge on the right-hand side of the picture, and which weir in this view does not appear, is diverted through the Pioneer head-gate on the left-hand side of the picture into the Pioneer Canal for irrigation on what are known as the McClung and Buena Vista ranches. (For farther explanation of this matter see statement headed: "Descriptive of irrigation as conducted in Kern County, Cal.")

No. 12, view of the Calloway Weir, Kern County. This is the river weir which serves to control the water used by the Calloway Canal for irrigating the large body of lands to the north of Kern River, the water being similarly handled as explained regarding pictures 9 and 10. The length of these weirs, which weirs cost from $20,000 to $30,000 each, can be appreciated from the pictures.

No. 13, view of Calloway head-gate and weir, Kern County. Near the center of the picture is shown the abutment dividing the river from the Calloway Canal. On the further side of this abutment and to the opposite bank extends the river Weir, which being closed by the weir-boards restrains the water from running down the river itself, which in the picture appears comparatively dry, turning it into the Calloway Canal, in the front of the picture, and allowing it to run through and over the Calloway head-gate, also appearing in the front of the picture, thus handling, with ease, the large volume of water which the river contains and turning it to profitable account. (In this same connection see remarks in statement headed: "Descriptive of irrigation as conducted in Kern County, Cal.")

No. 14, ditching and checking near Poso, Kern County. This picture represents a force of men engaged in the construction of ditches and checks preparatory to the reclamation and irrigation of these arid lands. The entire lack of verdure in this picture, when compared with some of the preceding pictures showing the irrigated and reclaimed lands, demonstrates most forcibly the absolute necessity of irrigation, and the most astonishing results proceeding therefrom.

No. 15, front view of Bellevue cottage on Bellevue ranch, Kern County, showing evergeen and deciduous trees, young orange-trees, blue-grass, etc. The blue-grass shown in the picture was, at the time the photograph was taken, not more than five months old from the date of seeding, thus demonstrating the productiveness of the soil under proper application of water.

No. 16, view of grounds at Bellevue ranch, Kern County, showing lombardy poplars of about ten years' growth, and through and between them the Bellevue vineyard.

No. 17, side view of Bellevue cottage, Bellevue ranch, Kern County, showing blue-grass as described in picture No. 15; also, young orange-trees. None of the larger trees in view are over ten years old.

No. 18, view of a portion of Mr. John Barker's ranch on the upper waters of Kern River, showing to the left the irrigated land, and to the right the unproductive arid land, which lacks irrigation.

No. 19, view at Miller & Lux's headquarters on the Buena Vista farm, Kern County, showing view of their irrigating canal, and in the farther left-hand direction, arid, unirrigated lands, supporting merely stunted sage-brush, and also their luxuriant corn and vegetable gardens, lately started, and not yet fully sprouted, to the right-hand of the picture.

No. 20, alfalfa fields, Kern County, showing view in the hay field, demonstrating the ample hay produced through irrigation, and showing several hay-stacks, representing the product of these alfalfa fields. A crop of hay such as represented in this picture will grow and mature in about six weeks.

No. 21, alfalfa fields, Kern County, showing luxuriant growth of alfalfa, affording sustenance for many cattle, and also demonstrating, by comparison of size, the large amount of hay afforded by these lands, under proper irrigation.

No. 22, view of alfalfa field in Kern County, showing a scene of reclamation and irrigation, results therefrom, and one of the distributing ditches, carrying the life-giving waters of Kern River.

No. 23, fig-tree on Tejon ranch, Kern County.

No. 24, hay scene at Messrs. Miller & Lux's Buena Vista farm, Kern County, showing manner of placing hay in stack.

No. 25, view of harvesting wheat and alfalfa hay in Kern County, showing luxuriance of its growth, ample quantity of hay afforded, and manner of stacking the same, on ground which not more than six months prior to the taking of the picture was unditched, unchecked, unirrigated, unproductive, and wholly arid.

No. 26, view similar to picture No. 25, showing a like crop of wheat and alfalfa, raised on lands similarly and in the same period reclaimed.

No. 27, "Late George Cling Peaches" as produced in Mr. Wible's eighteen-months'-old orchard, Kern County, showing actual size of box and fruit.

No. 28, "Orange Cling Peach," in the Maul orchard, Kern County, showing ladened trees and luxuriant fruit.

No. 29, "Orange Cling Peach," natural size, Maul orchard, Kern County.

No. 30, Wible's peach orchard, Kern County, showing his eighteen-months'-old trees, a photograph of the fruit, from which has already been shown in picture, No. 27, demonstrating the most satisfactory and profitable culture of peaches on lands which but for the artificial distribution of water would be utterly worthless.

No. 31, photograph of Kern County exhibit in the twenty-fourth industrial fair of the Mechanics' Institute, held at San Francisco, in August and September, 1889. Attention is called to the size and beauty of the fruit exhibit, both dried and fresh, as suggestive of the great possibilities awaiting the further development of Kern County under the continuation of its system of irrigation.

No. 32, another view of the Kern County exhibit, as shown in photograph No. 31, showing corn, cheese, fruit, grapes, alfalfa, hay, etc., produced in Kern County.

No. 33, another view of the Kern County exhibit at the Mechanics' Fair, as shown in photographs 31 and 32.

Framed photographs are likewise sent as follows:

First photograph, No. 953, view on the Calloway Canal, and alfalfa pasture fields, showing volume of water required for irrigation in that district, and results therefrom, as affording sustenance to the many cattle represented in the picture, as well as affording reserve feed in the hay-stacks, as shown.

Second photograph, No. 949, harvesting wheat and alfalfa irrigated from the Calloway Canal, in Kern County. (See description under photograph Nos. 25 and 26.)

Third photograph, No. 951, the Calloway Canal and alfalfa pasture fields, showing the results of irrigation as practiced in Kern County.

Fourth photograph, No. 955, the Calloway Canal and alfalfa pasture fields, showing results of irrigation in Kern County.

Also are inclosed Volumes A, B, and C, photographic views of Kern County, in which a short description of the view represented is affixed to each picture.

MEMORANDUM RELATIVE TO PRODUCTS RAISED AT VARIOUS TIMES IN KERN COUNTY.

[Inclosure No. 15.]

These consist of cotton, rice, tobacco, alfalfa, and vegetables (all kinds).

Cereals—Wheat, barley, oats, corn (Indian and Egyptian), and rye.

Orchard fruits—Apples, pears, and figs.

Pomegranates.

Stone fruits—Plums, apricots, peaches, cherries, and nectarines.

Vines—Hops, grapes, and melons.

Berries—Strawberries, raspberries, blackberries, and mulberries.

Nuts—Pecan, walnuts, almonds.

Citrus fruits—Oranges.

Live stock—Horses, jackasses, mules, cattle, sheep, hogs, and goats.

The different products as above enumerated have at various times been raised, and with complete success.

All of the cereals are produced abundantly; the seeded and the stone fruits are of an especially good quality, and the same may be said of grapes, a considerable body of Kern County land being particularly suitable for these latter products.

An excellent quality of cotton has been raised, and upland rice has done remarkably well. The tobacco produced has been luxuriant. Alfalfa has been a product largely raised. It has been remunerative, and from its growth and pasturage increases the productiveness of the lands.

Vegetables do remarkably well and are of most excellent quality, and make their appearance considerably earlier here than elsewhere in the State.

Whereas all of these products can be abundantly and remuneratively raised, their cultivation is absolutely precluded unless carried on under a system of irrigation, the lands being sterile without the artificial distribution of water.

A CLIPPING FROM THE KERN COUNTY CALIFORNIAN, A WEEKLY NEWSPAPER PUBLISHED IN BAKERSFIELD, KERN COUNTY.

[Inclosure No. 15.]

Kern County in 1867 vs. 1888.

Registered voters in 1867	751
Population	2,133
Assessed value of property	$1,150,417

In 1888 the record was as follows:

City and town lots	$406,667
Improvements on same	265,876
All other real estate	5,730,696
Improvements on same	400,270
Personal property	2,132,348
Southern Pacific Railroad Company	2,101,650
Atlantic and Pacific Railroad	12,492
Pullman Palace Car Company	1,087
Total assessed values	11,451,086

Acres assessed	1,079,698
Mortgages	401,674
Registered voters	2,715
Estimated population	10,000

These tables show that from 1867 to 1888, twenty-two years, taxable property has increased nearly tenfold, and registered voters show a gain of 360 per cent. The figures for 1867 were obtained by the courtesy of George W. McEwen, of Visalia, who at that time was assessor of this county.

Adjourned.

LOS ANGELES, CAL., *September* 1, 1889.

The committee met pursuant to the call of the chairman.

Present: Messrs. Stewart (chairman), and Reagan; also Director Powell.

STATEMENT OF DON ANTONIO F. CORONEL.

The CHAIRMAN. How long have you resided in Los Angeles County?

Mr. CORONEL. Fifty-five years.

The CHAIRMAN. Did you practice irrigation while California was a part of Mexico?

Mr. CORONEL. All my life; ever since I have been here; for everything—cereals, grains, oranges, and fruits of all kinds.

The CHAIRMAN. Was there ever a time in the history of California when you could raise all the crops without irrigation?

Mr. CORONEL. Never have I planted anything without irrigation.

The CHAIRMAN. From what country did you come to California?

Mr. CORONEL. From Mexico.

The CHAIRMAN. Are you a native of Mexico?

Mr. CORONEL. Yes. I was born in the City of Mexico; I came here in 1832.

The CHAIRMAN. What was your age at that time?

Mr. CORONEL. I am now seventy-two years old, and that was fifty-five years ago.

The CHAIRMAN. Where you lived in Mexico they practiced irrigation?

Mr. CORONEL. Yes; I saw many places in Mexico where they used irrigation.

The CHAIRMAN. There is where you learned to irrigate?

Mr. CORONEL. Here is where I learned to irrigate; I was too young to practice irrigation in Mexico.

The CHAIRMAN. During the time that this State was a part of Mexico, did they pursue farming to any considerable extent?

Mr. CORONEL. We raised crops for families.

The CHAIRMAN. None of the products were for export?

Mr. CORONEL No; the business here was the raising of cattle. The farming was simply for home consumption.

The CHAIRMAN. They established farming, in the first instance, about the missions?

Mr. CORONEL. Yes.

The CHAIRMAN. The country was a stock country?

Mr. CORONEL. Yes; the Missions had farms—the old Fathers were farmers.

The CHAIRMAN. And they had fruit orchards?

Mr. CORONEL. Yes; they had large fruit orchards, and they came from the water.

The **Chairman.** What usage did they have for distributing the water? How did they determine who had the right to use it? In other words, what were the laws governing the use of water?

Mr. **Coronel.** The same laws that govern here now. The Americans have followed the same system that they had.

The **Chairman.** The law of appropriation?

Mr. **Coronel.** Yes. There have been some improvements in the ditches. They have put in pipes—modern improvements. But it is the same law of appropriation.

The **Chairman.** Do you think if the judges had obeyed the law you made for us we would be happy?

Mr. **Coronel.** Yes, I think so.

STATEMENT OF H. W. PATTEN, OF LOS ANGELES.

The **Chairman.** What is your profession?

Mr. **Patten.** I am register of the United States land office.

The **Chairman.** Make any statement which you think would be of interest to the committee.

Mr. **Patten.** I have brought a map showing our land district, showing the land in the district—with the desert land marked off, defined.

The **Chairman.** You mean the land that may be reclaimed?

Mr. **Patten.** Yes; the land which we consider can be entered under the desert land act—land that will not raise ordinary crops without artificial irrigation. It is divided into three parts: The Antelope Valley, the Mojave Desert, and the Colorado Desert. I will also file a report showing the number of acres.

The **Chairman.** Have you the report with you?

Mr. **Patten.** Yes.

Senator **Reagan.** Do you describe the various areas in your report?

Mr. **Patten.** Yes; they are thoroughly described. I find that we have 13,156,000 acres of desert land in this district that have not been reclaimed; of that the Mojave has 6,302,000, the Colorado 4,699,000, and the Antelope Valley 2,185,000 acres.

Senator **Reagan.** What proportion of that land belongs to the Government?

Mr. **Patten.** Of that I should think that at least 12,000,000 acres belong to the Government.

The **Chairman.** Of the 13,000,000 acres?

Mr. **Patten.** Yes; and possibly a greater proportion will revert to the Government if it is not reclaimed.

The **Chairman.** They have attempted to reclaim it?

Mr. **Patten.** There have been 333,000 acres entered under the desert land act, from which the Government has received $99,617.05. That has been paid in this land district for such entries, and the number of the entries is 768, but only 23 persons have been able to prove up. I do not think the Government has parted with 6,627 acres out of the total 333,181 acres. The remainder has reverted to the Government, because of the failure of the parties to reclaim, or will fail because the work is too expensive for private enterprise.

The **Chairman.** Have you given any attention to the source of water supply for this land?

Mr. **Patten.** Yes.

The **Chairman.** Have you been over the Antelope Valley?

Mr. **Patten.** Yes.

The **Chairman**. Where is the water supply for the Antelope Valley?

Mr. **Patten**. It is surrounded on all sides by ranges of hills.

The **Chairman**. What hills?

Mr. **Patten**. Well, they are not thoroughly defined; they are not mountains.

The **Chairman**. Where is the Antelope Valley?

Mr. **Patten**. Eighty-five miles north of us.

The **Chairman**. This side of the mountains?

Mr. **Patten**. Yes.

The **Chairman**. The railroad goes through a portion of it, does it not?

Mr. **Patten**. Yes; here [indicating on a map] is the railroad line defined.

The **Chairman**. Have you examined the water supply for Antelope Valley, and seen what portions there are to irrigate portions of it?

Mr **Patten**. Yes; I have examined it to some extent.

The **Chairman**. What do you say of it?

Mr. **Patten**. I think that the greater portion of the land up there could be reclaimed. I think that it could be done by building dams across these mountains and storing up water for use in the summer season. There is one very good place up there—Elizabeth Creek. Of that I think a good catchment basin could be made. There is another place—Oak Creek, There are some eighteen or nineteen men who have entered on Oak Creek. They have been asking the Government for an extension of the time to bring water on to the land.

The **Chairman**. Are you familiar with the Mojave Desert?

Mr. **Patten**. Not so familiar as I have been with the portion up here.

The **Chairman**. Has the Mojave River been utilized?

Mr. **Patten**. It has not been. I will file another map with you, showing where water could be taken out of the main branch of the Mojave River to irrigate some 30,000 or 40,000 acres of land. I will file that map. That is a natural basin, and I will state that a good deal of that land was entered under the desert land act, and it has reverted to the Government.

The **Chairman**. With regard to the Colorado River: Have you examined to see whether that could be taken on to this desert?

Mr. **Patten**. Well, only superficially have I examined it.

The **Chairman**. Have you been up above The Needles?

Mr. **Patten**. Yes. I think that water could be taken out.

The **Chairman**. If it could be, there is abundant land to absorb it all?

Mr. **Patten**. Yes; but it would be too expensive for anybody but the Government to undertake it.

The **Chairman**. We do not know yet. It will cost a good deal of money; but that will be determined later. How would you irrigate the Colorado Desert?

Mr. **Patten**. By building catchment basins and catching the water throughout those hills.

The **Chairman**. Is there anything else you wish to state?

Mr. **Patten**. No. I simply wished to file this map and statement with you.

The statement is as follows:

At the request of the president of the chamber of commerce of this city I take pleasure in submitting to you a few figures in regard to the desert lands of the Los Angeles land district.

The act of Congress under which you gentlemen are prosecuting your inquiries would seem to, in a measure, confine your work to a consideration of the lands arid in character which still belong to, or are likely to revert to, the Government.

It is of such lands within the limits of the Los Angeles land district that I shall treat. My object will be to show you, by means of a map which I have had made, ranges of mountains containing many reservoir sites so sloped by nature that only supplemental work will have to be done by man to make them catchment basins of vast capacity; to show you the streams and water-sheds which will furnish the water for filling the storage reservoirs, and to show land lying under them belonging to the national domain upon which this water can be conducted, and thus the value of the lands be increased from nothing per acre to $100 per acre.

As to the cost of the work to be done by the Government in this district it is impossible for me to furnish an estimate, but it is not beyond my wildest hopes to convince you that the Government will receive in actual cash, through this land office, at the legal price for land, every dollar expended in the work done here, while at the same time $200,000,000 will be added to the assessment rolls of the several counties of this district.

As for the benefit of irrigation, other gentlemen will see to it that you are thoroughly informed, and visits to places where you will see land on one side of a ditch too high for the water to reach worth 75 cents per acre, and land on the other side of the ditch whereon water can be and is conducted worth $1,000 per acre, will have a very convincing effect.

Fortunately the Los Angeles land district contains more desert land susceptible of irrigation than all the rest of the State. I say fortunately, because now that the Government has taken this matter in hand our people have reason to believe that every acre of this now desert land will be reclaimed and put in a productive condition.

From a careful examination of the records of this office I find that in this district there are 13,156,000 acres of arid lands divided into three bodies:

	Acres.
Mojave Desert	6,302,000
Colorado Desert	4,699,000
Antelope Valley	2,185,000

These are lands which can be entered under the desert land act as lands "which will not without artificial irrigation produce agricultural crops in ordinary years." Under the provisions of this act a person can by paying 25 cents per acre on single-minimum land, or 50 cents per acre on double minimum land, enter not to exceed 640 acres; and if he conducts water on the same and reclaims it to such an extent that it will raise crops, he shall have the privilege within three years of proving up on said land, and by paying an additional $1 or $2 per acre, as the land may be single or double minimum, receive a patent therefor.

That there is much land of this character in the Los Angeles land district is evidenced by the fact that seven hundred and sixty-eight persons have found in this district 333,181 acres of land which they thought could be reclaimed, and have paid into the land office $99,617.05 in first payments for such entries. It may be surprising to know that out of the large number of entries—seven hundred and sixty-eight—only twenty-three persons have proved up, and the Government has only parted with title to 6,627 out of the total number of acres entered. The remainder of the 333,181 acres has either reverted to the Government because of the failure of the parties to reclaim, or will shortly revert because the work of reclamation is too expensive for private enterprise. To sum it up briefly, the Government has received from the people of the Los Angeles land district $92,989 for first payment on desert lands, and the Government still has the land.

In this connection I trust it will not be deemed indelicate to indulge in the hope that, inasmuch as the Government has secured this large sum from the people of this land district on account of desert lands, and the people have not been benefited thereby, a proportionate sum of the money appropriated for surveys be expended down here, and an investigation of our wants be made by the consulting engineers. It is a matter of reciprocity, and will be greatly to the advantage of the people and the Government.

It must not be taken as a discouraging sign that so few final entries of desert land have been made. It is purely a question of expenditure, and the class of people who seek to obtain title to land under the beneficent laws of the General Government are unfortunately not wealthy, and the reclamation of even a section of desert land is a work of some magnitude and considerable expense. What would be a comparatively easy task to the Government, where there are many thousand acres to be irrigated, becomes very onerous to the man who tries to put water on 640 acres of land.

Fortunately, however, the reclamation of desert land has been successfully tested in this district, and all difficulties have been met and overcome. In township 4 north of range 9 west two gentlemen of this city, Messrs. Rowan and Bent, entered about 1,000 acres of desert land and proceeded to take water out of Big Rock Creek with which to irrigate it. When their proof was presented it showed that these gentlemen had expended over $10,000 in developing and piping water to the land claimed by them. I understand that they have lately sold their land for $30,000. This is land which cost $1.25 per acre, and which, after an expenditure of $10 per acre to get water on it, sold for $30 per acre—rather a good profit, and an investment that could commend itself to any careful business man. But when it costs a private individual $10 per acre to irrigate land, the Government could do it for $1 or less per acre, because the Government would deal with larger tracts.

About four years ago some gentlemen entered desert land and began developing water in Cottonwood Cañon, situated in township 10 north, of range 15 west. I paid a visit to the ditch when the water was turned into it and it was a sight to make the heart glad. There could not have been less than 1,200 inches of water flowing in the ditch, and where water was taken out and put upon experimental crops the effect was wonderful. But all this came to naught, for in the summer season the water ceased to flow and the crops died. Now, there was no question of the quantity of water, because it was superabundant in the winter season, and there was no question of its effects on the crops. It was simply a question of storage, and reservoirs could have been built and the water saved and brought into use when needed, but the funds of the company gave out, and the lands reverted to the Government. In my judgment, a reservoir could be constructed to store up the water flowing in that cañon, and by using it economically a supply sufficient for the irrigation of 50,000 acres of land saved.

In township 11 north of range 14 west, eighteen sections of desert land have been entered, and an effort made to get water out of Oak Creek with which to irrigate this land. The time allowed by law for reclamation has expired, and the gentlemen making these entries are to-day asking the Government for an extension of time of one year in which to comply with the law. If the Government had this work in hand it could build a dam and reservoir, catch the water of Oak Creek and reclaim one hundred sections of land in that vicinity. At the Government price of $2.50 per acre, the United States would receive $160,000, the land would be worth $2,000,000, and the country would be that much benefited.

The map which I present to you carefully defines the desert area. It also shows the mountain ranges surrounding these desert lands. In those mountains are innumerable cañons capable of being made reservoirs, and through them are thousands of acres of lands, now worthless, that with water would be of great value.

I don't think I am extravagant in saying that in this district there are 4,000,000 acres of land which can be reclaimed without extraordinary expense, and the people will cheerfully pay the Government $10,000,000 for these lands. The matter resolves itself into a pure business proposition. Can the Government afford to expend $5,000,000 in this district, receive a direct return of $10,000,000, and add $200,000,000 to the assessment rolls of southern California?

Mr. Patten also filed with the committee a map showing a natural basin in San Bernardino County, where water can be obtained from the Mojave River and stored up for use. Also full facts in regard to this particular basin. For this map and the accompanying description he was indebted to Mr. H. Y. Harding, civil engineer, of Los Angeles.

ON PROPOSED DITCH AND RESERVOIR SYSTEM IN TOWNSHIPS 3, 4, AND 5 NORTH, AND RANGES 2, 3, AND 4 WEST, SAN BERNARDINO BASE AND MERIDIAN, SAN BERNARDINO COUNTY, CAL.

The water for this system will be taken from the east or main branch of the Mojave River about 1 mile above its junction with the west branch. This stream is fed by heavy snows in the mountains, whose elevations are from 8,000 to 10,000 feet.

The dryest season includes the months of July, August, and September.

For several months in the winter the river contains from 30,000 to 50,000 inches of water. This water sinks about 1 mile below the junction of the forks and, for a distance of 15 miles, runs under the sand, returning to the surface again at Victor. The east fork is rocky and precipitous, and is fed by several additional small streams on the south side; shown on the plan in red. The distance to the reservoir site is from 12 to 15 miles. The first half of the work would be heavy and the last light. Estimated cost, say, $25,000.

The reservoir site is naturally fine, covering an area of 1,500 acres; depth 50 feet, and by the addition of a short dam of moderate height its capacity would be doubled.

It is to be remembered that for nine months in the year the reservoir can be drawn on for an unlimited quantity of water which would be constantly supplied from the river. A short tunnel on the west side would drain the reservoir to the bottom, The land slopes to the north and west, and is well adapted for irrigation. There is at least 50,000 acres that could be supplied with water from the system.

The elevation is about 3,000 feet. The highest temperature in summer is 104°, with cool nights. Estimated rain-fall 8 inches. The soil is well adapted for the raisin grape, which has been successfully grown at Hesperia, and for a well-diversified system of general farming. As the engineer of the Hesperia water system, the writer speaks from experience, having passed about two years in the district. Mines of more than ordinary worth are being developed in the surrounding mountains, and the railroad gives assurance of a ready market for all products of the farm and mine.

STATEMENT OF E. W. JONES, OF LOS ANGELES.

The **CHAIRMAN**. You are president of the Los Angeles Chamber of Commerce, Mr. Jones?

Mr. **JONES**. I am, and I am well acquainted with the business interests of this county.

The **CHAIRMAN**. You have something to offer in regard to the different methods of water distribution in vogue here. Do so in your own way.

Mr. **JONES**. There are more systems of irrigation, more methods of application, more varieties of land irrigated, including mountain, foothill, bench land and valley, desert and habitable, more kinds of soil and crops, more valuable experience and information, than in all the rest of the country "put together." From the earliest Spanish-Mexican occupation to the present time, a period of more than a hundred years, the practice of irrigating has been a necessity, and the lea[illegible]tinctive feature of farming in this county.

The old Spanish methods still prevail here in some places, while every improvement and modification of them thus far invented is here to be seen in application. When one realizes that until irrigation was introduced here by the white race this region was regarded as irredeemable desert, fit only for the grazing of stock in a desultory way and during the rainy season, that the frequent drouths made that business a precarious one, and that without irrigation it would still remain so, some appreciation of the value of irrigation to arid regions can be had. When it is further realized that only by development by means of tunnels, artesian wells, and storage reservoirs can half our fertile lands be made habitable for human beings, and that these are beyond the means of ordinary private enterprise, the advantage and necessity of public aid becomes apparent.

The acreage in this county to which irrigation is actually applied is probably more than that of all the rest of the State put together. It is so situated that you can see much of it in the highest state of improvement, covered with every variety of crops, and under many different systems, in a comparatively few miles of very pleasant travel.

In Los Angeles County, then, the committee may see irrigation by means of earth canals with wooden gates, weirs, dams, flumes; open cement ditches; brick and stone, cement and iron pipe; conduits; subirrigation; lifting by wheels, windmills, and steam, gas, and hot-air engines, with pumps; flowing artesian wells (there are said to be 5,000 of these wells in this county alone, some throwing 4 to 7 inch streams 14 feet into the air); submerged and other dams; reservoirs of all sizes, some holding many million gallons, with every appliance for raising, distributing, and utilizing the beneficent fluid.

With all these methods in operation we feel assured that the committee's investigations will be in all ways profitable. We point with pride to our rapid growth, Within a few years from a population of

12,000 to one of 150,000, and that on an area reduced in size; a population more prosperous, too, than can elsewhere be found in our land.

STATEMENT OF B. S. EATON, OF PASADENA, LOS ANGELES COUNTY.

The CHAIRMAN. What is your profession?

Mr. EATON. I am a farmer.

The CHAIRMAN. How long have you resided in this county?

Mr. EATON. Fifty-one years.

The CHAIRMAN. How long have you been a farmer in Los Angeles County?

Mr. EATON. I have been a practical farmer for nearly the entire time.

The CHAIRMAN. By what means do you farm?

Mr. EATON. By irrigation entirely.

The CHAIRMAN. Can you produce all-around crops regularly without irrigation?

Mr. EATON. No; I can not.

The CHAIRMAN. Occasionally you can produce small grains without irrigation?

Mr. EATON. We can produce small grain. We raise it on the strength of the winter rains, and we get a good crop almost invariably. I do not think we have a failure once in ten years. All other crops here, on uplands, require irrigation.

The CHAIRMAN. What were the usages as to the distribution of water among the Spanish residents when you came here?

Mr. EATON. Entirely by appropriation.

The CHAIRMAN. How did they govern their relative rights?

Mr. EATON. Here in Los Angeles—I practiced irrigation in the city of Los Angeles twelve or fifteen years—we followed the practice that had governed under Mexican rule. Waters were diverted from the river and distributed through zangas. There were nine different tomas; now they are reduced to two. The general manner of paying for water was this: One man would give a sack of beans to the zanjero, or water-master. Each ditch had its water-master. We call him a zanjero, or water-storer. Our contribution consisted of what we raised.

The CHAIRMAN. You paid him for the use of the water?

Mr. EATON. Yes; and we would inquire of him what time he would give the water.

The CHAIRMAN. Did the right depend on the date of appropriation?

Mr. EATON. Not in those days. Do you mean for service?

The CHAIRMAN. Did you, when there was a conflict, determine by the principle of prior appropriation?

Mr. EATON. Not at all. We were served according to our turn on the ditches. It was supposed that we had plenty of water. At that time there were 2,000 acres under irrigation, and to-day there are 14,000 acres, and it is better served to-day than it was then. That is what intelligence does.

The CHAIRMAN. Your right depended on appropriation then, as it does now?

Mr. EATON. Yes; they appropriated the whole river.

Senator REAGAN. No one had a right above another to take his turn?

Mr. EATON. Yes. It was done at the expense of the city. They built a sand and brush dam. They have not advanced here.

The CHAIRMAN. They appointed a water-master for each ditch and they dealt the water out to the inhabitants?

Mr. **Eaton.** Yes. If it did not reach us we had to get along the best we could.

The **Chairman.** And the Americans adopted the same regulations that were in existence under Spanish rule?

Mr. **Eaton.** Yes.

The **Chairman.** And the usage of water depended on appropriation?

Mr. **Eaton.** Entirely.

The **Chairman.** Without regard to whether they owned the land on the river or not?

Mr. **Eaton.** We knew nothing of riparian rights.

The **Chairman.** That word is not a native of this country?

Mr. **Eaton.** No; it has not been in vogue anywhere in the country. The streams that have been developed in the mountains have been under prescription, occupation, and use.

The **Chairman.** With what success could crops be raised here without irrigation?

Mr. **Eaton.** Irrigation insures the farmer a certain crop.

The **Chairman.** What is a fair crop of alfalfa?

Mr. **Eaton.** From 7 to 10 tons a year.

The **Chairman.** Do you raise corn?

Mr. **Eaton.** Yes.

The **Chairman.** What is a crop of corn?

Mr. **Eaton.** From 75 to 125 bushels to the acre?

The **Chairman.** What is a good crop of wheat?

Mr. **Eaton.** It is raised without irrigation. I think an average crop of wheat is 20 sacks to the acre. I do not know whether the county would average that.

The **Chairman.** That would be something over 30 bushels to the acre?

Mr. **Eaton.** I hardly think the county would average that; perhaps 25 bushels.

The **Chairman.** What would be a fair crop of oats?

Mr. **Eaton.** We do not raise oats. It is hardly practicable to raise oats here.

The **Chairman.** How is barley?

Mr. **Eaton.** The country is naturally adapted to it. I have known as high as 90 sacks to the acre; but 40 to 45 and 50 sacks to the acre is the average.

The **Chairman.** Of 100 pounds to the sack?

Mr. **Eaton.** Yes.

The **Chairman.** What kinds of fruits do you raise here?

Mr. **Eaton.** Any kind that can be raised in the temperate zone, and some of the tropical fruits. Everything in the citrous family, besides guavas.

The **Chairman.** You stated that there were 2,000 acres under irrigation when you came here, and that now there are 14,000 acres, and you have a better water supply. How do you account for that?

Mr. **Eaton.** The water is better handled; the ditches are in a better condition, and the water is regulated from necessity. Formerly they did not economize, and they depended upon till. The old manner of raising crops was not to put the water on until June. They had a kind of corn that would perfect itself in ninety days. They would flood the ground with water, and then they would give it another irrigation, and then it was all right. I have seen 90 bushels to the acre of that.

The **Chairman.** You economize the water now?

Mr. **Eaton.** We economize in various ways. They stir the ground, pulverize it, and keep the surface in a perfect state of till, loose and pliable, so that it retains the moisture better. You see as you put water on the ground it dries and contracts and opens avenues for the moisture to escape. The systems have been very largely improved, so that the water is made to perform a much larger duty. Los Angeles has advanced in that respect.

The CHAIRMAN. Where have you best economized in this county?

Mr. EATON. Perhaps in Pasadena. The engineer gives us the credit of a higher duty there than anywhere in the State. There we make an inch of water accomplish more than anywhere else.

The CHAIRMAN. What do you think of the supply of Antelope Valley?

Mr. EATON. In this immediate neighborhood the Sierra Madre has afforded no facilities for storing in large quantities. I made a pretty thorough examination last year. The ridges there shape the valleys narrow, and the length on an average is one to five—one to four. Therefore a dam raised a foot high would only back it several feet. There is no lake surface, and you have to come down nearer the ocean.

The CHAIRMAN. Have you examined the Antelope Valley over these mountains?

Mr. EATON. I have been there. There they have two streams—Little Rock Creek and Big Rock Creek. They have considerable water at their sources. They are not utilized. The Little Rock Creek does not reach out into the country at all, and it is limited; Big Rock Creek could be made to serve two or three thousand acres.

STATEMENT OF GEORGE H. PECK, OF LOS ANGELES.

The CHAIRMAN. How long have you resided in Los Angeles?

Mr. PECK. Twenty years.

The CHAIRMAN. And are you a farmer by occupation?

Mr. PECK. I was a farmer in 1849.

The CHAIRMAN. Have you observed the water supply in this county?

Mr. PECK. Yes; very closely.

The CHAIRMAN. State what you know about the water supply of this valley in which Los Angeles is situated.

Mr. PECK. I will take it in a general sense. The average water-fall used to be 15 inches—a foot and a quarter. It has increased a good deal since then. That does not help us. But taking the average water-fall at a foot and a quarter on the plains you must take the water-shed also. If it be a foot and a quarter—15 inches—on the plains, you must estimate it is double 15 inches in the mountains. That makes 30 inches. That is my estimate. Then consider, as it is given in this very able report, that there is three times the water-shed that there is of arable land. Then there is a water supply from the mountains that covers 3 feet of water. That 3 feet is three times a foot and a quarter; that is to say, 3¾ feet, twice the rain-fall; that is to say, to double it makes 7½ feet, and adding that to the plain-fall makes it 8¾ feet.

The CHAIRMAN. How are you going to save that water?

Mr. PECK. The only way we are going to save it is by these reservoirs, holding the water in the mountains.

The CHAIRMAN. These mountains are very precipitous. Have you examined them to see whether there is an opportunity to store the water?

Mr. PECK. Yes. It seems as if nature had made it on purpose for a reservoir. Men, with all the money that could be advanced, could not make the reservoirs that are provided in the San Gabriel—the one that Mr. Hinton spoke of.

The **Chairman.** Have you been over that?

Mr. **Peck.** Not critically. There is something about Eagle Lake, and I think Mr. Hinton mentioned something about Elizabeth Lake. There is an excellent lake for a reservior. That is on one of the southern tributaries of the San Gabriel River. One man told me it was 6 miles long. I have not been there. I have been told it was 6 miles long. It might not have been over a mile, but it is fathomless.

I wish to say another thing. We have an immense volume of water, and while I am confident, if it could be stored, it would give us all the water we want, yet, in reply to your general talk about millions coming here, I would say we can not have the millions unless we have the water, and we can not have the water unless we have the reservoirs. In the winter the San Gabriel has 80 inches of water on the mountains, and it comes tearing down sweeping away large bridges. The Southern Pacific had to rebuild their bridges three times. If this water could be stored it would save that damage that is done in the winter and we could have the water for irrigation purposes in the summer.

The **Chairman.** Do you think a survey, determining where and how that could be done, would be valuable?

Mr. **Peck.** Yes, I think so.

The **Chairman.** Our inquiry among other things is what would be the value of a survey? Would a survey in your opinion facilitate the development of the water?

Mr. **Peck.** I think so. There are ridges in those places, I am told, that will bear damming. I have not been up there—not all through there—and I have not investigated the matter.

Mr. **Hinton.** You think the San Gabriel is not doing one-third the work it should because it is not handled. If you go up the river you think you can get from four to six times the water that is used to-day. What is the value of the land after the water has been introduced?

Mr. **Peck.** Do you mean the marketable value?

Mr. **Hinton.** I mean the intrinsic value as an investment.

Mr. **Peck.** The parties who own the San Pascual ranch, with about 14,000 acres, sold 5,000 acres at $6 an acre and 4,000 at $24 an acre. They thought they had made a good sale, because as a pasture it did not pay the interest on the money. To-day that same land, with the water applied to it, wherever it is applied, is worth $250 an acre without exaggeration, and you can make it pay at that figure. I heard Mr. Wilson say that from 8 acres, with 600 orange-trees, they had taken $21,200 worth of oranges, and that for five years there was an average of $15,000 a year. That orchard pays about 10 per cent. on $2,500 an acre, and it is not extra fine. The land cost him $12 an acre.

There is another point that I had not thought of before, and that is, what it costs to put water onto the land when you have the water. I have built seven different systems. Our system is an iron-pipe system. I believe it was the first one ever conceived—distributing water through iron pipes for irrigation. The system answers the double purpose of furnishing a system for domestic purposes equal to any city in the United States, and at the same time for irrigation. That is the reason why our water does such high duty.

The **Chairman.** The water passing through these pipes saves it from seepage.

Mr. **Peck.** Entirely so; and does duty in everyrespect. I am in South

Pasadena. Mr. Bristol is north of me. I have the water from nine to twelve, and he has it from twelve to four. The zanjero sends the guard and tells me when to take the water. I stop irrigating at 12 o'clock, and there is no water lost—it flows back to the reservoir. Mr. Bristol opens his main and there is not a drop of water lost. We make 1 inch of water serve over 40 acres.

The **CHAIRMAN**. Of fruit?

Mr. **PECK**. We produce everything—all around crops—and we use it for beautifying, for ornamentation around the houses, and we have some just as fine gardens as you have seen in Los Angeles.

Director **POWELL**. You were going to state what it cost to get the water onto the land.

Mr. **PECK**. We paid $25,000 for 1,500 acres. That gave us the pipe system and the reservoir. I have put in $14 to $28 per acre for reservoir and system both

Director **POWELL**. How did that compare in cost with the new patent method of clay pipe running along the ground?

Mr. **PECK**. Do you mean the subirrigation principle?

Director **POWELL**. Yes.

Mr. **PECK**. Well, it is of no account at all.

Director **POWELL**. How does the iron-pipe system compare in cost with the clay-pipe system?

Mr. **PECK**. It can be done for much less.

Director **POWELL**. State which.

Mr. **PECK**. The concrete pipe. But it is not a pressure pipe—you have to run your water. One contemplates continuous water on a place, the iron pipe; but if you are 10 miles from the reservoir the water is always there. They have the concrete-pipe system at Etiwanda. There you will sometimes have to ask the question, "How is it you have not plenty of water?" and they will answer, "It is not our week for water; the water is running over on the other side, and we have got to save it." But with us every individual has water right on his place all the time, just as if he owned the whole system.

The **CHAIRMAN**. The iron-pipe system costs how much per acre?

Mr. **PECK**. All the way from $10 to $28. It depends on the distance. There is one system that is put in here that has an excellent concrete reservoir; that is at Glendale. That cost $14 an acre, including the reservoir. It is a perfect system—perfect in this respect, that every man has water on his place continuously.

STATEMENT OF J. DE BARTH SHORB, OF SAN GABRIEL, LOS ANGELES COUNTY.

The **CHAIRMAN**. How long have you resided here?

Mr. **SHORB**. Since 1867.

The **CHAIRMAN**. Have you been engaged in farming and cultivating the soil?

Mr. **SHORB**. I have been engaged all that time in farming—vine culture, tree culture, in fact mixed farming—cultivating grain and everything else.

The **CHAIRMAN**. What do you say of the success of irrigation in this locality?

Mr. **SHORB**. It would be very difficult for me in detail to formulate an answer to that question.

The **CHAIRMAN**. State generally.

Mr. Shorb. It has been everything to our county—it has simply reclaimed large wastes and made of them blooming productive plains.

The Chairman. What would the average land outside of town be worth if it could not be irrigated?

Mr. Shorb. The land in the San Gabriel proper, about the first mesa beyond Pasadena, and bounded by these low hills, was valueless in 1874, before we carried water onto it. No one would have had it at any price. We bought land at $2.50 an acre. I have placed water on the land and it has sold at $500 an acre, $600 an acre, and $1,500 an acre.

The Chairman. Were they fancy prices?

Mr. Shorb. Not those in vines and orange trees. Those lands justify the price of $1,000 an acre. Mr. Eaton has well stated about the income from orchards. I made a net income of $1,400 an acre, and for years after that $1,000 an acre.

The Chairman. What did you cultivate?

Mr. Shorb. Orange trees. So far as grape culture is concerned in that valley, the average yield, according to my books, which I have kept since 1867 until recent years, was 4 tons to the acre, and they sold about $20 a ton until the last few years, making an income of $80 an acre, which should have given a net income, under careful management, of not less than $60 an acre; and if the man did his own work, it could be done at $10. I have done my work at San Gabriel, including cultivation, pruning, plowing, and selling to the buyer at a distance for not quite $10 an acre. Therefore it would gain an income of $60 an acre, which would be in that culture 6 per cent. on $1,000 an acre.

The Chairman. Does irrigation here increase the grain crops?

Mr. Shorb. We have not practiced irrigation for grain crops; but I have no doubt it would increase.

The Chairman. How is it as to hay?

Mr. Shorb. We do not use it on those crops. If the grains are irrigated we make a higher crop than in the Eastern States that I am familiar with.

The Chairman You irrigate alfalfa?

Mr. Shorb. Alfalfa we irrigate.

The Chairman. What do you say about the economy of water? What has been your experience about the quantity of water originally used and its economy in this valley?

Mr. Shorb. When I first came here there was a shameful misuse of water. I really thought they were doing more harm than good with the water. When I first came to this country they certainly required ten times as much water as they have now. As Mr. Eaton stated to you that is the result of more thorough cultivation after irrigation, thoroughly wetting the soil, keeping it soft on the top, and instead of the water going away in vapor it goes into the roots of the plants and increases the crops.

The Chairman. You say they injured the land as much as they did good. Was that by leaving the water on the land, thus producing alkali?

Mr. Shorb. Well, scarcely that—by not disturbing the ground in digging around the roots of plants, and the heat would bake the ground.

The Chairman. You needed drainage as well as irrigation.

Mr. Shorb. Drainage as much as irrigation. That matter we do not have to consider here, because the fall of the land is so great it naturally throws off the water.

The **CHAIRMAN.** Having improved the land by cultivation, how much have you reduced the amount of water necessary to produce crops?

Mr. **SHORB.** About one to ten.

The **CHAIRMAN.** What would be the duty of an inch of water, supposing that to be one-fiftieth part of a cubic foot per second, if it were carried in iron pipes and distributed to the best advantage?

Mr. **SHORB.** That would depend on the mechanical construction of the land itself. On some land 1 inch of water would be quite sufficient for, I would say, 25 acres of land, and I would say probably as high as Mr. Eaton has stated, 40 acres. That permits the water to run away before it has accomplished its purpose. It is perfectly safe to say, perhaps, that throughout the length and breadth of this country, which I am familiar with, 1 inch of water will serve all the purposes of 20 acres of land, and it should not have any more.

The **CHAIRMAN.** If the water should be delivered by iron pipes?

Mr. **SHORB.** Delivered by iron pipes. Of course, that 1 inch could not be used at one time. If irrigation is practiced once a month you have practically 30 inches for that one day.

The **CHAIRMAN.** What is your judgment about the water supply, if it be stored to the best advantage?

Mr. **SHORB.** Mr. Patten has given to your committee a good deal of valuable information, and I indorse it. I believe there is enough water falls upon these mountains, if it were stored in reservoirs and saved, to irrigate every acre of land between the mountains and the ocean—more than enough. I, for one, am not so afraid of these rapid descending cañons as I once was.

There is one other point. I think there is very nearly as good a reservoir site at Los Angeles, this town—as good as Bear Valley is.

STATEMENT OF FRED EATON, OF LOS ANGELES.

The **CHAIRMAN.** What is your profession?

Mr. **EATON.** Civil engineer.

The **CHAIRMAN.** Have you been engaged in your business in this vicinity?

Mr. **EATON.** Yes.

The **CHAIRMAN.** To what extent are you familiar with the irrigation of this valley and the sources of water supply?

Mr. **EATON.** I have been connected with almost all the irrigation works of this valley for the last ten years in the capacity of engineer, and I have examined all the works in this county.

The **CHAIRMAN.** Have you anything to say that would be of interest to the committee?

Mr. **EATON.** I do not know, except what has been stated here in regard to the benefits of irrigation in this particular section and the possibilities of increasing our present facilities for irrigation. I think that the present streams are developed very nearly to their fullest extent, that is, by the ditch and pipe systems which we have introduced, and in order to increase our irrigation facilities we have from now on to resort to storage. The duty of these streams would be extended by extending the present ditches by pipe systems. Experience has taught us that by economizing the water it is not only the water that we save in seepage alone, but the distribution. The convenience that these pipe systems offer in the distribution of water is a great economizer. We find that we can get along with a half or third the water that we get in running it around in ditches.

The **CHAIRMAN.** And serve the land as well?

Mr. **EATON.** I remember one gentleman thought that the San Gabriel was being used up by irrigating 2,000 acres. But it has been used since for irrigating 12,000 acres.

The **CHAIRMAN.** And it can be increased by the pipe system?

Mr. **EATON.** Yes.

The **CHAIRMAN.** What would be the duty of one-fiftieth of a cubic foot per second throughout this valley under the pipe system?

Mr. **EATON.** For all kinds of crops, 1 inch to 10 acres; that is, for vegetables and all kinds of crops. Of course, it depends altogether on the character of the soil. A soil that is well subdrained, that is composed of gravel, will require much less water. I remember Major Powell has explained that. This subsoil of gravel is a natural drain, and for that reason water will go a great deal farther on that kind of land than it will on an impervious subsoil. Then it depends on the locality. Some localities within 20 miles from here will require double the water that others do. Taking the average in this valley, with 10 inches you can irrigate all kinds of crops, orange trees, and all kinds of vegetables.

The **CHAIRMAN.** What is the expense per acre for the pipe service?

Mr. **EATON.** Of course that depends on the conditions. I estimated for one system not long ago to supply 10-acre tracts. Every tract had a frontage on the street, and the pipe was to run down the street. That was at a cost of $15 per acre. I also made an estimate on a 2,000-acre tract, and that figured out the same way.

The **CHAIRMAN.** Fifteen dollars an acre?

Mr. **EATON.** Yes. I have built works where it was $50 an acre. Where the streets are closer together they require more pipes. The cement pipes I do not think are cheaper than the pressure pipes, because it requires a good many more of them, and they are not so convenient as the pressure pipes.

The **CHAIRMAN.** What thickness of iron pipes do you use in this pressure system?

Mr. **EATON.** We generally use 16 iron. It is practically the sixteenth of an inch thick. A 4-inch pipe is more difficult to make than a 16-inch. We put asphaltum on, but it is impossible to keep it from being knocked off in spots, and those spots rust there. We can not inspect them closely enough to get at them all and paint them over. In ordinary soil, where there is no alkali, it will wear fifteen or sixteen years. I put in pipes fifteen years ago that are doing service now. I guess I put in pipes for you twelve or fifteen years ago and lighter iron than that—18 iron. The Pasadena pipes were 11 inches with 18 iron. That system was put in in 1873, and served up to this year.

We have not many storage facilities up in the mountains. They are confined practically to the foot-hills and the valleys. We have to bring our water down and make our reservoirs in the valley. In Bear Valley the reservoir will contain 60,000,000,000 cubic feet when it is fully developed, and I am told there are a number of similar ones up there; but the cañons are too precipitous.

STATEMENT OF M. A. KNAPP, CIVIL ENGINEER, OF OAKLAND.

Allow me to lay before your committee a plan for the utilization of the flood and winter flows of Owens River in irrigating the land of Antelope Valley, in Kern and Inyo Counties, Cal.

The outline of the plan is as follows:

A canal might be run from near Big Pine, on Owens River, south, past the west side of Owens Lake, passing over a low divide about 9 miles south of the lake, and flowing from there in a natural channel most of the way to Antelope Valley. About midway in this channel is Volcano Valley, which is a splendid reservoir site. In fact the lava flows at the lower end seem to have already dammed it sufficiently, so that an outlet tunnel rather than an additional dam would be necessary.

From the entrance to Antelope Valley a high-level canal could be run around the west side and subsidiary ditches would lead the water by easy slopes over the whole of this extensive tract of fertile but at present dry and almost desolate country.

Owens River is a good-sized stream, fed from the springs and snows of the Sierra Nevada Mountains. It flows south throughout the whole length of Owens Valley and empties into Owens Lake. This extensive but shallow alkali lake has no outlet, and the whole flow of the river is evaporated from its surface.

The principal streams flowing into the river are Bishop, Big Pine, Fish Spring, Independence, Lone Pine, and Cottonwood Creeks, all having their sources in the high Sierras to the west. The average flow of the river is about 60 feet wide and 5 feet deep. Such a stream, flowing at a velocity of 1½ miles per hour, carries about 20,000,000,000 cubic feet of water per year. This corresponds approximately to the amount evaporated from the lake, as calculated by the United States Weather Bureau from the report of the Signal Service station at Keeler, which amount was in 1887 100 inches, or about an average of 8 feet a year. According to this calculation there is evaporated on the 70,000 acres of lake surface 24,000,000,000 cubic feet of water per year.

This amount of water would cover 70,000 multiplied by 4, or 280,000 acres 2 feet deep, and as 20 inches of water applied gradually is sufficient for ordinary irrigation (at least, after the land has been watered several years), we may say that enough water flows into Owens Lake to irrigate 300,000 acres of land.

There are now irrigated in the valley about 30,000 acres. The taking of this amount of water from the stream has caused the shores of the lake to recede somewhat; but 70,000 acres is not far from the correct area. By canals proposed and those in process of construction in the valley, about 130,000 acres will be or may be irrigated beyond those already brought under cultivation. The completion of all these canals, however, would still leave flowing in the river enough water to irrigate 140,000 acres.

Let us consider another aspect of the question of the surplus water supply in Owens Valley. The irrigating months, under the climatic conditions which prevail there, are April, May, June, July, and August; and if thorough irrigation is practiced it must be carried on steadily throughout these months. The flood months are June and July, and during them the melting snows of the Sierras fill the stream until it carries six to eight times its ordinary volume. Of this flood not over one-third will ever be used to irrigate Owens Valley, as the amount of land reached by ditches will be only that amount irrigable by the ordinary flow during the months of April, May, and August, or very little more, at most.

During the rainy months of December, January, and February, the river is raised somewhat, but not to a flood height.

When all the available land in Owens Valley is irrigated there will still be running to waste in the lake almost the whole flow of the river during the months of September, October, November, December, January, February, and March—seven, or let us say six, months' flow. There will also be wasted two-thirds of the flood in June and July. In all, about five-eighths of the total flow of the river will be evaporated in Owens Lake. If it were possible to store a portion of this flow in extensive reservoirs at the headwaters of the river and its branches more of the valley might be irrigated. This, however, is impracticable on any large scale. The water-shed of the Sierras toward Owens River is extremely abrupt, rising 5,000 to 8,000 feet in two or three miles, and the only available reservoir sites are small valleys situated far up in the range, which drain from but small catchment areas.

One more point regarding the water supply is this: Owens Valley is a long narrow basin between two mountain ranges, and all water soaked up by the soil in irrigation seeps eventually to the river. If all the water were taken out high up in the valley the seepage from the lands irrigated there would soon form a stream amply sufficient to fill the small canals from the lower third of the river.

This condition would be more noticeable after a few years of extensive irrigation than at first.

To sum up, then, there is enough water flowing in Owens River to irrigate 300,000 acres of land. Owing to peculiar conditions of flow and usage of water, it is almost impossible that more than one-half this amount, or 150,000 acres, should ever be irrigated in Owens Valley, and highly improbable that it will be profitable to irrigate more than 125,000 acres. This leaves available for watering Antelope Valley about seven-twelfths of the total water supply, or enough to irrigate about 175,000 acres.

Antelope or Salt Wells Valley is situated about 50 miles south of Owens Lake. It contains about 475 square miles or 300,000 acres of valley land, not over two sections or 1,280 acres of which have been located. Fully 200,000 acres of this can be reached and covered with water by a canal entering at the north end, near Nine Mile Cañon Station.

The lowest point of the valley is on the east side, where a small salt marsh and a well of salt-water are found, which give the name found on Wheeler's map of "Salt Wells Valley."

The land slopes from all sides to this point at an average grade of 25 to 50 feet per mile. The dotted red line on the map accompanying this report is an approximate level around the valley from the mouth of the cañon at the north.

The land is excellent. The brush in places is from 5 to 6 feet high. Sand grass grew thickly upon it at one time, but has been fed off till the seed was exhausted. At present a few cattle range in the valley, and a few wild horses are found there.

The only good water in the valley is found at the mouth of "Nine Mile Cañon," at "Indian Wells," at "Cayote Holes," and at a well in the low eastern portion, where an abundance of good water is found about 30 feet below the surface of the earth. At none of these places does the supply amount to a miners' inch at the surface.

The main road south through the valley passes down the west side at the foot of the Sierras, through "Red Rock Cañon," to Mojave, 25 miles farther on, the junction of the Atlantic and Pacific Railroad with the Southern Pacific Railroad. Wagon roads from "Cayote Holes" to Darwin, Panamint, and "Searle's Borax Works" cross the even slope of the valley straight as arrows until they turn into the hills at the opposite side.

Back of "Cayote Holes" is Walker's Pass across the Sierra Nevada Mountains, one of the best passes over these mountains, and the only one between Tehachapi, on the south, and Mono Pass, 200 miles north of the valley under consideration.

At the southeast corner of the valley a break in a low range of hills opens to the low plains in which "Searle's Borax Works" are located.

Here the climate and soil are identical with those of Antelope Valley, but considerable water is obtained from springs and artesian wells, and at the Borax Works some 50 acres are under a high state of cultivation. In the orchard there are some thirty fine orange trees, which bear full crops of excellent fruit, besides many other more hardy species of fruit trees. From a 40-acre plat of alfalfa they cut a crop of hay every month in the year, an impossibility except on very rich and productive soil.

The climate of Antelope Valley is the same as that of all the interior of southern California. The little rain it receives is mostly from summer thunder-showers. In the winter the air is cool and strong winds blow from the south. In the middle of summer the temperature is no higher than that of San Joaquin Valley, ranging sometimes to 110° in the shade at meridian. The nights are, however, usually cool and pleasant, even more so than in the valleys west of the Sierras.

The summer heat of these so-called desert valleys has been maligned and called by some insufferable and deadly. The danger of travel here, however, is due entirely to another cause. An exceptionally clear atmosphere causes distances to appear to those unaccustomed to the country to be not more than one-third their real amount, and with an insufficient supply of water even for the trip contemplated travelers are often tortured with thirst before reaching water. Such carelessness has cost many a prospector his life in the arid sections of this country, where now, on account of the changes wrought by the hand of man, travel even on foot is comparatively easy and pleasant.

With water the heat of the sun here would be an advantage in all agricultural pursuits in the early and rapid maturing of all semi-tropical fruits, where now it is a drawback, on account of the total absence of water.

Having estimated the amount of good land available in Antelope Valley and the water supply in Owens River, it remains to consider the canal that would be required to carry the flood and winter flows of that stream to the land to be irrigated in this valley. The only reliable data to be had at present on this subject are of the section directly south of Owens Lake, and are obtained from the surveys of the Carson and Colorado Railroad extension, made in the year 1888.

Of the grade of Owens River and the slope of the land west of it nothing is definitely known; the general character of the country can be easily seen, but only a preliminary survey, or at least a careful reconnaissance, can be relied on to determine even to an approximation the course and length of the canal necessary.

The railroad levels show that the divide, which has its highest point about three-quarters of a mile north of "Hawai" Station, and about 9 miles south of Owens Lake, rises about 175 feet above the level of the lake. Since a cut could be made here, we may calculate upon a height of 160 feet. Let us suppose that a canal 90 miles long would have to be run from this point with a grade of 8 inches per mile to reach Owens River. This would make a height at the upper end of 160+8-12ths of 90, or 220 feet above Owens Lake.

The grade of Owens River is not known. It follows a rather tortuous course, and has a few rapids. Probably 4 feet to the mile is not too high an estimate of its fall; 6 feet per mile is probably about correct. A canal as proposed, running 90 miles north from Hawai, would tap it 60 miles up its winding course, and sixty times four, or 240 feet above Owens Lake, if the above estimate of the river's grade is correct.

Taking the water from a point 60 miles above the lake, near Big Pine, it could be carried on easy ground for about 25 miles. It would then be just north of the Alabama Hills, a low range lying parallel to the Sierras and close to their base. Whether the canal would pass behind or below them, only a level will show. In any case, only about 10 miles of rough work need be done.

To the west of the lake the ground would be fairly easy, and from Olancha to the entrance to the cañon, 4 miles north of Hawai, but little heavy cutting need be done. This point is 165 feet above the lake, and the ground falls, and then rises again 25 feet in going towards Hawai Meadows. The work along here might be quite difficult, but if extremely so, the whole narrow channel might be flooded.

From Hawai south to Volcano Valley the grade is quite heavy. No rock cutting would be necessary, but to keep the water from washing the loose soil it would have to be guided in its course part of the distance.

In Volcano Valley the line of wagon road on the west side (shown on the map), is about on a level. The ground to the east falls about 150 feet to the centre of the valley, two miles from the road. To the west of the volcano, at the southern end of the valley, the ground is about on the level of the road; and to the east it appears to be about the same height for most of the distance across to the hills on the opposite side. If it does continue across at this level, which a reconnaissance will show or disprove, no dam will be required and an outlet tunnel can be run through the narrowest part of the divide to the head of the cañon below.

If however a dam should be necessary, it need be but a comparatively small one to flood from 5 to 10 square miles to a depth of from 50 to 75 feet—a reservoir sufficient to store one-third the yearly flow of Owens River, at least.

Immediately below Volcano Valley is Little Lake, which could be used as a secondary reservoir. Below the lake a good channel could be secured with but little cutting, to the entrance to Antelope Valley.

In our consideration of water supply we have found that water enough for 175,000 acres is available in Owens Valley. Let us allow a very liberal margin for seepage and other losses, and say that only about one-half of this amount can be brought to Antelope Valley. This would make productive nearly 90,000 acres of land. This at a value of $100 an acre, which is not an exorbitant price for such fertile land when thoroughly irrigated, would make a valuation of $9,000,000.

I do not attempt to make even a rough estimate of the cost of construction of such a canal; but since 70 out of the 100 miles would be in easy ground, the rest must be extravagantly expensive to bring the total cost so high as not to leave a very large margin out of the $9,000,000 increase in value of what is now worthless land.

It is almost unnecessary for me to enlarge upon the splendid future of Antelope Valley should the proposed scheme be carried out. Two railroad surveys have crossed the valley; the Carson and Colorado from north to south, and the Utah Southern from east to west through Walker's Pass. It is probable that both these roads will be built in the near future. Owens Valley must have an outlet south, and Utah must some time continue her road from Frisco to California. The Sierra Nevada

Mountains to the west would yield from inexhaustible forests immense quantities of wood and timber for the railroads and the industries of the valley. To the north and east lies a splendid mining country, containing the Darwin, Paniment, Coso, Slate Range, Lyons, Death Valley, Armagosa, and other mining districts, which only wait railroad transportation to ship large quantities of rich silver and lead ores to some place where wood and fuel are to be had for smelting purposes. These, together with cheap water-power from the falls in the cañon, would be had at Antelope Valley.

I have said that $100 would not be too high a valuation for an acre of irrigated land in this valley were the proposed canal completed; but when we consider that the valley has as fine a climate as Los Angeles; that the soil is as good as any in the State; that a large and rich mining country would be tributary to it, and that the crossing of two railroads in it would give outlets north, south, east, and west, it does not seem improbable that, considering all the varied interests which would concentrate there, the value of property in a few years would be fully $200 per acre of land actually irrigated, and a thriving population of twenty to thirty thousand people would be supported where now but a few head of cattle can be ranged.

In conclusion, allow me to give the sources of the information furnished in this report:

Mr. L. F. J. Wrinkle, surveyor on the Comstock mines in Virginia City, made an examination of the proposed route of the canal, and collected data regarding Owens Valley and River. Being pressed for time, and knowing that I was well acquainted with the country south of the lake and with Owens Valley, he requested me to use his notes, and from them and my own knowledge to make a report on the plan to the Senate Committee on Irrigation. Almost all the information regarding Owens Valley and River I quote from his notes; that of the country south is of my own knowledge or from reliable information obtained while employed as surveyor of the Carson and Colorado Railroad extension to Mojave.

It may, of course, be the character of the country on the proposed canal route, and perhaps the configurations of Volcano Valley are so different from what is supposed in this report that the canal would be utterly impracticable. No facts are at hand, however, which prove this to be the case.

Probably there is no place in the country where so large a body of fertile, but at present dry and desolate, land is to be found, with water enough going to waste 50 miles away and 1,000 feet above it to irrigate 100,000 acres of it, which land belongs entirely to the Government, and might be reserved from sale until, with a good water right, it could be sold at a price to pay the cost of the canal.

I therefore take the liberty of laying this proposition before your committee, hoping that while you are having surveys made in California for Government canals and storage reservoirs, you will cause either a survey or a reconnaissance to be made in Owens and Antelope Valleys, and not dismiss the plan offered as visionary and impossible until you may have proved it so by reliable data.

Mr. Oliver, formerly engineer of the Carson and Colorado Railroad is authority for the statement that the average grade of Owens River from Bishop Creek to the lake is 7 feet per mile, and it is generally understood that near Bishop the grade is about 10 feet per mile. Mr. Wrinkle informs me that he leveled up the river for 4 miles from the lake and found the average grade to be 5 feet per mile for that distance. This is probably the lowest grade on the whole river.

The average velocity of flow in a stream such as Owens River, flowing 300 feet wide and 6 feet deep (with a fall of 5.28 feet per mile,) is (by "Kutter's" formula) 3.2 feet per second, or over 2 miles per hour, and the yearly flow 30,000,000,000 cubic feet, instead of 20,000,000,000, as I have estimated in this report.

The amount of evaporation from the lake is calculated as from a quiet surface, but the waves on the lake increase the actual surface and the evaporation is probably considerably in excess of 8 feet (the amount given by the United States Weather Bureau), and the total evaporation is probably 30,000,000,000 cubic feet.

The proposed canal would be expected to carry something over the average flow of the river; or, an amount equal to that which would be carried by all the other canals in Owens Valley. A canal 60 feet wide and 5 feet deep, with a fall of 1 foot to the mile, would carry (by Kutter's formula) the full flow of Owens River, or 30,000,000,000 cubic feet per year. The amount delivered at the lower end would depend on the length of the canal, the character of the soil in the country passed through, and the care exercised in the construction. The highest loss on record is 40 per cent. of total flow. The loss in the proposed canal would decrease considerably after several years' use of the water, as the fine silt carried by the stream would fill up the loose soil on the banks and bottom of the canal. This has been found to be the case in India, where very porous and poorly constructed dams have, after long use, become perfectly tight from the silt carried into them by the water.

The objection has been raised by some to whom this scheme has been proposed that the water rights of Owens River are all appropriated. This is true of the ordinary flow in the irrigating months, but the winter flow will never be used in Owens Valley, as the rain-fall during this season is fairly heavy. The flood flows will always be too large to be handled by the canals in the valley. Should the proposed canal be built it is probable that it would be profitable to take two-thirds of the flow of the river to the land of Antelope Valley, which is not only more fertile than most of that in Owens Valley, but also much nearer the markets of the country and the great overland roads.

Adjourned.

ON TRAIN, NEAR SAN BERNARDINO, CAL.,
September 2, 1889.

The committee met pursuant to the call of the chairman.

Present, Messrs. Stewart (chairman) and Reagan; also Director Powell.

STATEMENT OF W. C. BUTLER, OF REDLANDS, SAN BERNARDINO COUNTY.

The CHAIRMAN. What is your occupation?

Mr. BUTLER. I am an engineer.

The CHAIRMAN. What engineering work have you been engaged in in this county?

Mr. BUTLER. I have been connected with the Bear Valley reservoir, principally. I have here a map which shows what it is, giving the elevation of the dam, etc. [Hands in the map.]

The CHAIRMAN. Does it show the width at the base?

Mr. **Butler**. Yes; it shows the horizontal projection and the area at the present time covered by it.

The **Chairman**. Are all these areas represented on this map by figures?

Mr. **Butler**. Yes.

The **Chairman**. Upon what basis did you estimate the extent of waste weir? Can all the water run out at flood time without getting to the top of the dam?

Mr. **Butler**. Yes.

The **Chairman**. What provision have you made against flooding.

Mr. **Butler**. The work is not yet completed but we are working at it.

The **Chairman**. How much of a water-shed have you there?

Mr. **Butler**. Sixty miles. The present elevation of the waste-weir is 10 feet below the top of the dam.

The **Chairman**. In those waste-weirs do you not have a temporary gate so that you can keep in a part of the water?

Mr. **Butler**. Yes.

The **Chairman**. I wish to say to you that if any calamity should happen to this dam it would injure the cause of irrigation in the United States very greatly.

Mr. **Butler**. There is no doubt of that.

The **Chairman**. What is the width of it?

Mr. **Butler**. The thickness of the foundation is about 20 feet through at the bottom.

The **Chairman**. What is the height of the dam?

Mr. **Butler**. Fifty feet. You may recollect that this dam is not a gravity dam, but acts as an arch.

The **Chairman**. Explain that.

Mr. **Butler**. It acts as a curve, or arch, instead of a gravity dam. The radius of the curve is 325 feet. It depends upon its strength—upon the crushing resistance of the material rather than on its resistance to being shoved out. This dam has stood for five years. It is the first dam that has been built on this coast on that principle. It has been under considerable discussion during the past year, and I think the dam is taken by engineers to be a demonstration of the value of this principle. The Sweetwater dam is on this principle, but that is 90 feet high, 40 feet through at the base.

The **Chairman**. Do you intend to build that any higher?

Mr. **Butler**. Not on that base.

The **Chairman**. Can you not build another one below it?

Mr. **Butler**. It is cheaper to build below.

The **Chairman**. Have you commenced the construction of one below?

Mr. **Butler**. No.

The **Chairman**. (Showing the witness a map of the sections and cross-sections of the proposed dam.) How far is that from the other dam?

Mr. **Butler**. It is 150 feet below.

The **Chairman**. Are you going to fill in between the two?

Mr. **Butler**. No. This plan, if completed, will have a gravity section. That is, it will resist, to a pushing force down the cañon, a coefficient of two; and, in addition to this, it is built as an arch, and ends the same as the present one does.

The **Chairman**. Then you will abandon the present one when you get the second one?

Mr. **Butler**. Yes, practically. The present dam has cubical contents of 3,300 yards. The difficulty of completing the new dam so as to make a perfect bond between the two is so great that it would be cheaper to build the new dam below—starting on a new foundation. These 3,300 cubic yards cut so small a figure in the new dam that it would not be of sufficient value to include it. The cubical contents of this 80-foot dam on the side would be perhaps 25,000 cubic yards.

The CHAIRMAN. What other engineering have you done?

Mr. BUTLER. That is my principal work. Do not understand me as saying that I was the engineer of that work. I was simply an assistant. Mr. F. E. Brown was the engineer that planned and built the work, and I acted as his assistant.

STATEMENT OF G. W. BEATTIE, OF SAN BERNARDINO COUNTY

The CHAIRMAN. What is your occupation?

Mr. BEATTIE. I am county treasurer, but have had considerable to do with the water-works in the eastern end of the valley.

The CHAIRMAN. What do you say of the duty of water in the eastern end of San Bernardino Valley? How much will an inch of water irrigate?

Mr. BEATTIE. It depends to a great extent upon what we are growing. The orange I put from an inch to 3 acres up to an inch to 6 or 7 acres. Some crops require more than others.

The CHAIRMAN. Will you explain the mode of the distribution of water there? Do you take it up by ditches, pipes, or how?

Mr. BEATTIE. In this settlement we make stone ditches altogether. We have the ditches paved with stone, and the water is let out from the ditch by measuring weirs, and each party gets his pro rata.

The CHAIRMAN. You bring the water to a man's land?

Mr. BEATTIE. Yes.

The CHAIRMAN. How is it brought to the land?

Mr. BEATTIE. Through perforated flumes largely. But a large extent of it was a V-flume, with little slides over the openings to regulate the flow of water.

The CHAIRMAN. Then you do not flood?

Mr. BEATTIE. No; we do no flooding at all, except on alfalfa. Our use for water is largely for fruit growing. An inch of water is good for from 3 to 6 or 7 acres in that part of the country.

The CHAIRMAN. Have you paid any attention to drainage?

Mr. BEATTIE. No.

The CHAIRMAN. What is the difference between the value of land that is irrigated in that valley and land that has no chance to be irrigated?

Mr. BEATTIE. Land that could not be irrigated would not be worth over $25 an acre, while the same land if irrigated would bring from $150 to $200 or $300. It will vary according to the climatic conditions.

The CHAIRMAN. What does it cost, per acre, to irrigate it? What are the factors that fix the value at from $25 to $300 an acre?

Mr. BEATTIE. I hardly know how to answer that question.

The CHAIRMAN. Does the company own the water?

Mr. BEATTIE. The company consists of the people. It is a community company, and the company manages the water strictly for the good of the people. It is not conducted for a profit, but simply to manage the water rights.

The CHAIRMAN. About what does it cost to get things into that condition?

Mr. **BEATTIE.** The water ditches are a very small part of the valuation of the water rights. I suppose you understand that they are quite distinct.

The **CHAIRMAN** Take the water right, or anything you please, about how much an acre would it cost?

Mr. **BEATTIE.** I can not give you an answer to that.

The **CHAIRMAN.** What success have you with crops on irrigated land?

Mr. **BEATTIE.** On irrigated land we never have a failure with crops, except in some extraordinary or exceptional case.

The **CHAIRMAN.** What is an average return from the raisin vine?

Mr. **BEATTIE.** We do not consider $150 an acre gross to be an excessive amount.

The **CHAIRMAN.** How much net?

Mr. **BEATTIE.** One hundred dollars an acre.

The **CHAIRMAN.** How is it with oranges?

Mr. **BEATTIE.** We have very little experience on my place with those. We have growing trees that are beginning to bear.

The **CHAIRMAN.** Have you ever used too much water, or does that affect the crops?

Mr. **BEATTIE.** It does, because crops will mildew with excessive water, and the excessive use of water is apt to start certain diseases on the trees.

Adjourned.

ON TRAIN AT RIVERSIDE, *September* 2, 1889.

The committee met pursuant to the call of the chairman.

Present: Messrs. Stewart (chairman) and Reagan, also Director Powell.

STATEMENT OF CHARLES FRANKISH, OF ONTARIO.

The **CHAIRMAN.** In what county is Ontario?

Mr. **FRANKISK.** San Bernardino County.

The **CHAIRMAN.** What is your occupation?

Mr. **FRANKISH.** I am manager of the Ontario Land and Improvement Company.

The **CHAIRMAN.** What do you mean by manager?

Mr. **FRANKISH.** I have the full management of the company's lands and irrigating systems.

The **CHAIRMAN.** What is your irrigation system at Ontario?

Mr. **FRANKISH.** We take the mountain waters and distribute them by pipes through the irrigated lands.

The **CHAIRMAN.** How by pipes—what kind of pipes do you use?

Mr. **FRANKISH.** Cement pipes for irrigation, iron pipes for domestic purposes.

The **CHAIRMAN.** What kind of iron pipes?

Mr. **FRANKISH.** Wrought-iron and cast-iron; varying in size from 4 to 12 inches, cast-iron; cement pipes, 8 to 48 inches.

The **CHAIRMAN.** How are the cement pipes constructed?

Mr. **FRANKISH.** They are molded in lengths of about two feet and laid in sections, joined together by cement.

The **CHAIRMAN.** Do you lay them on the ground?

Mr. **FRANKISH.** Yes.

The **Chairman**. Of what size are they?

Mr. **Frankish**. From 8 to 48 inches in diameter.

The **Chairman**. What does a 48-inch pipe cost per lineal foot?

Mr. **Frankish**. They are 25 cents per lineal foot now.

The **Chairman**. What pressure will they stand?

Mr. **Frankish**. They are not supposed to stand over 25 or 30 feet head. We never put over that on them.

The **Chairman**. What quantity of water will pass through a 48-inch pipe with 25 feet head, say for a mile, without taking off the friction?

Mr. **Frankish**. If I remember, 3,000 inches, with a grade of one to the hundred.

The **Chairman**. What is the cost of a 24-inch pipe per lineal foot?

Mr. **Frankish**. About 50 cents per lineal foot.

The **Chairman**. What does a foot pipe cost?

Mr. **Frankish**. Twenty-four cents.

The **Chairman**. An 8-inch pipe?

Mr. **Frankish**. Seventeen cents per lineal foot.

The **Chairman**. How much land will a miner's inch, or one-fiftieth of a cubic foot, per second irrigate?

Mr. **Frankish**. Ten acres of land. Gravelly loam holds the moisture.

The **Chairman**. For what kind of crops will that irrigate 10 acres?

Mr. **Frankish**. The citrous fruits, oranges and lemons.

The **Chairman**. How much would it require to raise ordinary farm vegetables?

Mr. **Frankish**. I do not think any more would be required except it would be alfalfa.

The **Chairman**. I am not speaking of that; I am speaking of just the ordinary farm vegetables.

Mr. **Frankish**. It would require no more than for oranges.

The **Chairman**. Have you an ample supply of water?

Mr. **Frankish**. Not for all our land. We have the longest tunnel in the State; it is 2,900 feet long.

The **Chairman**. Running into what mountains?

Mr. **Frankish**. San Antonio Cañon, in the Sierra Madra Mountains.

The **Chairman**. Have you by means of that tunnel developed any water?

Mr. **Frankish**. Yes; we have flowing only a limited quantity; 60 or 75 inches at present. We are 400 feet beyond the point where we expected to get water.

The **Chairman**. Have you any opportunities there for the storage of water?

Mr. **Frankish**. Yes; four good reservoir sites at San Antonio Cañon, which are owned by the company.

The **Chairman**. Does much of the water run to waste in the winter season?

Mr. **Frankish**. Much, except what is used for domestic purposes. Of course the stream in the winter is ten times as great as in the summer season.

The **Chairman**. And that is all lost?

Mr. **Frankish**. Yes.

The **Chairman**. At what season of the year do you irrigate?

Mr. **Frankish**. From about the 1st of June to about the 1st of October.

The **Chairman**. Have you experimented with winter irrigation?

Mr. **Frankish**. Not to any extent. I think one or two individuals have, but I think our rains in the winter are ample. Unless there was a dry season, I do not think irrigation would benefit our locality, unless it came in a very exceptionally dry season.

The CHAIRMAN. How long has your system been in operation at Ontario, and what was the condition of things there when you commenced operations?

Mr. FRANKISH. The first sod was turned in June, 1883. It was an ordinary desert at that time, producing no crops whatever, and to-day we have an orange grove of three boxes to the tree. We have that this season.

The CHAIRMAN. What is the size of your orange grove?

Mr. FRANKISH. About 2,000 acres.

The CHAIRMAN. Do you raise any other citrous fruits there?

Mr. FRANKISH. Lemons. Lemons do exceedingly well with us. I believe there are probably 125 acres there in lemons.

The CHAIRMAN. Your trees have just commenced to bear?

Mr. FRANKISH. Yes. They bore last year, in some places 2 boxes to the tree, and this season they have fully 3 boxes to the tree. I am speaking of the older growth.

The CHAIRMAN. What was the land worth at Ontario before you commenced.

Mr. FRANKISH. I think the land might have been bought for $1.25 an acre.

The CHAIRMAN. What is it worth now?

Mr. FRANKISH. Our lowest price is $200 an acre. I have sold as high as $400 and $500, choice locations.

The CHAIRMAN. What water did you have to start with.

Mr. FRANKISH. The first measurement of the creek was 365 inches.

The CHAIRMAN. To what extent have you developed that?

Mr. FRANKISH. To a little over 400 inches at the present time. And we have a number of details showing more water, but not actual measurement, such as shafts sunk.

The CHAIRMAN. How many acres have you under your water system?

Mr. FRANKISH. There are about 5,000 acres piped. We have about 9,000 suitable for irrigation.

The CHAIRMAN. Do you expect to extend your pipes to the full 9,000 acres?

Mr. FRANKISH. Yes.

Adjourned.

RIVERSIDE, CAL., *September* 2, 1889.

The committee met pursuant to the call of the chairman.

Present: Messrs. Stewart (chairman) and Reagan; also Director Powell.

STATEMENT OF C. S. EVANS, OF RIVERSIDE.

The CHAIRMAN. How long have you resided in Riverside?

Mr. EVANS. I have resided here fifteen years.

The CHAIRMAN. Were you one of the originators of the scheme?

Mr. EVANS. I am the second originator. I built the second canal, which was originated by Judge North in the first instance.

The CHAIRMAN. What was the then condition of this country which is now covered by orange groves?

Mr. EVANS. It was a barren plain—dry land.

The CHAIRMAN. What was it worth per acre at that time?

Mr. EVANS. I suppose it was worth about the price it was sold for—from $3 to $5 an acre.

The CHAIRMAN. What is it worth per acre now, with water on it?

Mr. EVANS. It is worth, with water attached to the land, from $200 to $300 an acre—dry land, unimproved land, I mean.

The CHAIRMAN. What is it worth when you get oranges on it?

Mr. EVANS. Our orange orchards are selling at from $750 to $2,500 an acre.

The CHAIRMAN. What is the net annual return from orange orchards selling at that price?

Mr. EVANS. They will pay 10 per cent. on the money that is paid for them.

The CHAIRMAN. Then the land is worth the price on which you can pay 10 per cent?

Mr. EVANS. Yes.

The CHAIRMAN. How much land here is under cultivation, under water; how much can be covered by irrigation?

Mr. EVANS. About 12,000 acres.

The CHAIRMAN. What part of that is actually under irrigation?

Mr. EVANS. I am speaking of the area that is under the Riverside Water Company's canal—12,000 acres.

The CHAIRMAN. How much is under other water-works?

Mr. EVANS. There is about the same amount.

The CHAIRMAN. Making about 24,000 acres in all?

Mr. EVANS. Yes.

The CHAIRMAN. How much of the 24,000 acres is actually under cultivation?

Mr. EVANS. Perhaps more than 12,000 outside of this company; that is, the Gage system—what is called the Vivienda.

The CHAIRMAN. Then that would make more than 24,000 acres?

Mr. EVANS. Perhaps from 25,000 to 30,000 acres.

The CHAIRMAN. Of that land which is covered by these systems, what amount is actually under cultivation?

Mr. EVANS. There is actually under cultivation under the old canals—that is, the Riverside Water Company's canals—6,300 acres.

The CHAIRMAN. How much under the new system?

Mr. EVANS. About 1,500 acres. There is none under cultivation in the Vivienda. That comprises the amount under cultivation.

The CHAIRMAN. Have you a water supply for the 25,000 acres, so that it may be ultimately put under cultivation?

Mr. EVANS. I think we have, without any question.

The CHAIRMAN. Have you made any attempts to increase your supply of water beyond what naturally flows in the streams.

Mr. EVANS. Yes. We have built in the last two years flumes and aqueducts, and have cemented a portion of the canals. We have extended our upper canal system where it originally headed in the river from the tributary, Warm Creek, so that we get water through a canal that is partly cemented, partly in the earth, and from a long flume or tunnel from which it is taken into the old canal about a mile and a half above our town.

The CHAIRMAN. Do you find that it is of material value in saving water to cement your ditches.

Mr. EVANS. Yes, a very great saving of water. It saves in evaporation and seepage very considerably.

The CHAIRMAN. Is that an expensive system?

Mr. EVANS. Yes, somewhat expensive.

The CHAIRMAN. What is the size of your ditch?

Mr. EVANS. Mr. Newman, the engineer, can give you that.

The CHAIRMAN. What system have you for distributing water? Do you allow it to run into the ditches, or do you have it piped?

Mr. EVANS. We have both systems. We are extending the pipe system. That is not the irrigation system. We have a system of iron pipes, for domestic purposes, in the artesian belt through our town and throughout the valley seven miles below.

The CHAIRMAN. For irrigation purposes you have now commenced to use pipes. What kind did you use before?

Mr. EVANS. Concrete cement pipes.

The CHAIRMAN. Have you estimated per acre the cost of the pipe system?

Mr. EVANS. Yes.

The CHAIRMAN. How much is it?

Mr. EVANS. The engineer can give you that better than I can.

The CHAIRMAN. Can you tell something with regard to the productiveness of the soil for oranges, etc.? Can you make a statement as to the result of irrigation?

Mr. EVANS. We have certain areas in grapes and oranges. Those are our staple productions. We have experimented from fifteen years ago with everything until we have gotten down to a standard– raisin grapes, oranges, and lemons. Our vineyards are from four to six years old; a fair production, I think, will average $100 per acre.

The CHAIRMAN. One hundred dollars an acre gross or net?

Mr. EVANS. That is the gross return. They net $75 per acre per annum.

The CHAIRMAN. What do you find with regard to oranges?

Mr. EVANS. They are paying according to their condition and age from $300 to $1,250 per acre. Our best oranges are paying from $1,000 to $1,250 per acre, and younger oranges from $300 to $500 per acre.

The CHAIRMAN. Are those the net or gross returns?

Mr. EVANS. Those are the gross returns.

The CHAIRMAN. What would they be net?

Mr. EVANS. Take off $50 an acre, and that would represent the cost of cultivation.

The CHAIRMAN. That would be $1,100 net?

Mr. EVANS. Yes. You can say $1,000 for the oldest oranges.

The CHAIRMAN. How much would it be for trees four years old?

Mr. EVANS. That would depend entirely upon the kind of trees they were. If budding trees, they would commence to bear at three years old, and would get a pretty fair paying crop; if seedlings, they would bear from ten to twelve years from the seed.

Senator REAGAN. What is the distance from the source of your water to the main canal? What distance do you have to bring your water?

Mr. EVANS. We have two main canals; one of them 12, and the other under Mr. Newman, which is from 4 to 5 miles.

Senator REAGAN. Do you raise small grain in this valley?

Mr. EVANS. Yes, we do; but it is on dry land. We do not raise much by irrigation.

Senator REAGAN. What kind of crops do you raise on the dry land?

Mr. EVANS. Barley is the principal crop in this country.

Senator REAGAN. Can you state what is the profit on unirrigated land that is in barley?

Mr. Evans. I do not know that I can give you that as well as other parties. Well, we will probably get two or three crops out of five.

Senator Reagan. Do you raise wheat?

Mr. Evans. We do; but it is not a valuable crop with us. It is subject to the rust. We raise alfalfa to good advantage on irrigated land.

Senator Reagan. How many tons of alfalfa to the acre do you expect to realize on irrigated land?

Mr. Evans. A crop of alfalfa, attended to as it ought to be, will produce from 6 to 8 tons per acre a year.

STATEMENT OF G. O. NEWMAN, OF RIVERSIDE.

The Chairman. How long have you resided at Riverside?

Mr. Newman. Since January, 1875.

The Chairman. What is your profession?

Mr. Newman. Civil engineer.

The Chairman. Are you acquainted with the Riverside irrigation works?

Mr. Newman. I am the engineer of the Riverside Water Company.

The Chairman. Make a statement in your own way of the sources of your water supply, how much water you have, the amount of land you cover, and the expenses, etc.

Mr. Newman. Our main supply is from the Santa Ana River, and this summer we have sunk some artesian wells. We have also put in some underground drains. Altogether we take in about 3,200 inches of water.

The Chairman. How many cubic feet per second would that be?

Mr. Newman. That is 40 cubic feet per second, and of that we sell but 2,000 inches; the balance is lost by seepage and evaporation in the ditches. We have about 32 miles of main canal and 150 miles of distributing ditches.

The Chairman. You have made some efforts to diminish the amount of evaporation and seepage?

Mr. Newman. Yes; by cementing the canal.

The Chairman. State how much that cost, and how it affected the evaporation and seepage.

Mr. Newman. Where we cement the canal we lay 6 inches of stone and rubble masonry, and plaster that over with cement. That cost $2.75 a lineal foot.

The Chairman. That is along your canal?

Mr. Newman. Yes.

The Chairman. How large is your canal?

Mr. Newman. Eight feet wide at the bottom and four feet deep.

The Chairman. How much of your canal have you improved in that way?

Mr. Newman. We have not more than about a half-mile altogether, except the tunnel. We have a tunnel 3,300 feet long, and that is all cemented.

The Chairman. Have you cemented enough to estimate the difference between letting it run in the ditch without improvement and in the cemented work? Can you state what the difference between the two is?

Mr. Newman. No, I cannot say that. We have run in from where we take the water out of Warm Creek 1,400 feet of cemented canal;

after that 7,000 feet of flume, and 3,300 feet of tunnel cemented. There is a five-inch stream, and when it leaves the tunnel it will sink 150 feet.

The **CHAIRMAN**. What quantity will it discharge at the lower end?

Mr. **NEWMAN**. About 3 inches of it—about three-fifths will run through. But that will sink entirely within 150 feet of the tunnel.

The **CHAIRMAN**. If you had the same kind of cement work all along how far would it run?

Mr. **NEWMAN**. It ought to run 3 miles before it all could run out.

The **CHAIRMAN**. In distributing the water do you do it in ditches or by pipes?

Mr. **NEWMAN**. Mostly in ditches. We have lately commenced to put in cement pipes in the lateral ditches.

The **CHAIRMAN**. Have you experimented enough with cement pipes to know what would be the difference?

Mr. **NEWMAN**. Yes.

The **CHAIRMAN**. What is the difference between the duty of water in cement pipes and water in ditches?

Mr. **NEWMAN**. In ditches we lose at least 15 per cent. Still that varies. If a ditch is used when it is dry we will lose more during the first days of irrigation. With the pipe lines the loss cannot be more than 5 per cent.

The **CHAIRMAN**. What is the duty of water with your ditches?

Mr. **NEWMAN**. Do you mean how many inches to the acre?

The **CHAIRMAN**. How much land will an inch of water serve?

Mr. **NEWMAN**. One inch to three acres.

The **CHAIRMAN**. Have you estimated what would be the duty of water if you had pipes put down to the best advantage?

Mr. **NEWMAN**. Yes. Well, I can not say that I have estimated that fully, because we have not had in enough pipes to draw from.

The **CHAIRMAN**. The engineer at Ontario estimates the duty of water to be an inch to 10 acres.

Mr. **NEWMAN**. When the trees get to bearing?

The **CHAIRMAN**. I will ask you this question. Do you know the character of soil that they have at Ontario, and whether it is different from this soil here?

Mr **NEWMAN** The Ontario soil is very sandy.

The **CHAIRMAN**. Which would require the most water, the Ontario soil or this here?

Mr. **NEWMAN**. I should judge that the Ontario soil would require the most.

The **CHAIRMAN**. They say they serve 10 acres with an inch of water.

Mr. **NEWMAN**. But they can not make a success of raising oranges. They can make the trees grow, but they can not get the fruit without giving the trees the water.

The **CHAIRMAN**. Suppose the water were carried in pipes to the tree, or where you wanted to use it?

Mr. **NEWMAN**. It would pretty nearly come to that.

The **CHAIRMAN**. One inch to 5 acres?

Mr. **NEWMAN**. Yes, 1 inch to 5 acres. And I think that is the limit.

Mr. **HINTON**. The difference then would be 3 acres in ditches and 5 in pipes?

Mr. **NEWMAN**. Yes.

The **CHAIRMAN**. Do you agree as to the amount of land that is covered by these streams, that is to say, that it is 25,000 acres?

Mr. **NEWMAN**. Yes; about that.

The **CHAIRMAN**. Is there a water supply for the whole of that?

Mr. **Newman**. That I could not say; this summer it has shown that the artesian basin is rather low.

The **Chairman**. Is this the usual season or is it dryer than usual?

Mr. **Newman**. It is rather a dry season, but it is not one of the dryest.

The **Chairman**. You have not tried to store water?

Mr. **Newman**. No, not here.

The **Chairman**. Nor have you examined to see whether there are any opportunities for storing water?

Mr. **Newman**. Right here there is not a good opportunity; we have Bear Valley up above. That is an excellent place.

The **Chairman**. That is used at other places; the water does not come here.

Mr. **Newman**. Some water from there got down here this summer. They had to let it out and we got the benefit of it.

The **Chairman**. What does it cost per acre to irrigate by the pipe system; to use cement pipes? What does it cost to provide that system?

Mr. **Newman**. We have very little of the cement pipe, having just commenced this summer, and it would be difficult to tell. We have used open ditches here altogether.

Mr. **Hinton**. What is the cost per acre for the ditches?

Mr. **Newman**. That varies considerable; some persons irrigate so much more than others. Here is the percentage of water used in different months: In January, 2 per cent; in February, 1 per cent; in March, 2 per cent; April, 9 per cent; May, 15 per cent; June, 18 per cent; July, 16 per cent; August, 15 per cent; September, 12 per cent; October, 7 per cent; November, 4 per cent; and December, 1 per cent.

The **Chairman**. You spoke of selling the water to the people. How is the water owned, and how do the people acquire it?

Mr. **Newman**. The oldest settlers own the water, and they just pay enough to keep up the running expenses of the company.

The **Chairman**. And the water is connected with the land?

Mr. **Newman**. The water is connected with the land.

The **Chairman**. And the charge is made according to the amount of water they use, sufficient only to get a living for keeping up the company?

Mr. **Newman**. Yes.

The **Chairman**. And the settlers elect their officers and carry this out?

Mr. **Newman**. Yes.

Mr. **Evans**. Each acre of land under these canals is provided with water stock, and the owner of the land has the water stock. There are three shares of water stock to each acre of land, because some sections are laid off into half-acre lots. The half acre represents a share of stock, and the owners of the land throughout the whole valley are the stock owners. There are two companies, and the settlers and the different companies are stockholders in the Riverside Company.

The **Chairman**. And they vote in proportion to the amount of stock they own.

Mr. **Evans**. Yes. One share of stock is entitled to a vote.

The **Chairman**. And they assess themselves to say how much is to be charged to the consumer?

Mr. **Evans**. The rate is fixed by the authorities, the municipal or county government. Here we have city trustees to fix the rate according to law They fix it at the dictation or suggestion of the water company.

The CHAIRMAN. They rate it at the amount that they require for their own purposes in order to declare dividends?

Mr. EVANS. Only to cover expenses. The rate until this last year for several years back was 7½ cents per inch for twenty-four hours. This year the rate was advanced to 10 cents an inch.

The CHAIRMAN. Why did you advance it?

Mr. EVANS. Because we increased the expense by making improvements on our water-works.

STATEMENT OF JOSEPH JARVIS, OF RIVERSIDE.

The CHAIRMAN. How long have you resided in Riverside?

Mr. JARVIS. Between twelve and thirteen years.

The CHAIRMAN. What is your occupation?

Mr. JARVIS. Fruit growing, principally.

The CHAIRMAN. What do you say as to the duty of water?

Mr. JARVIS. In the midsummer months it is 1 inch to 3 acres; but during the winter months a good deal less water is required. But during the active season, when we require the water, the duty is 1 inch to 3 acres, whether delivered through the ditch or the pipe line.

The CHAIRMAN. Is there a surplus of water in the winter season in the river that you could take out and prevent from going to waste?

Mr. JARVIS. Yes, for several months in the winter season there is a loss of water.

The CHAIRMAN. You make no effort to store or save that water?

Mr. JARVIS. We have no storage reservoirs provided by our system here.

The CHAIRMAN. If you had reservoirs would there be surplus water that you could store?

Mr. JARVIS. Yes, during the winter months there would be.

The CHAIRMAN. What system of irrigation do you use on your place? Have you ditches, or have you the pipe service?

Mr. JARVIS. There are ditches and a flume upon my place.

The CHAIRMAN. Is a flume better than a ditch to save evaporation and seepage?

Mr. JARVIS. It saves the seepage nearly altogether, and narrows the exposed surface very much, and thus saves evaporation. If the asphalt be properly placed in the ditch, and it be cemented, there would be no seepage. Probably at the joints there would be a little.

The CHAIRMAN. What has been your experience with regard to irrigation on cultivated land? What does the land produce here?

Mr. JARVIS. Do you mean as to the acre?

The CHAIRMAN. No, I mean quantity, the value of the produce.

Mr. JARVIS. From orchards in full bearing I have taken as high as $300 for peaches, $250 for pears, $450 for oranges, and $250 for grapes.

The CHAIRMAN. Are those the net or gross returns?

Mr. JARVIS. Gross.

The CHAIRMAN. What would be the net return?

Mr. JARVIS. It would be about $150 for raisins and grapes, $125 for pears, and oranges $300. I have taken off a single acre of apricots $500, and that would net $450 or $350. My orchards, I wish to say, are not in full bearing, but the vineyards are in full bearing. My orchards have some years to grow before they will attain their best.

The CHAIRMAN. How long have they been growing to produce the results you have mentioned?

Mr. Jarvis. Last spring it was eleven years since I commenced to plant.

The Chairman. How are the best orange orchards? What do they yield in the gross?

Mr. Jarvis. There are some that yield in gross $1,100; others $1,000 and $800. Numbers receive $800—$600 and $800 are quite common.

The Chairman. Including the water, cultivation, planting out, and nursing, until you would commence to get results from an orange grove, what would it cost per acre?

Mr. Jarvis. That is modified very largely by the first cost of the trees. At the present time trees are expensive, and have been for three or four years. Prior to that, when we could buy trees for 75 cents each instead of $2, as we have been paying recently, an orchard could be set out very moderately. Then it would have cost $30 per acre per annum until they would commence to bear. Good budding trees will pay running expenses and possibly leave a small margin the fourth year. That is doing exceedingly well; but they do that occasionally.

The Chairman. For planting out and attending to them for three years until they commence to bear, about what is the gross expense?

Mr. Jarvis. The average would be about $300 per acre. That is taking it all around, and counting the medium price per tree at $1.

The Chairman. What is the land worth?

Mr. Jarvis. From $500 to $750 an acre, depending upon the condition of the trees.

The Chairman. What is the value of the land here where there is no prospect of irrigation?

Mr. Jarvis. About $2.50 an acre, depending upon the character of the land. If it is somewhat moist land, that will grow grain, it is worth from $25 to $50 an acre.

The Chairman. I mean such land as Riverside is on. Provided there was no chance for irrigation what would it be worth?

Mr. Jarvis. It would not be worth over $10 an acre.

The Chairman. Take the land itself now when you have water on it, but before you have put any trees on it, what is it worth?

Mr. Jarvis. From $250 to $400 per acre.

The Chairman. What is it worth after you have got on to it a four-years' growth of well-cared-for orange trees?

Mr. Jarvis. From $700 to $800 per acre.

The Chairman. What is it worth when the trees get to be ten years old?

Mr. Jarvis. Orchards have sold here as high as $2,000 per acre, and they are worth more, because they have paid an interst of 10 per cent. on that.

The Chairman. How long is the life of an orange tree that is well-cared for? Of course you have not seen the end of it here, but what is your opinion?

Mr. Jarvis. The history of the orange tree is that it has the longest life of any tree we have. In the old country they have orange trees in good bearing one hundred years old, and many of them older than that and in good bearing. Whether in this climate they will live that long is a question that will have to be decided by the future.

STATEMENT OF A. H. NAFTZGER, OF RIVERSIDE.

The **CHAIRMAN**. You may go on and make any statement you think would be of interest to the committee.

Mr. **NAFTZGER**. I wish to say what I think of the relative values of irrigated and unirrigated land. I think Dr. Jarvis has expressed my views exactly, except that I think the land that can not be irrigated is of no value at all. I would not pay taxes on it myself. So that the land that can not be irrigated, or has no prospect of being irrigated, I should consider as having no value whatever. A man might use it ten years to grow a little winter hay or barley on, but I should consider it to be absolutely of no value. With regard to lands that have water on them, I think Dr. Jarvis's estimate a fair one, from $250 to $400 per acre, depending upon the quality of the soil and its relation to the markets, etc.

The **CHAIRMAN**. Do you agree as to the value of the crops that the land will produce?

Mr. **NAFTZGER**. Yes. I judge from the results that have been produced and the sales that have been made. I think that Dr. Jarvis's estimates are certainly conservative.

STATEMENT OF MATTHEW GAGE, OF RIVERSIDE.

The **CHAIRMAN**. What have you to say as to your system of canals?

Mr. **GAGE**. About five years ago I purchased a tract of about 2,400 acres in Santa Ana River bottom, about 12 miles from Riverside. On that land I dug a number of trenches and bored a system of artesian wells, forty-two in number; in depth from 100 to 500 feet, averaging about 175 feet each. From these wells I have a flow of about 1,700 inches of water in the dry season of the year. That water comes from a strata of coarse gravel, sand, and bowlders that underlie the Santa Ana Valley. I have constructed a canal from the supply down to the land on the east side of the Colonnade, Riverside, 25 miles from the head. I have sold water-rights to about 3,500 acres of land along the line of the canal, and I have a tract of about 5,000 acres of my own, which I am now putting upon the market. I purpose distributing this water through iron pipes. The cost of that pipe system is about $12.50 an acre, in large tracts.

The **CHAIRMAN**. Can you do it as cheaply as that?

Mr. **GAGE**. I think so. It depends on the price of iron.

The **CHAIRMAN**. Describe the pipe you use.

Mr. **GAGE**. It is about No. 16 iron, and ranging in size from 8 inches to 4 inches in lateral distributing lines.

The **CHAIRMAN**. What means do you take to keep the pipe from rusting.

Mr. **GAGE**. A coating of asphaltum and some other things that practically preserve it for a great many years. With this system there can be no waste by seepage or evaporation, and the duty of the water under the Gage system is 1 inch to 5 acres.

The **CHAIRMAN**. Have you tested it so that you know you can get along with one inch to five acres?

Mr. **GAGE**. We have not tested it to the extent that the Riverside water people have; but from the general use of the water throughout the country we estimate that it is ample.

The **CHAIRMAN**. With the pipe system is it equal to 3 inches by ditches.

Mr. GAGE. No, it is 1 inch to 5 acres.

The CHAIRMAN. Will an inch serve five acres under the pipe system as well as an inch will serve three acres under the ditch system?

Mr GAGE. No; because the Riverside Water Company delivers its water on the land as I do; so that, with their system they have a greater use of water than we think necessary with ours. There is a difference somewhat in the soil and local conditions making the use of water varied. One inch to three acres on some land may not be any better than one inch to five acres on other land. We have considered one inch ample water to five acres under our system. We purpose cementing our pipes. We have a mile and a half down now through a line of tunnels. We purpose continuing it in places where the land is porous. We do not consider that the amount of water lost in seepage would compensate for the amount of money necessary to concrete the ditch.

The CHAIRMAN. All the way?

Mr. GAGE. Yes.

The CHAIRMAN. You only take the places where the land is porous.

Mr. GAGE. Yes. I would supply the money for the waste rather than for the concrete.

The CHAIRMAN. Is there anything further that you wish to state of the advantages of your system?

Mr. GAGE. There is nothing special in its advantages over the Riverside system.

The CHAIRMAN. What did you pay for your land?

Mr. GAGE. Six hundred and forty acres of it I paid $1.25 an acre for, and being poor at that time I could not deal with my friend Mr. Evans, and I had to go back and pay $75 an acre when I made it valuable.

The CHAIRMAN. What have you been selling your land for?

Mr. GAGE. From $300 to $600 an acre.

Adjourned.

SANTA ANA, CAL., *September* 2, 1889.

The committee met on the call of the chairman.

Present, Messrs. Stewart (chairman) and Reagan; also Director Powell.

STATEMENT OF JAMES McFADDEN, OF SANTA ANA.

The CHAIRMAN. What is your occupation?

Mr. McFADDEN. Farming, and a number of other things.

The CHAIRMAN. Do you practice irrigation in this locality?

Mr. McFADDEN. In part of it—the part toward the foothills. Perhaps from Santa Ana north toward the foothills they practice irrigation more or less.

The CHAIRMAN. In some portions of the country here you can cultivate crops without irrigation?

Mr. McFADDEN. Yes; in some portions of the valley.

The CHAIRMAN. What crops do you raise?

Mr. McFADDEN. Almost anything you can plant that grows in other parts of the United States—corn, barley, and potatoes.

The CHAIRMAN. The land is irrigated by the subsoil or dampness from below, which percolates from the river?

Mr. McFADDEN. I do not know about the river. In that section of the country we get artesian water.

The CHAIRMAN. What crops do you raise where you irrigate?

Mr. McFadden. We raise almost any kind of crops that you put in. But the crop that needs irrigation most is probably the orange tree.

The Chairman. From where do you get your water with which to irrigate?

Mr. McFadden. In the Santa Ana river, mostly.

The Chairman. How extensively are you cultivating the orange tree in this locality?

Mr. McFadden. I am not sure about the acreage. Perhaps some of these other gentlemen can answer that question better than I can. If I were to answer, it would be only a guess. But, I suppose, in the Santa Ana valley there are perhaps 4,000 or 5,000 acres in orange trees. Do you think that is about right, in the aggregate, Mr. Taylor?

Mr. Taylor. I think fully that many.

The Chairman. What is the land worth before it is irrigated—the land that requires irrigation? If it could not be irrigated what would it be worth?

Mr. McFadden. If the orange land could not be irrigated it would not be worth anything for orange trees. But it could be used for something else.

The Chairman. What?

Mr. McFadden. For small grain; and without irrigation it would probably grow vines very well, most of it.

The Chairman. What is it worth with irrigation?

Mr. McFadden. Do you mean the land without the trees, or with the trees?

The Chairman. The land without the trees, but when you have water on it.

Mr. McFadden. Good orange land without the tree and with irrigation is worth from $300 to $500 an acre.

The Chairman. When the trees are upon it and five or six years old, bearing, what is it worth?

Mr. McFadden. I suppose some of it has sold for about $1,000 an acre.

The Chairman. What does an orange grove in this locality yield per acre when it is in good condition?

Mr. McFadden. I am not strictly an orange man, and I wish some other gentleman would answer that question. I have not followed that business much.

The Chairman. Have you abundance of water here for irrigation?

Mr. McFadden. Yes; we have quite an abundance in the river for most of the valley. We extend that irrigation over lands, perhaps, to a greater extent than we have water to cover.

The Chairman. You have not been under the necessity of attempting to increase the water supply?

Mr. McFadden. Not yet. We use most of the water at the present time that is needed.

STATEMENT OF D. M. BAKER, OF SANTA ANA.

The Chairman. What is your occupation?

Mr. Baker. My occupation is that of editor—newspaper publisher.

The Chairman. And as such you have paid attention to the result of irrigation to the orange business, etc.?

Mr. Baker. Yes; to some extent. I am a man, only a tax-payer, as well as the other gentlemen around here. To that extent it has been my business.

The Chairman. What is the net proceeds from an orange grove after it comes to maturity, five or six years old?

Mr. **BAKER**. If you want an average, I can give you facts from authentic and reliable sources. For the last year or two I know one gentleman, a Mr. Wall, our county treasurer, who has a 12-acre orchard, and two years ago it netted him $6,750. That orchard is about twelve or fourteen years old. He is exceedingly good at agriculture and horticulture, and has made that a business here for many years. Those are the figures he gave me, and he is as reliable a man as there is in the State. That is the net result of his orange grove two years ago.

The **CHAIRMAN**. That is over $500 an acre.

Mr. **BAKER**. Yes; that is over $500 an acre.

The **CHAIRMAN**. What would be his average profit?

Mr. **BAKER**. I can not give you the average. I think myself that was extremely large for the time. It was an unusually good yield, and an extraordinarily good season. What had been his average before, I do not know. However, every crop in the valley here up to that period was large; but he seemed by good management to realize more than the average person. I think a well-matured orange grove ought to realize $500 an acre with irrigation. I think our friend, P. T. Adams, realizes that every year. He lives down here a couple of miles.

The **CHAIRMAN**. Do they ever have much of a failure?

Mr. **BAKER**. Not unless they get affected by the booms. I have never known a man being affected in his orchard where he attended to his business.

The **CHAIRMAN**. That disease is subsiding to some extent?

Mr. **BAKER**. I think it has gone down to some extent. So far as I can tell, it has subsided considerably in southern California.

The **CHAIRMAN**. The people are now attending to their business?

Mr. **BAKER**. Yes; they have been for the last two years. It is a necessity that they should.

The **CHAIRMAN**. You say that your crops have been destroyed?

Mr. **BAKER**. Crops have been exterminated in this valley by disease.

The **CHAIRMAN**. You have not discovered what it is.

Mr. **BAKER**. I can not tell what it is. Mr. Pierce, the entomologist, says he knows what it is.

The **CHAIRMAN**. Has he suggested a remedy?

Mr. **BAKER**. No; he has not the slightest idea of a remedy.

The **CHAIRMAN**. Does it extend into your county?

Mr. **BAKER**. No, it extends from Fresno to Ensenada. He finds it at Riverside, and we thought it exempt. He finds symptoms of it at Fresno, and he finds it prevails all over southern California. He finds they are badly affected with it at Ensenada. He is preparing a report to make to headquarters.

The **CHAIRMAN**. You have had no difficulty in supplying all the water you want from Santa Ana river?

Mr. **BAKER**. So far as my experience goes we have never had any difficulty. I own land on the other side of the river, 10 miles from here. We have abundance of water there, and, in fact, the land I own requires very little irrigation. I have not put a drop on it for two years, and it is a large tract. All over the surface we find plenty of water. The land produces grapes, oranges, and lemons, all along.

STATEMENT OF E. E. EDWARDS, OF SANTA ANA.

Senator **REAGAN**. What is the territory that may be irrigated by the Santa Ana River?

Mr. **EDWARDS**. I should say about 60,000 acres.

Senator **Reagan**. How much of that is now under irrigation?

Mr. **Edwards**. It is only a rough estimate; but I should say 20,000 acres.

Senator **Reagan**. Is there any portion of the valley cultivated and in crops that is not under irrigation?

Mr. **Edwards**. Yes; especially the wet years. The San Juan Ranch, adjoining Tustin, has 115,000 acres. There are probably 40,000 acres of land that is level, nice for irrigation, but that has no water on it. San Juan Ranch, ever since I have known it, has been pastured with sheep until this year. This is the first year that I have seen any extensive crops on it.

Senator **Reagan**. What crops?

Mr. **Edwards**. Crops of barley.

Senator **Reagan**. Have they tried wheat?

Mr. **Edwards**. I do not know.

Senator **Reagan**. You do not know what the production of barley to the acre has been.

Mr. **Edwards**. No; I can not tell you. I passed over it last week, and there are several hundred acres planted this year, and they were threshing it out. Here is Mr. French, who has been superintendent of that ranch for many years, and he could tell you more than I.

STATEMENT OF VICTOR MONTGOMERY, OF SANTA ANA.

The **Chairman**. State anything you think may be of interest to the committee.

Mr. **Montgomery**. I came to this valley seventeen years ago, and there was very little land irrigated. The colonists at Anaheim had a few acres under cultivation and were raising vines. This side was struggling with a small ditch that they plowed out in furrows, and had a few hundred acres under irrigation. I have seen that extended from year to year, until I see now both sides of the river have in the neighborhood of 15,000 or 16,000 acres covered.

The **Chairman**. And 40,000 that has no water on it.

Mr. **Montgomery**. Yes.

The **Chairman**. What would it be worth if it had water on it to irrigate it?

Mr. **Montgomery**. From $250 to $500 an acre, depending on its accessibility to market.

The **Chairman**. Would it bring $300 an acre?

Mr. **Montgomery**. I think it might.

The **Chairman**. And it is worth—how much?

Mr. **Montgomery**. That land would sell for from $25 to $50 an acre, depending on its accessibility to market.

The **Chairman**. Water would add $250 to its value.

Mr. **Montgomery**. Yes; San Diego Creek, that comes in about the range into the plain there, is a fine place for storing water, and storage reservoirs might be built all along that bench. When I first bought land there they were irrigating a few hundred acres of land, and now I think our system covers 2,000 acres. We put in a submerged dam and cement pipes, and we are using the same source of supply that our predecessors used. They used it all on a couple of hundred acres, and we are now irrigating 2,000 acres as successfully as they irrigated 200 acres, and with the same water supply.

The **Chairman**. You would not take much interest in Government surveys. They would not help you much if there were no public lands to be reserved.

Mr. Montgomery. In the valley I do not know but that public surveys would do good, because of the jealousy of local land-holders. There a man could have a source of water supply and might not want to divide with his neighbor, and I think it will have to be brought under some Governmental control before there will be enough water.

The Chairman. And you think there would be enough water in the Santa Ana River if it were all saved.

Mr. Montgomery. Yes; I think a submerged dam could be put in profitably.

The Chairman. I should think 40,000 acres of land with $250 added to each acre would be a big inducement.

Mr. Montgomery. That is in various holdings, and you could not get concentrated efforts, concentration of means.

The Chairman. Perhaps you might form an irrigation district.

Mr. Montgomery. Our friends across the river tried that. We want to see how they get along. Without irrigation this country is comparatively worthless, and with irrigation I do not know what might be done here. Everything seems to be possible in the way of production. I do not think the estimate of profits on orange culture has been placed too high by Mr. Baker—$500 per acre for a good bearing orange orchard certainly is not too high.

The Chairman. Do you every year have the same demand for oranges?

Mr. Montgomery. No. Some years the demand is not good. When the Florida crop is good we do not find ready sale for our crop here. But lately Florida has suffered and we have profited by it.

Adjourned

San Diego, Cal., *September* 3, 1889.

The committee met pursuant to the call of the chairman.

Present: Messrs. Stewart (chairman) and Reagan, also Director Powell.

STATEMENT OF THEODORE VAN DYKE, OF SAN DIEGO.

The Chairman. How long have you resided in San Diego?

Mr. Van Dyke. I have lived about fourteen years in this county.

The Chairman. What is your profession?

Mr. Van Dyke. I have been engaged for the last four or five years in the development of the water supply.

The Chairman. What enterprise?

Mr. Van Dyke. The San Diego Flume Company principally.

The Chairman. Explain the purposes of that company.

Mr. Van Dyke. It has an aqueduct that drains the water-sheds of the interior here and brings it upon the arid lands of the coast. A storage reservoir is its main supply of water during the summer. During the winter and spring the water is drawn directly from the rivers and streams.

The Chairman. What storage reservoirs have you?

Mr. Van Dyke. We have only one now of 2,000,000,000 gallons. It will cover about 1,000 acres about 4½ feet deep. That is its present capacity, and it is to be enlarged.

The **CHAIRMAN.** What is the duty of water?

Mr. **VAN DYKE.** That depends very much upon the amount of natural rain-fall and the retentive character of the land—about 9 inches deep, with proper cultivation.

The **CHAIRMAN.** Your reservoir will cover 1,000 acres how many feet deep?

Mr. **VAN DYKE.** About 4½ feet deep.

The **CHAIRMAN.** How much land have you?

Mr. **VAN DYKE.** Eighty thousand acres.

The **CHAIRMAN.** Do you think you can store water sufficient to irrigate that land?

Mr. **VAN DYKE.** Not by storage alone; but the natural flow of the streams and the tunnels will be sufficient for the whole of it.

The **CHAIRMAN.** What is the land worth before it is irrigated?

Mr. **VAN DYKE.** The greater part is of no value at all. About 60,000 acres would be worth nothing at all except for sheep, etc.—$1 an acre.

The **CHAIRMAN.** How much would it be worth under water?

Mr. **VAN DYKE.** We have had no test of that, because the water has been on the land but a few months—from $150 to $200 an acre.

The **CHAIRMAN.** Have you estimated how much it would cost per acre to put water on the land?

Mr. **VAN DYKE.** Twenty-five dollars, $50, and $75 in some places. That is on account of the sea-level, hauling it up a long distance, which makes it more expensive. We do not raise any grain in this country by irrigation, but everything else is irrigated.

The **CHAIRMAN.** You depend upon the rain-fall to raise grain?

Mr. **VAN DYKE.** Yes.

The **CHAIRMAN.** You raise what kind of fruits?

Mr. **VAN DYKE.** All kinds that are raised in California—grapes, pears, peaches, apricots, olives, oranges, etc.

The **CHAIRMAN.** Which of the fruits flourishes best here?

Mr. **VAN DYKE.** I think the lemon is of more permanent success. There are other parts that succeed as well on the oranges, at Riverside, for instance. The lemon, grape, and apricot are better here.

The **CHAIRMAN.** You have gone into the orange culture more than any place that we have noticed.

Mr. **VAN DYKE.** The olive does well here.

The **CHAIRMAN.** Under your water system 80,000 acres could be ultimately reclaimed?

Mr. **VAN DYKE.** Yes. Then there are several other systems that are being got under way; one at San Luis Rey.

The **CHAIRMAN.** Where is San Luis Rey?

Mr. **VAN DYKE.** About 50 miles north of San Diego. Then there are 20,000 acres at Fall Brook and 50,000 acres at San Jacinto.

The **CHAIRMAN.** They are not able to reclaim all the San Jacinto land?

Mr. **VAN DYKE.** No; they can not get water from there; it is too rough. There is more land than they could get water for. There are over 200,000 acres in that country.

The **CHAIRMAN.** What is the altitude of the mountains?

Mr. **VAN DYKE.** The highest point is 6,000 feet. The general average is 4,000 feet.

The **CHAIRMAN.** What is the rain-fall?

Mr. **VAN DYKE.** Two or three times what it is on the coast.

The **CHAIRMAN.** Then the rain-fall is very abundant in the mountains?

Mr. **VAN DYKE.** Yes.

The **CHAIRMAN**. What is the character of the country—its topography?

Mr. **VAN DYKE**. It is a slow rising country.

The **CHAIRMAN**. Has it a broad water-shed?

Mr. **VAN DYKE**. Yes, good water-sheds of all kinds and descriptions. It is only a question of expenditure of money. There is enough water to irrigate the whole dry area upon the coast.

The **CHAIRMAN**. About how much do you think that will amount to in acres?

Mr. **VAN DYKE**. Over 300,000 acres of the first class, and 100,000 acres more of the second class.

The **CHAIRMAN**. Are there any reservoir sites on the public lands?

Mr. **VAN DYKE**. No, all the reservoir sites have been taken. Most of the broad valleys have been taken up long ago.

The **CHAIRMAN**. But there would be no difficulty in getting water sites from private parties.

Mr. **VAN DYKE**. I have seen no startling evidence of that. They will not let you have them at the lowest price. They would a short time ago; but I would not gamble on that now.

The **CHAIRMAN**. Public opinion will produce a reaction.

Mr. **VAN DYKE**. I think it will eventually. I have been asked to prepare a condensed description of this county, which, with the committee's leave, I will present later on.

STATEMENT OF WILLIAM ENNEKING, OF SAN DIEGO.

The **CHAIRMAN**. What is your occupation?

Mr. **ENNEKING**. I am assistant secretary to the chamber of commerce here.

The **CHAIRMAN**. In this town?

Mr. **ENNEKING**. Yes.

The **CHAIRMAN**. Have you, at the suggestion of Senator Reagan, made a measurement of some of the products of the soil of this county?

Mr. **ENNEKING**. Yes.

The **CHAIRMAN**. Will you call off the articles that you have measured in this room.

Mr. **ENNEKING**. Stock beet, 46 inches long and 29 inches in circumference; squash, 150 pounds, 66 inches in circumference; pumpkin, 103 pounds, 76 inches in circumference; watermelon, 91 pounds, 50 inches in circumference; squash, 50 inches long, 17 inches in circumference; collard, weight 20 pounds, 27 inches in circumference; apple, 2 pounds, 14½ inches in circumference; pumpkin, 120 pounds, 86 inches in circumference; sugar beet, 30 inches long, 28 inches in circumference, weight 50 pounds; silver-skinned onion, 18½ inches in circumference, weight 2½ pounds.

The **CHAIRMAN**. Those are the vegetables and fruits raised in the county of San Diego, and they are on exhibition here in the rooms of the chamber of commerce?

Mr. **ENNEKING**. Yes.

The **CHAIRMAN**. They were produced by irrigation?

Mr. **ENNEKING**. Without irrigation.

The **CHAIRMAN**. All of them without irrigation?

Mr. **ENNEKING**. The majority of them.

The **CHAIRMAN**. Then there is no necessity for irrigation here.

Mr. ENNEKING. We do not need very much of it. This is the showing without irrigation. The majority of the people who irrigate think it might be double the size.

The CHAIRMAN. Do you know how much ground there is of the character from which these things were produced?

Mr. ENNEKING. I do not know how much there is.

The CHAIRMAN. Could you raise products of that character on these dry plains?

Mr. ENNEKING. Mesa land. Yes. A great deal is raised on the mesa land at San Marcus, at Tia Juana, and Oneonta.

STATEMENT OF GEORGE P. HENSLEY, OF SAN DIEGO.

The CHAIRMAN. Do you know on what lands the vegetables and fruits named by the last witness were raised?

Mr. HENSLEY. Some were raised at San Marcus, some at Oneonta, and some at Highlands; some at Cajon and different settlements through the county.

The CHAIRMAN. Raised without irrigation?

Mr. HENSLEY. The larger portion of them. In the San Marcus country they are raised without irrigation.

The CHAIRMAN. Is the country where you do not require irrigation extensive as compared with the country that does require it?

Mr. HENSLEY. No; the country that will be benefited by irrigation, as shown by our exhibits, will be two to one as against the land that will raise a full crop without irrigation.

The CHAIRMAN. Then there is twice as much land on which you can. not raise full crops without irrigation as there is of the other kind?

Mr. HENSLEY. Irrigation is necessary to raise a full crop on twice the quantity of land as there is where crops are raised without it.

STATEMENT OF HENRY C. LANGREHR, OF SAN DIEGO.

The CHAIRMAN. What is your profession?

Mr. LA N REHR. Civil engineer.

The CHARMAN. Are you familiar with San Diego County?

Mr. LANGREHR. I am, sir.

The CHAIRMAN. Is irrigation practiced here, and, if so, to what extent?

Mr. LANGREHR. It is practiced very little; it is just at the initial point of irrigation; that is all.

The CHAIRMAN. Do you find it necessary to produce all around crops?

Mr. LANGREHR. It is essential to this county.

The CHAIRMAN. Can you raise crops without irrigation?

Mr. LANGREHR. I think some can; but that land is rather scarce.

The CHAIRMAN. The area is small?

Mr. LANGREHR. Very small, indeed. By irrigation I believe we could produce fifteen times as much as we can without it.

The CHAIRMAN. What extent of country have you in this county that is susceptible of irrigation?

Mr. LANGREHR. About one-fourth of the entire county. There are thirty-odd square miles that could be supported by irrigation.

The CHAIRMAN. That might be reclaimed by irrigation?

Mr. LANGREHR. Yes.

The CHAIRMAN. From what source would you obtain the supply of water?

Mr. **LANGREHR.** Part by artesian wells, part by reservoirs, and part by canals—about forty miles, for instance, leading from the Colorado to the interior of our great desert here.

The **CHAIRMAN.** If you were to take out the Colorado at the foothills of the mountains it would supply more than 30 square miles on that side.

Mr. **LANGREHR.** Yes.

The **CHAIRMAN.** In the 30 square miles mentioned do you refer to what is on the west side?

Mr. **LANGREHR.** On the mountain side?

The **CHAIRMAN.** On the west side of the mountains. How much is on this side?

Mr. **LANGREHR.** I do not know exactly, but it will probably amount to what I have already stated.

The **CHAIRMAN.** There are 30 square miles on this side.

Mr. **LANGREHR.** That is the approximate amount. Water can be raised by artesian wells, by these underground rivers that we have in this county, underground streams, and also, as I have said, by reservoir sites.

The **CHAIRMAN.** Are the reservoir sites which are in the mountains on private land or are they on public land?

Mr. **LANGREHR.** Some on public land and some on private land.

The **CHAIRMAN.** The public land is reserved; the Government gives that to the irrigator.

Mr. **LANGREHR.** I have found some that is part private and part public.

The **CHAIRMAN.** Of course if you take that you will pay the men who have it what it is worth?

Mr. **LANGREHR.** Yes.

The **CHAIRMAN.** Of course every man who owns it will be ready to sell it for what it is worth?

Mr. **LANGREHR.** Yes.

The **CHAIRMAN.** You represent the board of supervisors who extended to the committee the invitation on the part of the people of the county?

Mr. **LANGREHR.** Yes.

STATEMENT OF DOUGLASS GUNN, OF SAN DIEGO.

The **CHAIRMAN.** What is your official position?

Mr. **GUNN.** I am the mayor of San Diego.

The **CHAIRMAN.** You have a publication in your hand. Did you prepare that?

Mr. **GUNN.** I did.

The **CHAIRMAN.** What does it represent?

Mr. **GUNN.** It represents the climate, resources, topography, productions, etc., of this country.

The **CHAIRMAN.** Do you wish to file it with the committee?

Mr. **GUNN.** Yes. In here there are a number of questions answered, questions relating to the climatic conditions of the country and its rain-fall.

The **CHAIRMAN.** You made a report on the Colorado desert?

Mr. **GUNN.** At one time I did.

The **CHAIRMAN.** Have you that report?

Mr. **GUNN.** It is embodied in that book.

The Chairman. Leaving out what you find on the sloping hills and taking into consideration the alluvial land which is in a body, how much land is there here?

Mr. Gunn. I can not answer that question definitely. There are gentlemen who are capable of giving you definite figures in regard to that, and their statement would be better than a loose one from me.

STATEMENT OF THOMAS S. SEDGWICK, OF SAN DIEGO.

The Chairman. How long have you resided in San Diego?

Mr. Sedgwick. I have been making my home here for the last year.

The Chairman. You have been familiar with it how many years?

Mr. Sedgwick. Twenty years.

The Chairman. Have you paid any attention to irrigation and the water supply for that purpose?

Mr. Sedgwick. To some extent, yes.

The Chairman. Have you any suggestions to make with regard to the Sweetwater Reservoir?

Mr. Sedgwick. No; I can not say that I have.

The Chairman. Have you any suggestions to make as to the improvements that might be made in it?

Mr. Sedgwick. No; Mr. Hinton was asking me some questions about it this morning. He asked me in regard to the principles of construction, and I made some explanations in that direction.

The Chairman. The Sweetwater Dam is that which we have visited to-day. Will you give us a general description of it in the absence of the engineer, Mr. Schuyler?

Mr. Sedgwick. As you observed to-day, the dam is placed across the upper end of the ravine of the Sweetwater Creek, some 7 miles from its débouché into San Diego Bay.

The dam is 76 feet long at the bottom, and 396 feet long at the top, and 90 feet high. Its thickness at the bottom is 46 feet, and at the top 12 feet, including parapet and cornice, with a parapet wall on top on the up-stream side 3½ feet high and 2 feet thick, and a hand-rail on the down-stream side. The profile of the dam batters 15 feet on the up-stream face and 19 feet in three slopes on the down-stream face. (See profile, fig. 2.)

The horizontal plan of the dam is a curve of 213 feet radius.

The waste-weir is 45 feet long by 5 feet depth, divided into eight sections by masonry piers, inclined on the up-stream face to receive loose flash boards, which, when in place, increase the depth of the reservoir by 5 feet. A training-wall carries the waste water well away from the foot of the dam. It is estimated that the wasteway will allow a continuous flow from the full reservoir of 1,500 cubic feet of water a second, which is believed to be about the flood regimen of the stream.

The masonry of the dam is from the rock forming the walls of the ravine, laid in Portland cement mortar, with large, rough blocks, uncoursed or otherwise ranged, the down-stream face presenting an even face.

The reservoir formed by this dam is about 3½ miles long and about three-fourths of a mile wide at its widest place, covering 720 acres, and has a storage capacity of 786,390,000 cubic feet, equal to 5,882,248,000 gallons.

The catchment basin feeding the reservoir is estimated to cover 186 square miles, flowing by the Sweetwater River from the southern slopes of the Cuyamaca Mountain, lying nearly east from the Bay of San Diego, and about 60 miles distant.

The distributing system comprises 57 miles of iron pipes varying from 36 inches to 6 inches diameter, and supplies water for irrigation to some 10,000 to 15,000 acres of land, including the town of National City and other outlying settlements.

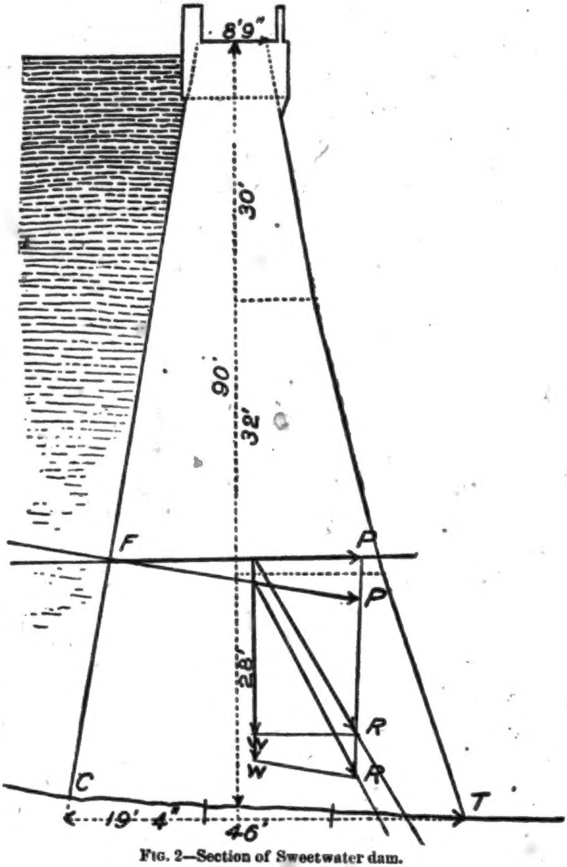


FIG. 2—Section of Sweetwater dam.

Q. Do you comprehend the principles of designing and constructing dams for the storage of water?—A. I believe I do.

Q. Will you kindly prepare a short paper on the subject, to be embodied in the report of the committee?—A. I will be pleased to do so to the best of my ability.

EARTH DAMS.

Embankments or dams for obstructing the flow of streams to form reservoirs of water may be successfully made of earth, for moderate heights, especially if suitable clays can be had by excavating for enlargment of the area, or depth of the reservoir, or in the near vicinity.

In such cases the embankments are wide on the base and have very flat slopes, generally from 2 to 3 feet horizontally on 1 of height. If the clay be of good character, such a dam or embankment will generally be impervious to the water; but if the clay be of uncertain imperviousness, a core of puddled clay or a thin wall of masonry may be placed in the middle of the embankment to render it water-tight.

The slopes are usually faced with hand-laid protection of stone or brick, clay tiles, or even boards, to protect the slopes from wear by overflowing water, and from sliding, which is prevented by the weight of the paving. If the embankment is to be constructed with a view to allow it to be submerged when the stream is in flood, the top of the embankment and its down-stream slope should be covered with a good quality of pavement to prevent injury from drift likely to be carried over the dam in flood stages of the obstructed stream. Often the wasteway extends along a part only of the dam, or is placed at either end thereof, as may be indicated by some favorable condition of the locality. Figure 1 shows an earth-embankment dam of this description, which is a good example of English practice.

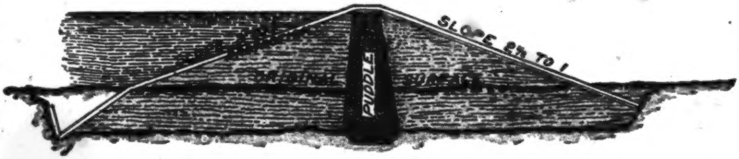


FIG. 1—Nethertrees reservoir embankment, Paisley, England.

The original surface of the ground on which such an embankment is to be built should be removed to a stratum of consistent material of clay or earth, or to an underlying rock.

There is no mathematical principle of mechanics necessary to be applied to the construction of an earthen dam, with reference to its weight and the pressure of the impounded water, for the reason that material for the dam is usually plentifully at hand, and can be so economically obtained as to render the cost of putting it in the dam an almost inconsiderable item, with reference to the importance of the benefits to be derived from the success of the projected dam and reservoir. Such a dam will be of ample stability if it be solidly made, but it may fail because of infiltration of water through it when of faulty construction, so that it may crack from settlement, which may also break the puddle wall.

There have been a great many such earth-embankment dams made in India for irrigation purposes, some of which are believed to be two thousand years old. The material is said to have been carried in baskets on the heads of the laborers, and deposited so as to have been compacted by the continual tramping of the workmen, which would account for their solid condition. There are many such dams in England and in our own Eastern States.

When the cause of the failure of this type of dams has been investigated it has generally been found that the embankment had been badly constructed or had been carelessly taken care of. Such a dam at Estrecho de Rientes, Spain, gave way in the year 1802, causing the death of 600 people and destroying some $7,000,000 value of property. In 1864 the Dale Dike Dam, near Sheffield, England, 95 feet high, gave way, causing the death of 300 persons and destroying much property. In 1874 a dam near the town of Williamsburgh, Mass., failed, and 150 persons lost their lives and $1,000,000 of property was destroyed. The most disastrous failure was that of the Conemaugh Dam, near Johnstown, Pa., in June this year (1889), completely washing away three or four villages, with a loss of some 3,500 lives and millions of dollars value of property. Unless the top and slopes of earth dams are well protected, the overflow water will wear away the embankment and destroy the dam.

MASONRY DAMS.

When the valley of drainage desired to be closed by a dam to form a reservoir is of less width, and requires a higher dam than is usually ventured to be made in an earth embankment, say, of 70 or 80 feet in height, stone masonry is resorted to as the proper material for the dam, and the mathematical rules of applied mechanics are taken into consideration and applied to the problem of proportioning the dimensions of the dam and disposing the forces acting on it in accordance with the science of civil engineering, so as to make the structure stable; that is to say, that it must be of such a weight that it shall not be pushed down stream nor overturned by the pressure of the water in the reservoir.

The forces to be considered in the construction of a masonry dam are the weight of the masonry and the pressure of the water resting against it. The weight of the material of the dam resting on its foundations is readily found.

The pressure of water against the vertical face of the dam at the top is equal to the weight of a cubic foot of water (62½ pounds) for the first foot of depth, and increases as the depth, so that at a depth of h feet it is 162½ times the depth ($62\frac{1}{2} \times h$). Now, as the pressure at the top is nothing and at the bottom $62\frac{1}{2}\,h$, the average pressure is one-half of $62\frac{1}{2}\,h$, or $\left(\frac{62\frac{1}{2}h}{2}\right)$; and this multiplied by the depth h gives the whole pressure against the face of h feet height, and $\frac{62\frac{1}{2}h}{2} \times h = \frac{62\frac{1}{2}h^2}{2}$ is the algebraic expression for the pressure of water on a vertical face of the height h.

It is demonstrated in the text-books on engineering that this pressure acts by concentration at a point two-thirds of the depth from the surface of the water. If we consider the case of a dam of a given height, say, 100 feet, and 100 feet long, the pressure for each foot of length will be $\frac{62\frac{1}{2}h^2}{2}$ or $\frac{62\frac{1}{2} \times 100 \times 100}{2}$, or 312,500 pounds, and for the whole length of the dam $312{,}500 \times 100 = 31{,}250{,}000$ pounds. For the purposes of discussion of the sectional proportions of the dam it is usual to consider 1 foot only of length, which section is called its "profile."

Considering the dam to have a profile of uniform thickness, A B C D, Fig. 2, supporting 100 feet depth of water, the pressure is 312,500 pounds, as has just been computed. That the dam shall not slide on its base, it must have a weight equal to this pressure. For the purposes of this discussion stone masonry will be considered as having a weight of 150 pounds to the cubic foot; consequently our dam must have a sectional or profile area, to be found by dividing the weight of the pressure F (312,500 pounds) by the weight per cubic foot of the masonry, which is

$\left(\frac{312500}{150}\right)$, 2,083⅓ cubic feet of masonry for each foot in length of full height. As our dam is 100 feet high its thickness must be $\left(\frac{2083\frac{1}{3}}{100}\right)$, 20.83+ feet wide on C D, the area of the profile expressing also the cubic feet of one foot in thickness of this profile.

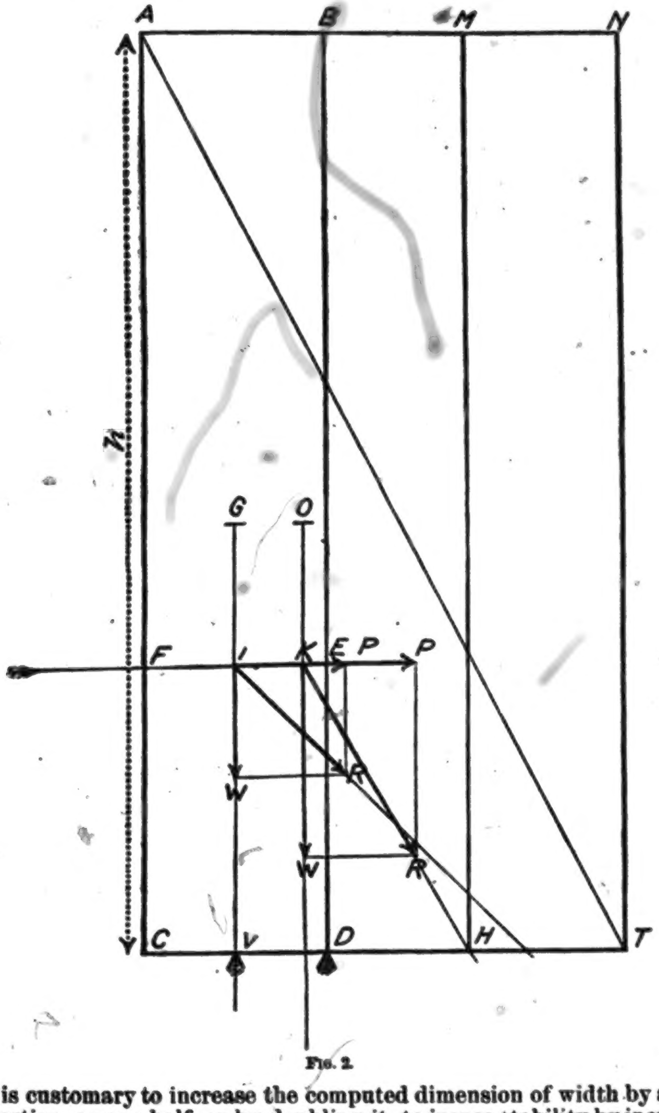


FIG. 2.

It is customary to increase the computed dimension of width by some proportion, as one-half, or by doubling it, to insure stability by increasing the weight of the dam proportionately.

If these forces—the weight of the dam and the pressure of the water—were just equal, the dam would yet remain in place against sliding, because of the friction of the masonry on its base, which is dependent on its weight and the surface of contact at C D, and has an established value for stone masonry resting on a rock bed of six-tenths of 1 per cent., which is practically equivalent to increasing the weight of the masonry by that proportion. If a good quality of cement mortar be used in bedding the masonry on its foundation, the shearing resistance of the mortar may, properly, be considered.

OVERTURNING.

The probability of the dam sliding on its base is not the only manner of failure to be considered. A more important problem is to so proportion the dimensions and profile that it may not be turned over down stream by the pressure of the water in the reservoir.

Referring to the last figure (2) we find the forces acting on the dam to be its weight, represented by its center of gravity G, acting in the vertical line G V, and the water pressure F acting in the horizontal line F P, at two-thirds the depth of the water. If from the intersection of the lines of action of these forces at I there be laid off, by scale, the proportionate values of the forces in the direction in which they act, we shall have the lines I W and I P, respectively, each scaled to represent 312,500 units (or 31), the weight and water pressure being equal. If from W and P the lines W R and P R be drawn parallel, respectively, to I P and I W, there results a (square) parallelogram I P W R, called in engineering language the parallelogram of forces, in which the diagonal I R is the "resultant" of the forces, representing the direction and value of the combined action of the two forces I W and I P. This value is readily found in this case by the well-known geometrical relation that in a right-angled triangle the square of the hypothenuse (or diagonal) is equal to the sum of the squares of the sides.

This resultant represents two principles, the first that if its equivalent force were applied to the masonry, and acting in that line, it would cause the masonry to slide on its base, disregarding friction of the base or the resistance of the mortar; the second, that as the line of the resultant passes out of, or cuts the down-stream face of the dam at a point above the down-stream toe D, its action is to overturn the dam by turning it around the point D. To resist and prevent such an overturning it has been demonstrated that the width of the masonry on its base C D must be enough to bring the resultant I R to cut the base C D inside of the point D.

To determine this width the moment of the forces W and F must be considered. If the masonry, considered as a column, were supported on a point at V (referring again to Fig. 2), vertically under the center of gravity G, the downward action would be equal to its weight, and a small force would hold it in equilibrium (upright) in the absence of the water pressure, but if the column were supported at the point D (as shown), the downward action would be much greater, so that a great force acting somewhere on the face A C would be required to hold the column in a vertical position. The force of the downward action of the weight W is found, or represented, by multiplying the weight by the perpendicular distance from the line of action of the force, or weight, to the assumed point of support; in this case this distance is V D equal half the width of the base.

This product is said to be the moment of the weight, or force, W about the point D, *minus* in this case 312,500 × 10.41 + = 3,253,125 foot-pounds moment. The force that, acting against the face A C, would hold the column in equilibrium, must have an equal moment about D, to be found by multiplying the force by its lever arm with reference to the same point D *minus* the perpendicular distance from the line of action F P of the force F to the point D, which will be E D. In the case of the water-pressure force applied at one-third the height h, F C = E D = 33⅓ feet, the moment is therefore (312,500 × 33⅓) 10,416,666 foot-pounds—3⅓ times the moment of the masonry weight, so that about one-third of the water-pressure force would support the column in an upright position, and any greater force would certainly overturn it on the toe D.

The moment of the force F (water pressure) about the toe D being 3⅓ the moment of the weight about the same point, proves conclusively that the column, or dam, would be overturned about D. To find the width of base C H, such that the column shall be stable against overturning, the moment of the weight must equal the moment of the water pressure (10,416,666 foot-pounds). If the base to be found be represented by x, the area (and cubic feet) of the column will be 100 multiplied by x ($100x$) and its weight that product by 150 pounds to the cubic foot ($100x \times 150 = 15{,}000x$), and this multiplied by the lever arm of $\frac{1}{2}x\left(\frac{x}{2}\right)$ gives $\left(15000\,x \times \frac{x}{2}\right)$

$$\frac{15000\,x^2}{2} = 7500\,x^2,$$

must be the moment to equal 10,416,666 foot-pounds. To solve this, to find the value of x, we must divide 10,416,666 by 7,500 = 1,388.8888+ for the value of x^2, and the square root of this—37.2678+ = x, and $\frac{1}{2}x = 18.6339+$. Substituting these values for x, and $\frac{1}{2}x$, in the last computations the results will be for the area and cubic feet of the profile (100 × 37.2678+) 3,726.78 feet, for the weight (3,726.78 by 1.50) 559,017+, and for the moment (559,017 × 18.6339+) 10,416,667 foot-pounds, proving that if the base C H be taken as 37.27 feet the moment of the weight will equal the moment of the water pressure. If now a new parallelogram of the forces be constructed (the center of gravity of the column having transferred to O, the center of A M H C, from K the intersection of the forces), we have K P W R, and the direction of the resultant K R cutting the toe H, indicating stability.

If the last found base be increased by its one-half to T = 55.90 feet, to secure stability, the weight of the masonry will be increased one-half, or to 838,525 pounds. One-half this weight is in excess of the weight found to resist sliding in respect of the water pressure (312,500 pounds), an excess of more than one-third (419,262 − 312,500 = 106,762), which would secure stability against sliding, so that if the profile of the dam should be divided in half by a diagonal line from A to T, thus dividing the masonry into equal parts, we yet have weight enough to prevent sliding, and finding the center of gravity of the triangle A C T, at G, at one-third the height and base from C, and constructing a new parallelogram of forces G P W R, Fig. 3, we will find that the resultant cuts the base inside the toe T, indicating stability with reference to overturning about the toe T. Now, as there is no material pressure of water at the top A of the dam, indicating very little thickness of masonry there, and finding that width of base is the requirement for stability against overturning, we are led to the conclusion that the theoretic profile of a dam of stable equilibrium is that of a right-angled triangle, with the water resting against the perpendicular side.

Argument is not necessary to show that this form will bring the quantity of masonry to the least practicable weight.

Considering this triangle form of profile with reference to the equality of moments of the forces about the toe T (Fig. 3), we shall have the

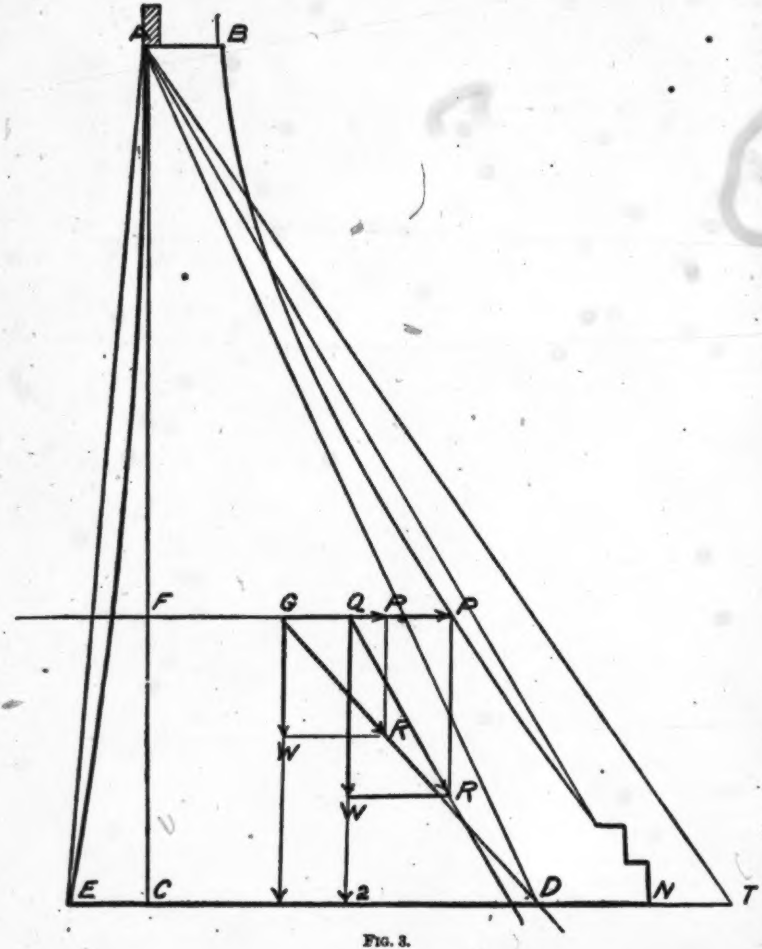


FIG. 3.

center of gravity of the dam (G) at one-third of its height above the base, and vertically above V, one-third of the width of the base C D, from E, and two-thirds of the base from D, this last distance being the lever arm for the weight W. Calling, again, the height of the dam and depth of water h (100 feet), and its base x equal C D, the area and cubic of the profile will be $\frac{1}{2}hx$ its weight $\frac{1}{2}hx$ by 150 $\left(\frac{hx}{2} \times 150\right)$, and its moment $\frac{150\,hx}{2}$ by the lever arm V D $= \frac{2}{3}x\left(\frac{2x}{3}\right)$. Putting this in algebraic form $\frac{150\,hx}{2} \times \frac{2\,x}{3}$, and completing the multiplication we get $\frac{300hx^2}{6} = 50\,hx^2$ for the moment of the weight about the toe D. Putting this equal to the moment of the water pressure, as before, we have, substituting 100 for h, $5{,}000\,x^2 = 10{,}416{,}666$, and dividing 10,416,666 by 5,000 we have for the value of x^2 2,083.33, and extracting the square root of this number we find for the value of x (the base C D of the dam) 45.6435+ feet, which value will, if substituted for x in the last equation, make the moments of the two forces acting about D equal, for the weight of the profile of the dam will be $\left(\frac{100 \times 45.6435+}{2} \times 150\right)$ 342,326.25 pounds, which multiplied by its lever arm, two-thirds of 45.6435+ (30.429+) gives 10,416,666 foot-pounds, equal to the moment of the water pressure.

The weight of the masonry thus found (342,326.25 pounds) is nearly 10 per cent. in excess of the weight determined to guard against sliding on the base (312,500 pounds), so that the profile just determined is heavy enough to prevent failure by sliding.

As in the case of guarding against sliding, so in this case the base of the dam is increased in width to guard against overturning, and the members of the engineering profession have agreed that this increase, called co-efficient of stability, shall be one-half of the base, as above determined, making the base in this case 68.465+ feet = C T., only 13.5 feet more than was found for the final base of the masonry column dam.

By this increase of the bottom width of the dam, its profile area and weight are increased one-half, as shown in the triangle C A T, and its center of gravity is now found at Q, at one-third of the height and base from C, as for C A D, and acts in the vertical Q Y. For a new parallelogram of forces from Q we shall have for the water pressure, as before, 312,500 pounds, and for the weight of the masonry W (100 × 68.46 × 150 ÷ 2) 513,489 pounds. Completing the parallelogram of

---

NOTE.—The algebraic expression of these relations is as follows: When h represents the height of the dam and the contained water, calling the weight of water 1, and of the masonry 2.4 ($62\frac{1}{2} \times 2.4 = 150$) $= w$, the moment of the water pressure will be expressed by

$$\frac{h^2}{2} \times \frac{h}{3} = \frac{h^3}{6}$$

and the moment of the masonry by

$$\frac{hx}{2}w \times \frac{2x}{3} = \frac{2\,hx^2w}{6}.$$

Equating these expressions, we have

$$\frac{2\,hx^2w}{6} = \frac{h^3}{6} \text{ or } 2\,hx^2w = h^3.$$

Dividing by h and reducing $2\,x^2w = h^2$ and $x^2 = \frac{h^2}{2\,w}$ and $x = \sqrt{\frac{h^2}{2\,w}}$. Substituting the value of h and w, we have $x^2 = \frac{10{,}000}{4.8} = 2{,}083.33$, as before.

forces, we find that the resultant cuts the base somewhat [illegible] the point D. Now, as C Y was taken one-third of the base, C [illegible] for line of center of gravity Q, and D T is one-half C D, it is one-third the whole base, and equals C Y, and there remains Y T as the middle third of the base and it is cut by the resultant of the acting forces. The result of this disposition of the forces with reference to the profile, is the generally accepted maxim. *A masonry dam is stable when the resultant of the forces acting upon it cuts the base within the middle third.*

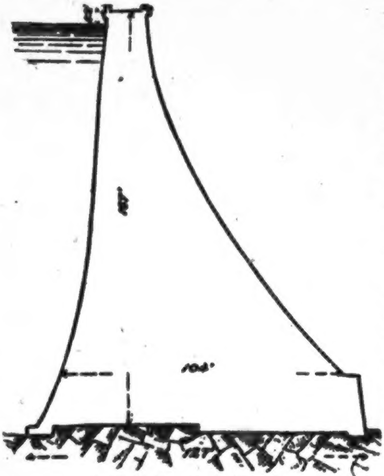


FIG. 5—Ban Dam, France.

If the upstream face A C of the dam be built with a batir or slope, C E, and the bottom width be kept the same as before, bringing T back to N, there will be no change in the area or weight of the profile. The center of gravity will be transferred upstream two-thirds of C E, and the intersection of the line of the resultant with the base will be changed by an equal distance, but will be nearer the down-stream toe by one-third of C E, reducing the co-efficient of stability by that amount, but at the same time the weight of the water resting vertically over the upstream batir C E may be considered as increasing the weight acting on the base E N, and also of the force W.

If there should be such a condition of over-fullness of the reservoir as would cause the water to overflow to a depth of 10 feet, the pressure F would be increased. and the point of action raised accordingly, reducing the stability of the dam proportionately. To avoid this effect a spill or waste-way is provided, generally at one end of the dam, through which the surplus water is allowed to flow away. The waste-way should have a capacity equal to the greatest known flood flow of the stream to be obstructed to form the reservoir.

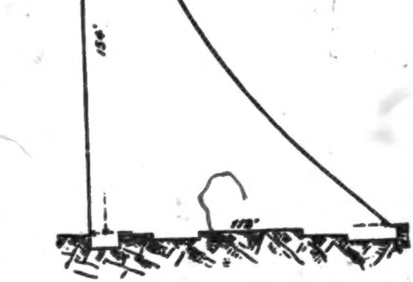


FIG. 6.—Terrasse Dam.

The dam may receive shocks from waves, or masses of ice floating on the surface of the water of the reservoir, which would to some extent affect the stability of the narrow top of the triangular dam. To guard against this effect, and to, at the same time, provide a convenient road-way from end to end of the dam, the top is given a width, A B, which is added to the down-stream slope A T or A N, in a curved form, as shown; and if a parapet wall be placed on the up stream face, as shown, to prevent a flood overflow and cause the surplus water to flow through the waste-way, we shall have a complete dam; and if, further, we give the faces slightly curved batirs, as shown by the curved lines, we will have the standard scientific form of profile for masonry dams as shown by the profiles of the Ban, Ternay, Habra, and Terrasse Dams in France, where the profile and stability of masonry dams have been most thoroughly investigated and many dams built. (See Figs. 5, 6,7, 8, and 9.)

The value found for x, on page 367 (45.64+) may be taken for a constant ratio of base to height (0.456), for a difference in weight of 25 pounds per cubic foot in the masonry would not materially affect the stability of the dam.

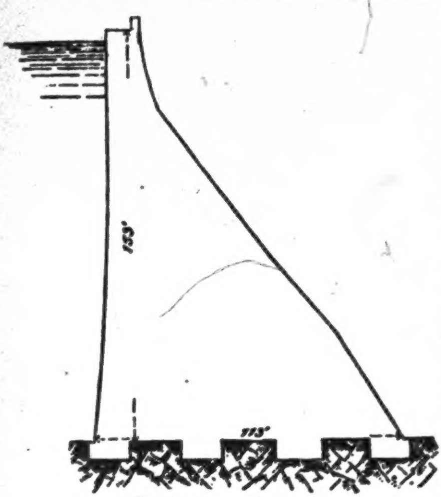


Fig. 7.—Perair Dam.

The condition that the resultant of forces shall cut the middle third of the base is an arbitrary precept for a co-efficient of safety, and it might be assumed that were the resultant to cut the base within the second, fourth, or fifth, or even sixth of the base from the down-stream toe, the dam would yet be stable,* and because the cement mortar acts with a tensile force of, say, 10 tons per square foot at the face A C or A E, to prevent a rising or ruprute of the up-stream face, it enters into the co-efficient of stability, and may be considered as so much weight added to the masonry, in the same way as the column of water resting over the up-stream batir A D; and considering these forces (weights) as acting at the up-stream face, the center of gravity of the profile would be somewhat nearer the up-stream face, and the side G W of the parallelogram of forces would be lengthened, and the resultant would be brought farther within the base.

The engineering profession is not agreed as to the precept of stability of a dam built on a curved plan, as in the case of the Sweetwater Dam, which has been described and a profile given.

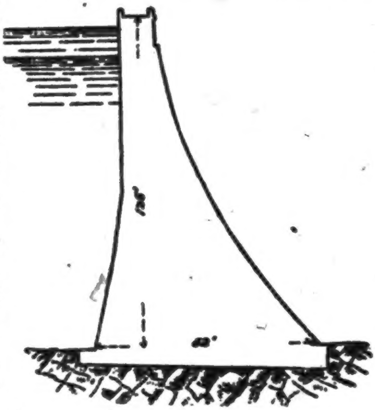


Fig. 8.—Ternay Dam.

---

*Reducing the co-efficient of safety to one-fourth or one-fifth or one-sixth,

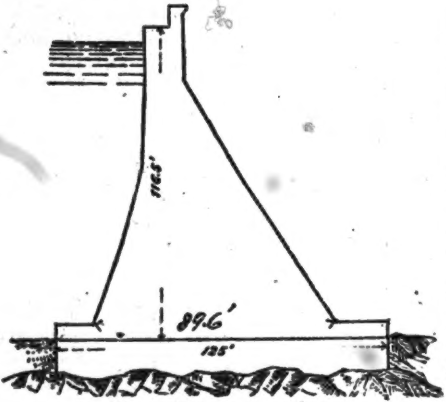


FIG. 9—Haba Dam, Algeria.

The most notable case is that of Bear Valley Dam, near San Bernardino, Cal., which, above a bottom face, is 46 feet high, 2½ feet wide at top, and only 8½ feet wide at bottom. Its plan is on a curve of about 250 feet radius, and the resultant of forces cuts the base some 15 feet outside of the down-stream toe.

If the dam is so well built as to resist overturning as a solid segment of a ring, the center of gravity being between the segment and its chord, yet we must infer that the dam is held in place because cemented to its foundation, a force that may in good cementation amount to 20 tons per square foot.

THE CONSTRUCTION OF THE SWEETWATER DAM,* BY JAMES D. SCHUYLER, M. AM. SOC. C. E.

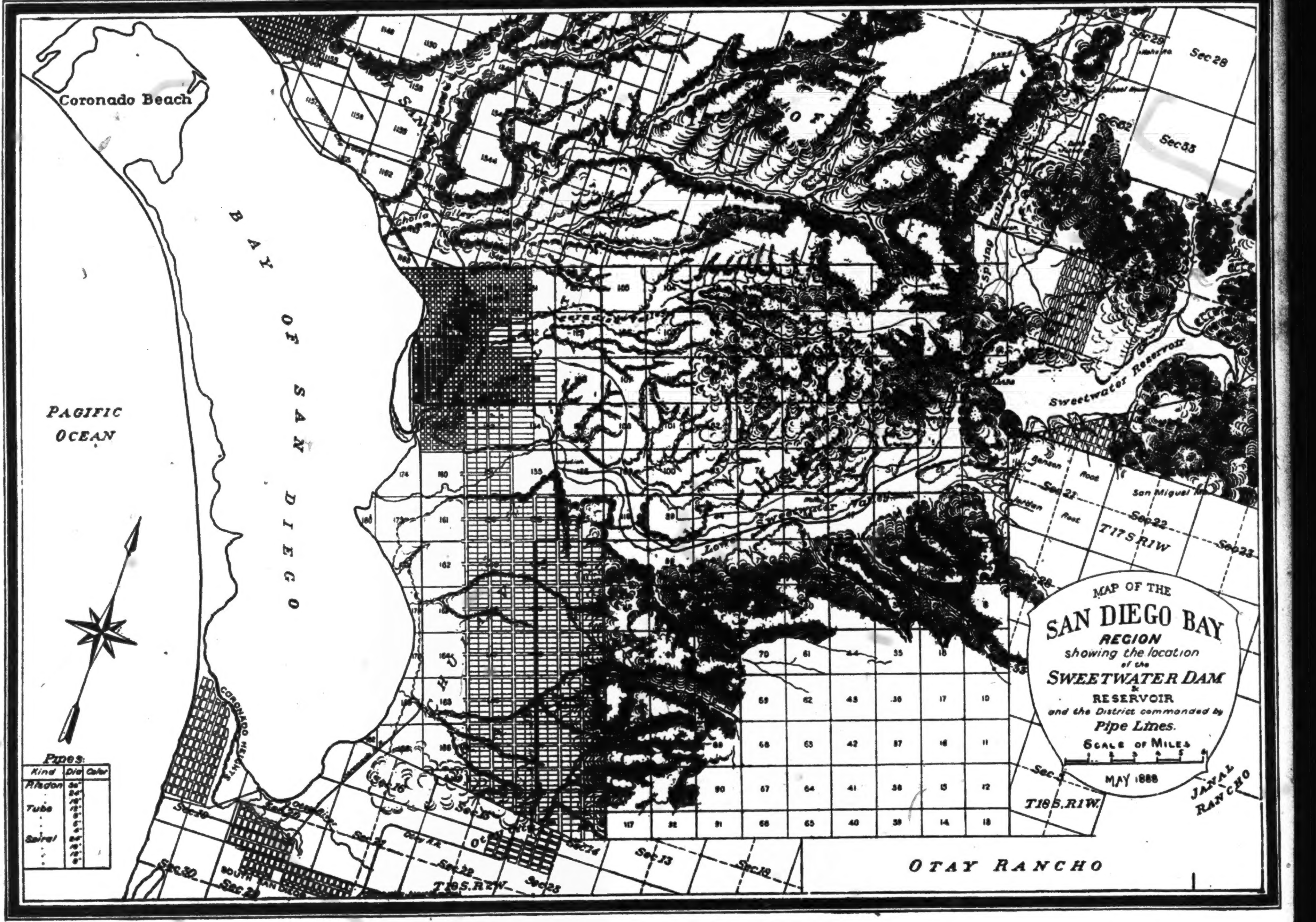
The question of an adequate water supply for irrigation as well as for the domestic use of cities and towns is one which in San Diego County, Cal., necessarily involves storage reservoirs. The streams of the county are of an intermittent character. The mountain ranges in which they head and from which they flow to the coast do not generally exceed 6,000 to 6,500 feet in elevation—an altitude too low in the latitude of San Diego to maintain perpetual snow upon their summits, or even to retain such proportion of the winter precipitation as comes in the form of snow (not usually more than 10 per cent.) for more than a few days or weeks. As a result the streams are torrential in winter and carry large volumes of water, but in summer and fall, when most needed for irrigation, are almost dry for 20 to 30 miles of their lower course, with the exception of certain seasons of such unusual rainfall that no irrigation is required—seasons that come at rare intervals. Ordinarily the streams in summer reverse the usual order of nature, and are largest at the small end, and to get a water supply the engineer must either go far back into the mountains and gather together a number of small living streams and springs and pipe them out long distances, or construct dam and storage reservoirs to retain the winter floods. Fortunately nature has compensated for the existing conditions by providing numerous favorable sites for such construction, and every stream of importance in the county has available sites for storage dams of large capacity. A number of water companies are engaged in preparing for extensive works of this character, which, when completed, will provide irrigation facilities for several hundred thousand acres of land otherwise unproductive.

This era of development was inaugurated but recently, and the first completed work of the character is the Sweetwater Dam and Reservoir and the extensive pipe system reaching out from it.

The circumstances which led to the building of the dam were that the San Diego Land and Town Company (a first cousin of the Atchison, Topeka and Santa Fé Railway), owned a large body of fertile and desirable mesa and valley lands bordering on San Diego Bay, adjacent to San Diego on the south, which were unsalable without water to irrigate them. These lands constitute the greater part of the "Rancho de la Nacion," including the town site of National City, which also languished with thirst. The Sweetwater River passes nearly through the center of the lands, and is of the nature described—intermittent in flow, at least for many miles above its mouth. The first storm or two of the rainy season is absorbed by the thirsty earth, and the

---

* Summarized by order of the chairman from "Transactions of the American Society of Civil Engineers," November, 1888.


MAP OF THE
SAN DIEGO BAY
REGION
showing the location
of the
SWEETWATER DAM
&
RESERVOIR
and the District commanded by
Pipe Lines.
Scale of Miles
MAY 1888
Coronado Beach
PACIFIC OCEAN
BAY OF SAN DIEGO
CORONADO HEIGHTS
SOUTH SAN DIEGO
Sweetwater Reservoir
Sweetwater Valley
Chollas Valley
Spring Valley
OTAY RANCHO
JANAL RANCHO
T17S.R1W
T18S.R1W.
T18S.R2W
Sec 28
Sec 29
Sec 33
Sec 32
Sec 22
Sec 23
Sec 13
Sec 19
Sec 30
Sec 24
Sec 25
Sec 36
Bonsall Road
Jordan Road
San Miguel
Otay R.R.
Pipes:
Kind
Dia
Color
Risdon 36"
24"
18"
Tube 12"
8"
6"
4"
Spiral 24"
18"
12"
8"

SCHUYLER ON SWEETWATER DAM.

(From Trans. Am. Soc. Civil Engineers, Vol. XIX.)

stream generally does not begin flowing into the bay until late in December or in January. After each heavy storm thereafter its volume will reach 500 to 1,000 cubic feet per second for a few days, and within a fortnight recede to 10 cubic feet per second.

The last severe storms of the rainy season are usually in March, and the flow of the stream will generally dwindle to 1 or 2 cubic feet per second by June 1, which amount may be maintained through the remainder of the year, but not always. The large supply running to waste each year, followed by months of scarcity, naturally suggested storage, and the first cañon above the mouth of the stream was selected as the place to accomplish the object. This narrow gorge, 7 miles east of the bay, is a deep and narrow cut, half a mile in length, through a dike of trap rock or trachyte that intersected the valley of the Sweetwater, leaving above it a broad level valley some 3 miles long, one-quarter to three-quarters of a mile in width. This is the site of the reservoir formed by the dam built at the head of the gorge.

The construction of this dam was decided upon and work begun in November, 1886. The original plan designed was a narrow wall of concrete masonry, 50 feet high, 10 feet wide at bottom, 3 feet on top, arched up-stream. On the upper side an embankment of loose earth was to be filled in against the masonry wall to its full height. After two months' work had developed the character of the design, the plan was disapproved by the management, and the writer was called upon to design a suitable structure and execute its construction. Some $35,000 had already been expended, and in order to utilize as much of the old work as possible the new structure was planned to rest upon and incase the foundations already laid. This decision influenced to some extent the radius of the arch of the new dam, as well as its position relative to the axis of the cañon and the location of the anchorage on the sides. In other words, to avoid throwing away the work already done, the new work was adapted to the old in a way that ultimately increased the length of the dam on the crest somewhat more than would have been necessary by shifting the point of radius to one side of the central axis of the cañon, and making the radius somewhat shorter than it otherwise would have been. An engineer is sometimes driven to adaptations of this sort against his judgment, to save, or to give the appearance of saving, the pockets of his employers.

The modifications of the original plan were radical ones. The combination of earth and masonry was rejected, as it seemed to the writer that water alone was sufficiently heavy for the masonry wall to support without adding the last straw on the camel's back, of a mass of saturated earth. A gravity profile was adopted, and rubble masonry formed of blocks of stone up to 4 tons weight was substituted for bastard concrete composed of cement mortar, with small stones rammed into it, which had been previously used. So much of the old plan was retained, however, as to form an embankment 50 feet wide on top, 10 to 15 feet high across the cañon, against the face of the wall, but clay well rammed in layers was substituted for the silt and quicksand loosely dumped, with which the dam was formerly being made. The object of this clay filling was to cut off possible seams in the bed rock underneath the dam and reduce the pressure on the structure. The top of the embankment is 70 feet below the top of the dam.

The foundation.—After the bowlders, sand, and gravel had been stripped from the base of the dam on either side of the old work, the bed rock was found to be very irregular in surface, presenting the appearance of a number of pyramids and cones thrown heterogeneously together, but bound solidly in one mass and well polished by attrition. The rock was very close in texture and exceedingly hard. No attempt was made to cut out the bed in the level benches, as the unevenness of the bottom, as nature left it, gave the assurance that whatever movement might occur in the structure built on such a base there could be no possibility of its slipping or sliding on the base. Wherever there were seams in the rock they were invariably occupied by roots, and the excavation was carried down till the seams pinched out and the roots disappeared. The rock was then thoroughly scrubbed by hand, and a thin grout of pure cement applied with brooms, filling the minutest crevices and angles in the rock, before starting the masonry.

The side walls of the cañon required more excavation to reach a satisfactory anchorage than the bottom. The north side was composed of shattered rock scored with innumerable seams filled with red clay. In thismaterial the excavation was carried to a depth (perpendicular to the slope) of 20 to 25 feet before a solid ledge free from seams was encountered. This ledge lay with a slope nearly parallel with the surface slope, and in direction so nearly parallel to the radial line of the curve of the dam that it could not have been better placed to receive the arch thrust and formed a natural skewback. This was carefully stripped and treated with cement grout in the same manner as the base.

The abutment on the south side was against the end of a dike of trap rock, crossing over the hills to the south in a direction nearly parallel to a line passing through the center of radius and dipping westward at an angle of about 10 degrees from the vertical. After cutting into the face of this rock 5 to 10 feet all seamy, loose material was stripped away, and a bedding that was deemed sufficiently good was obtained, although the rock was not as free from seams nor as solid in mass as the north abutment. However, the entire foundation is an admirable one, of rock in place throughout.

The plan.—The original height of 50 feet was arbitrarily adopted at the beginning of the work, without any special investigation of the quantity of water to be stored by a dam of that height, but was "guessed" to be sufficient for present necessities, and the estimate of its cost was considered to be about the limit of the expenditure the company cared to make on an experimental scheme. There was an immediate and pressing need for water, the rainy season was passing, and it was desired to get up a part of the structure as rapidly as possible in order to catch a partial supply for the coming summer. Accordingly, in compliance with this desire, the foundation was rapidly laid and the structure hurriedly carried up to a point where it was safe to begin catchment. The base of the dam was laid with a width of 36 feet, and at a height of about 15 feet above the lowest course it was drawn in to a thickness of 24 feet. At this level (whose elevation above tide is 140 feet) the lowest pipes pass through the dam. Above this level the structure was carried to a height of 45 feet, with a top width of 5 feet, base as stated of 24 feet, face batter (up-stream) of 1 to 6. In anticipation of a probable addition to the height of the dam in future, the back was built in three steps, to give an opportunity of bonding the new work to the old. The profile of this portion of the structure is shown in Plate XXX. It was a gravity profile, whose line of pressure passed within the inner third of the base. It was constructed in arch form, convex to the stream, on a radius of 225 feet on the face line at top.

During construction the stream was carried in a conduit 30 inches square through the masonry near the bottom of the original creek bed. But one storm of the season of 1886-'87 (a dry one) swelled the creek sufficiently to exceed the capacity of this conduit, and then it rose and ran over the top of the masonry for two days only, without injury. This occurred February 14 and 15, 1887, when the flow reached a maximum of about 500 cubic feet per second. The gate at the upper end of the conduit was finally closed April 20, 1887, and the conduit was filled solid with masonry from below. From that time until June 1, the catchment was about 80,000,000 gallons.

By the 1st of June the structure, as planned, was completed to the height of 60 feet above the bottom, 10 feet higher than the height originally contemplated. It contained about 7,500 cubic yards of masonry and had cost, all told (including the preliminary experiments), about $100,000. Meantime, surveys of the reservoir basin and water-shed had developed the fact that the 60-foot dam would impound 1,221 million gallons, whereas, its extension to 90 feet in height would give a capacity of nearly five times that quantity, or 5,882 million gallons. Also that the area of the water-shed tributary to the dam is about 186 square miles, of which one-third is above an elevation of 3,000 feet, and between that elevation and 6,500 feet. The water-shed was evidently ample to justify the hope that the greater reservoir would be filled almost every year of ordinary rain-fall. The increased volume of water stored would so largely extend the utility of the works, and give so considerable increase in security against the disasters following a severe drought, that the increased expense of extending the height of the dam while the working force and plant were on the ground and fully organized, seemed to be immediately justifiable. These arguments were embodied in a report, which was favorably considered by the directors of the company, and orders were given, about a fortnight before the 60-foot dam was completed, to extend the structure to a height of 90 feet.

This somewhat extended account of the growth of the enterprise from small beginnings is necessary to an understanding of the causes that led to the building of the structure in two sections rather than as a mass. The fact is that the work was nearly half done before all the conditions were thoroughly understood—conditions which ordinarily in works of such magnitude and importance are known, studied, and exhaustively discussed preliminary to the beginning of any work whatever.

In designing the plan of the higher structure, greater reliance was placed upon the arched form than in the lower dam, then approaching completion. The profile adopted was one which theoretically gave stability by its own gravity, but without as large a factor of safety. The line of pressure falls about the center of the lower third. It was reasoned that as the foundation was as near perfection as can be generally found, apprehension on that score was unnecessary—and the source of the failure of such of the great masonry dams of the world as have given way—insecure foundation—need not be regarded as a factor in this case. If one can imagine a monolith to be carved in the form of a true arch, of such weight and dimension that any section of it is capable of withstanding the pressure of quiet water against it to its full height, without sliding or overturning, and such a monolith be firmly wedged between the rock-bound walls of a narrow cañon, the possibility of its being ruptured, displaced, or destroyed from water pressure alone can not readily be conceived. Now, if by the use of rich cement mortar and the best of building stone a structure be formed of the same dimensions and in the same position, which in time becomes virtually a monolith, based on the firmest of bed-rock, its stability must be equally assuring to the mind.

The dimensions adopted were the following: Base, 46 feet; top thickness, 12 feet; height, 90 feet; radius of arch, 222 feet on line of face at top. The face batter of 1 to 6 was carried to within 6 feet of the top; thence to the top of the parapet wall, vertical. The batter on the back started at the top with 1 to 3 for 28 feet; thence 1 to 4 for 32 feet; thence 1 to 6 to the coping.

The construction.—When the new work was begun at the base of the completed structure, special care was taken to secure a perfect footing for the toe. When the foundation was stripped it was found that there was a slight leakage at various points along the bottom of the masonry, amounting altogether to about 10,000 gallons daily. The only perceptible leakage through the masonry was along the sides of the waste conduit, which had been recently filled in, although there were moist spots all along near the bottom.

All the leakage was entirely cut off by the new work, although it was necessary to carry up small well-holes alongside the old masonry to within about 15 feet of the level of the water surface in the reservoir, and keep them pumped out, before it was safe to close them entirely. Water was standing in the reservoir at a height of about 35 feet above the base of the dam, and the small quantity of leakage, and the ease with which it was stopped, was considered a favorable test of the superior quality of the masonry.

The stone used was of two grades, a dark blue and a gray metamorphic rock, impregnated with iron. The gray stone is full of minute quartz crystals, and is of slightly less specific gravity than the blue stone, which carries more iron. It was obtained from a quarry opened in the face of a vertical cliff over 100 feet high, situated 800 feet below the dam. It has no well-defined cleavage, and broke out in irregular masses, although generally having one or more tolerably smooth faces. Numerous tests of its specific gravity gave its weight as 175 to 200 pounds per cubic foot. The average weight of the masonry in place was estimated at 164 pounds per cubic foot, which was the value used in the calculation of stability and strains.

Portland cement of the best obtainable quality was used in the proportion of one part of cement to three parts of sharp river sand. For the upper 4 feet next to the water a richer mixture of one to two was used. The sand was clean, sharp, and of the most suitable degree of coarseness to make the best of mortar.

* * * * * * *

The work was completed April 7, 1888, having occupied sixteen months in construction, including two months of delay on account of shortage of cement.

The total volume of masonry laid was as follows:

	Cubic yards.
In the dam proper	19,269.0
In the wasteway	481.2
In the inlet tower	376.8
In the conduit from dam to tower	182.0
In the gate-houses	71.0
In various accessories	127.0
Total	20,507.0

In this work 17,562 barrels of cement were used, an average of 1.17 cubic yards of masonry per barrel of cement.

The total cost of the dam was $234,074.11, distributed as follows:

Plant: Tools, etc		$6,236.76
Materials:		
Cement	$63,111.03	
Cement hauling	8,614.18	
Lumber	2,408.08	
Iron work	4,915.99	
Pipes, gates, etc	5,152.58	
Miscellaneous materials, powder, etc	3,229.84	
		87,431.70
Labor:		
Common and skilled labor	93,590.55	
Foremen	6,866.49	
Teams	19,696.12	
Engineering, salaries and expenses	10,555.20	
Clerical work	653.88	
Earth work (contract)	7,666.51	
Miscellaneous expenses	1,376.90	
		140,405.65
Total		234,074.11

The cost of the flowage tract for the reservoir is not included in the above. A little over one-half the land cost $16,426.93. The remainder is in litigation under an action of condemnation. A San Diego jury under the stimulus of "boom" prices awarded the owner $280 an acre, or a little over $100,000 for land, one-third of which was worthless, and the remainder unimproved. This judgment is being contested before the Supreme Court. The clearing and grubbing of about 300 acres of the reservoir basin cost $10,808.46.

The wasteway.—This important adjunct to the dam was carefully considered and proportioned to carry the probable maximum flow of the stream that may be presented for discharge, with a full reservoir. It is located at the south end of the structure, and is 40 feet in length by 5 feet in depth, divided into eight bays of 5 feet each. These bays are formed by piers of masonry, set at right angles to the flow, and provided with recesses on the upper face, in which loose flash-boards of 2-inch plank rest on an incline of 35 degrees from the vertical. Any set of boards may be removed from top to bottom, or the water may be held at successive levels from the top to the bottom of the weir by removing the top boards all the way across. The water falling over the weir drops into a series of pools, 3 feet deep, which relieve the structure of shock, and passes down an inclined plane with a fall of 1 to 10, until it is carried away from the dam a distance of 50 feet, and then plunges into the cañon below. The capacity of the wasteway is about 1,500 cubic feet per second. This may be increased to about 1,800 cubic feet per second by opening a 30-inch blow-off gate in the main pipe below the dam.

The inlet tower.—This structure is located 50 feet above the dam, nearly opposite its center. It is built of masonry, with cement mortar mixed two to one, plastered outside and in with two coats of mortar mixed with one of sand to one of cement. It is 16 feet square at the base for a height of 10 feet, where its form is changed to a hexagon, with walls of a uniform thickness of 3 feet to the top. Each of the sides of the hexagon measure 3 feet on the interior face. Into the walls of the tower are built seven cast-iron elbows, at an elevation of 10 feet apart from bottom to top, the upper one being 10 feet below high-water line. The bell-mouths of the elbows open upward, and are ordinarily closed with a plain valve or cover of iron. The design is to draw water from the surface at whatever stage it may be. When any one cover is removed, a basket screen is lowered in its place, fitting closely into the mouth of the elbow. Three pipes pass through the dam and enter the tower at the bottom. The two lowest pipes are of cast-iron, 14 and 18 inches in diameter respectively, and lie side by side. They are encased in concrete throughout, from the tower to the dam. On top of them is built a conduit of masonry with a circular orifice 40 inches in diameter, formed of walls 30 inches in diameter, in double arches. This conduit leads from the interior of the tower to the center of the dam, where it joins a pipe of ¼-inch boiler-iron, 36 inches in diameter, leading to the main gate immediately below the dam, and from this gate is carried the main pipe line down the valley. The smaller pipes are not at present used, except to supply a hydraulic ram throwing water to the keeper's house on the hill, 150 feet above, and to drain the tower when all the valves are shut. They are intended to be used for supplying a turbine and pump to throw water to a higher level than the dam will now reach.

As an illustration of the fact that masonry laid in Portland cement in the proportion of two of sand to one of cement may be made water-tight with care exercised in laying, this tower, and the conduit leading from it, may be cited. When they are empty the pressure from the outside at present is somewhat more than 20 pounds per square inch on the conduit and at the bottom of the tower, and there is no leakage in either of them.

The reservoir.—Red clay soil constitutes the bed of the reservoir basin, or the major portion, outside of the old river-bed and bottoms, and is of an impervious nature. The following table of area and contents of reservoir is presented:

Contour elevation.	Area.	Contents.	Contour elevation.	Area.	Contents.
Feet.	*Acres.*	*Gallons.*	*Feet.*	*Acres.*	*Gallons.*
145 (level of lowest outlet valve in tower)	3.51	....	180	200.77	835,851,000
150	10.72	11,640,000	185	272.22	1,221,355,000
155	17.12	30,577,000	190	326.96	1,710,583,000
160	43.10	79,631,000	195	397.85	2,302,261,000
165	75.21	175,819,000	200	463.80	3,005,642,000
170	113.40	329,546,000	205	538.94	3,824,197,000
175	153.75	547,060,000	210	630.94	4,778,549,000
			215	721.88	5,882,278,000

The table shows that 80 per cent. of the capacity of the reservoir is within the upper 30 feet of height, and that 40 per cent. is within the last 10 feet. This fact reduces within small limits the fluctuation of head on the mains after the reservoir is once filled, and constitutes one of the reasons for increasing the height of the structure, as it enables the establishment of the probable limit of irrigation on the lands below, at a line not lower than 25 to 35 feet from the top of the dam. The irrigable area was thus largely increased, by reason of the decrease in fluctuation of depth in the reservoir.

* * * * * * *

There has been no lack of wiseacres who predicted the failure of the enterprise as a permanent irrigation scheme; and some of the most intelligent citizens of the country criticised the location of the reservoir so near the mouth of the stream, on account of its presumed liability to obliteration as a reservoir by reason of the deposit of sand and silt. A careful examination of the water of the stream at flood time, when it was most heavily charged with sediment, convinced the writer that fears of this nature were groundless. An estimate made, within reasonable limits, indicated one thousand years as the time when it might be expected to fill. Samples taken by the State engineer department of California of the water of the Yuba, Bear, and American Rivers, immediately below the hydraulic mines, yielded an average of only about one half of one per cent. of sediment. Were the Sweetwater as heavily charged, it might fill the reservoir basin in one to two hundred years, but the voids would still contain a considerable volume of water that would drain out and be available, and the utility of the reservoir would not be destroyed if it were entirely filled with sand.

The distributing system.—From the dam to the lower end of the cañon, 1,600 feet, the main pipe is 36 inches in diameter, and covered with masonry laid in lime mortar, plastered with cement. From this point it is reduced to 30 inches diameter, and follows the valley for 5 miles, and thence rises to the top of the Chula Vista Mesa 92 feet above sea level. Its entire length is 29,800 feet, and at its terminus the water is divided into two 24-inch pipes, one running south 1 mile, the other west half a mile, where it is reduced to 18 inches diameter, and is carried northward to and through National City.

At the terminus of the 36-inch main a blow-off gate is located, to be used as a relief to the wasteway of the dam in case of a sudden flood which might exceed the capacity of the wasteway, or to draw off the water from the reservoir if, for any cause, it was desired to do so.

Wrought-iron pipes were used throughout. The total length of mains and laterals that have been laid is 58 miles, with 5½ miles on hand to be laid this season. They are of three classes, viz, straight double riveted pipe; converse lock joint, kalamined lap-welded tube; and spiral riveted pipe. About 16 per cent. of the pipe was of the first class, 72 per cent. of the second, and 12 per cent. of the third.

The introduction of spiral pipe into the system was unfortunate, as it does not stand the test of transportation across the continent, and will have to be taken up and specially treated to make it water-tight. It will answer very well for sub-irrigation, if it could be properly controlled, but as it is laid in streets and avenues that system is not desirable or conducive to comfort in traveling.

The total cost of the pipe lines was as follows:

Pipe	$301,928.80
Freight	39,183.03
Distribution	6,271.06
Gates	1,849.62
Materials, tools, etc	5,932.57
Right of way and miscellaneous expenses	2,968.00
Pipe laying	144,630.78
Total	502,763.86

Probable duty of the works.—One of the most interesting questions to the stockholders of the company is the result that may be reasonably expected in the way of irrigation from such a reservoir. The assumption is made that in average years, say three out of five, the water-shed will yield a sufficient supply to fill the reservoir, besides maintaining the consumption through the rainy season, thus starting on the irrigation season about May 1st with a full reservoir. From May 1st to October 1st is the average season of irrigation—about 150 days. Where pipe distribution is in use, a fair average allowance in southern California is a duty of 10 acres per miner's inch (500 acres per cubic foot per second). There are instances of a much higher duty having been attained—a duty of even 40 acres per miners' inch having been accomplished in one place. Allotting 700,000,000 gallons for the annual consumption of National City, and for loss by evaporation during the summer months, the remainder would yield a flow of 2,000 miner's inches per day for 200 days; with a duty of 10 acres per inch, this amount would irrigate 20,000 acres. In the course of time it is expected that a duty as high as 20 acres per inch will be reached, in which event a reservoir full may be extended over two years' time, and still irrigate 20,000 acres, and afford a domestic supply to the town of National City.

Water rights, giving to the purchaser simply the privilege of becoming a customer for water, have been sold on the San Diego Flume Company flume at the rate of $2,000 per miner's inch. At this rate the value of the irrigation supply of the reservoir is $4,000,000. The construction of the works has already added a value of $1,500,000 to the principal tract of 5,000 acres which has been supplied with a complete system of water pipes, and another million to the value of town property in National City, and lands in its immediate vicinity.

STATEMENT OF WILLIAM DENTON, OF SAN DIEGO.

The **CHAIRMAN**. You are familiar with the Colorado Desert?

Mr. **DENTON**. Yes.

The **CHAIRMAN**. Have you reported on it several times?

Mr. **DENTON**. Yes.

The **CHAIRMAN**. Are you willing to furnish us a copy of your report?

Mr. **DENTON**. I gave extracts to Mr. Berry, of the Union, and if I had time I would be willing to present the committee with a copy.

The **CHAIRMAN**. Will you send it to Washington at any time within six weeks?

Mr. **DENTON**. I will do so. It will afford me a great deal of pleasure to send it.

Adjourned.

PAPER PREPARED BY WILLIAM DENTON.

Agreeably to request, I have the pleasure of submitting my report upon the basin of the Colorado, situated in San Diego County, and in the northeastern part of the northern district of the peninsula of Baja California, Mexico, although a portion of this basin is in Mexico and outside of the jurisdiction of the United States, and might at first glance appear irrelevant to the matter which I propose to discuss; but that part of the basin situated north of the boundary line between the United States and Mexico is, practically speaking, dependent upon the Mexican side as a medium through which water must be introduced for the irrigation of an important part of the territory under consideration. The area of the land north of the boundary line (United States) that is susceptible of cultivation through irrigation is approximately 1,797,120 acres. Of this area, 1,336,320 acres, owing to its situation, would be irrigated from the Colorado River, the rest, 460,800 acres, from reservoirs that could be made in Jacume, Carizo, upper Vallecitos, San Felipe, which would collect annually in the vicinity of 50,000,000,000 gallons of water, sufficient if economically used to irrigate by pipe all that portion of territory on both sides of the basin, situated at a higher elevation than the canal, lands formed from the washings from the surrounding mountains, not from the alluvial deposits from the Colorado River or the marine deposits of the Gulf of California, of which most certainly the central and lower portions of the Colorado Basin are composed.

Although desirable to build the entire canal upon United States territory, it would be impracticable to attempt it, owing to the heavy excavations and embankments, together with shifting sand hills that would be encountered for a great distance, which would be not only very expensive, but a hindrance of such a character that it may be considered at present impracticable. There is no doubt in my mind that the time will arrive when these lands will become so valuable that an outlay would be warranted for the construction of such a canal from some point on the Colorado River at a sufficient elevation to enter the Colorado Basin at its northeast extremity, branching at that point and running down both sides of the basin to the boundary line, thus irrigating all the lands in the Colorado Basin between the foot-hills, and carrying a sufficient velocity to keep a clear channel. On account of the turbidity of the water, velocity will require serious consideration.

Under existing circumstances I would suggest that the Colorado River be taken as a medium to irrigate the greater portion of the lands alluded to, that the matter be made international, that a canal be made (the main trunk) through Mexican territory from the Colorado River to the Cucupah Range of mountains, say a distance of 60 miles, at a point near the Siete Pozos (seven wells), that the canal be tapped with a branch canal, taking it through the sand hills at a natural opening near that point, thence following the eastern side of the basin with the canal to the northeast extremity of the basin and as much farther as possible, thence tapping the main canal near the Cucupah Range, following the western side of the basin, meeting the canal that circuits the eastern side (see map). Naturally flood-gates would be established on the canal at suitable points, thus controlling the water supply as to quantity. Another plan: Making the objective or initial point the Colorado River, so that in passing Pilot Knob, in United States territory, the bed of the canal would be 200 feet above sea-level, and 466 feet above the lowest point near Salton, in the Colorado Basin, the bed of the canal being 15 feet in width, with slopes of 60 degrees. Carrying a depth of 5 feet of water with sufficient fall the canal would have an easy flow, bearing a large volume of water nearly the entire round of the basin, not, however, on the line of canal laid down and shown on the accompanying map, but more or less like that shown by the dotted lines in red ink. However, the dotted line does not extend a sufficient distance up the river to give the 200 feet at Pilot Knob. The entire line of the canal in the latter method would be in United States territory. It would, however, be expensive, demanding a large amount of fluming; also in passing through the sand hills the flume would have to be boardered over tight. However, before any of these suggestions (the smallest of which would require a large outlay) could be acted upon thorough surveys would have to be made, when, after the subject had received mature consideration, the most feasible plan of irrigation could be determined upon.

Formation of the soil.—The central portion of the basin is formed by alluvial and marine deposits from the Colorado River and the Gulf of California, composed of decomposed vegetable matter, lime, and phosphorus, a great deal of it sufficiently rich to export as a fertilizer. It is an erroneous idea to suppose that the basin is a deposit of alkalies, when in the basin proper there is hardly any of that commodity. On the eastern slope, it is true that there are portions of the country impregnated with alkalies, but not so much so but that mangel-wurzel, beets, date palm, sugar-cane, and tobacco could be grown in great abundance, as it is a well-known fact that those articles thrive better in alkaline soils than in others. All plants require salts of some kind for their nourishment; they are continual absorbers. I am now speaking of the general character of the soil, and do not wish to be understood as inferring that there are not some patches on this immense tract that are not impregnated with alkali and sulphur, so as to make the existence of vegetable life an impossibility. I know that such is the case. But comparatively speaking, taking the whole into consideration, the alkaline patches alluded to would cut no figure.

Having paid more attention to that portion of the Colorado Basin (during the last sixteen years) situated in Mexico south of the boundary line between the United States and Mexico, which is of a similar character as to formation and composition, I will give you the advantage of my experience and knowledge, both in regard to its resources and proper mode of development and utilization, and which would apply equally to that part of the basin that exists in the United States, although, to a great extent equal in soil, it must be taken into consideration that circumstances have not admitted it to be clothed with the prolific growths of vegetation that is to be found on the Mexican side of the line, for the reasons that it has been debarred the privilege of receiving seed at the time of overflows, owing to the land a short distance south of the boundary line having become raised by the deposits of alluvium at the time of the overflows, likewise aided by the winds collecting matter which has formed a backbone or elevation that now prevents the water from passing over. New River, and that called the Rio in Medio (Middle River), at the time of the overflow, water the basin. Middle River's mouth is a long distance above tide-water. Not so that of New River. The latter is caused by the backing up of the waters of the Colorado River by the tide of the Gulf of California at the time of the freshets, produced by the melting of the snows. The Colorado River runs at a velocity of 7½ miles per hour, the Gulf tide at a velocity of 10½ miles an hour.

Water runs through the Rio in Medio nearly every year, at any rate every freshet, but not in sufficient quantity to irrigate any great extent of country. Not so with New River; unless the freshet is sudden and great, the water does not reach farther than the Hog's Back, situated south and immediately in the vicinity of Purdy's, or Cerro del Volcan, which causes a barrier to the further progress of the water through this channel (see section of New River bed on accompanying map). Since this survey was made of New River, the bed has filled up considerably south of the Hog's Back, where previously steamers have navigated as far as Promontory Point; that was the Embarcadero (landing) of that section of the country; here large quantities of sulphur were shipped on the steamer and forwarded to San Francisco. At this writing, however, even a light-draught stern-wheel steamer can not approach this landing within 400 yards, except at extreme high tides. This, as a matter of course, could be remedied by a little dredging at a small cost. The waters that could be supplied by these rivers (New and del Medio) could be used to very little advantage without the aid of reservoirs and powerful machinery, so that in the event of irrigating the lands alluded to, I would suggest the plan of dealing directly with the Colorado River at a commanding point, sufficiently to water a vast territory without the further aid of machinery or reservoirs as far as the Colorado water is concerned.

If it should be found that the supplies from the projected reservoirs already alluded to were not sufficient for those lands situated at an elevation out of reach of the canal that circuits the basin, then by all means I should advocate the construction of reservoirs of a sufficient capacity to hold the needed supply, which would have to be situated at proper distances apart, and elevations that would command the situation; with such a necessity, powerful machinery would be required to lift the water from the canal to the reservoirs.

The lands on the Colorado and New Rivers, to which I have already referred, and are more clearly set forth by the accompanying map, are rich beyond description, being composed of clay alluvial from the Colorado River and marine deposits from the Gulf of California, a great portion of which are annually overflowed, leaving rich deposits, which would prevent the land becoming impoverished, no matter how heavily cropped. The present wild growth is a species of wild hemp (*Sabomica Macrocarpia*), hog weed, or wild beet, that attain a height of 15 and 20 feet and a diameter of 5 inches. The latter plant is valuable as food for hogs, in its green state, and when dry it is excellent as fodder for horses and cattle. It produces a large quantity of seed, which fattens stock of all kinds very rapidly. And now a word in regard to the hemp, which covers large sections of the lands described.

With reference to this as a hemp country, we have the evidence that it is indigenous, of a superior quality, and at this present moment there are thousands of acres of last year's growth now standing, which simply requires to be gathered and broken and placed on the market. It compares very favorably with the Kentucky hemp, is equally as strong, and nearly as fine a fibre; it makes an excellent article of rope, matting, bagging, and paper, specimens of which can be seen in San Francisco in its broken, dressed, and natural states. Although this hemp is generally sown in ordinary good land, growing to a height of 7 feet, and twice as thick as a wheat straw, here it grows to the height of 20 feet, and 3 inches in diameter. There can be seen thousands of acres in a body that attains the height of 15 feet, and three-fourths of an inch in diameter. These plants are annuals. Besides the fiber which the hemp produces, it yields a heavy crop of seed, on which animals greedily feed. As a fattening food there is nothing superior; besides large quantities of excellent oil could be made and produced therefrom. There are other fibers in small quantities of a finer growth. Annual grasses of a nutritious character grow here, which mature in less than two months after the waters recede.

The timber is cottonwood, willow, and mesquite. The latter tree yields a fine nutritious honey bean, which fattens all kinds of stock very rapidly. The soil is from 10 to 40 feet in depth, strongly impregnated with lime and phosphorus, owing to the immense deposits of shell-fish and other matters.

Potable water can be obtained at a depth of say from 10 to 40 feet.

The soil and climate of this section of the country are susceptible of producing cotton, tobacco, hemp, which is indigenous, as well as the Manilla, New Zealand, Indian, and South American fibers, of which I should recommend the introduction; rice, sugar-cane, sugar-beets, pepper, ginger, peanuts, sweet potatoes, plantains, bananas, oranges, grapes, and all fruits and cereals of temperate and semi-tropical zones. Corn has attained the height of 25 feet, yielding from three to four ears of rare proportions and quality; the finest field of corn I have ever seen was grown in this basin, planted by the Indians without any cultivation or irrigation. I feel satisfied that on the western rim of this basin both tea and Liberia coffee would do well. In portions of Bajai California are grown rice and dates equal if not superior to any other grown in the world. The date-palm grows prolifically throughout the peninsula of Lower California, particularly the far-famed black date of San Ignacio, which surpasses all other kinds in yield, size, and flavor. This tree is peculiar in its necessities, adapting itself to the most sterile and arid localities; after the first year of its planting it requires no water. The most inferior portions of this country, and those impregnated with alkali, can be utilized with profitable results by the introduction of this tree. A good healthy tree in full bearing will yield annually 60 pounds (let us say 20) without looking after, except the picking and drying of the fruit, packing, and marketing; after the first year no cultivation or irrigation is required.

Let us hear what General Charles P. Stone, who was chief of commission for the survey of the Occidental States of Mexico, including Lower California (of which I had the honor of being a member), and who afterwards went to Egypt and formed that army. Writing from there in regard to the date-palm and the Colorado Basin, in answer to a letter of General W. G. Le Duc, Commissioner of Agriculture, in Washington city, under date of January 28, 1878, says:

"WAR OFFICE, BUREAU OF THE GENERAL STAFF,
"*Cairo, Egypt, January* 28, 1878.

"SIR: I have the honor of acknowledging the receipt of your letter of the 3d instant, informing me of the safe arrival of the red date seed, etc.

"Had I known that you desired to plant the date seed in large numbers the quantity sent would have been much greater, and I have now given orders for the collection of several thousand seeds in each of the northern districts, where the best dates are grown.

"The provinces of Charkieh, Gharbish, and Dahkaleeych, as well as the district of Rosetta, all produce in the northern portion excellent varieties of dates, the cultivation of which is very profitable. From what I have seen of the date-producing regions of this part of the world, and from what I know of the desert of the Colorado between Carrisso Creek and Fort Yuma, I am inclined to believe that the greater portion of the latter region can be made productive and very valuable by making plantations of the date palm.

"This tree not only does not require much water, but much water is prejudicial to it, and the climate of the Colorado Desert is singularly similar to that of some of the best date-producing districts here.

"In any case, I feel assured that all of the New River portion of the Colorado Desert would grow the date tree without difficulty.

"Such is the opinion of an able man with a world-wide reputation, who thoroughly understood the subject and whose word is authority."

Extensive forests of eucalyptus could be planted which in five years would not only beautify the surrounding country but would render a respectable revenue to the planters, as it affords an excellent timber for ship-building, wagons, etc., and firewood equal to the best maple.

The countries of which it is indigenous are free from all kinds of fever, the leaf of this tree being an absorbent of malaria, and on account of its sanitary and other useful properties large quantities of it have been planted all over the East Indies and part of Africa by orders of the English and French Governments. Taking into consideration the extreme richness of the soil, and during the greater portion of the year the mildness of the climate, there is no reason why this tree should not attain the stately proportions that it does in Australia. The sugar-beet, mangel-wurtzel, sugar-cane, rice, bananas, corn, and tobacco could be grown with great success and most profitable results. The pig-weed (*Heracleum*, Bot.), which grows to such immense dimensions, I have already alluded to as being of the best family. There are certain portions of this basin that are peculiarly adapted to the production of the best tobacco, sugar-cane, and dates; I allude to those slightly impregnated with alkaline matter; indeed, the most luxuriant date trees, the most prolific growth of sugar-cane and beets, I have seen growing in lands strongly impregnated with alkaline matter.

Any quantity of beets, mangel-wurtzel, and sugar-cane could be grown on these lands, which not only would supply food for immense herds of stock but would yield a large amount of sugar annually, which would be quite an item to the commercial world, and particularly so to San Diego.

The climate is hot for four months of the year—June, July, August, and September; the other eight months are pleasant, and during the four very hot months there is a ventilation that does not allow it to become very oppressive or sultry. The ventilation that I allude to I attribute to the breeze which springs up in the afternoon carried (I presume) by the vacuum which the heat produces in the Mohave Desert (this being its out-let). The cool air, comparatively speaking, rushes in from the Gulf of California, thus to an extent cooling the atmosphere.

Were this country utilized by cultivation, planted with groves of trees adapted to the climate, with the introduction of water on a liberal scale, the whole face of the country would not only be changed, but the temperature would be decreased many degrees.

In conclusion, I will give you the opinion of Prof. Justin S. Moore, president of the botanical department of the California Academy of Sciences.

CALIFORNIA ACADEMY OF SCIENCES,
San Francisco, June 16, 1879.

DEAR SIR: You have requested of me my views of the soil, climate, and flora of the region of the mouth of the Colorado River, especially of that portion lying below the Algadones Rancho, in Lower California, and extending westward therefrom.

I have watched with interest your efforts to bring this region to the attention of our people of this coast, as well as to the notice of foreign immigration seeking good locations.

In the month of February last, in company with a gentleman well known in commercial circles in California, I paid a visit to the land above mentioned. In some respects the time of year chosen was unfortunate, in that the season of vegetation was passed and everything showed to its worst advantage.

I must say, however, that in every respect I found things as you represented.

The soil is of a rich alluvium, annually enriched by a deposit (slight) from the river, and a still greater deposit of carbonaceous matter from the decay of the rank vegetation. In no portion of North America have I seen a soil that will at all compare with this in fertility. It closely resembles, however, the soil of the delta of the Nile.

As to the flora observed by me, I herewith append a list; I am sure it is at best a meager list, as compared with what might be found in the proper season of the Gramineæ. I have added nothing, as both flowers and seeds were absent, and consequently the species were not determinable. At one or two places I saw the alfalfa thriving without irrigation; of the Cryptogams I saw but few, and those as yet I have not determined. The more useful plants, which abound, are the various species of the *Prosopis*, *Parkinsonia*, *Sesbania*, *Philibertia*, *Tessaria*, *Sales*, and *Populus*.

No one who rides through the rank growth of *Sesbania*, *Philibertia*, and *Tessaria* can deny the evidence of his senses, that in this tract is to be found as rich soil as earth affords, capable of supporting as dense a population as any region on the globe. I have, therefore, no hesitation in saying that any and all semi-tropical plants may there be grown to the greatest advantage and with the certainty of a large yield.

Of the climate, I can only say that it resembles that of the countries of the Old World lying on the same isogeothermal line.

While it is much warmer than the climate of the coast region, it is yet far more pleasant than that about Fort Yuma.

This is no doubt due to the fact that a constant current of air is passing from the Gulf of California inland to the basin of the Colorado Desert: this current is more or less laden with moisture, and so comes as a refreshing breeze. I can see no cause to apprehend anything like miasma, for the reason that the presence of so large a body of salt water, together with the constant air currents passing the ground, is hostile to any miasmatic influences.

From those who have spent much time in this region, and especially along the river, where misama might be expected if anywhere, I learn that nothing of the kind has ever been known.

It seems to me, in view of all these circumstances, that no fairer land, no richer soil, or better climate can be afforded on this continent.

But one thing is needed, and that is the hearty co-operation of the Government of the Republic of Mexico in the grand enterprise you have undertaken, and for which you have spent and are spending so much of your time and such liberal sums of money. But for your efforts, I am sure our people would not as yet know of that vast and fertile region.

Already you are beginning to see the fruits of your unremitting toil.

Should now your Government second your labors, as they so richly deserve, I predict that it will be but a short time ere you will have the pleasure of seeing prosperous colonies settled on the tract, and the entire frontier be reaping rich advantage from thriving communities, cherishing the arts and manufactures, and developing the resources of the country.

Very respectfully, yours,

JUSTIN S. MOORE, A. M.,
Member California Academy of Sciences, San Francisco.

WILLIAM DENTON, Esq.

LIST OF PLANTS GROWING ON THE COLORADO BASIN, FEBRUARY, 1879.

Parkinsinia Aculoata Sinn.
Parkinsinia Microphylla Tove.
Parkinsinia Tarreyena Watson (Palo Verdi).
Prosopis Juliflora D. C., (Algaroba).
Prosopis Subuscens "Tounilla."
Salia Longifolia (Huhl).
Topertus Manilifera.
Chilopsis Saligna Dobn, (Desert Willows).
Tessaria Borealis Gray (*Cashamulla* or arrow wood).
Sarvea Mexicana Mor. (*Gobernadoia* or *Hidonia*).
Baccharis Enongi (Grey).
Datura Diocolvi Beruh.

Sesbania Macrocarpa; this is the so-called hemp, or Indian hemp, as that is an Apocynum. This is a very valuable plant for the fiber, for paper-making, etc. It is used by the Indians for making huts. There are thousands of acres of it in the tract. The other fine fiber found on the tract may be *Sinum Aristatum* (England).

There is another fibrous plant which I am sure will prove useful for paper stock, viz, *Philibertai lineare*, Var., Heterophyllun. It is abundant and will pay. Of the grasses I can not speak, as I did not find them in a condition to determine.

JUSTIN S. MOORE,
President Botanical Section California Academy of Sciences.

In conclusion, I will say that for the last thirty years I have been familiar with the Colorado Basin and its surroundings, and in regard to the statement of Professor Moore, touching the sanitary condition of that country, I can thoroughly indorse his statements. There is neither natural disease nor fever of any description; nor have I ever known or heard of a case As an evidence of the salubrity of the climate, see the Indian to the manor born. No finer race of man (beautifully developed, free from sickness) exists on the face of the earth. Professor Moore said that he preferred to come to the Colorado Desert to see the grander living statuary—grander than any dead statuary that can be produced in either Athens or Rome. He remarked that fact alone speaks for the climate and soil of this section of the country.

A greater portion of the Colorado Desert north of the boundary line between the United States and Mexico is of a similar character to that which I have just described, having the same composition and made from the same sources, with the same climate and the same necessities, requiring the same aid, labor, intelligence, and energy to make it yield vast wealth which would appear nearly incredible, making the entire basin the wonder of the west, second in importance to no Delta of the Nile or any other area of the same size on earth.

As an engineer, I have made the utilization of that portion of the basin below the line, or in Mexican territory, a study for many years, and I think that I fairly understand the subject, not only in regard to the plan for irrigation but also as to a proper system of cultivation and cropping. The same system or plan of operation is applicable to the entire Colorado Basin.

STATEMENT OF F. H. HEALD, OF ELSINORE.

The **CHAIRMAN**. Where do you reside, Mr. Heald?

Mr. **HEALD**. At Elsinore, San Diego County, Cal.

The **CHAIRMAN**. How long have you resided in southern California?

Mr. **HEALD**. Since 1877.

The **CHAIRMAN**. At what places?

Mr. **HEALD**. Los Angeles, Pasadena, and Elsinore?

The **CHAIRMAN**. How long have you resided at Elsinore?

Mr. **HEALD**. Since June, 1883.

The **CHAIRMAN**. Have you had any experience in irrigation?

Mr. **HEALD**. I have had considerable.

The **CHAIRMAN**. Please state it.

Mr. **HEALD**. I have irrigated for myself and others several years at Los Angeles and Pasadena. Have developed water by wells, tunnels, submerged dams, and other ways, and am conversant with the Los Angeles and Pasadena systems as well as with others. I own two artesian wells (hot water); also a water system, supplying the city of Elsinore, 6 to 13 inch iron pipe. I own Elsinore Lake by virtue of succession of title to La Laguna Rancho, No. 495, descending from the Mexican Government, in which the United States Government has no vested rights.

The **CHAIRMAN**. Will you state length, breadth, and depth of Elsinore Lake?

Mr. **HEALD**. It is about 6 miles long, 2½ (average) miles wide, and from 35 to 80 feet deep, with a crater or center, the area and depth of which are unknown to me.

The **CHAIRMAN**. What is the source of supply of Elsinore Lake?

Mr. **HEALD**. The San Jacinto River and its water-shed, and various cañons of the Elsinore Mountains.

The **CHAIRMAN**. What is the area of its water-shed?

Mr. **HEALD**. About 522,000 acres.

The **CHAIRMAN**. Is the water of the lake fresh?

Mr. **HEALD**. It is fresh water from mountain snows and rains, but purifies once a year during the summer. There is an outlet to the lake at Temescal Creek, which flows into the Santa Ana River. The lake does not overflow, except in seasons of more than average rain-fall. A dam could be made at the head of the Temescal Cañon, which would increase the area about 2,000 acres and increase the depth 30 feet.

The **Chairman**. How much arid land is there in the vicinity of Elsinore which would be benefited by irrigation?

Mr. **Heald**. I estimate 25,000 acres. Land not needing irrigation I estimate 4,000 acres. The altitude of Elsinore Lake is 1,280 feet.

The **Chairman**. Could the water be piped or conducted to irrigate arid lands in this or San Bernardino County?

Mr. **Heald**. Yes.

The **Chairman**. Are you in favor of storing water in mountain cañons by means of dams?

Mr. **Heald**. I am not.

The **Chairman**. State your reasons.

Mr. **Heald**. Great floods have occurred during my observation in this country in the winter season after the ground has become thoroughly saturated with water and then aided by a sudden and warm rain which rushes down the steep slopes and carries with it the water converted from melted snows. In this way thousands of lateral cañons and gulches pour their waters suddenly into the main cañon or river (already carrying all the water which it can with safety), creating a volume and force which no dam or obstruction created by human hands can withhold. At such a time the breaking of a great mountain reservoir and the adding of its waters to the flood might cause great loss of life and property. We build for future generations as well as for ourselves, and must remember that with water for our arid lands our population would be continuously increased.

FURTHER STATEMENT OF DOUGLASS GUNN, MAYOR OF SAN DIEGO.

This county is bounded on the north by San Bernardino and Los Angeles Counties; on the east by the Colorado River, dividing it from Arizona; on the south by the Mexican Territory of Lower California; on the west by the Pacific Ocean. Its area is 14,969 square miles, or more than 9,580,000 acres. Exclusive of the Colorado Desert section and of the mountain country lying adjacent on the east, there are over 3,000,000 acres of valley and mountain land adapted to a diversified agriculture and grazing. There are several large Mexican grants in the county, yet it is true that their aggregate acreage, as compared with the total area (exclusive of desert lands), is not large. The figures of the United States surveyor-general's office give the following:

	Acres.
Total area	9,580,000
Mexican and Spanish grants	784,783
Public lands	8,795,217

An approximately correct statement of the lands of this county, as open to settlement and purchase (1888), would therefore be as follows:

	Acres.
Total area (exclusive of desert)	3,000,000
Grants (still unsubdivided)	275,965
Subdivided grants	508,818
Public lands (settled and unsettled)	2,215,217

Two mountain ranges run through our county from northwest to southeast, dividing it into three districts, each possessing marked peculiarities of climate and soil.

The coast belt, between the mountains and the sea, is exceedingly fertile; it has now three-fourths of the population and exhibits most of the development of the county. This belt varies from 25 to 40 miles in width and is about 75 miles in length, comprising a series of low, rolling hills, or "mesa" lands, as they are termed—plains and valleys—drained by the Tia Juana, Sweetwater, San Diego, San Bernardo, San Luis Rey, and Santa Margarita Rivers, and several smaller streams. These streams are nearly all dry in the summer months for several miles from their outlets. The San Diego is the largest of them, and in the winter and spring is often unfordable.

The middle division of the county lies mainly between the two mountain ranges, and comprises numerous broad and fertile valleys and plains, over which thousands of sheep and cattle may gaze all the year; while in the mountains are rich mineral deposits and extensive forests of timber. The natural wealth of this important division of the county is very great, and it is capable of supporting a large population. The cereals and all the fruits of the temperate zone grow here luxuriantly, and the apple, the cherry, and the plum are especially at home. Orchards are multiplying in this section.

The third, or desert division, lies east of the second, or San Jacinto range, of mountains. The peak of San Jacinto, at the northern end of the range, is the highest land south of Mount San Bernardino, rising precipitously to the height of 9,000 feet, and its snow-crowned summit appears in strange contrast to the sweltering desert which it overlooks. Along the eastern base of this range extends the great Choahuila valley, 50 miles in length by 10 in width, connecting southerly with the valley of the New River, which flows from the Colorado in time of freshets and fructifies the fertile lands along its bottoms. The Southern Pacific Railroad crosses this division, entering San Diego County from the San Gorgonio Pass, and running thence across the desert southeasterly to Yuma about 160 miles.

FURTHER STATEMENT OF T. S. VAN DYKE, OF SAN DIEGO COUNTY.

SOILS AND THEIR CULTIVATION.

San Diego is the most difficult of all the southern counties to examine. Its coast line, like the southern coast line in general, gives little indication of what lies beyond it, and seemed almost worthless without irrigation. The thousand springs and streams of its high mountain ranges, where the winter rains are always heavy and frequent, and where the snow often lies several feet deep for weeks, sank from sight in underground channels and deep beds of granite sand miles back from the coast line. Moreover, its arable lands are broken into hills and dales, rolled aloft in table-lands, mountain valleys, and parks, and scattered over a space larger than the State of New Jersey. This makes it impossible for any one to see any considerable portion of it except by days of constant travel.

No one, then, can form a correct idea of the present value of Southern California land without knowing how the Californians themselves have changed their opinion thereof within a few years. Up to twelve or fifteen years ago the low bottom lands were deemed far the most valuable; the uplands or slopes being of little use except for stock range and the raising of hay and grain in winters of abundant rain. A few years ago, although it was becoming generally known that the uplands were the best for vines and fruits, especially when irrigable, yet in the partition of the large ranchos the bottom land was still rated at from three to five times the value of the best uplands. Not only were the bottom lands deemed more valuable because the surface was nearer to water beneath and more easily reached by water from the larger streams, but they were considered the only really rich lands there were. The uplands, being hard and dry, were often nearly bare of grass, and what there was seemed small beside the luxuriant growth on the loose soil of the damp alluvial bottoms. In time it has been found that the uplands only need good plowing and thorough cultivation to equal in production the best bottom lands; while the warmer nights in winter, cooler days in summer, their greater freedom from spring frosts, combined with superiority in the quality of nearly all fruits, make them far better for nearly everything but corn, alfalfa, and a few other products. The scale of values has been quite reversed; the uplands were irrigable, being about the only lands now sought for fruit-growing and attractive homes, while the low lands are used more for pasture or ordinary farming. For this purpose they are still very valuable, but it is a value that has close limits, while the uplands, being sought by people of wealth in pursuit mainly of comfort and places fit for the raising of the choicest and most tender fruits, have a constantly rising value, the end of which none can foresee.

The Mexican method of irrigating was to constantly drench the land from their shallow ditches. This practice was blindly followed for years by the Americans, who supposed that six or seven months of clear, warm weather would kill anything not rooted in wet ground. As population has increased and irrigable lands became scarce, moist lands along the river bottoms were tried; but it was many a year before any one supposed that the dry uplands would raise anything. First, it was discovered that these would raise as good grain as the low lands, provided there was winter rain enough; while in winters of excessive rain they would raise better grain, and in some winters of moderate rain-fall they would also do better, because the warmer nights permitted constant growth while the colder nights of the bottom lands often checked it until the ground was dried out. As arable land became scarcer the plow crept gradually farther away from the moist lands and up the drier slopes, until it was gradually learned first in the north, then in the south, that ground once thoroughly wet, then thoroughly plowed and thoroughly cultivated during the dry season, will retain enough moisture up to within a few inches of the surface to keep alive and in good condition during the longest, hottest, and driest summer almost every kind of plant or tree that is grown in rows or hills. For some things, such as oranges and lemons, this is generally insufficient to raise a good quality of fruit. For others, such as raisins, deciduous fruit, when the trees are well grown, corn, potatoes, etc., it may also be insufficient to produce very profitable results in some years. In no case is it quite equal to the same thorough cultivation combined with a little judicious irrigation. The arable soils of Southern California, though very varied, may be classed under two heads, the granite and the adobe, though there is sometimes a mixture of the two that at first glance resembles pure adobe.

The adobe is mainly clay and is of four prominent colors, though these sometimes shade into one another. These are dark, light-grayish brown, red, and dark brown. They are all very strong soils, probably standing longer cropping without fertilization, rest, or rotation than any other soil in the United States. They are, however, all hard to work unless taken in the right stage of moisture, when they are very tractable, and then if well cultivated they retain moisture as well as any soil. With sufficient moisture they raise the heaviest grain, and for some kinds of vegetables, such as beets, and for such fruits as pears they can not be excelled. The granite soils are all formed from the disintegration of the soft red or gray granite which forms the bed rock of most of the interior hills. This soil generally lacks that fine rich shade which elsewhere is deemed a sure test of goodness. The eye can not be relied upon as a judge of any soil in Southern California. Even that which appears to be pure sand, when well treated to seed and water, under the California sun, will give results that will astonish the most experienced farmer or gardener from any other land. These granite soils run through all shades of color between dark red, caused by the presence of iron, and light gray, and through all degrees of fineness from the fine red soils which show no mica, unless dissolved in water, to heavy gray sand coarse enough to make a gravel-walk.

WATER.

Thus far the area has been estimated as plow land pure and simple. Ninety-five per cent. of it needs no clearing whatever, none of it now needs fertilization, and for many kinds of products never will need any. It does, however, need water.

The rain-fall increases with elevation, as has been stated already. There are four different rain-belts caused by this change. Other changes can not be accounted for in this way. Thus Fallbrook has generally more rain than many other places having a greater elevation and distance from the coast; while the coast line above the Santa Margarita River has generally more than the coast below. Still the general rule is that the rain-fall depends upon elevation, especially where a broad tract is elevated. The general impression that San Diego is a dry country has been caused by the constant publication of the rain record of San Diego City to prove that it has the best climate in California, to-wit, the driest.

The following is the rain-fall by seasons for San Diego City for fifteen years. This record is compiled at the United States signal station at San Diego, and is the only accurate one at hand:

Years.	Inches.	Years.	Inches.	Years.	Inches.
1871–'72	7.18	1876–'77	3.65	1881–'82	9.44
1872–'73	7.41	1877–'78	16.10	1882–'83	4.92
1873–'74	14.95	1878–'79	7.81	1883–'84	25.97
1874–'75	5.48	1879–'80	14.48	1884–'85	8.60
1875–'76	9.46	1880–'81	5.20	1885–'86	16.62

Thus it will be seen from this that the rain-fall is very variable. The difference between the different rain-belts is most apparent in the years of very low rain-fall.

The second rain-belt is shown by the rain-fall at Fallbrook, where there we have a record for eleven years as follows:

Years.	Inches.	Years.	Inches.	Years.	Inches.
1875–'76	17.51	1879–'80	20.45	1883–'84	40.25
1876–'77	8.75	1880–'81	11.45	1884–'85	12.78
1877–'78	24.84	1881–'82	12.24	1885–'86	26.50
1878–'79	8.52	1882–'83	10.60		

The third rain-belt, best represented by Bear Valley, Santa Maria, Viejas, and similar elevations within that range, has about 35 per cent. more rain than Fallbrook.

The fourth, or high mountain belt, is best represented by the rain-fall of Julian, 4,200 feet high, and about 40 miles from the coast.

There is but five years of reliable report.

Years.	Inches.	Years.	Inches.	Years.	Inches.
1879-'80	30.63	1881-'82	29.28	1883-'84	61.42
1880-'81	25.89	1882-'83	41.31		

A record of the snow was kept in only one of these years, 1882-'83, when it was 5 feet, making 7 inches of water which are included in the 41.31 inches. Reference to the San Diego table shows this to be the driest winter on the coast since 1877. As a large proportion of the water at this elevation is every year precipitated in snow, especially in wet years, it will be safe to add about 20 per cent. for snow to the other four years. This snow-fall increases, of course, with elevation, and on the high mountains it often takes weeks to melt off. Following the analogies of elevation from the coast upward, it would be safe to add at least 35 per cent. more for the next 1,000 feet of elevation. The average rain-fall is doubtless 50 inches at 5,000 feet.

Our high rain belt embraces forty townships, being 1,440 square miles, or 921,600 acres of land. As most of this is quite steep hill-side with a tight soil, the amount of water that runs off is fully 60 per cent. Of the remaining 40 per cent. fully 30 per cent. finds its way seaward under ground, trickling out in thousands of springs and rivulets which in the mountains combine their water into little brooks and run all summer, but as they approach the coast sink in sand, or into the soft granite bed-rock or old under-ground channels, and disappear.

The drainage of this broad highland area forms seven rivers which in wet winters often carry water enough all the way to the coast to float a large steam-boat. They are often impassable for days at a time. During the summer they generally cease running above ground except in a few spots where a small thread may run for half a mile or so. Water may however generally be found in abundance a foot or two below the surface of the sand. In years of excessive rain these rivers flow to the coast all summer. In years of low rain-fall the excess above the summer flow is only in the mountains, the water though in abundance there serving only to fill up the sand and under-ground channels below.

The irrigation possibilities of this country are far beyond what they are generally supposed. The lowest rain-fall recorded anywhere on its area of highland in fifteen years was at Mesa Grande in 1877, where at an elevation of 3,500 feet the fall was 24½ inches. At Pine Valley, 30 miles south, and same elevation, the rain gauge for the same year gave 25 inches. Reducing the percentage of water running off to 40 per cent. we have about 10 inches. Twenty inches being sufficient for full irrigation we have water enough lost by surface drainage to irrigate 450,000 acres of land, to say nothing of the amount that afterward drains from below the surface. And this for the driest season yet recorded. As a matter of fact, however, water that will cover land 10 inches deep will serve very well for irrigation, though it is not enough for the best results.

The proportion of this drainage that can be secured for irrigation can not be easily estimated, as it is in most cases merely a question of what expense the present value of the land will justify. There are many places where large reservoirs may be made in the mountains to catch the flood waters there, many others where they may be made in the lowlands and water from the mountains led into them, many others in the lowlands where dams may be made to catch the waters of wet winters and hold them over for dry ones. Several such enterprises are completed, under way, or projected, and are described by others.

In addition to these large systems there are numerous ways in which water enough for a few hundred or a thousand acres may be had. In almost every valley water may be stored to some extent.

Long, low dams may be made of simple earth as in India. These are quite safe up to about 20 feet without any puddle wall, and can be made by home labor without any engineering skill. In the higher lands there are scores of small streams whose waters may be piped or flumed out. There are hundreds of springs whose waters piped into a cistern and saved will irrigate all the land one needs. Hundreds of others may be tunneled out and the flow of water increased from ten to fifty fold. Water may be pumped or drawn by under-ground pipes from wells sunk in river beds or washes, and horizontal wells may be driven into a thousand hill-sides and reach a fair supply of water where none now shows upon the surface. Artesian water has been found in some places and doubtless exists in more. At San Jacinto there are now eighty-three flowing wells made by boring into old river beds about 150 feet below the present banks of the river.

All over the valley lands water is easily found at from 10 to 40 feet in abundant supply for windmills or other power and nearly all valleys have some wet ground where irrigation is unnecessary for any purpose. The average depth of water in wells is less here than in the East owing to the different formation of the country. Irrigation is also unnecessary on nearly all the highest lands, and on the highest rain belt might be only a detriment for most things. Many of the lowland valleys and slopes do surprisingly well with nothing but good cultivation, especially when the subsoil is clay or red granite, which hold water like sponges. On the lowlands generally irrigation is, however, necessary for some things, and on the mesas is needed for nearly everything except grain which is irrigated nowhere south of the San Joaquin Valley. As a rule whatever can be done without irrigation can be far excelled by it, provided it be not done to excess and be accompanied by thorough cultivation.

It is not always necessary that irrigation be continued all summer. It is not to keep things alive through months of rainless weather that irrigation is needed in California. There is little trouble in doing that. Many things need no irrigation later than June, and many more do well enough with the ground well wet down by the middle of May. In many places where water can not be obtained in summer plenty may be had in winter and spring, and in many others where a summer flow would be too expensive to maintain a winter flow is easily and cheaply secured.

I have made a careful estimate, and place the amount of land irrigable in this county by all systems, of both winter and summer irrigation (except vertical and horizontal wells or tunnels), at about 200,000 acres. This supposes the first cost to be not greater than about $50 an acre. Generally it will not exceed $30 for the first cost with an annual cost of about $4. The amount irrigable by wells and tunnels and small dams can hardly be estimated at much less than 200,000 acres more as it is solely a question of expense.

PRODUCTION.

San Diego County produces in the highest perfection everything that can be grown in California at all. The great peculiarity of southern California is that it is the only southern land where all the products of the temperate zone reach their highest excellence side by side with those of the tropics. This peculiarity San Diego County has in the highest degree. As in California generally, special soils and elevations are best adapted to special products, and only in certain places do some things reach the highest excellence. But subject to these modifications this county is fully equal, and in some respects superior, to any of the southern counties. A few miles from San Diego grow the finest apples and potatoes in California. Apples, peaches, and plums, fully equal to those of the north, are grown along the lowlands here, but those of the mountains excel those of the coast. The same is the case with all berries and small fruits. Most of these can be grown nearly to perfection on the low lands, but in the mountains all that can stand heavy frosts reach their fullest excellence. Cherries, raspberries, blackberries, gooseberries, currants, strawberries, etc., can all be seen bearing in abundance large fruit of the finest flavor, and without irrigation. The superiority of nearly all deciduous fruits and vegetables grown in these mountains will in time make them extremely valuable. All sorts of fancy fruits grow well; the guavas, the Japanese persimmon, the pomegranate, and others. The almond is not a prolific bearer anywhere in the south, though otherwise a beautiful tree; but the English walnut has done marvelously well at places where it has been tried, while all varieties of fig trees hang full of excellent fruit. The olive thrives almost anywhere on the low lands without care or water, though like the fig and everything else it will do better with both. Peaches also do very well, though those of the mountains are much the best as well as the most prolific.

Fancy trees, bushes, shrubbery, flowers of all varieties, the camphor tree, rubber tree, banana, palms, and a thousand other things, seen only in green-houses in the East, grow here with little or no trouble, though such things as the banana require a place quite free from frost and also from wind.

Most kinds of vegetables grow in winter, and many kinds, such as peas, turnips, onions, beets, cabbage, carrots, cauliflower, then grow the best. The tomato, if planted above the frost belt, becomes a perennial, growing year after year, climbing often over a small house, and bearing the year round. Nowhere else will the same acreage produce such a variety and quantity as on the irrigated lands of southern California. Even where the whole tract can not be irrigated fine results can be secured. Ten acres of land, with the water that an inch and a half pipe will carry from a stream, spring, or ditch, and the work that a successful gardener in the east puts upon 10 acres, will, with 30 acres of dry land outside, not only support a family, but leave more money over than the best 160-acre farm east of the Rocky Mountains. Three acres in alfalfa, well irrigated, will keep two milch cows, a dozen hogs, and a score of chickens the year round with all their increase. Half an acre more will raise all the vegetables a large family can use in a year, while the rest in raisin grapes, fine oranges, or a dozen other varieties of fruits, will yield a fair income. On dry lands outside of this, thorough plowing without irrigation will raise plenty of the best hay, which is made of grain cut in the dough or milk; also olives, apricots, wine grapes, figs, and many other things that bear well with cultivation alone. Irrigation will of course improve the yield of all such fruits, especially in some years; but very little water is needed, and fair results may be had without any. Many things that are sure to be profitable in the future are very easily raised. The olive, for instance, grows on dry land with very little attention, is a hardy, prolific, and steady bearer, and outlives its owner's family. As soon as enough are grown in the vicinity to supply an oil press the profits are large and constant. Pickled when ripe they form an article of food which the whole family soon learns to like, as substantial as potatoes and infinitely better to the taste than the foreign olives, which are pickled green to preserve a stylish color.

To run through the list of trees, vegetables, grains, and berries that can be grown here, with their special modes of cultivation and their profits, would take a volume. Suffice it to say that about everything can be raised in San Diego county that can be grown in the temperate zone at all, with many of the best products of the tropics. The profits will depend upon the industry, attention, and business capacity of the producer.

Prices of land vary so with locality, rain-fall, and irrigation facilities that it is useless to attempt to give any scales. There is enough to be had from $10 an acre up to $150. There is little held at over $125. Plenty of fine land may yet be had at $50, and in the mountains the surest land in the world for crops may be had for $20 to $40, and even as low as $10 in remote places. This of course is outside Government lands.

CLIMATE.

There is no better test of a desirable climate than the number of days one can spend out of doors. The following record kept during my first winter in California is extraordinary for a country where one can live and raise anything. Yet it was the unusually good season of 1875-'76, when 6,000 acres of wheat in El Cajon, scratched in with a harrow, yielded an average of 20 bushels to the acre, and the honey crop and other crops were immense. The record was kept in El Cajon, to see how many days could be spent out of doors in hunting, etc. From first to last rain, one hundred and fifty-nine days, there were one hundred and twelve days warm and clear. Noon temperature, 65 to 75 degrees. There were thirteen days cloudy but warm; clear and cool, eight days; cloudy and cool, six days. Noon temperature of cool days, 55 to 65 degrees. Rainy all day, ten; showery, ten. The lowest noon temperature was 55 degrees. The days marked "showery" were days of clearing-up showers after rainy nights, and were exactly like "April showers" at the East; days when one could not venture out for a whole day, or perhaps a whole half day, but could still spend one-half the day out of doors. Here were one hundred and thirty-nine out of one hundred and fifty-nine days that one could spend entirely out of doors, and but ten days that one need spend wholly within. And this in a year wetter than two-thirds of the years in all southern California. Of course all the rest of the year one could spend the whole day out of doors.

Leaving the details of settlements and their growth and advantages entirely aside, let me say in conclusion that it has often been said that San Diego County is but a desert. Over half of it is so. So is half of

Los Angeles County and more than three-fourths of San Bernardino County. But upon two things one can rely:

(1) That thousands of wealthy people do not make permanent homes in deserts.

(2) That great railroads do not cross deserts for the sake of making a terminus in another desert.

THE WATER SUPPLY.

Mr. James D. Schuyler, construction engineer of the Sweetwater Dam and Reservoir, while serving as assistant State engineer, made a thorough examination of the water-supply of San Diego County. On that subject he said:

> Careful investigation has convinced me that the supply furnished by the rain in the mountains 40 to 60 miles back from the coast, properly husbanded, is ample for all probable necessities. From Temecula south to the Mexican border there are over 1,000 square miles of territory draining seaward, ranging in altitude from 2,500 feet upwards, upon which the observed rain-fall is reported to be never less than 25 inches and often reaches 60 inches. It will be readily admitted that every square mile of this area, therefore, must shed more than sufficient water to irrigate an equal area within the dry belt along the coast, and we may roughly say that the waste water flowing to the sea within this section in the driest years is sufficient to irrigate 500,000 acres of land. Is it practicable to store water in the rainy season to maintain the needed supply throughout the year? Nature has provided great numbers of flat, commodious valleys, with narrow outlets, well adapted to the construction of retaining dams, for which the best of material, solid granite, is generally supplied on the spot. Indeed the entire county is remarkable in this respect. I know of no other section of California containing so many large and capacious sites for reservoirs. Their conversion into artificial lakes is a mere question of cost and engineering skill. A doubt has been frequently raised as to their being made water-tight, and fears have been expressed that the fissures everywhere to be seen in the mountains would swallow up the contents of the reservoirs when filled. The best answer to this objection may be given by referring to the frequent natural ponds and lakes in the mountains. Wherever a valley is level or a slight elevation at its outlet obstructs its drainage, water may be found standing the year round.
>
> As the first irrigation project of any magnitude in the county, the works of the San Diego Flume Company are naturally regarded with special interest. As a type of many similar works that may be carried out successfully in the county, I have given them careful attention, the more so as the surveys, plans, and levelings of the company have given me more exact data to examine than I have had in other sections. Briefly stated, they propose to divert the waters of the San Diego River, at a point 35 miles above San Diego where, at an altitude of 800 feet, all the higher mountain drainage is concentrated, and carry them in an open flume, a distance of nearly 50 miles, to San Diego. The surplus waters of the Upper Sweetwater and Santa Isabel Rivers are to be diverted into the higher tributaries of the San Diego. Reservoirs covering 300 to 1,200 acres are to be constructed to store the winter rains and furnish a summer supply when the streams fail. Three reservoirs are to be immediately constructed, and several others are selected for construction if required. Their flume is projected to carry 5,000 miner's inches of water (100 cubic feet per second). A miner's inch is considered adequate to irrigate 10 acres in orchard or vineyard, and many important districts have to eke out 1 inch to 30 acres. At the former rate the supply to be carried will be adequate for the irrigation of 50,000 acres of land. In Riverside and elsewhere water adds an immediate value to dry land of $100 to $150 per acre. Applying these figures to equally desirable lands in this county, it requires but a simple calculation to establish the disproportionate relations between cost and value of water for irrigation. The feasibility of constructing a flume of this character along the mountain sides for such a distance can not be questioned. There are too many precedents to such works to raise a doubt on that score. The loss of water by evaporation will not exceed one-half of 1 per cent. of the maximum flow, and leakage may be reduced to a small amount by careful construction and calking seams.
>
> Comparing this county with other sections of the State, I have noticed several advantages favoring irrigation development, aside from the one mentioned of a remarkable number of storage reservoir sites, viz, the general freedom of the higher mountain streams from sand and fine débris that would tend to fill up and destroy reservoirs, and the absence of landslides that are so much to be dreaded. The soft granite may be cut vertically, and stands for years without a slip or slide into the excavation.

CALIFORNIA PAPERS RECEIVED BY THE COMMITTEE.

STATEMENT OF JOSEPH DUNBAVARD, OF LIVERMORE, IN RELATION TO "GANG" OR "DRIVEN" AND ARTESIAN WELLS.

My opportunity for forming an opinion of drive wells and artesian wells has been by a residence of nearly three years in Florida, also in Brooklyn, N. Y., Vineland, N. J., and other places. But principally I have acquired knowledge concerning them during the time I was editor of a newspaper at Eustis, Fla., called the Florida New Yorker, at which time I entered into correspondence with various parties—with Geo. H. Clark, then postmaster at Daytona, Fla.; with Henry A. Harrison, manufacturer, Newburg, N. Y., and also with Andrews Bros., the proprietors of the Brooklyn water works or drive wells. I desire to present these points: Artesian and drive wells I consider essentially the same in principle and action, differing only in size and in this, that the drive well, being of smaller diameter, is *driven* into the ground, hence its name. The artesian well being larger can not be so driven.

As the two kinds of wells differ only in size, as a result of this difference the smaller or drive well brings up water sooner or from a less depth than the larger or artesian well can.

That it really is a matter of dynamics—the smaller well bringing up water sooner because of the lesser weight to be lifted.

That in the arid regions of California and elsewhere drive wells, or gang drive wells could, without a doubt, be put down in numberless situations, and water be drawn up to and above the surface.

That the fact of the surface being dry is no argument against the probability of water being underneath.

That it is rather a presumption that the repulsive force would there be stronger and the water abundant.

That in situations where rocky strata intervene to prevent drive wells being put down borings of small diameter can be made to suit the smaller pipes.

My leading point is a refutation of the prevalent idea of a head of water being required to make water rise in artesian wells. That a head of water will make water rise, if contained in a pipe, is a matter of everyday experience. Thus, let Fig. 1 represent a pipe, and water being poured into the smaller end at A it rises to the same level in the larger end:

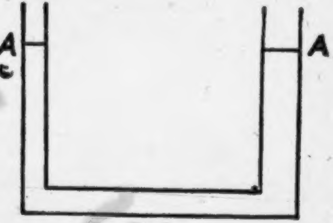


FIG. 1.

This is an axiom, and at once admitted. But it must be remembered the water is in a pipe that is watertight. In the underground geological arrangement there is no such thing as a pipe, nor any resemblance to one. If we take the same figure and dislocate it it will then have somewhat of a resemblance to geological strata, but it will be seen at once the conditions of the first-represented figure are entirely changed, and water would not ascend at all, either to the level of its head, or to any other point:

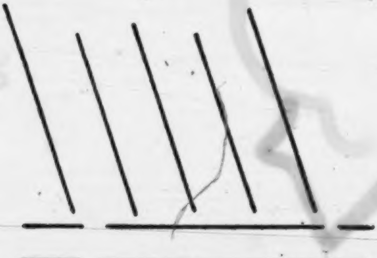


FIG. 2.

And yet such is nearly a correct representation of geological strata. There is absolutely not the least foundation for this "head of water" theory in any arrangement of the earth's strata. If there were such an abnormal stratification as would form something like a bent pipe, of course the water in that case would act precisely as in the artificial pipe; but it can not be found.

If this theory were correct, everything would be in confusion, and Heaven's first law, that of order and harmony, would be set at naught. On the low lands the water would be everywhere bursting up from the "heads" of water on the high lands, and we should have nothing but disruption of the pent-up waters in every direction.

A large part of the rains which fall must necessarily be carried away by the underground courses and traverse towards the oceans, the same as the rivers do on the surface. If we consider the quantity of rain that falls on the earth annually, we shall see how little comparatively finds its way to the sea by the river courses. From 12 to 50 or 60 inches falls annually. In the tropics perhaps it averages 100 inches. By this is meant that the whole face of the land would be covered to that depth, supposing it were retained as on a dead level upon a retentive surface. If all this water were passed off by the rivers they would be filled to overflowing after every shower, and we should have Mississippis and Marañons in every direction. But these things are differently arranged; a large part of every shower passes into the soil, where it is absorbed and retained; but a still greater part sinks into the strata beneath, through the various laminæ, fissures, and faults, through caverns, and still onwards, much the same as on the surface. When it gets still deeper, the repulsive force keeps it up, saying, Thus far, but no farther.

When these great depths are penetrated artificially by a "boring" or perpendicular shaft, the water is thrown up to the surface, and in many cases high above it. If the boring is large, like the Paris well, which is over 3 feet in diameter, the earth has to be penetrated or bored so much the deeper to attain the high pressure necessary to lift such an immense bulk. At, say, 5,000 feet of depth, the eruptive force becomes volcanic in its strength, and the pent waters are thrown upwards with Titanic power.

It must not be inferred, however, that this force acts only at great depths. It commences at the surface, where it shows itself in the form of what is called capillary attraction, as in the illustration:

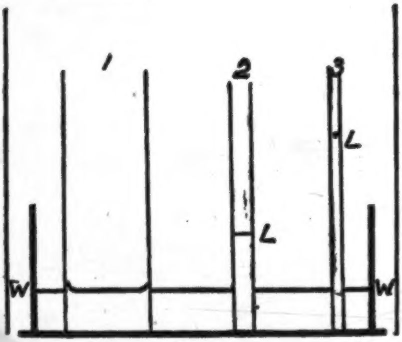


FIG. 3.

No experiments have yet been made with pipes of very small bore. But if the principles here enunciated are correct, pipes of half-inch bore, or less, would be quite practicable. Half-inch bore pumps are not uncommon. A pipe of half-inch bore, but retaining the same outside circumference as the one inch, would be likely to bring up a stream of water above the surface at 30 to 40 feet depth.

In plowed fields, where the surface is made fine, the water or moisture is forced upwards from below by this ever-acting power (of capillary attraction) during our rainless summer. As attraction diminishes with the square of the distance, so repulsion—the counter of attraction—increases as the square of the depth. At 100 feet depth it has little or no effect on a 6-inch well, but at from 400 to 500 feet the water begins to move upward. In a well of 1 square inch, according to an approximate calculation, the water begins to lift at 70 or 80 feet. In a well of 2 inches square the water begins to move at 140 to 150 feet. These calculations are made in square, not cylindrical inches. The unit from which calculations are made is 1 inch. In calculating for 2 inches the weight of water is multiplied by 4, the repulsive force by 2. The weight increases as the area, the repulsive force with the increase of circumference of pipe.

At this point I give a table of reference. As this paper advocates only wells from 1 to 2 inches diameter, which need not go more than 150 feet deep as a general rule, I do not extend the table beyond that point:

Table of reference.

Weight of water.	Depth.	Square of depth.	Repulsive force.
Pounds.	*Feet.*		*Lbs. Oz.*
4.3280	10	100	10
8.6560	20	400	2 08
12.9840	30	900	5 10
17.3120	40	1,600	10
21.6400	50	2,500	15 10
25.9680	60	3,600	22 08
*30.2960	*70	4,900	*30 10
34.6240	80	6,400	40
38.9520	90	8,100	50 10
43.2800	100	10,000	62 08
47.6080	110	12,100	75 10
51.9360	120	14,400	90
56.2640	130	16,900	105 10
†60.5920	†140	19,600	†122 08
64.9200	150	22,500	140 10

* At the depth of 70 feet the repulsive force balances the weight of water in pipe, the area being equal to 1 square inch.

† At this point a pipe equal to 2 inches square, the water is balanced by the repulsive force. In this case the weight of water as given has to be multiplied by four, and the repulsive force by 2, which gives weight 243, repulsive force 245. Any other size of pipe may be calculated in the same way by multiplying the first column by the increase in area and the last column by increase in circumference of pipe. In pipes of less than one inch bore the figures have to be reduced accordingly.

Yet another consideration in favor of the repulsive force: If we suppose a column of water of, say, 400 feet deep by 6 inches diameter, the weight per square inch would be 173 pounds, or 6,228 pounds on the six inches square. Now is it possible that any rock, much less earth, could long resist such a pressure? Here is a weight of 3¼ tons of water on a space of six inches square. It would, undoubtedly, disintegrate the rock or earth, and force its way either straight down or sideways, and disappear from the pipe in double quick time; but the repulsive force comes in and holds the water, as it were, in the palm of its hand. As soon as the water begins to move upwards a vacuum must be formed beneath the pipe; or rather a tendency to form a vacuum, for a vacuum itself is impossible, and the water must be drawn straight upwards, and a stream started from the internal reservoirs which never fails. Here is a solution of the question of perpetual motion, for the stream once in motion furnishes a perpetual motor.

To the perplexity of well-borers they often find the water disappear in the progress of the well downwards. The truth is, the column of water becomes too heavy to be retained in the boring, and it presses itself downwards and disappears. But when the point is attained where the repulsive force comes into effective operation, the water stays and gradually rises with the increasing depth of well.

This matter of drawing the water upwards is of incalculable importance. A true artesian well, below the surface drainage, drawing the water upwards, does not affect neighboring wells, which retain their usual amount of water. In the alkali countries the layer of alkali can be pierced and good water brought from beneath. The water from a moderate depth, but below the surface drainage, invariably brings up good water.

PUBLIC OWNERSHIP AND CONTROL OF THE WATER THE ONLY SAFETY FOR THE IRRIGATOR.

[Paper forwarded to the committee by ex-State Senator John M. Day, of California.]

The question of irrigation is the most important now prominently before the people of the United States. It has been considered by State legislatures, constitutional conventions, and other gatherings; and the Congress of the United States has at various times appointed commissions to inquire into it. It is most important because it relates to the people's right to the use of a natural element essential to man's existence. No writer of intelligence has ever had the temerity to proclaim that there could be such a thing as private property in running water, and yet I question if every inch of navigable water in the now navigable rivers, streams, rivulets, streamlets, creeks, and other courses in California is not claimed as private property many times over by water and land grabbers and speculators. In the single instance of King's River, which, according to the ex-State engineer, William Hammond Hall, there were appropriated 24,000 cubic feet, while the records show an average of only 1,730 cubic feet. It is true the law of appropriation which gives this private property says water may be appropriated for beneficial uses, but when once the appropriator appropriates the water, unless he is some poor fellow without means or brass, he construes the meaning of the words "beneficial uses" to be for his benefit, and no government that I have read of has ever had the power to enforce any other interpretation thereof. This is not peculiar to California and the United States, but is the history of irrigation the world over.

During the Senate committee's visit to California all the testimony taken was chiefly about the benefit of irrigation. The benefits of irrigation are incalculable. We have millions of acres of lands in California that will not grow a blade of grass without irrigation, but with irrigation will grow two crops, and in cases of alfalfa and other grasses, for hay, four crops each year. The two important sets of questions to us are, "Does your district need irrigation?" and "Which would be the best mode to benefit your district and the people thereof?"

Any public inquiry into irrigation should inform itself from the history of other countries what would be the best mode in this, so as to protect the rights of every citizen to a use in the water necessary to secure crops. It should be able to propose means to Congress to prevent the plunder of a neighbor. The principle applied to irrigation should be such as to insure a settler the use of water without having to apply to and pay exorbitant charges to private individuals, or having to mortgage his home to the district or any other bondholder. In my study of the question I can see only one way of accomplishing that, and that is by governmental ownership and control.

In California we have three general laws regulating the use of water; the common law in favor of riparian rights, the code in favor of private property through appropriation, and the district law, originally passed in 1872, but a dead letter until amended in 1887, and known as the "Wright bill." Without going into particulars, the common law gives the land owner on the banks of a stream the right to an undiminished flow of the water in the stream minus what may be used by riparian owners above him, its use for domestic purposes and for irrigation, provided he returns what he does not use to the stream. It requires no formula to become a riparian owner. The law of appropriation requires the appropriator to go through a formula. He goes to the bank of the river, or stream, writes on a piece of paper that he has appropriated so many inches or feet of water, puts the paper on a bush or other place as a notice to others, records his appropriation within ten days at the county seat, and commences operations in ninety days to construct head or other works. There is no limit to the amount a man or corporation may appropriate or claim; ten times the average amount the river carries has been appropriated. The district law provides for the land-holders of a district to organize, elect trustees, assess the cost, issue bonds, condemn water rights, and sell out the land-holder for delinquent assessments. The latter law seems now to be in favor and may work for a time without much apparent injury, but there is no doubt in my mind that before many years elapse many a poor land-holder will have to succumb and give up his land to the bondholder.

For several years last past, in California, there has been a fierce war waging between the riparianists and rich appropriators, which finally culminated in a decision of the supreme court in favor of vested rights, and a special session of the legislature, intended to turn out the supreme court members and change the law, and induce candidates for the new supreme bench into agreeing to reconsider the decision in favor of vested rights, and decide the appropriators to be the exclusive owners of the water. The decision of the supreme court of California in a nut-shell is: If the riparian owner settles on the banks of the river before the water above him is appropriated according to law, he acquires a vested right which he can not be deprived of, except by payment for his so-acquired right. If the appropriator first takes his appropriation he has the same vested right.

The origin of the fight is the desert land act, signed March 3, 1877. Under its provision in four years, 897,160 acres were taken up. In the county of Kern, thousands upon thousands of acres were said to be taken up by dummies, and transferred to other parties in bulk. Years before this, however, another land firm became the owners according to law of immense numbers of acres of land, and acquired, through the common law, riparian rights.

There were many appropriators in the valley but no conflict, until the second party claimed nearly the whole of the water in Kern River by direct appropriation and the absorption of the small appropriators. After the supreme court had decided the fight in favor of vested rights, the question was taken to the legislature. Failing there during one or two sessions, a special session of the legislature was called to pass bills in the interest of the appropriators. A fierce public agitation was aroused. This was the condition of things when, on the 20th of July, 1886, at the call of the governor of the State, I took my seat in the State senate. During the first week of the session advance copies of a magazine article on irrigation, from the pen of the late A. A. Sargent, were distributed. The article quoted the history of irrigation, and to a person who had not read about the subject, appropriation was the only mode of water-use that had ever been established with success.

A great deal of the ex-Senator's article is about Italy. He says: "The length of canals in Lombardy alone is over 5,000 miles, and there is scarcely an acre of the Milanese that is without several intersecting canals. In round numbers there are a million acres irrigated in Lombardy. The system has been perfecting for seven hundred years, and has gone on under all changes of dynasty and all civil commotions. It has converted a barren waste into a garden. * * * In exercising its right of property in waters available for irrigation, the government of Lombardy follows one of three courses: First, it disposes of the water in absolute property, to parties paying certain established sums for the right to divert it; second, it grants perpetual leases of the water on payment of a certain annual amount; third, it grants a temporary lease for a variable time at a certain annual rate, the water reverting to the State on the termination of the lease. By far the most common of these courses is the first, and it operates the most beneficially."

The whole of this quotation is taken from Baird Smith's Irrigation in Italy. The fault I find is in garbling the last sentence, which reads: "By far the most common of these courses is the first; *and it has, on the whole, I think, operated beneficially in the actual circumstances of the country.*"

Captain Smith lays great stress upon the statement just quoted, and goes on in pages 136 to 140 of his work to explain it at great length.

I propose to show from the writings of Mr. Hall, the ex-State engineer of California, and others, that although the rivers of Italy have been considered public property for seven hundred years, the Government has never been able to regulate them after granting the *use* in perpetuity, which is not so strong a term as we use—appropriation. On page 258 of Hall's "Irrigation Development," in speaking of the conflict between appropriators and irrigators in Italy, he says: "In Italy, as in irrigating countries generally, where there has been a clashing of interests between the owners of canals or holders of great water privileges and the irrigators to whom the waters were to be distributed, special points came up in this connection. Many water rights were established there by grant and prescription, in times when from a troubled condition of society no thought was had of future agricultural masses of people with interests to be protected. A water right aristocracy grew up, the canal owners claimed the absolute property in the water held by them and undertook to do with it what they chose."

M. Giovanetti, an Italian lawyer, quoted by Captain Smith (page 134), says: "It appears to me that it was not for purposes of police that the feudal superiors exercised all the rights of masters over the various water courses, but that their right of *absolute property* necessarily absorbed everything previously held to belong to the community. There existed in fact merely the relations of masters and subjects." He further says, on page 148: "I find that the waters of the Olona River were granted to the Cistercian Monks, of Charavalle; were in the twelfth century claimed by a society of Employers (Utenti) of the Olona, and from time to time it raised claims to entire independence of the administrative authority of the State, on the grounds that its right of property in the stream was absolute." On pages 198 and 199 I find that the proprietors of the streams on the borders of two countries were so in conflict, one with the other, that in spite of edicts passed by the General Government in 1602, 1603, 1607, and 1610, and of all efforts made to settle the difficulties, the two countries were nearly embroiled in war. The power of the appropriator for evil is seen in the following. I quote from page 257:

"In 1832 the Marquis of St. G., farmer of the canals of the Vercellese, having quarreled with his neighbor, the Marquis Pal, persisted during eight consecutive years in throwing into the river Po two route (about 24 cubic feet per second) of water, for which the Marquis Pal offered to pay him 12,000 francs a year. * * * This same Marquis St. G., wishing to force the commune of T. to submit to an arrangement which it regarded as oppressive, refused to allow the surplus waters of his vast domains to flow into the land of this district, although he was offered 6,000 francs a year for them. He preferred throwing them for two years into the Po, to his own loss and to the injury of his neighbors."

This illustrates one of the beauties of private property in water. 'Tis true the law finally interfered and compelled the Marquis to sell his surplus water instead of wasting it.

It is asserted that the State can regulate the use of water even when appropriated. I quote again from Captain Smith: "The holders of ancient grants in perpetuity have occasionally asserted an absolute right of property in the water thus granted to them; but the legal tribunals have invariably rejected such claims, on the ground that the grants were made for the general good of the country as much as the special advantage of the grantees. The large canals, Mora, Busca, and Buaga, derived from the Sesia, have been held by grantees since the close of the fifteenth century. On these works a very large portion of the irrigated land of the province of Novara is dependent, and the outlets are held under annual leases continually renewed. Farther to the southward, in the district of Lumellina, water is less abundant, and therefore bears a considerably higher value. This latter fact led the grantees of the canal Mora to attempt, about the close of the last century, to discontinue the supplies which have been furnished for centuries to a number of proprietors near the head of the canal, with the view of carrying the water thus obtained to the southward and there renting it at higher rates. To this project very decided opposition was naturally enough offered by the parties whom it was thus proposed to ruin. * * * The case was carried before the senate of Turin, which by a decree under date April 13, 1787, decided that the proprietors of the canal should continue to give to the employers of the waters those volumes which they and their forefathers had so long enjoyed pending the further investigation of the case; and the employers were called upon to submit evidence in support of the reasons on which their opposition was founded. The suit was, however, pursued no further, the grantees of the canal abandoned their design, and the employers continued to enjoy their ordinary supplies of water at the present day. * * *

"The temporary effect of these decisions was to create an impression that no employer holding a term lease of an outlet of irrigation could be deprived of it so long as he paid the price for the water. Subsequent decrees of the court, however, showed that unless such outlets had been held for long periods, had been established and maintained during these periods at considerable expense, had been accompanied by other agricultural works, and that no special agreement to the contrary existed between the proprietor of the canal and the lessee of the water, temporary leases were revocable at the will of the former. M. Giovanetti mentions that he proposed to the commission on the civil code to define and establish the principle involved in the decisions of the courts above referred to, and that it was accordingly introduced into the first draught of the code. The senates of Nice, Savoy, and Turin approved the principle, only altering the terms of expression; but the chamber of accounts and the senate of Genoa demanded its suppression as incompatible with the right of property. The commission on the code adopted the latter view, and the two articles defining the right were accordingly struck out."

This, I believe, is the final adjudication of the question in Italy. This is a flat refutation of the position assumed by Engineer Hall and the appropriators. For seven hundred years the waters of Italy have been said to be the property of the government to regulate, etc., and during seven hundred years trial to regulate the waters and the appropriating holders in perpetuity has gone on continually. The highest power in that land has declared that to regulate and interfere in the interest of the irrigator is to interfere with the rights of property.

This, however, is only one of the phases of irrigation, for it is not simply a question of who shall own the water and apply it to the land. It is a more complex problem. It includes water storage by reservoirs and forestry; the proper building of head works and ditches in relation to safety and health; a just and proper distribution of water for the benefit of all concerned; the most consummate hydraulic engineering, and intelligent, thoughtful, and deeply studied legislative enactments in the interest of the people of the whole state. One of the effects of the system of appropriation is, the water being frequently appropriated for speculative purposes, and the appropriator caring for nothing but the profits from the sale of water, waste follows, and malaria and other diseases are the consequence.

Colonel Alexander, Major Mendell, and Professor Davidson, of the Coast Survey, were a commission appointed by the United States Government in 1873 to examine the San Joaquin Valley as to its possible reclamation. In their report they say "the profession of the hydraulic engineer for agricultural purposes is almost unknown, and the farmers, as a general thing, do not understand how to use the water when it is delivered alongside their lands." Continuing, this commission pointed out canals and places by name, and showed that the places were unhealthy because of the canals being improperly built. But this is the history of private ownership of water for irrigation all over the world. The private appropriator cares only for what he can make out of the water at the least cost to himself, irrespective of the influence of his mode of doing it. If we contrast that with the care taken by the Government of the irrigation districts in India in examining into the condition of the people as to their health, it will be seen at once that it is in the interest of all the people that the system of irrigation should be under the ownership and control of the people in their collective capacity; in other words, of the Government.

In the fourteenth century the canals of India were beautified by the planting of shade and fruit trees, and everything was made pleasing and profitable. The British

Government has within the present century taken up the matter and appointed commissioners to take charge of this part of irrigation, and beside the great beufit accruing to the country, the cost is estimated at about one-fourth of the income. How much better would it be for everybody in the United States to have a proper system, than allow these things to go on slip-shod fashion as they are going on here. Every man, woman, and child in the country is interested in having a proper system established, not alone because it will give them better and cheaper food, but because it will affect the health and well-being of the nation for good. In India, under government ownership and control, the cost of maintaining the works is 14 cents per acre, the original cost about 60 cents, while the original cost in private property appropriating Italy is upwards of $74 per acre; while the cost to the irrigator is upwards of sixty times greater in Italy than in India in the same class of works. In Spain, where the water is private property, immense sums of money are paid by the users; on one occasion according to Engineer Hall, $11,000 was paid for 1 cubic foot per second for twenty-four hours. Where the system has been handed down from the Moors the cost is merely nominal. This is because it is controlled by the community. In France many peasant proprietors are too poor to purchase water for irrigating, and where the works are the property of private individuals the rivers are unfit for use in many places, owing to the neglect of the proprietors, while the reverse is the case where the Government owns the head works.

As a member of the State Senate and of an investigating committee appointed by it, I arrived at Bakersfield, the county seat of Kern County, late at night, on the 28th day of August, 1886, with the intention of going over the ground made so famous in the controversy between the riparianists and appropriators. On the following day I saw many of the fields made fruitful by irrigation; immense alfalfa and stock ranches, horses, cattle, sheep, ditches, etc. On the 30th Messrs. Chandler, Steele, Whitney, and Cross, State senators, also arrived, and we were taken to view the grounds of Miller and Lux, a distance of about 24 miles from Bakersfield. We lunched at their headquarters, and then were driven miles over the grounds. We looked in vain for any signs of the water in the river which made them riparian owners. 'Tis true we saw a channel for water to run in, but no water. As near as we could tell, we rode about 20 miles over ground claimed by Messrs. Haggin and Carr. I don't remember seeing a school-house the entire way, and, in fact, very few houses of any kind. We returned to Bakersfield about 9.30 p. m. On our arrival we found a great commotion. The appropriators were out in full force.

The small farmers were also in force and desired to talk over the situation with us. This congregation of farmers were all owners of shares in ditches, but opposed to the appropriation monopoly. The next morning we were taken by three of the farmers for a birds'-eye view of the valley, and also to see the celebrated Calloway Canal. This is the largest irrigating canal in California, being 120 feet wide at its mouth. We found the Calloway empty, and were informed the water had been shut off. Before taking this trip several farmers again called upon us. I was the only one present. I saw three other senators, and by their consent I made an agreement for all to meet the citizens that night, listen to their grievances, and talk the matter over with them as to the best mode of finally settling the irrigation question. An effort was made to retain us over night at one of the ranch mansions. I demurred to this on the ground that we had agreed to meet the citizens. I intended to keep my word, and, as I was obstinate, they promised to bring me back at the stated time.

We were then driven rapidly through the country; saw irrigated fields of alfalfa, many hay-stacks, cattle, horses, sheep, a few turkey-buzzards, occasionally a building, and one school-house. I eyed the school-house for a long time to see if there was any life near, but I saw none, although it seemed to have been newly painted. We were driven into an alfalfa field of about 700 acres, belonging to a banker, in which was one shanty. Several hay-stacks, some sheep, and one sheep-herder were the residents of this immense field. We were at last driven to Belle View, the principal ranch of the principal appropriator in California, where I left my brother senators to eat turkey and to be further instructed into the mystery of legislating all the waters of the State into the pockets of the appropriators. At Bakersville I found quite a number of farmers waiting to meet the senators. I passed a couple of hours in their company listening to their story. On the next day I rode over a deal of ground with John Barker, editor of the Echo, published in Bakersfield. We passed over a good site for a reservoir for the storage of water, which he considered would by an outlay of about $5,000 be made to store enough water to irrigate 70,000 acres of land. He also informed me that at a place some miles above a storage for an immense amount of water could be obtained by buying out two ranches.

Mr. Barker was thoroughly able to give information on the matter, as he had surveyed the head of the valley in every conceivable way, with reference to a thorough knowledge of the utilization of the waters for the benefit of irrigation.

On my return I again found a large number of farmers patiently waiting for the senators. But they were doomed once more to disappointment, for they were informed that the banker was to entertain them at dinner. These men who had so very patiently waited four days, some of them coming a distance of 20 miles, naturally felt angry. They hired a hall and held a meeting and at half past 9 o'clock the five senators took their seats on the platform, and, after a speech by the chairman, resolutions were unanimously adopted condemning the principle of appropriation as conducted by Haggin and Carr. The following facts I gleaned at the meeting and during my interview with the farmers:

When this firm entered the valley they found a large number of small ditch-owners and prevailed upon them to put their ditches into corporations, etc. The corporations were organized, larger ditches were built, and in every instance the new comers had a majority of stock, elected their own officers, and have run the entire concern. Many of these men were deprived of water while it was supplied to Chinese tenants. Mr. Randall testified at the public meeting that when he wanted water it was frequently turned out of the ditch to prevent him using it. Seventeen of the farmers present at that meeting verified his statement in letters to the senators when they returned to the State capital, both as to his and their cases, all being owners in ditches similarly situated.

The average school attendance had dwindled down from 649 in the year 1880 to 246 in 1886; and this is the effect of private property in water.

One farmer had settled in Kern County years before the appropriator had ever dreamed of going there, had paid the Government for his land; a natural water-course ran through the land from which he irrigated and made a good living. The appropriator claimed to have appropriated the water, forbid Mr. Judd's using it even when it was running to waste upon the desert, and finally turned it off from his land altogether.

The school district of San Emigdio is not subject to irrigation from the river. It is a portion of an old Spanish grant, and a few families had lived there many years. A spring supplied them with irrigation. The spring was confiscated under the law of appropriation, and the water diverted to beneficial uses in a ditch past their lands. Offers were made to buy them out. These poor Mexican farmers refused. Here they had raised their families; here was the only world they knew; here they wanted to stay. The little seepage water which was allowed to escape the large ditches would do service in the support of their families. For the purpose of freezing them out cement was used to prevent even a drop of water escaping on to their lands, and the poor farmers succumbed, while the school with its average attendance of twenty-six children collapsed. The land passed into the canal owners' possession. Under our law of appropriation, then, one firm in Kern County owns a strip of land 75 miles long, which in many places is 30 miles wide; that upon 49,903 acres of land they are assessed at a land valuation of 25 cents per acre; that 15,000 acres are growing alfalfa and wheat, while other crops could be raised to make the county rich. This course has depopulated the county and shut up the schools. It is time to cry halt to this system of private property in natural waters and demand that all waters for irrigation purposes shall be under the ownership and control of the Government.

In conclusion, let me contrast this state of things in Kern County, Cal., with the following facts which occurred in India, where the waters for irrigation is owned and controlled by the Government:

In 1820, when the British got control of the district of Mairwara, the inhabitants had been freebooters for centuries, had been notorious for their depredations, and robbery was the profession of the whole race. Each district in Mairwara had its assigned field for plunder in the adjoining lowlands. The horsemen in small parties haunted the highways, looking out for marriage cavalcades and pilgrims bound for the shrines of Rajpootana. When Ajmeer fell into the hands of the British it was not safe for an unarmed man to be outside the walls after sunset. Repeated attempts to subjugate them were made by the larger states of Rajpootana. The efforts were unsuccessful, and not only emboldened the freebooters but encouraged them to levy revenue from other districts. They were eventually conquered by British soldiers, divided into three sections, and placed under three separate governments, where they were supposed to be in such a minority that they could easily be kept in subjection; but such was the desperate character of these people that they would have subjugated the native governments under which they were placed, had it not been for the superior force of the British. Then, under the control of a British captain, they were collected again on their own lands. With assistance from the Government, they commenced anew as tillers of the soil. They were assisted with provisions, implements of labor, canals and ditches were dug, and every means provided to give them a fair start.

Baird Smith says (page 410 vol. 1) in his Italian Irrigation: "The village [villages] was formally inaugurated, and remissions in rent were granted until the hamlet was considered sufficiently advanced to bear the usual rates. During the first year, one-sixth of the produce was taken as the government share; during the second year, one-fifth; and during the next four years, one-fourth. After that period the rates were the same as in old villages. At the same time the settlers were furnished with advances of money for the purchase of bullocks, and for the construction of small works. These advances were repaid in four or six installments, within three years after the establishment of the village. Tools were furnished free to all who needed them, but the settlers were expected to build their own houses."

From this time to the time Captain Baird Smith published his book, a period of about thirty years, no complaint had ever been made against them. In fact, they became a model for industry, probity, and honesty. Such was the effect of their contentment and prosperity that the peasants of the adjoining provinces of Ajmeer and Rajpootana began to emigrate to Mairwara. The chiefs of these provinces wrote to the chief of Mairwara protesting against the loss of their subjects, who replied that they must do something to better the condition of their own peasantry. The chiefs took the hint, made the desired improvements, and were blessed by the return of their people. It was not many years after they had established themselves in their new pursuits that they were called to assume the defense, not only of themselves, but of their neighbors. And we find the same good offices which converted them from pestilential robbers to honest tillers of the soil again put in requisition, again by the same man, and again with the same effect. The following account I take from Baird Smith (page 338, vol. 1), slightly changing the language:

In 1836, a gang of robbers from Marwar having plundered the town of Gungapoor, in Mewar, in returning with their booty though British Mairwara, were attacked by the villagers, who in their new character as cultivators had suffered from the depredations of the gang. Twelve of the gang were killed and twenty-nine made prisoners. These were confined in the Mairwara jail under sentence for four years, but before the expiration of this period a plan was suggested for converting these men, whom poverty and ignorance had made robbers, into thrifty and useful subjects. A portion of the uncultivated land some miles from the jail at Nya Nuggur was assigned to them. The prisoners were permitted to quit their confinement every morning, partially unfettered, for the purpose of digging wells at the new settlement, returning every evening unattended to sleep at the jail. On the expiration of their sentence they were joined by their families and relatives and commenced in earnest on the cultivation of the soil. A year after their release the new village exhibited signs of prosperity. It soon contained twenty-seven families and paid a yearly revenue of £77 sterling. From the day of their location no charge of misconduct had been brought against them up to the time Captain Smith published his book. The character of the people has been marked by order, propriety and untiring diligence.

Captain Smith further says: "The scope and success of Colonel Dixon's measures have been sufficiently indicated in the preceding pages. Though much was done by his predecessor for the the civilization of the Mairs, yet undoubtedly all this was most precarious whiile their subsistence and employment were dependent on most uncertain seasons, and the development of a great system of irrigation works (by which the fallen rain is economized to the utmost, and distributed in time and place of need, instead of sweeping down the valleys and passing away in a useless torrent) has been the means of giving permanence and advancement to the improvement in the character and habits of the people."

For the reasons set forth in the foregoing statement I would earnestly recommend that in whatever may be done by the United States Government to assist the irrigators of the various States in the way of irrigation, that every right be reserved; and that no power to "appropriate," even the use of water be given. History shows that if the appropriation of even "the use" be granted, the apropriators will in time set the Government and the people at defiance. And I further urge that if any sites for storage, or forestry, or other water privileges be granted to any State, the right of revocation should be reserved to the General Government to be applied, if said State should alienate the grant on any ground whatever.

ARIZONA DIVISION.

YUMA, ARIZONA, *September* 4, 1889.

The committee met pursuant to the call of the Chairman.

Present, Messrs. Stewart (chairman) and Reagan; also, Director Powell.

STATEMENT OF H. W. BLAISDELL, OF YUMA.

The CHAIRMAN. What is your profession?

Mr. BLAISDELL. I have a ranch of 25 acres in fruit 9 miles east of this town.

The CHAIRMAN. Near the railroad?

Mr. BLAISDELL. Yes.

The CHAIRMAN. When did you commence to cultivate your ranch?

Mr. BLAISDELL. About the 1st of January last I commenced to break ground, and late in January I commenced setting out my trees and vines. They were all set out later than they should have been owing to delay in starting. What I have to show you here are the results of eight months only.

The CHAIRMAN. Describe the result?

Mr. BLAISDELL. The peach trees have grown from small stems to an inch and a half in diameter. But a growth of 3½ and 4 feet of grapevines have grown 6 and 8 feet. Orange trees have made a heavy growth, and figs are growing well.

The CHAIRMAN. Have you planted any dates?

Mr. BLAISDELL. I have no dates set out. We have had them in this place fourteen years, about 8 miles below the city.

The CHAIRMAN. How do they prosper?

Mr. BLAISDELL. Very well; scarcely anything grows better. The trees are 25 feet high and 2 feet in diameter, the result of four years' growth. The limbs fall down as they increase in years, as the date that you see in tropical climates.

Senator REAGAN. Do you raise enough dates to send to market?

Mr. BLAISDELL. Hardly, yet. Our home consumption would exceed the production.

The CHAIRMAN. Can you produce dates generally throughout the Territory?

Mr. BLAISDELL. Yes. It is the natural wild date that grows here.

The CHAIRMAN. What variety of citrous fruits can be raised here?

Mr. BLAISDELL. The lemon, the lime, and the orange do exceedingly well here, especially the lemon and the lime. They ripen very soon, two months earlier than they do in California. We have no early oranges here; so we can not say what time they will ripen. We have them growing, but not bearing yet.

The CHAIRMAN. What are the facilities here for irrigating this land?

Mr. BLAISDELL. We have abundant water supply in the winter and spring, up to about the 1st of June.

Senator **REAGAN**. Without irrigation?

Mr. **BLAISDELL**. No, we have no rain here to speak of. The rain-fall being about 2½ inches, practically amounts to nothing. We have in the Gila River an abundance of water up to the 1st of June. It varies according to the position of the county, the upper part having more water than the lower part.

The **CHAIRMAN**. In the upper part they take it out first?

Mr. **BLAISDELL**. Yes.

The **CHAIRMAN**. Is there enough water in the Gila River to provide all that you want?

Mr. **BLAISDELL**. In the winter the stream is wide, and something like 4 feet deep. We can fill almost any reservoir that you can build. The evaporation, by the report of the Signal Service, is one-third of an inch a day for the three summer months, an average of 10 inches for the three summer months. They made a survey for the reservoir site, and allowed for an evaporation of 7 feet—over half an inch a day for the whole year; and, making that allowance, we have a storage capacity with a flow of 150,000 inches for six months in addition to the natural flow of the river during the summer.

The **CHAIRMAN**. Have you near here a good site for a reservoir?

Mr. **BLAISDELL**. Yes; we have an excellent site about 80 miles east of this place.

The **CHAIRMAN**. Then you think in the Gila River there is plenty of water that could be stored?

Mr. **BLAISDELL**. In the winter-time and the spring we have the freshets. That covers a large part of the bottoms.

The **CHAIRMAN**. When you do have rainy seasons what time in the year are they?

Mr. **BLAISDELL**. Generally in the winter. We generally have no rain in the summer. Rain is the exception in the summer.

The **CHAIRMAN**. Further east from here they have rain in the summer?

Mr. **BLAISDELL**. Yes, at the ranch we occasionally get some; but it is the exception.

The **CHAIRMAN**. What area of country have you in the vicinity of Yuma that could be irrigated if you stored your water?

Mr. **BLAISDELL**. About 600,000 acres of land below the reservoir.

The **CHAIRMAN**. Is the reservoir site on public land?

Mr. **BLAISDELL**. Yes. There are two cattle ranches located on the reservoir site, but no filings have been obtained. The dam would be required to be 100 feet high to flood an area of 48½ square miles.

The **CHAIRMAN**. How large would your reservoir site be?

Mr. **BLAISDELL**. Forty-eight and one-half square miles. It flows back about 24 miles. The average depth we estimate to be 35 feet, allowing for evaporation. I think the capacity will exceed our estimates at least 25 per cent., because we have made no estimate of the cañons.

The **CHAIRMAN**. What crops do you produce, taking the winter irrigation that you have in the flood-time?

Mr. **BLAISDELL**. Barley, wheat, hay, and all kinds of sugar-beet can be produced here. You will find that this will, in all probability, be the sugar-beet country. There is 17 per cent. of sugar in our beets, and it is estimated that the yield from properly cultivated beets will be over 20 per cent.

The **CHAIRMAN**. How do the laborers in this climate stand working in the sun? This country has the reputation of being a very hot one.

Mr. **Blaisdell.** Our extreme heat this summer was 117 or 118, but it is equivalent to 88 or 90 only, taking moisture into consideration.

The **Chairman.** It is equivalent to a temperature of 88 or 90 degrees in New York or Washington?

Mr. **Blaisdell.** Yes; it would not be over 88 or 90. We have no trouble in getting all the labor we need.

The **Chairman.** The people who work here are healthy?

Mr. **Blaisdell.** Yes. The only thing we have to be careful about is not to drink an unlimited quantity of ice-water when working out in the sun. I will state that we have no difficulty in raising all kinds of oranges.

STATEMENT OF O. T. S. INGALLS, OF YUMA.

The **Chairman.** What is your occupation?

Mr. **Ingalls.** I am a farmer at the present time.

The **Chairman.** State where you are farming and what are the results you obtain.

Mr. **Ingalls.** I will state that I am occupying a piece of land in town which I am leveling and getting ready to cultivate when I get sufficient water. I propose to use pumps so soon as my land is in a condition to work. At the present time I have not done anything.

The **Chairman.** Do you know what kind of farming is principally carried on here—what do you raise?

Mr. **Ingalls.** Mostly fruits—oranges, lemons, limes, dates, pomegranates, figs, apricots, pears, and peaches.

The **Chairman.** Is the land well adapted to the raising of such fruits?

Mr. **Ingalls.** We find no difficulty in raising them, and we get them very early in the season. They grow very rapidly, and we get various varieties.

The **Chairman.** How are they as to quality?

Mr. **Ingalls.** Very fine as to quality, and the yield is good. We have also made some experiments with sugar-beets. We find that we can raise them here by planting them two seasons of the year, one crop in March and the other in October. In that way we have them growing the whole year round. We sent a sample of our sugar-beet to San Francisco, and it was reported to contain 17 per cent. of sugar. That is a very fine return. Then we have wild hemp. This grows on the overflowed lands of the Colorado. It grows without any irrigation immediately after the overflow, and this sample [producing] was obtained by putting the sticks of the hemp in water and allowing it to wash off the gum.

The **Chairman.** What height does it grow?

Mr. **Ingalls.** From 12 to 14 feet in height.

The **Chairman.** How is it as to quality?

Mr. **Ingalls.** It is considered to be a very fine quality. We have been offered 8 cents a pound for that material.

The **Chairman.** That grows down in the Mexican territory, also.

Mr. **Ingalls.** Large quantities grow in Mexican territory.

Senator **Reagan.** Is there any one engaged in putting it into this condition?

Mr. **Ingalls.** No; that was done for experimental purposes. I saw a party in San Francisco who had just returned from Paris, and he stated they were anxious to get it.

The **Chairman.** Is the territory here large?

Mr. **Ingalls.** Yes; hundreds of thousands of acres. Cotton grows here year after year.

Senator **REAGAN**. From the same stump?

Mr. **INGALLS**. Yes, and Judge Brinley has had some trees growing in his yard for some years.

The **CHAIRMAN**. Is cotton cultivated here so as to enable you to speak of the quantity produced?

Mr. **INGALLS**. It is not.

Senator **REAGAN**. You do not know how much is produced to the acre?

Mr. **INGALLS**. No.

STATEMENT OF CHARLES H. BRINLEY, OF YUMA.

The **CHAIRMAN**. How long have you resided in Yuma?

Mr. **BRINLEY**. Twenty-odd years.

The **CHAIRMAN**. Have you observed the production of crops here by irrigation?

Mr. **BRINLEY**. Somewhat.

The **CHAIRMAN**. And you have engaged in it to some extent?

Mr. **BRINLEY**. As a gardener.

The **CHAIRMAN**. What is the character of crops produced here?

Mr. **BRINLEY**. In former times there was produced wheat, barley, and hay. They were the principal crops. That was a number of years ago. That was when the government was here.

The **CHAIRMAN**. Then you had a market for that class of crops?

Mr. **BRINLEY**. Yes. Since that time it has been nondescript in its character. With Mexicans and others it never rose to the dignity of a crop. So soon as the railroad was established, and when we were able to get water from our pipes, etc., we commenced our gardens. So far as that is concerned, I can speak from a personal stand-point. I have put in oranges, lemons, limes, figs, olives, pomegranates, plums, a variety of flowers, cotton and one or two trees from Sonora, a kind of wild tamarind. I have planted the tamarind and found it to grow well and free. You could produce ornamental trees and bananas.

The **CHAIRMAN**. What success have you had in them?

Mr. **BRINLEY**. Good success.

The **CHAIRMAN**. You have raised each of those?

Mr. **BRINLEY**. Yes. I have raised bananas. I am speaking from a crop stand-point. I do not think bananas would answer?

The **CHAIRMAN**. What would then.

Mr. **BRINLEY**. Oranges, limes, and lemons.

The **CHAIRMAN**. What success have you had in oranges?

Mr. **BRINLEY**. Admirable. I could demonstrate that better if you were to step off the cars and see my oranges. I have but two trees. I have them in my garden, the Marianna Sweet, and it is as clear and delicious a fruit as you ever saw, without a speck, beautiful in color, and just a few seed.

The **CHAIRMAN**. Do they produce largely in quantity?

Mr. **BRINLEY**. Abundantly.

The **CHAIRMAN**. As much as the trees will bear?

Mr. **BRINLEY**. Yes; and when they are in flower I never saw anything like it. I have seen an abundance produced on oranges and lemons; but in this place there appears to be a struggle as to which tree can produce the most.

The **CHAIRMAN**. How much of this country is suitable for oranges of that kind?

Mr. BRINLEY. That has to be experimented upon. I can not answer as to that, because my operations are limited.

The CHAIRMAN. To Yuma?

Mr. BRINLEY. To a small area near it; but I judge, with proper care, we could hardly name the limit in this county.

The CHAIRMAN. Where were the dates raised that we see here?

Mr. BRINLEY. They were raised on the Colorado, about 6 miles from here.

The CHAIRMAN. Am I to understand that there is an abundance of water in the Gila River in the spring?

Mr. BRINLEY. Yes; in the winter-time.

The CHAIRMAN. Covering a large extent of country?

Mr. BRINLEY. Yes.

The CHAIRMAN. How is this country with regard to its healthfulness?

Mr. BRINLEY. Perfect. I am rather a good specimen for the number of years that I have lived here. I have been sick but once, and I have not slept in my house for thirteen years. I sleep out of doors. In the winter-time I sleep under a corridor.

The CHAIRMAN. What effect would this climate have upon consumptives?

Mr. BRINLEY. If they come here at not too late a period in the disease, I think they can be improved in every instance. I do not think, however, any one could stand the extreme hot weather. But if they came here in the winter and gradually worked into it, I think they could stand the heat and be wonderfully benefited by the country.

The CHAIRMAN. How would it do to spend the winter here and the summer at Santa Fé?

Mr. BRINLEY. That might do. So far as this climate is concerned, in the winter-time it is admirable.

The CHAIRMAN. Do persons contract consumption here?

Mr. BRINLEY. I have never known a local disease; everything that has occurred here was some person who was brought here sick. We have had sporadic cases of measles and small-pox. But that is milder in form than it is anywhere else; the fatality is insignificant as compared with other places.

STATEMENT OF J. H. TAGGART, OF YUMA.

The CHAIRMAN. State what your experience has been in fruit-raising in this country.

Mr. TAGGART. Outside of a garden I have had no personal experience. About six years ago, when we got our water, we put in some trees, some oranges, lemons, limes, figs, grapes, a variety of flowers, tube roses, and the whole list. My wife attended to that department. The success in everything has been all that could be expected, and even more, in some instances. The citrous fruits we have found to improve in quality from what they were when transplanted from California. The skin becomes thinner, the flower finer, and the seeds fewer. The quality of citrous fruit is equal to the Sonora limes, lemons, etc.

The CHAIRMAN. Do you think you can raise as good oranges as they can at Sonora?

Mr. TAGGART. I have never tasted a better orange than I have gotten here. I have compared them with the Sonora oranges, and found them fully their equal. They are much better than the Riverside oranges, or the best Florida oranges.

The CHAIRMAN. How much country have you in which you could raise oranges like the Sonora oranges?

Mr. TAGGART. It is estimated that we have in this country some half million acres, and I do not know any reason why the fruit should not be raised over the whole area.

The CHAIRMAN. It is very similar to the land on which you raise oranges.

Mr. TAGGART. Yes, except that throughout the county the soil is excellent, and here in Yuma we are in a sand-hill. So that, we are at a disadvantage here, where we have gardens. A few months ago we put out some blue figs, and to-day they represent trees 10 and 11 inches in diameter. Before the slips are a year old we gather fruit from them, and from some of them we have gathered two or three times a year. We get bushels from each tree every season. The yield is simply immense. Some varieties of grapes do not color here as well as they do elsewhere; but they are of a finer flavor than I have seen elsewhere.

The CHAIRMAN. Would this be a good place to cultivate raisin grapes?

Mr. TAGGART. Yes. I have had bunches of raisin grapes on the ground in the garden exposed to the sun, and in eight or nine days pick up as fine raisins as I would want to use, and without giving further attention. They do not become sun-burned under such circumstances, and the atmosphere is so dry that we have no difficulty at all. There is no necessity to protect the crop.

The CHAIRMAN. You can dry them almost any season of the year?

Mr. TAGGART. Yes. We claim from four to six weeks earlier than California in ripening most fruits, especially grapes. We can discount that time. I took from my garden this season in May ripe grapes of the standard varieties—Black Hamburgs, raisin grapes, Black Malaga, Muscatelles, etc. So that we could have gathered freely had we vineyards from the 10th to the 15th of June.

The CHAIRMAN. You would have the eastern market two months earlier than your California neighbors.

Mr. TAGGART. That is what we claim; and we could hold it.

The CHAIRMAN. Are your citrous fruits ripened much earlier than theirs?

Mr. TAGGART. Our limes are. Here are are some limes just picked from the tree [producing].

The CHAIRMAN. What is the general character of the soil through this country?

Mr. TAGGART. It is deep, from 10 to 20 feet on the valley; on the mesas it is different—more iron, and somewhat more gravelly, and of unknown depth.

The CHAIRMAN. Are the mesa lands fertile when you get water or to them?

Mr. TAGGART. Yes, they have produced abundantly wherever we have had water on them, seemingly as well as in the valley.

Director POWELL. How long have you lived here?

Mr. TAGGART. Twelve years.

Director POWELL. Have you kept a rain-gauge in this section

Mr. TAGGART. No.

Director POWELL. Do you know any one who has?

Mr. TAGGART. The Signal Service.

Director POWELL. Do you know what the rain-fall has been here in late years?

Mr. **TAGGART.** They have registered between 2 and 3 inches—2 inches and a fraction.

Director **POWELL.** Have you ever been west 50 or 60 miles?

Mr. **TAGGART.** Yes.

Director **POWELL.** So as to know a good deal about that country?

Mr. **TAGGART.** Fairly well.

Director **POWELL.** Does the rain increase going westward?

Mr. **TAGGART.** Yes.

Director **POWELL.** How much is the rain-fall within 100 miles of here, not along the coast, but out on the desert?

Mr. **TAGGART.** The rains out on the desert are very frequent and very heavy. They have washouts there, and we seldom have rain here. That is the best comparison I can give. But it is certain the rain is very much greater as you go west, and I think you will find a material difference in a hundred miles.

STATEMENT OF LOUIS A. HICKS, OF YUMA.

The **CHAIRMAN.** What is your occupation?

Mr. **HICKS.** Civil engineer.

The **CHAIRMAN.** Have you made surveys in the vicinity of Yuma?

Mr. **HICKS.** Yes, I have been located here some time. I have been engaged in the construction of irrigation works for the last year and a half.

The **CHAIRMAN.** Have you any maps representing your works or any portion of them?

Mr. **HICKS.** The intention is to send you blue prints so soon as we can have them prepared.

The **CHAIRMAN.** You will forward them to Washington?

Mr. **HICKS.** Yes.

The **CHAIRMAN.** Can you state the amount of irrigable land in this county?

Mr. **HICKS.** The amount to be irrigated approximates 600,000 acres, and of that we estimate that 450,000 acres will be good land. The other 25 per cent. is land of not entirely good character; it is irregular or sandy, or for some other reason broken up, so that it is not available for cultivation.

The **CHAIRMAN.** How would you irrigate the land?

Mr. **HICKS.** By means of a storage dam, the dam to be 100 feet high.

The **CHAIRMAN.** Have you ample water to supply it?

Mr. **HICKS.** Yes. The Gila River in the winter would fill any reservoir that could be built. I have seen flood places 3½ miles wide.

STATEMENT OF E. G. TRIPPEL, OF YUMA.

The **CHAIRMAN.** How long have you resided in Yuma?

Mr. **TRIPPEL.** I have been here about two and a half years.

The **CHAIRMAN.** Have you a report prepared by the citizens or by some organization with regard to irrigation in this county?

Mr. **TRIPPEL.** Yes.

The **CHAIRMAN.** State by whom it was prepared, and why?

Mr. **TRIPPEL.** It was prepared for your use by a committee appointed by the citizens at a mass-meeting held for that express purpose. I, under the direction of this committee and with its assistance and authority, have prepared this data. It is a report which we presume will be of some use to the committee.

The report is as follows:

REPORT OF THE CITIZENS' EXECUTIVE COMMITTEE OF YUMA COUNTY, ARIZ., TO THE SENATORIAL COMMITTEE ON THE IRRIGATION AND RECLAMATION OF ARID LANDS.

[Written and compiled by E. J. Trippel, secretary of the committee, under the direction and by the authority of the Citizens' Executive Committee, September 3, 1889.]

Members of the executive committee: C. H. Brinley, F. S. Ingalls, F. L. Ewing, S. Purdy, C. E. Spencer, A. Frank, Hiram W. Blaisdell. Officers: H. W. Blaisdell, chairman; E. J. Trippel, secretary.

This report has been prepared with the view of presenting to the Senatorial Committee on the Reclamation and Irrigation of Arid Lands data pertaining to the climate, rivers, lands, irrigation facilities, available water, storage sites, peculiar products, water supply, and such other points as are properly connected with a truthful statement of the present condition and future possibilities of the agricultural interests of Yuma County, Ariz.

Immediately following the correspondence between Col. R. J. Hinton, irrigation engineer of the U. S. Geological Survey, and the governor of Arizona, relative to the proposed visit of the Senatorial committee to various portions of the Territory, the governor issued a proclamation requesting the different county supervisors to take prompt action in the matter of collecting suitable data for the use of the visiting committee. In compliance with the call an enthusiastic meeting was held in the town of Yuma by the citizens on the 8th of July, 1889, and plans of action formulated to this end. An executive committee of seven were appointed and authorized to take in hand the collection and computation of the requisite data and also the direction of such additional details as might to them seem necessary.

This committee, therefore, in behalf of the citizens of Yuma County, respectfully submit for the consideration of the Senatorial committee the following report, accompanied by maps from the surveys of Messrs. L. A. Hicks and J. B. Steiger, both eminent civil engineers, showing the area of fertile and irrigable land in and about the lower portions of the Gila and Colorado Valleys, and also the proposed site of an immense and perfectly practicable water-storage reservoir with a capacity more than sufficient to furnish the means of cultivation to hundreds of thousands of acres of arable land, much of which is now lying idle, useless, and unproductive. No attempts have been made to exhaustively review the subject in all its ramifications, and yet enough might be written upon our numerous and varied resources to fill a volume. It has rather been the purpose to briefly touch upon the more important points, including the many peculiar and almost unique features showered upon this really favored though apparently cruelly neglected, region. Unfortunately, however, there are among the most valuable of our natural gifts a number quite latent and dormant, and so they will remain until the Government in its wisdom sees fit to quicken them into life, and by affording the necessary facilities for storing water against the seasons when it is most needed, bring about a wondrous and magical change in contradistinction to the present state of affairs.

These pages are sent upon their mission with the hope of attracting the attention of the statesmen high in the councils of the nation to the plainly manifested necessities of Yuma County. It is believed that when it is once accomplished the desired results will follow as a matter of course, and thousands of happy, prosperous, and contented citizens will live to bless the practical efforts of a wise and benignant Government in effecting so thorough, so radical, and so desirable a change.

CITIZENS' EXECUTIVE COMMITTEE.

PHYSICAL AND TOPOGRAPHICAL FEATURES OF YUMA COUNTY, ARIZ.

Yuma County, one of the four original political subdivisions of the Territory when first established by act of Congress, on February 24, 1863, as an independent Commonwealth, forms the extreme southwestern portion of Arizona. It lies between 32° and 34° 24′ north latitude and 113° 20′ and 114° 14′ west longitude. It is bounded by Pima, Maricopa, and Yavapai Counties on the east, the Colorado River on the west, Mohave County on the north, and Sonora, Mexico, on the south. It has an area of 10,138 square miles (6,448,320 acres), an expanse greater than either of the seven smaller States of the Union, and larger than Connecticut, Rhode Island, and Delaware combined.

For more than 100 miles it is crossed from east to west by the Gila River, which thoroughly drains the southern and western portions, eventually emptying into the Colorado at the town of Yuma, while the Colorado washes its western boundary, effectually draining the remainder.

The topographical configuration of the surface includes a series of wide plateaus rising gradually from a point situated at the southwestern extremity with an altitude of about 60 or 70 feet above sea-level, to an elevation in the north and northeast very much greater, the whole sloping gently in a southwesterly direction. These plateaus are crossed by numerous mountain ranges, especially in the northern part, the ranges being separated by broad valleys, many consisting of excellent lands. The various mountain systems, though rough and abrupt in character, are highly mineralized, carrying gold, silver, copper, lead, iron, and other minerals in paying quantities. The eastern and southern portions include gradually-sloping plains covered in places with native grasses and trees, among the latter being the mesquite, ironwood and paloverde. Here and there are detached hills and mountain spurs, often of eruptive origin.

All that country embraced within the county confines, situated north of the natural water-shed of the Gila River, owing to the slight rain-fall and few streams from which water can be taken for agricultural purposes, is practically worthless, so far, at least, as the feasibility of bringing large bodies of irrigable land under cultivation is concerned. The available arable region, therefore, is limited by nature to broad strips of country lying directly north of the Gila and east of the Colorado Rivers, and also hundreds of square miles of splendid land stretching directly southward from the Gila River to the Sonora (Mexico) frontier. Consequently it is upon these rivers that water-storage reservoirs must be established.

It is more than probable that less is known of the physical and topographical peculiarities of Yuma County than of any other county in the Territory. According to the map of the Interior Department, issued from the General Land Office in 1883, it is shown that less than 10 per cent of the total area was surveyed by the Federal authorities. It is believed that no further surveys have been ordered since the date mentioned, and therefore, so far as official recognition extends, more than nine-tenths of the country is a veritable *terra incognito*. The population numbers 2,500 souls and the valuation of taxable property reaches in round numbers $800,000.

RIVERS.—The Gila River, though second in size to its mighty rival, the Colorado, is destined for the present, at least, to figure far more prominently in the solution of the problem of redeeming and making valuable to the husbandman the immense bodies of hitherto arid and worthless lands tributary to it.

The Gila drains a vast territory. Rising in the western part of New Mexico, it flows in a nearly westerly direction through the entire Territory of Arizona. Its northern and eastern sources are among mountains covered for several months in the year with snows of varying depths, the melting of which, added to the many natural springs emptying into it at different points, form a considerable river long before it passes through Graham County. It enters the latter county in the neighborhood of the Clifton Copper mines, then courses through the Pueblo Vieja Valley and the San Carlos or White Mountain Indian Reservation, finally entering the Gila Valley some 5 miles above Florence, thence for nearly 300 miles it winds through the now famous Gila Valley, eventually merging into the large stream at Yumma.

The entire course of the river is erratic and irregular, as it follows a naturally tortuous route caused by the diversified character of the country traversed. The total length from its source in New Mexico to its confluence with the Colorado, including its many windings, is fully 650 miles. Before reaching the eastern boundary of Yuma County it is fed by numerous rivers, among the most important being the San Pedro, a singular stream, rising near the line between Sonora and Arizona and draining the Huachuca, Mule, Caliuro, Dragoon, and Whetstone Mountains, and also the eastern slope of the Santa Catalinas. Flowing northerly for more than 100 miles it enters the Gila River at the southern extremity of Gila Cañon, in Pinal County. Along its course the rain-fall is perhaps greater than elsewhere in Arizona, being estimated at 24 inches yearly in the vicinity of the Dragoon Mountains. Certain of the ranges mentioned are during winter frequently covered with snow, which on some do not disappear until the commencement of summer.

Another notable tributary is the Salt River, in itself a large stream, having its headwaters in the White Mountains, near Green's Peak. It rises in the eastern portion of the Territory, draining the mountainous region in the far north, including among others the San Francisco, Sierra Ancha, White, Apache, and Tontó Basin Mountains. Among the most important streams that feed it may be mentioned the Verde River and Tonto, Raccoon, Cherry, Cañon, Cibica, Carrizo, Cedar, Pinal, and Perito Creeks. Its general direction is west and south, until it empties into the Gila some distance below Phœnix, its entire length closely approximating 200 miles. An important adjunct towards increasing its volume is the heavy rain-fall about Prescott, amounting during the past ten years, as is shown by the reported observations of the United States Signal Service office at that place, to an average of 15.18 inches annually. Much of its waters are used in irrigating its own valley at Phœnix, but the waste water of the Salt River Valley, irrigating canals is gradually returned in part through seepage to the Gila, thereby augmenting the latter. Other rivers, like the Agua Fria, Hassayampa, etc., bring down further supplies drained from the heavily-timbered mountain region traversed by them, pouring their precious stores into the Gila.

Thus for the major portion of each year the Gila carries a large stream, more than sufficient, in fact, to irrigate its own valley, a domain princely in extent. During the summer months, however, owing to the extremely dry and heated climate, extraordinary rapid evaporation, decreased supply at its headwaters due to the cessation of springs and snows, and, also, the peculiarity, during the heated term, of drying in its bed for many miles, rising and sinking at intervals as the bed-rock approaches or recedes from the surface, the available supply falls short of the demand, leaving hundreds of thousands of acres in the lurch, and that, too, at the very time when ample irrigation facilities are the most needed. For this reason alone if for no other dams and other constructions for storing water against such times are imperatively needed and should be inaugurated as early as possible. None of the streams so far touched upon are navigable.

The Colorado.—The Colorado River is formed by the union of the Green and Grand Rivers. The former rises in Wyoming, near Fremont's Peak, and, running southerly, joins the latter in Utah. The Grand River rises near Long's Peak, in Colorado, and, running in a southwesterly direction, meets the Green as stated. From their juncture the stream takes the name of the Colorado, and, following a general southerly course, empties into the Gulf of California. The entire length, including tributaries, is over 1,200 miles. It flows during the low-water period at a rate not exceeding 4 miles per hour, although, of course, the speed is very much greater when the river is high. Among its principal tributaries are the Rio San Juan, the Colorado, Chiquito, the Bill Williams River, and finally, as already explained, the Gila. The Colorado constitutes the entire western boundary of Yuma County, its total length between the Sonora line and the mouth of Bill Williams River, being about 235 miles, the latter forming its northern boundary, separating, as it does the counties of Yuma and Mojave. It is navigable during high water for nearly 650 miles, from the Gulf of California to the Virgin River, by steamers registered and licensed through the customs district of Paso del Norte.

The river is capable of affording at all periods an almost incredible amount of water for irrigation purposes, sufficient, in fact, to bring hundreds of square miles of fertile lands on each side of the river under cultivation besides supporting an enormous population. Near Yuma the current sometimes attains a speed of 4 knots per hour, with an average depth of 10 or 12 feet.

The Bill Williams fork unites with the Colorado at Aubrey. Rising in the mountains southwest of Prescott it flows southerly and westerly to its mouth a distance close upon 150 miles. Its chief tributaries are the Santa Maria and Big Sandy Rivers. It passes through a region much distorted and disturbed by past volcanic influences and containing but little tillable land. Consequently, so far as the intents and purposes of this report are concerned, the Bill Williams River, being devoid of extensive agricultural and irrigation facilities, will not be further treated.

ARABLE LANDS.—Within the county limits there are large aggregations of Government land. The majority of the most favorably situated in the valleys were the first taken, the early pioneers occupying the tracts nearest the rivers for the reason that they could be more cheaply irrigated. The mesas are entirely unoccupied, although they comprise much of the most desirable land, such especially as are adapted to the growth of the citrus and other semi-tropical fruit. Water can not easily be brought upon them on account of their elevation above the river bed. Canals capable of carrying sufficient water for irrigation would entail comparatively heavy expense, because many miles must necessarily be constructed before the water can be brought to the surface. Such outlay would prove far too excessive for the slender resources of the average settler, and so, as matters stand, they lie scorching under the burning rays of a semi-tropical sun untouched by the spade and plow.

This condition of things, however, can not long continue. Neither physical nor topographical difficulties exist that can not be surmounted by the expenditure of a reasonable amount of capital, and consequently it is only a matter of time when the completion of constructions of this nature will be effected by private corporations or by the Government. There are but few points along the slopes of the many mountain ranges calculated for farming locations. Such places are generally situated where small living springs afford the means of irrigation for a few scattered acres. Above the Gila are great sloping plateaus which may in the future be placed under cultivation provided the boring of artesian wells is prosecuted extensively. As the surface inclination is toward the river, commencing many miles away from its nearest point, the bringing of water from the Gila itself is entirely impracticable and other methods must be adopted. It may safely be assumed, in view of what has just been explained, that the large bodies of available agricultural lands are confined to the valleys of the Gila and Colorado, and also to the comparatively level plains stretching from the Gila River to the Mexican line.

The Gila Valley is by far the most important of the two from an agricultural stand-point. It extends from the Gila Cañon, near the junction of the San Pedro River, westerly to the east banks of the Colorado, a distance slightly exceeding 250 miles. That portion of it situated in the county of Yuma, and known as the Lower Gila Valley, is about 100 miles long by from 2 to 16 miles wide, all of which is susceptible of profitable cultivation. The river from which it takes its name cuts the valley in two. Its water-shed extends some 30 miles north and upwards of 50 miles south of its channel, the land from either extreme inclining more or less rapidly towards the stream. The Gila traverses a marvelously fertile country, very great in extent, and splendidly adapted to the cultivation of nearly all the products of the temperate and semi-tropic zones, besides many of the fruits common in the tropics. Nor is this longer a matter of idle speculation, for flourishing ranches in various portions of the valley and drawing water from several important canals amply demonstrate the magnificent results that will ensue should the water supply be rendered permanently equable and adequate through appropriate storage systems. The following, taken from "The Hand-Book to Arizona," by Col. R. J. Hinton, alluding to the valley in question, is as interesting as it is accurate.

"This consists of a broad expanse of tillable valley land, sometimes overflowed by the river, which is at times 'mighty uncertain' and a steep range of volcanic hills coming close to the highways is for a dozen miles or so hot, heavy, and sandy. It is hardly fair to say sandy, as it is really a friable alluvial loam of grayish hue and loose texture. Several ranches are passed, showing that the Gila bottom is cultivable. With irrigation every square mile of the Gila valley is capable of producing prolific crops of grains and semi-tropical fruits, as well as cotten and sugar in great abundance. The river is able to furnish all the water needed, and a good deal more. It would take no very great skill in engineering, and not a very large sum of money either, to construct reservoirs or lakes in which to receive and store the overflow. There are natural basins or dry lakes into which by simple means the water could be conveyed."

The lands situated in and about the Gila valley may conveniently be classified as follows:

(1) The bottoms or overflowed lands.
(2) Slightly higher valley lands not subject to overflow.
(3) Mesas or sloping uplands.
(4) High but comparatively level plains.
(5) Mountains.

The bottoms and higher lands.—The bottom lands, as well as those slightly higher, stretch along either side of the Gila River for varying distances north and south until they meet the more elevated mesas which rise abruptly from the valley. The bottoms lie immediately along the river and are subject to inundation annually. Immediately following the subsidence of the waters the local Indians were in former times, accustomed to plant corn, pumpkins, melons, and other vegetables. These sprung into maturity with startling rapidity, rarely failing to yield bountifully without additional irrigation. The custom is occasionally followed by resident farmers to this day with excellent results, although but a single crop can be harvested. These bottoms form, perhaps, 25 per cent. of the valley lands, and may without particular difficulty be secured from further invasion by a system of dikes and levees if deemed necessary or desirable. The soil throughout the valley is a rich brownish yellow sandy loam, generous, mellow, and porous, with a depth ranging from 6 to 20 feet, the whole resting upon underlying stratas of gravel and sand that readily carry from the surface such excess of water as might otherwise prove injurious to seeds and growing plants.

There is unmistakably geologic evidence that the entire lower Gila valley was, during some pre-historic period, covered with water, constituting, in fact, an enormous lake, the surface rising in places to the upper portion of the outskirting mesas. The soil lying at the bottom was made by the washing and erosion of the surrounding mountains. The soda from the decomposed vegetation, the magnesia and lime from the magnesium lime formations, and the potash from the decomposing granitic rocks were carried with unceasing regularity year by year until deposited in the bottom. Eventually, upon the disappearance of the lake, the rich, fertile alluvium, than which there is none better, was left to reward the efforts of the modern husbandman. But nature, not yet satisfied with her handiwork, directed the accumulation of the detritus washed from the distant mountainous region. As a result the soil is extremely rich in the elements best adapted to thorough fertilization, for it contains a certain amount of organic matter, which, on decomposing, further enhances its agricultural value.

By constant overflow and change of channel the deposits are equally distributed over considerable areas, the process continuing through centuries. These soils are further enriched by decomposed inorganic contributions, including the sandstones, limestones, marls, shales, etc. Besides the ingredients mentioned a chemical analysis shows that iron, ammonia, and phosphoric acid enter into its composition in the proportions best adapted to add to its fertilizing qualities. The extremes of temperature are somewhat greater than on the high lands, but there is also more moisture.

The bottom lands are so easy of cultivation that it is not uncommon, after clearing the surface from brush and stubble, to pass over the ground with an ordinary cultivator a single time, afterwards sowing to grain or grass. In three or four months large crops are harvested, the soil meanwhile being entirely innocent of the plow. All plants seem to grow rapidly, maturing remarkably early. Indications of ancient ditches are apparent throughout the valley, showing plainly the existence of irrigation works by the ancient Aztecs. Curiously enough, in certain instances the identical routes of these long-extinct people have been followed for considerable distances by their modern successors.

The MESAS.—The mesas are warmer and better adapted to the cultivation of citrus fruits. The soil is also somewhat different, being of a reddish color, and loose enough to receive water without causing the ground to bake. While of a loamy nature, it is more sandy or gravelly. It is also lighter, but therefore better adapted for the culture of the fig, the olive, and the various kinds of wine grapes. Indeed, it has been asserted by several of the most experienced wine growers of California that these very mesas are better calculated for the production of the true port and sherry grapes than any of the lands within the borders of their own grand State. It is claimed that wine can be made possessing preserving qualities such as would allow of improvement year by year, instead of deterioration. These lands are greater in area than those directly upon the river, and almost imperceptibly slope away from the distant mountains. The drainage is admirable, not too excessive, and just sufficient to carry off surplus water. Vegetables, grasses, grains, sugar beets and cane, cotton, and, in truth, almost everything can be raised successfully.

The HIGH *plains.*—These include extensive bodies of land connecting with the mesas along the south side of the Gila valley. So gradual is the slope that they hardly deviate from the horizontal. At the highest point southwards they as gently incline towards the Mexican line, the slope in this case being directly opposite to that along its northern base. In the latter instance it is first towards the mesas, and from thence indirectly to the river. The soil is very similar to that of the mesas, the two classes exhibiting common characteristics. Like the mesas, these plains are susceptible of the highest cultivation, providing always that sufficient irrigation facilities are afforded. Here and there they are crossed arbitrarily by mountain ranges, which do not all trend in the same direction, but they present no important engineering obstacles to the canal builder.

The wonderful fertility of the bottoms and other valley lands, as well as the mesas and high plains, is established beyond denial by actual experimentations. Neither is the soil likely to degenerate in the future, for in answer to the question, "Will it last," O. L. Wheeler, D. D., LL.D., a recognized expert in such matters upon the Pacific coast, says:

"To this query the answer in general is the longer land is properly cultivated and properly fertilized the stronger and more productive it becomes. While the mountains surrounding the valley continue to disintegrate under the operation of the elements, and while the detritus thus eliminated continues under the laws of gravitation to descend and work its way over the plains, so long will there be perennial additions to the amount of producing element in a state of refinement and assimilation. And so long as the water flowing from these mountains, holding in solution the débris which always in some degree is spread upon the land in irrigation, so long will the fertilizing properties of the soil continue to receive additions and its fecundic power will continue to be increased. And so long as the water, containing more or less of salts and ammoniac compounds, as all water does, is used for irrigating purposes, and so long as the process of cultivation continues to throw up the soil, exposing it to the indispensable and even fructifying influences of the atmosphere, so long will the soil continue to be refreshed and invigorated and prepared to give larger rewards to the labor of the husbandman."

MOUNTAINS.—The mountains forming the last and outer environments are, of course, in no way to be discussed. Nevertheless they play an important part in the advancement of the agricultural interests of the valley by shielding, more or less, the lower lands from the effects of the high strong winds that prevail at times.

The total acreage of the Gila Valley and outskirting lands, as just described, is estimated at 600,000 acres, of which there are 33,000 acres of bottom lands, 97,000 acres of higher valley lands, and 470,000 acres of mesas and level plains. By far the largest portion of the valley has been filed upon, under one or other of the Congressional enactments. The entire amount under actual cultivation will probably not exceed 1,500 acres at the present time although, owing to the recent completion of one of the most prominent irrigating canals, it is believed that between 3,000 and 5,000 acres additional will be worked during the coming autumn and winter. The writer is credibly informed that 5,000 acres or more have either been patented or are nearly ready for final proof.

THE VALLEY OF THE COLORADO.—Several miles above Fort Yuma, in the neighborhood of Explorer's Pass, near the Purple Hills, the great Colorado Valley proper commences. From this point northerly the river is shut in by cliffs which, with intervening mountain systems, absolutely precludes the possibility of canal construction. Passing southwards the cliffs are seen to gradually disappear until they become merged in the low bottom lands. The valley meanwhile widens with every mile until the Gulf of California, in Mexican territory, is reached. There are large quantities of land which could be made productive were irrigation practicable. These are generally fertile bottoms, inclining towards the river, and covered in spots with dense undergrowth and cotton-wood and mesquite trees. Considerable of the valley is raised above the river as much as 100 feet, and to this height water must be brought as the bottoms are, during certain months of the year, entirely overflowed by the waters of the swollen stream. The soil is extraordinarily rich and particularly adapted to the cultivation of sugar, rice, and all the textile plants, in addition to an extended list of tropical, semi-tropical, and temperate products. According to careful chemical analysis the fertilizing reddish mud carried by the Colorado closely resembles the waters of the Nile, while its volume at low water has been estimated by competent authority as sufficient to easily irrigate more than 1,750,000 acres.

Until recently the construction of adequate canal systems was considered impracticable. That such is not the fact is shown by the following, reprinted from the pamphlet on "The Resources of Yuma County," published in 1887, by Hon. Cameron H. King, late Commissioner of Immigration for Arizona.

THE GREAT COLORADO CANAL.—One of the most important irrigating enterprises which will, above all others, be productive of the greatest benefit to Yuma County is the proposed canal from the Colorado River.

George W. Norton, a civil engineer of acknowledged great ability and distinguished reputation, has made careful surveys and estimates for this gigantic undertaking, which, if completed as designed, will bring more than 1,000,000 acres under irrigation and cultivation.

The Colorado and Gila Rivers have their confluence at Yuma. The course of the Colorado River, looking up stream from this point, is northeasterly for some 25 miles, and then turns to the north, while that of the Gila is almost due east. Some 18 miles above Yuma commences a range of hilly country, flattening out at its sides into table-lands, and this range separates the two valleys until they finally diverge at right angles. Between this point and Yuma both valleys join and merge into one cut, from east to west, by the channel of the Gila River.

The Colorado Canal will head at a point about 28 miles above the town of Yuma, and will be carried around the hilly country above alluded to, across the Gila River, through pipes or flumes. It will irrigate the land lying between the Colorado and Gila Rivers, and also the land embraced by the table-lands on the south and the Gila River on the north, making fully 25,000 acres above Yuma, subject to redemption. Below Yuma, all the land between the line of table-lands and the Colorado River, as far as the Mexican boundary line, will be reclaimed, some 70,000 acres, and when carried onto the table-lands will redeem 80,000 acres more—a grand total, in Arizona, of 175,000 acres of as fine land as there is on the continent.

If this canal can be carried on into Sonora, by concession from the Mexican Government, it will make productive what is estimated at 1,000,000 acres of land. The cost of this canal system, from its source to the boundary line, will roughly approximate $2,000,000. The width of the canal will be 50 feet on the bottom.

The Colorado Canal heads opposite Stevenson's Island, a rocky protuberance which rears its head above the surface of the water in mid-channel of the Colorado River. This is the only point on this river, for a great many miles, from which an irrigating canal can be taken, owing to the fact that there is such a slight fall to the river it necessitates many miles of expensive work before the water can be brought to the surface of the land. Stevenson's Island, above alluded to, acts as a dam to the waters, raising their surface several feet from the level of which the river rushes with tremendous force and rapidity. In a distance of less than 600 feet there is a fall of fully 4 feet. From this point the taking out of the proposed canal is not only practicable but comparatively a simple and an inexpensive matter. At Stevenson's Island it is proposed to erect a dam and lock, which will not in any way impede or interfere with the navigation of the river, but will be of sufficient capacity to allow the largest steam-boats and barges to pass through. This lock will be so constructed as to raise the water 12 feet above low-water mark. One of the objects in thus raising the water is to enable the canal to cover much more of the table or mesa lands than it otherwise would, but the principal advantage to be gained is that since the water of the Colorado at times holds a very considerable amount of mud or sediment, sometimes as much as 10 per cent., the raising of the water by means of the dam or lock will cause the greater portion of this sediment to be precipitated and the water will thus be partially settled and cleared.

By means of waste-gates and the lock this precipitation of mud is easily cleared out, so that it can not encumber or fill up the canal. The bottom of the canal will be above the bottom of the lock. Waste-gates and sluice ways along the canals, at intervals for a distance of 3 miles, will clear out any surplus of mud in the water, so that the canal will not carry any more sediment than enough to act as a fertilizer.

A bill carefully prepared is to be presented to Congress to obtain permission to construct the proposed lock, and as there can be no objection to it, since it will assist rather than impede navigation by overcoming the heavy fall at this point in the river, there is little doubt that the measure will meet with legislative sanction. The advantages of this great Colorado canal not only lies in the increased quantity of land made subject to redemption, but it will form a most important factor in furnishing this necessary water supply, owing to a peculiar providence of nature. The high-water periods of the Colorado and Gila Rivers alternate, the former having its greatest rise in summer, at which period water is most needed and useful.

Nor does the grand project benefit Arizona alone, for from the western bank of the Colorado at the lock at Stevenson's Island, a large canal will also be taken out of the California side, which will irrigate an immense tract of land in the Golden State and aid in advancing the prosperity of the town of Yuma, which will thus become the center of one of the largest agricultural districts in the West. It is almost impossible within the space allowed for this description to illustrate all the wealth which must necessarily accrue from the construction of such a system of irrigation, or to call attention to all the points of feasibility in such construction. The whole matter is open to investigation.

IRRIGATION.—The question of irrigation has nothing new about it. While the history of remote times exemplifies the endeavors of the people to enlarge and improve upon their methods, the same history depictures abundance and happiness upon the one hand and scarcity with entailed distress upon the other. The methods of to-day among our own people have not yet reached the most economic point. Correct judgment in the use of water, resulting from the experience gathered from an extended and diversified field, will be the future guide.

In this vicinity, a capricious supply of water, under an irrigating system, will return nothing but defeat. Water must be permanent and abundant. The land must be saturated at regular intervals as may be found necessary. The average annual rain-fall, as shown by the Signal Service reports, calculated for the past ten years, is but 2.7 inches, and this, every one will admit, does not, and can not, in itself suffice for the needs of the irrigationist. It is perfectly plain that this section can not exist in an agricultural sense without irrigation. With it, intelligent direction and steadiness of application will lead to abundant harvests even during the hot summer months. Certain small canals may possibly be maintained by the natural flow, but the limit is exceedingly small. The natural supply fostered and stored for an ever-flowing and constant distribution will, in this peculiarly favored climate, endow thousands of families with the attributes of prosperity, and delightful homes will spring like magic upon the now desolate and deserted plains. The omnipresent water thoroughly incorporated with the dormant elements of richness in the soil, will render prolific every acre that can be reached, and upon which the moisture can be maintained.

The lands described in this report possess all the requisite conditions for successful irrigation. The rivers furnish more than ample water during the largest portion of the year, they have sufficient fall, the Gila averaging 4.5 feet per mile; the banks are not too high, as they range between 4 and 18 feet; and finally, there is an abundance of fertile, gently sloping land upon which to carry the water. These lands, without irrigation, are absolutely valueless, but with proper storage and conducting facilities they will surely be worth not less than $200 per acre, the more especially when the healthful climate and the fact that grapes and citrus fruits ripen from one month to six weeks earlier than the most favored part of California is taken into consideration.

CANALS OF YUMA COUNTY.—Of the several large irrigation canals operating in Yuma County but one is completed. The remainder, while only partially finished, are nevertheless in a position to meet the requirements of many acres of bottom and valley lands, with the promise of extending their range of usefulness to many times as much again.

All head at some point or other upon the Gila River, and each is confined entirely within the environs of the valley bearing the same name. The aggregate cost is very great, but proportionate returns upon the invested capital will, for the first time, become apparent during the coming twelve months. Canal building is of comparatively recent origin in the county. A few years since the fertile valleys were almost literally destitute of human inhabitants, while to-day it is safe to say that every acre of valley land along the line of these canals has been filed upon, not to mention considerable mesa land taken up along the line of their projected extensions. The names of the most prominent water-ways, together with the length, carrying capacity, estimated cost, and number of acres tributary to each, are given herewith.

Name of canals.	Length.	Capacity.	Estimated cost.	Number of acres reclaimable.
	Miles.	*Inches.*		
Mohawk	35	11.000	$150,000	40,000
Redondo	5	.600	8,000	1,500
Farmer's	13	5.000	15,000	10,000
South Gila	22	8.000	45,000	12,000
Purdy	10	9.000	25,000	7,000
Contreras	7	3.000	9,000	2,000
Saunder's	10	5.000	25,000	4,000
Araby	8½	2.500	35,000	2,000
Antelope	7	2.000	10,000	2,500
Toltec	3	30.000	15,000	....
Total	120½	77.100	337,000	81,000

In the event of the completion of the above described works in accordance with the original plans of the projectors, the total length would reach 241 miles, reclaiming 267,000 acres of bottom, valley, and mesa land at an estimated cost of $1,318,000. The various works, commencing at Oatman Cañon and extending westerly at intervals to within a few miles of the Colorado River, do not, of course, cover all the arable land in the lower Gila Valley. With no Territorial laws upon the subject of irrigation and ownership of water, excepting the statute that the riparian doctrine shall not be recognized and that the prior locator shall hold as against all others, it has followed naturally that the first comers were the first served. Of the few available sites for canal-headings, situated upon either side of the river, such as seemed likely to prove the cheapest and most convenient during the periodic seasons of low water were taken up, leaving those that remained of little value until the time when water can be stored in sufficient quantities to render them of practical consequence.

The "duty" of water is not constant, but varies according to the locality. The quantity used per acre under the lower Gila Valley canals is rated at about one-third of an inch. It should be explained that but little of the land has been irrigated earlier than eighteen months ago, and being virgin soil requires more water than what will be necessary during the coming seasons. For this reason it is fair to assume that the duty per inch will be materially increased. In California an inch will irrigate from 4 to 12 acres, and it is not only possible, but it is also likely, that the wasteful custom of applying more water to the soil than is actually needed in vogue among the majority of Yuma County farmers may have much to do with the apparent deficiency.

It may be stated incidentally that by irrigation the fertilization of land fluctuates according to the nature and quantity of the silty matter deposited upon it by water, and this, it is estimated, is from 30 to 100 per cent. Both the Gila and the Colorado are especially rich in such matter, and therefore the constant fertilization effected through the operating canals renders any further enrichment of the soil superfluous, useless, and unnecessary.

WATER SUPPLY.—The original source of water supply is comprised in the fall of rain and snow in Arizona, and the States and Territories north and northeast of it, where the fall is greater than the evaporation, the water eventually finds its way to rivers and streams that drain the mountainous regions by seepage, percolation, and surface flow. It may also be taken from springs and wells fed similarly.

Water occurs in any portion of the Gila and Colorado Valleys at a depth of from 12 to 25 feet, but of course the quantity thus obtained is altogether inefficient for extensive irrigation. A few attempts were made to secure a flow from artesian wells, but thus far unsuccessfully. It is more than probable that sinking was in no instance prosecuted to commensurate depths, as the borings were in every case undertaken by private individuals. But, withal, the supply upon which the settlers are forced to place reliance is the inexhaustible volume that during high water passes along the channels of the Gila and Colorado Rivers to the sea. The drainage of much of Nevada, Utah, Colorado, and all of Arizona, finds lodgment in the Colorado throughout its 1,200 miles of channel. An admirable feature in this connection is the peculiarity of reaching its highest dimensions in the months of June and July, the very time when other streams are low. But it must be said that there is sufficient at all times to irrigate every acre of land tributary to it. The river supply at the season of irrigation is greater than that of all the utilized streams of California combined.

The Gila at certain annual periods spreads to close upon 2 miles where the surface contour so permits, with an average depth of 4 feet. In June, July, and August, for 60 miles from its mouth, it is either very low or absolutely dry, although considerable running water can always be found along the bed-rock. It happens frequently that where reefs of rock cross the river the water comes to the surface only to disappear in the thirsty sand on passing the barrier. An excellent site for storing enormous bodies of water has been surveyed by a competent engineer, the location being in the Gila Valley, a few miles east of the county line in Maricopa County. The hoarding capacity is in every way equal to furnishing irrigation facilities for the entire lower Gila Valley, as well as the outlying mesas and higher plains, while the construction will not be attended with unusual difficulties, nor would the cost prove excessive in comparison with the increased value of the lands tributary to it, much of which are now worthless. Such works would effectually obviate the disheartening effects of the sinking of water to bed-rock in summer, for the amount saved during high water that would otherwise have gone to waste would furnish the means of livelihood to a large population as against the present meager number.

The Colorado and Gila are included among the most prominent streams of the Pacific coast and afford far more than sufficient irrigation capacity for the cultivation of the rich areas included within the county lines. The former drains a catchment area of more than 242,000 square miles of mountainous country, while the latter also drains an immense surface very similar topographically. Thus it can easily be seen that water is superabundant. Whether the Government, with an overflowing Treasury and command over the most advanced engineering skill of the times, will utilize to the best advantage what is placed before it or not is a question that can be answered only by itself.

CLIMATE.—It is rather without the intents of this report to dwell in detail upon the sanitary advantages offered by our almost perfect climate, and yet a few words upon this subject may not be inappropriate. For nine out of twelve months the climate is simply superb. Three months are warm, but not excessively so, although the thermometer ranges far higher than would be conducive to health or comfort in any section of the East. The conditions, however, are most dissimilar, as may be seen by the following, taken from the official communication of Lieut. W. A. Glassford, of the United States Signal Corps, to the governor of the Territory:

"A few words upon the heat. It is recorded as extreme, yet no one suffers and sunstrokes are unknown. This is usually accounted for from purity and dryness of the air. Both are true, but the dryness is perhaps the correct reason. I have calculated the difference between the shade and sensible temperature at Yuma during the heated hour of the day, and it is about 30 degrees. At New York or Washington it is only a few degrees and often identical. The highest shade temperature ever recorded at Yuma is 118 degrees. When the heat is at this point the sensible temperature is about 88 degrees. The shade temperature of New York being 105 degrees the sensible temperature is certainly near 100 degrees. The difference between the mean temperature and mean sensible temperature for July is over 17 degrees at Yuma. These considerations of the sensible and shade temperature will account for the absence of any detrimental effect upon the extreme heat of Arizona.

"The air is dry; the moisture in the atmosphere is from 25 to 30 per cent. as against 75 to 85 per cent. in other localities. Every afternoon in summer there is a refreshing breeze from the Gulf of California that relieves the day of undesirable heat; it passes over a desert, much of which is below sea-level, that acts as a desiccant, so that when the plains of Central Arizona are reached the air is dry to the last possible degree." There are neither sunstrokes in summer nor pneumonia in winter; neither fever nor malaria live or germinate in this section. The air is pure; absolutely free from those compounds that poison the system and bring on disease. In no country is there a greater number of bright nights and sunny days. Hundreds affected with lung trouble, after visiting Florida and southern California, have found relief in this invigorating climate, where the pure air is a tonic to shattered constitutions, a healing balsam to the consumptive. The meteorological conditions are indeed admirable for the cure of all rheumatic, bronchial, and pulmonary troubles, as has been proven time and time again. In summer the rapid evaporation lowers the temperature and promotes comfort, while in winter the mild, equable, and pleasant weather is delightful to the invalid. Herewith is given a table of average temperatures compiled from the official reports, extending over ten years:

	°		°
January	53.6	July	92.0
February	58.8	August	90.9
March	65.0	September	81.9
April	69.4	October	72.4
May	77.2	November	61.2
June	85.2	December	55.9

Concerning the effect in regard to early fruit the late commissioner of immigration Hon. Cameron H. King, already quoted in the preceding pages, has this to say, "The average spring, summer, and autumn temperature of Yuma are nearly 9 degrees more than at Riverside. This is sufficient to explain the fact that the citrus and other fruit of Yuma ripen from a month to six weeks earlier than at Riverside, or other points in southern California. Yuma has an earlier and warmer spring. The trees have an earlier start, and the higher temperature matures the fruit sooner. It is evident that since oranges in Yuma ripen in the first of December, instead of about the middle of January, as in southern California, that the fruit in Arizona can never be injured by any low temperature in the winter season. And since the labor of the tree is for the season practically over at Yuma before the winter season begins, it is better prepared to stand a lower temperature in winter than it could in California, even were the atmosphere as dry in the latter State as in Arizona. It is known that Riverside raises better oranges than Los Angeles, and the reason is that Riverside escapes the fogs which hang over Los Angeles.

"It is proper to observe that the maximums and minimums of temperature, as shown by the Signal Service records, indicate little of practical utility, since such extremes may not last more than a second, and may be the effect of one small wave or ripple of the air. The warm sunshine of the spring, summer, and autumn days causes the fruit in Yuma to mature early, and gives a delicious sweetness, flavor, and color to the orange, lime, lemon, and other citrus fruits, which they can not attain on the coast of the Pacific, where fogs dampen the fruit, mildew is produced, and dust coats both fruit and leaf. It is undeniable that nowhere upon the globe can a spot be found more favorable for the growth of citrus fruits than Yuma County."

The statement of the commissioner can be thoroughly substantiated, as may be seen by the annexed table showing the time of maturity for certain products:

Strawberries	January 15.
Apricots	April 1 to 21.
Mulberries	April 1 to 21.
Figs	April 14 to 20.
Grapes	April 20 to May 1.
Watermelons, etc	June 1 to 7.
Peaches	May 15 to 20.
Pomegranates	June 15.
Lemons	August 1.
Limes	September 15 to 25.
Dates	September 15 to 25.
Oranges	September 1 to 5.
	Nov. 25 to Dec. 1.

Products.—Fruit culture has so far been prosecuted upon a limited scale, but enough has been learned from experimental tests to demonstrate the positive feasibility of not only producing an excellent quality of the most profitable fruit but also the ability to raise them for market three to six weeks earlier than any section of California. The orange, lemon, and lime, finding soils and climate congenial, yield in abundance large, clean-skinned, and exceedingly juicy fruit. They color handsomely, contain the requisite sweetness and acidity, and are very luscious.

The fig and pomegranate offer a character of fruit that almost stamp them as indigenous. The latter is not yet recognized to any great extent, but it will certainly become an important factor in arboriculture when its economic qualities are better known.

As to the fig, the most desirable variety has yet to be determined. The true "white Smyrna" would probably prove the best, and that its yield would prove prodigious goes without saying. This assertion is a deduction based upon actual productive results of the "Mediterranean white" fig, that is known not to be the true Smyrna.

The grape seizes upon what is proffered to it and becomes hardy, thrifty, and adaptable. The choice naturally inclines to the earliest for table purposes. What those varieties should be is in process of experiment upon a scale that will soon solve the question, but it may be said that all kinds mature from three to four weeks before they do in California. They attain great size, cluster tightly on the bunches, are firm and highly colored, and possess exquisite flavor. Heavy wines and brandies of a super-excellent character can be made, but with light wines the reverse is true, for everything apparently goes to saccharine. For ripening wines the climatic conditions are admirable. A quantity of common white wine, costing 45 cents per gallon, was brought here from California by water years ago, and, on being found unsalable, was placed in cellars and its history almost forgotten. Nine years later the wine was brought to light, when it was discovered that it resembled a brown sherry, rich in boquet, smooth as oil, and delicious to the taste. It was carefully drawn from the casks, bottled, and sold at $2.50 per bottle.

The olive grows luxuriantly and will in the future become a most profitable investment. Whatever its characteristics elsewhere, here it requires water and cultivation; the more water the better. The mulberry grows rapidly, and when firmly rooted vigorously withstands the heat and lack of water. It produces an early, large, and sweet fruit, and is a highly desirable tree to plant along the canals for its grateful shade.

The plum can easily be raised from the seed. It fruits early, though so far the product does not commend itself particularly for table use, but as a stock upon which to engraft prunes, or even superior varieties of plums, it is everything to be desired. An experiment in this line with the best prune known in California showed a growth of 23 inches in forty days from the insertion of the graft.

The date has passed beyond conjecture. The plant produces magnificently, and its cultivation will be prosecuted more extensively this winter than ever before. The soil is in every way suitable, and with occasional cultivation and intelligent irrigation a quick and permanent growth is assured.

Apricots and peaches have been tested. They mature rapidly, bear choice fruit, and are always healthy, giving flattering indications of future success.

As facilities increase other fruit trees will be introduced, and with the same care that is bestowed upon them elsewhere will so soon as they become acclimated come to a yield materially in advance of the places from whence they came. The field is too large to admit of extended comment at this time, but it may suffice to refer briefly to certain other products which may in time equal if not surpass fruit-growing as a commercial proposition—as, for example, cotton, wild hemp, ramie, sugar-cane, sugar beets, etc. Cotton has been tried from time to time for years with varying but always satisfactory results, and even then without care. If watered regularly it becomes a large bush, and if properly pruned a tree, being in flower, boll and cotton, the year round. These bushes and trees have in instances borne steadily for fourteen years. The staple of course diminishes in course of time, but at ten years it is not inferior to the average staple of Western India.

Wild hemp is a textile plant indigenous to the country. It grows freely and luxuriously to a great height, often averaging 15 to 17 feet. It has a long strong fiber and is frequently worked into nets and fishing-lines by the Yuma Indians. Convulsive attempts have been made to utilize this plant, with the practical result of fixing its value, among the fibers used in the manufacture of cordage, at about $160 per ton of 2,000 pounds. After proper bleaching and manipulation a beautiful fiber has been produced and manufactured into colored fabrics, taking the dye, retaining the elasticity and luster, exactly as well as the fabrics of true flax and ramie. It seeds itself annually, and immediately following the overflows of the Colorado River takes possession of every nook, corner, and open area, to the exclusion of everything else. It covers not less than 100 square miles in an unbroken stretch, commencing near the boundary line of the Gadsen purchase and extending southwards along the river to Hardy's, Colorado, below the point where the rising tides of the Gulf of California force back the flow of the Colorado River proper.

The fibrous plant ramie has been given a partial trial. The soil, on analysis, was found to contain all the essential properties to render the most favorable results, but the absence of water, together with injudiciously planting the roots too late, retarded the growth. Enough data was obtained, however, to warrant the belief that this will eventually become one of our most important industries. Sugar-cane has been fairly tested with the Sonora cane. The growth was surprisingly great and the percentage of juice much increased over the yield at the place from which it was originally brought. A superior quality of panocha and sirup was manufactured, the prices realized leaving handsome margins for profit. The capriciousness of the water supply, as in the case of ramie, dissolved the industry, and it has not since been revived.

The sugar beet promises better results for the future than many of the products already mentioned as prominent in the same direction. Samples not fully matured polarized 17 per cent. With proper cultivation the percentage can be raised to 20 per cent. and 25 per cent., and, besides, will harvest two crops each year.

Wheat does splendidly, but complete data is not at hand from which to compute the average yield. In one instance, however, 483 pounds seeded to 20 acres, about 9 miles east of Yuma, on the Gila River, returned 52,750 pounds after being irrigated five times. This was sold in San Francisco, bringing 50 cents the cental over every other kind then in the market. The grain is remarkable for its plump berry-like appearance. The winter and spring are warm enough to insure a vigorous growth and yet cool enough in April and May to allow the heads to fill out without shriveling. It is so perfect as to sell for seed, and, so far as known, is proof against rust. Two crops are raised annually.

Barley also does well and will produce two crops, the first yielding from 35 to 40 bushels of barley, and the second a large amount of hay.

Corn is produced in great quantity, yields enormously, and can be grown the year round. The "Cocopah" corn is noted for sweetness, plumpness, earliness, and for its firm and solid grains. Five weeks after planting roasting-ears are plentiful. This variety commands a ready sale at higher prices than any other kind.

Alfalfa will cut from five to seven times, at an average of 2¼ tons to the acre. Eight acres, but one year old, has this year yielded 74 tons, with more cuttings yet to be made. The hay brings $15 per ton. Sorghum, raised for feed, is both valuable and prolific. It frequently reaches 15 feet in height, yields 15 to 20 tons per acre, and is worth $15 per ton. Several crops can be harvested annually.

Vegetables, kitchen and garden stuff, melons, etc., grow all the year in unlimited quantities and of excellent quality. Sometime since a Gila valley farmer planted 15 pounds of Irish potatoes on a piece of bottom land that had been overflowed, from which he harvested over 700 pounds, and this record, it is believed, has rarely, if ever, been excelled. The sweet potato produces enormously, and equals the choicest from South Carolina. Peanuts mature rapidly and abundantly, yielding a nut both plump and toothsome.

Wherever there is sufficient moisture the natural flora abound in profusion and variety. They are of rare beauty and delicious fragrance, the bulbous plants particularly. The lily surpasses the famous imported "Japan." It has been claimed by experts that at no distant period opium will be manufactured from the poppy and attar from roses, both flowers thriving vigorously. There are but few trees and shrubs, capable of adorning the surroundings of a lovely modern home, that can not be satisfactorily grown.

Every plant, vine, or tree mentioned in the foregoing list has been actually proven adaptable to our soils and climate. Many others have been omitted through lack of space, but there seems no doubt that time will demonstrate our ability to profitably raise all the semi-tropic and most of the tropical and temperate productions.

TRANSPORTATION.—An important factor in connection with the early ripening of horticultural, viniticultural, and agricultural products, is the question of easy and rapid conveyance to prominent marketing centers east and west. The Southern Pacific Railroad, one of the largest transcontinental lines in America, runs through the Gila Valley as far as Adonde, a station some 30 miles east of Yuma. It then passes upon the mesas south of the Gila, the track extending upon an average not more than 5 miles from the river, until the county line is reached. Thus is afforded convenient egress from any section of the valley and direct communication from thence with all parts of the United States.

Other roads have been surveyed along both sides of the river. Construction is already commenced on the direct broad-gauge from San Diego to Yuma, and will, it is expected, be continued from the latter town to Deming, N. Mex., but nothing definite can be advanced as to the time of completion.

OATMAN CAÑON RESERVOIR SITE.—It is quite apparent that more water is needed in the summer months than flows in the Gila River during the heated term. In view of remedying the deficiency, a site for an immense storage reservoir was located, and an engineer engaged to examine and report upon its adaptability. Mr. J. B. Steiger, the engineer in charge of the work, has submitted the following report to the local committee:

To the Committee on Storage Reservoir Sites for Yuma County, Ariz.:

GENTLEMEN: In accordance with your instructions, I have made a reconnaissance survey of the proposed water storage reservoir on the Gila River at Oatman and Cottonwood Flats, and summit the following report on the same: The most available site for a dam 100 feet in height is at a point on the river about half a mile above the

South Gila Canal Company's head-gate. Solid bluffs of dolomite (limestone) 111 to 125 feet above the present water-level, and distant 1,595 feet from each other, are found at this point. The width of 1,595 feet given is the distance between the bluffs at the 100-foot flow-line, or proposed top of dam. The storage capacity of the cañon extending about 1½ miles up the river from the dam to Oatman Flat is comparatively small, for the average width on the 100-foot flow-line is but one-half a mile, with steep bluffs on either side.

Above this one-half mile point the bottoms widen out to an average width of 1½ miles for 3 miles, forming what is called Oatman Flat, with an area of 4.7 square miles on the 100-foot contour. At the head of Oatman Flat the bottoms narrow to about three-quarters of a mile, and then widen out and form Cottonwood Flat, the main storage basin, with a length of 8 miles and a width of 4½ miles, with an area of 35.2 square miles. About 2 miles above the head of Cottonwood Flat, at Rock Islands, the bottom narrows to a width of about 2,000 feet, including an island 500 feet wide, and above this point they again widen to 3 miles. The length of this basin will be 8½ miles, with an area of 8½ square miles.

The depth of the water at the lower Rock Island will be 40 feet. The average fall in the river from this point to the dam, some 14 miles by the river channel, is 4.3 feet per mile. The river has a much greater grade above the Rock Islands.

The distance from the islands to Gila Bend is about 20 miles. The total area of the three basins is as follows:

	Square miles.
Oatman Flat	4.7
Cottonwood Flat	35.2
Gila Bend Flat	8.5
Total flowage (with 100-foot dam)	48.4

As there will be considerable evaporation from a body of water in this hot summer climate, estimated at half an inch a day for six months, equal to 7½ feet, I assume the average available depth to be 35 feet, which with an area of 48.4 square miles will store 47,227,009,600 cubic feet. This will give a daily supply for six months of 262,372,200 cubic feet, equal to 151,835 miners' inches of the California standard.

The area which it is proposed to flood contains no cultivated land and only three cattle ranches.

J. B. STEIGER, *C. E.*

YUMA COUNTY, ARIZ., *August* 7, 1889.

The proposed storage reservoir is situated on the Gila River about 100 miles northeast of the town of Yuma, and a few miles east of the boundary line of the county. At this point the river is subject to heavy floods that will insure the filling of the reservoir every winter and spring, the heavy flow lasting until the 1st of May.

About the 1st of June the works would be called upon to make good the diminishing supply in the Gila. This draft would be at its maximum in July and August. The evaporation in this climate is very great but the engineer has allowed amply for the losses thereby incurred. The depth of evaporation in inches averaged for every month in the year, as shown by the Signal Service records at Yuma, is as follows:

	Inches.		Inches.
January	4.4	August	10.2
February	5.2	September	8.2
March	6.6	October	8.2
April	9.6	November	5.5
May	9.6	December	4.6
June	12.6		
July	11.0	Total	95.7

The rainfall is practically insignificant. The monthly fall in inches, averaged for eleven years, is given herewith:

	Inches.		Inches
January	0.403	August	0.496
February	0.532	September	0.060
March	0.217	October	0.124
April	0.120	November	0.180
May	0.062	December	0.403
June	Inappreciable		
July	0.155	Total	2.752

The drainage basin supplying the river is known to be enormous and its service constant during certain months. At the lowest rate of calculation in use in California—1 inch to 4 acres—the amount of water stored would suffice to irrigate over 600,000 acres. Rock suitable for the construction of a masonry dam is found in unlimited quantities adjacent to the proposed site. Elsewhere we have endeavored to show that large and constant water supplies are imperatively needed. While it is true that the several canals along the Gila cover considerable areas, it is also true that the Oatman Cañon reservoir will bring very much larger tracts under control, and, therefore, an increased population, much larger property valuation, vastly augmented agricultural output, and, consequently greater prosperity. With storage works of the described capacity a permanent summer supply of water could be relied upon to thoroughly irrigate most of the accessible arable land in southern Yuma County lying below the reservoir, and thus remove the present cause of non-development of this fertile section. It has been explained that about 25 per cent. of the valley land is overflowed by the river during certain regular periods. The establishment of such works would also reclaim the bottoms by storing the surplus water that would otherwise flood the surface.

CONCLUSION.—With this report a topographical map, drawn by Mr. Lewis A. Hicks, C. E., is submitted, showing the entire lower Gila Valley from Oatman Cañon westward to the Colorado River, and also all the lands between the Gila River and the Sonora frontier. Two lines are drawn, the first indicating the extent of the area that would be capable of producing at least one crop of cereals or forage each year, supposing the dam to contain 25 feet of water. This second line shows the limit of the fruit belt, but the area between these two lines will be valuable for the raising of all forage plants, sugar-beets, etc. Below their junction all the land shown will be available. The varied topographical features are faithfully and intelligently delineated and will greatly assist in a correct understanding of the subject treated in these pages.

The vast importance of the inquiries set in motion by the Senatorial committee, and their direct bearing upon our own surroundings, are fully understood by the people of Yuma County, who highly appreciate the opportunity of placing before their distinguished visitors such data concerning the quantity and quality of the lands, the necessity and future possibilities of irrigation, the number and extent of canals, the rivers and water supply, the climate and its influence upon the early maturity of crops, the products, the transportation facilities, and finally, the need of water-storage reservoirs and selection of appropriate sites as, it is hoped, may meet their purposes. If this has been accomplished, the citizens' executive committee will consider their duty as satisfactorily performed.

STATEMENT OF HENRY GEORGE, UNITED STATES INDIAN AGENT, OF PARKER, ARIZ.

[Colorado River Indian Agency.]

That the valley or bottom lands of the Colorado River, properly watered, can be made one of the finest farming sections of the United States, I presume is no longer a question among those who have investigated the subject.

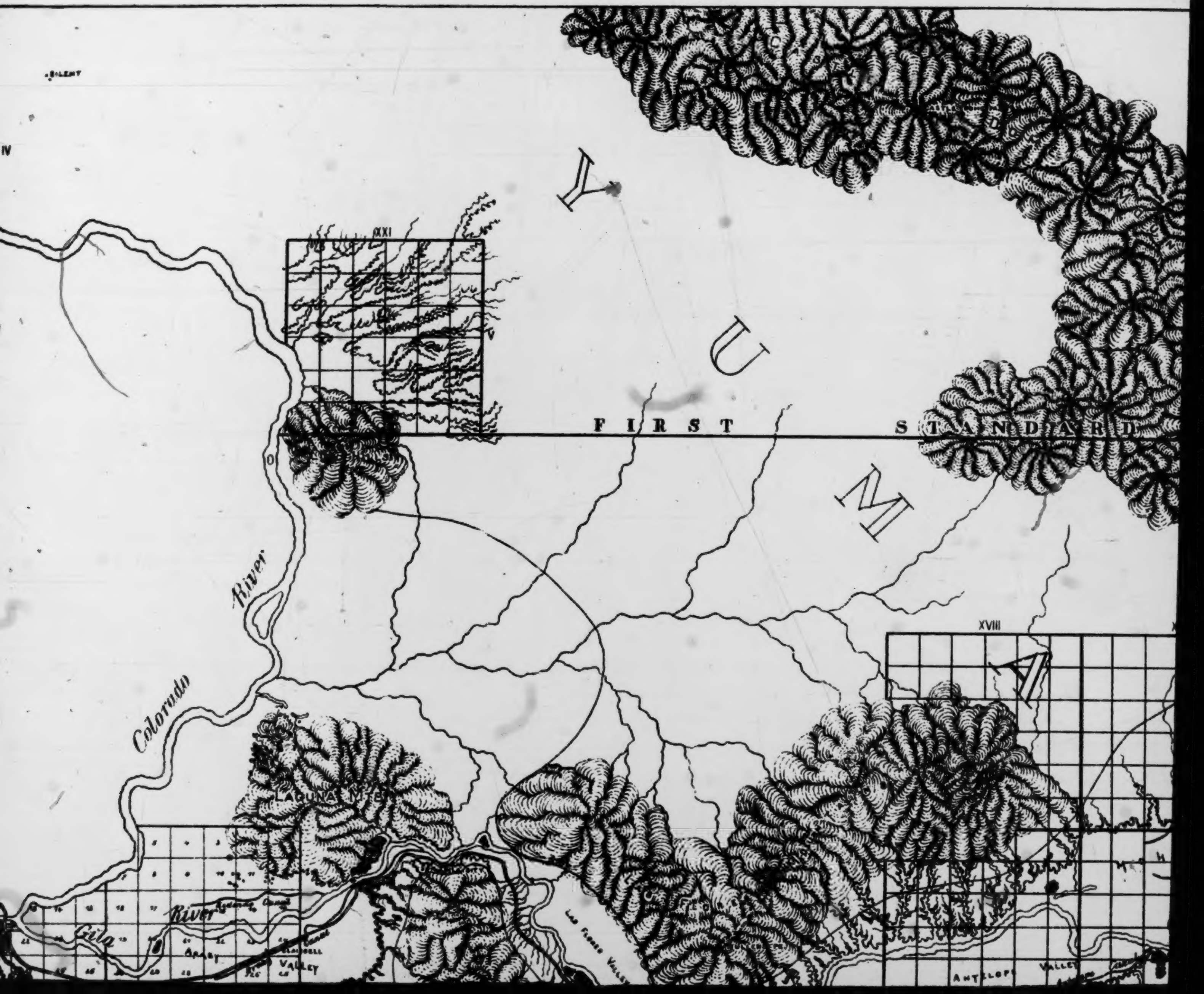
In the Annual Report of Indian Affairs in Arizona, 1867, I find the following:

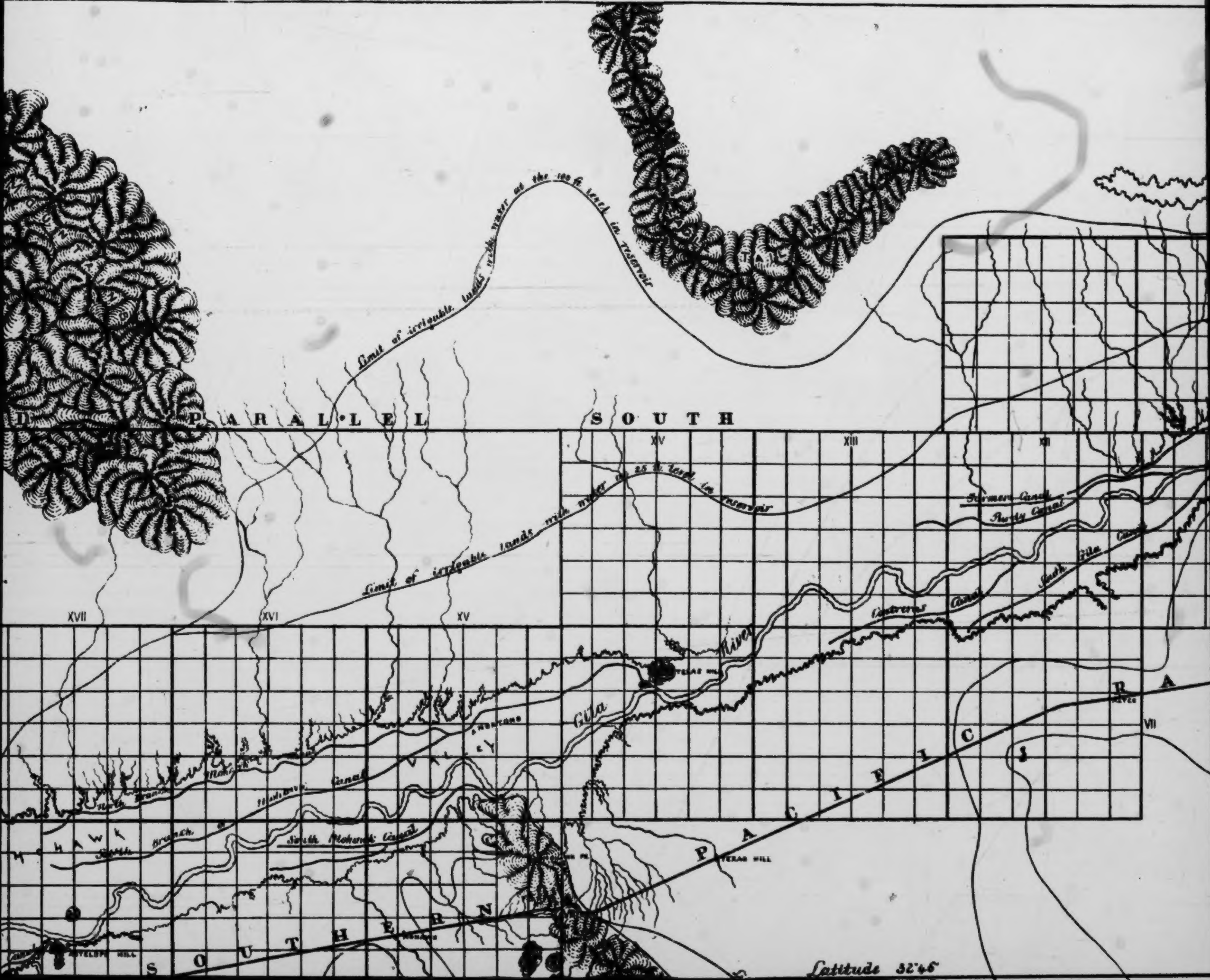
> The experiences of this season have proved beyond doubt, were evidence on the subject still wanting, the thorough capability of the lands of the Colorado River valley for all the purposes of agriculture in every case where water can be made to reach the surface. To depend upon the annual overflow is somewhat hazardous, for lands reached by it one year may not be again for several, or they may be so deeply submerged as to be unavailable for planting during the season. There are thousands of acres in the reservation which the overflow from the river never reaches, but which the artificial application of water would render as productive as any of the lands that are naturally overflowed.

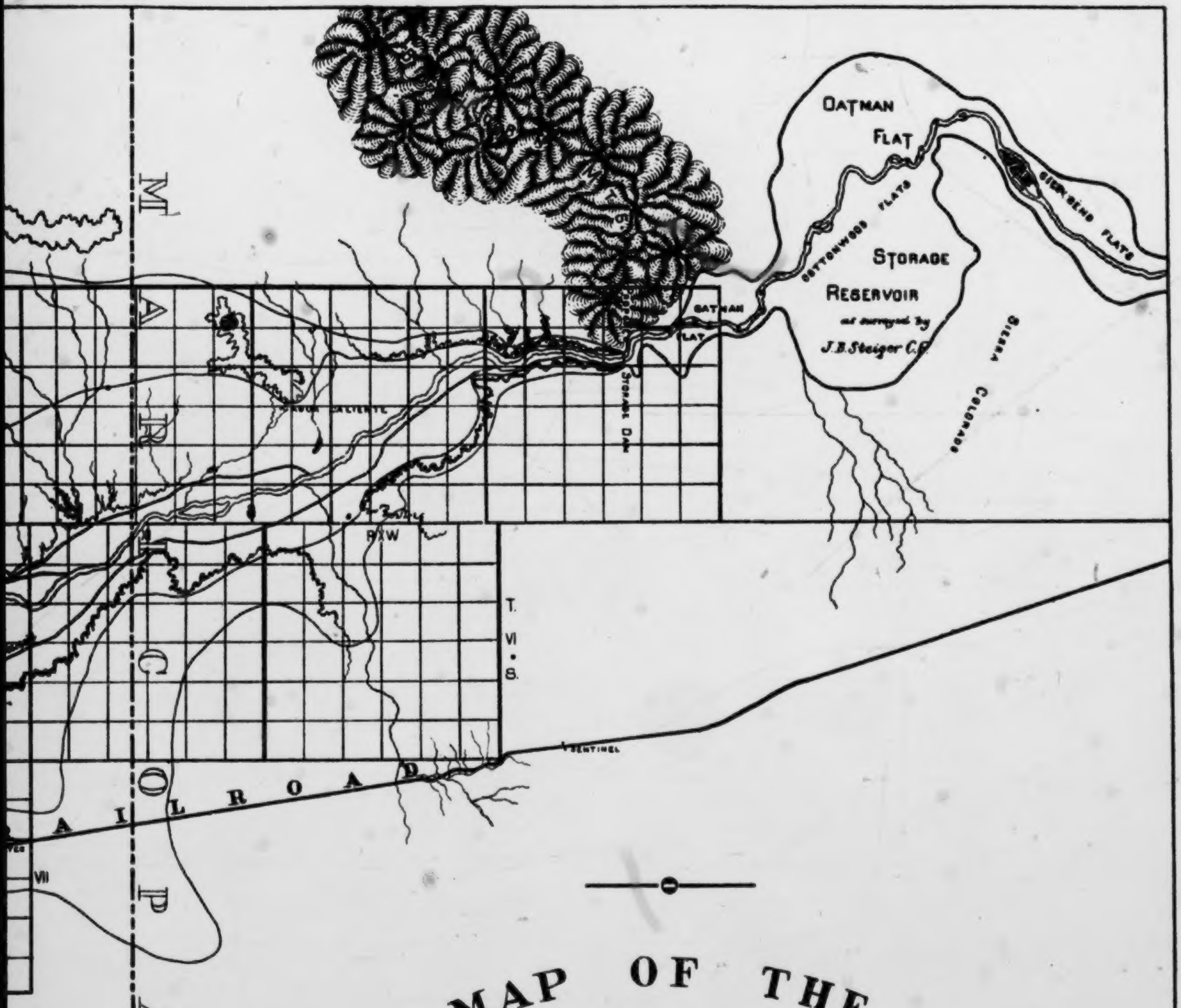
All experience from that time up to the present proves the correctness of the ideas of that paragraph.

The custom of irrigation in vogue on the reservation is carrying water by hand from the river and lagunas. The Indians select their locations for their small farms, or rather patches, near the banks of the river or some laguna. After choosing the land they dig holes about 12 inches

CALIFORNIA
IV
Pilot Knob
Yuma
CALIFORNIA

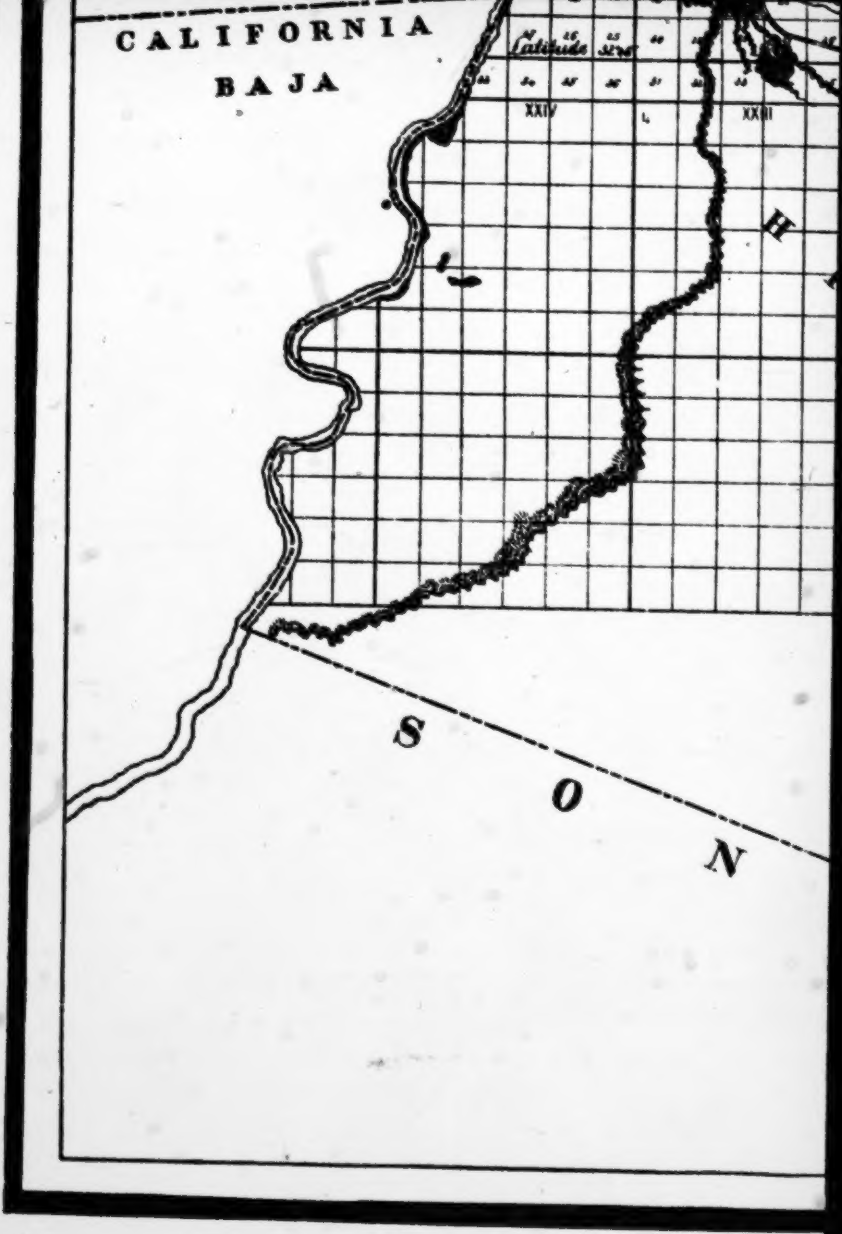

SILENT
IV
XXI
V
Y U M A
FIRST STANDARD
River
Colorado
LAGUNA MTS
River
Gila
VALLEY
XVIII
LAS FLORES VALLEY
ANTELOPE VALLEY

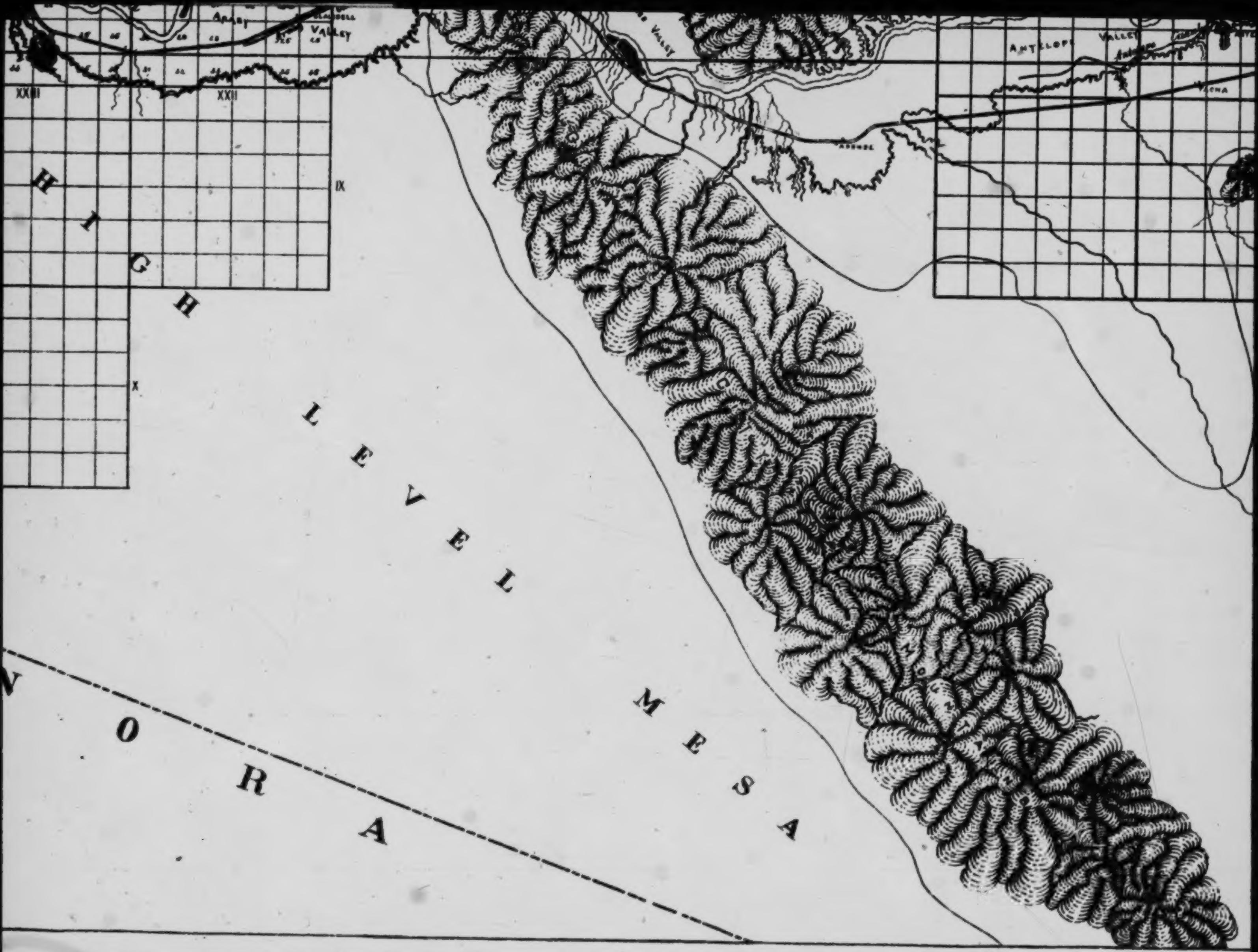

Limit of irrigable lands with water at the 100 ft. level in reservoir
D PARALLEL SOUTH
XV
XIII
XII
Limit of irrigable lands with water at 25 ft. level in reservoir
Farmers Canal
Purdy Canal
Contreras Canal
South Gila Canal
XVII
XVI
XV
Gila River
TEXAS HILL
MONTANO
VALLEY
North Branch Mohawk
Mohawk Canal
MOHAWK
South Branch
South Mohawk Canal
SOUTHERN PACIFIC RA
TEXAS HILL
ANTELOPE HILL
MOHAWK
VII
Latitude 32°46'

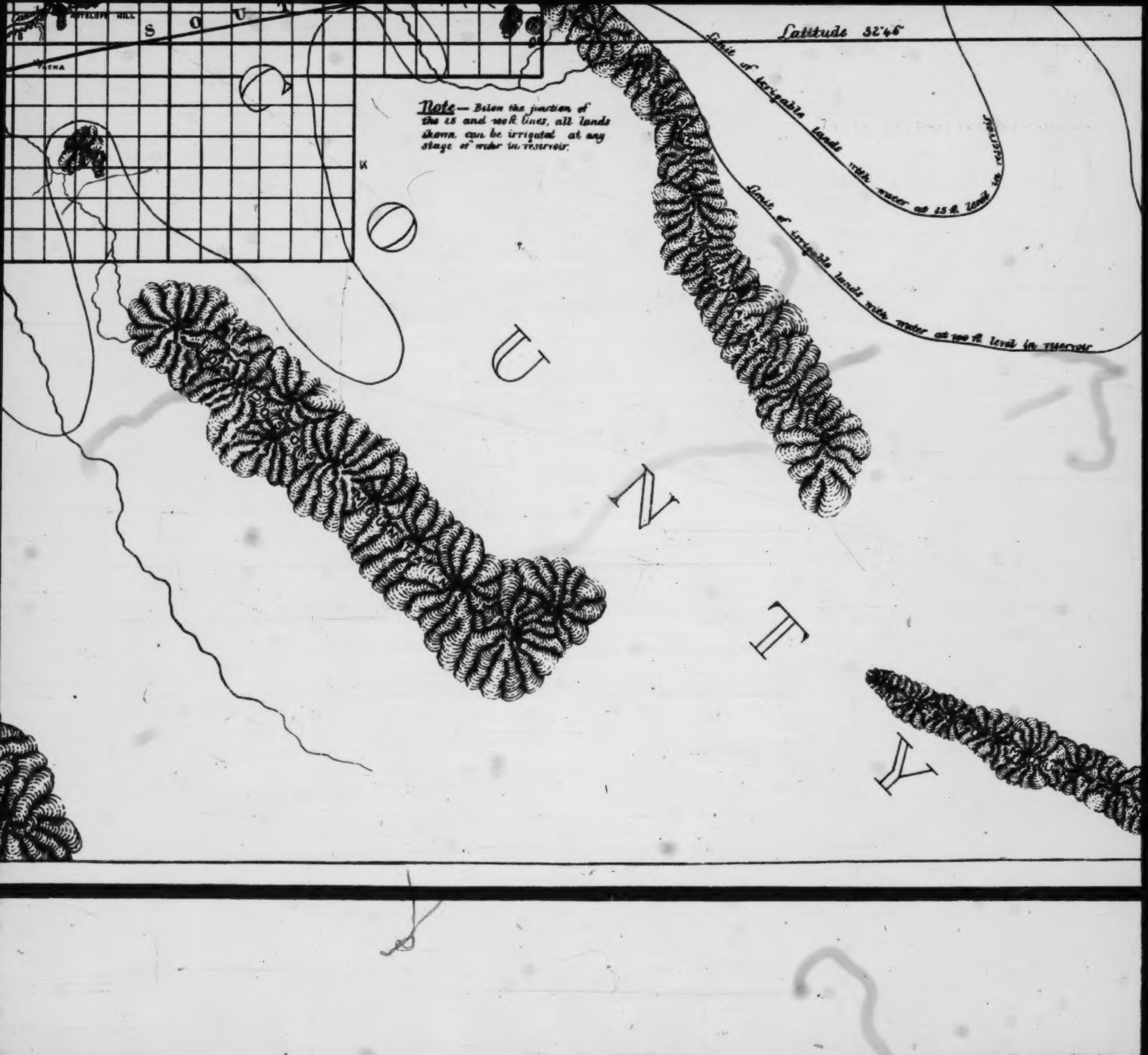

OATMAN FLAT
GIEN BEND FLATS
COTTONWOOD FLATS
STORAGE RESERVOIR
as surveyed by
J.B. Steiger C.E.
SIERRA COLORADO
OATMAN FLAT
STORAGE DAM
AGUA CALIENTE
R X W
T. VI S.
VII
SENTINEL
MARICOPA
RAILROAD

MAP OF THE

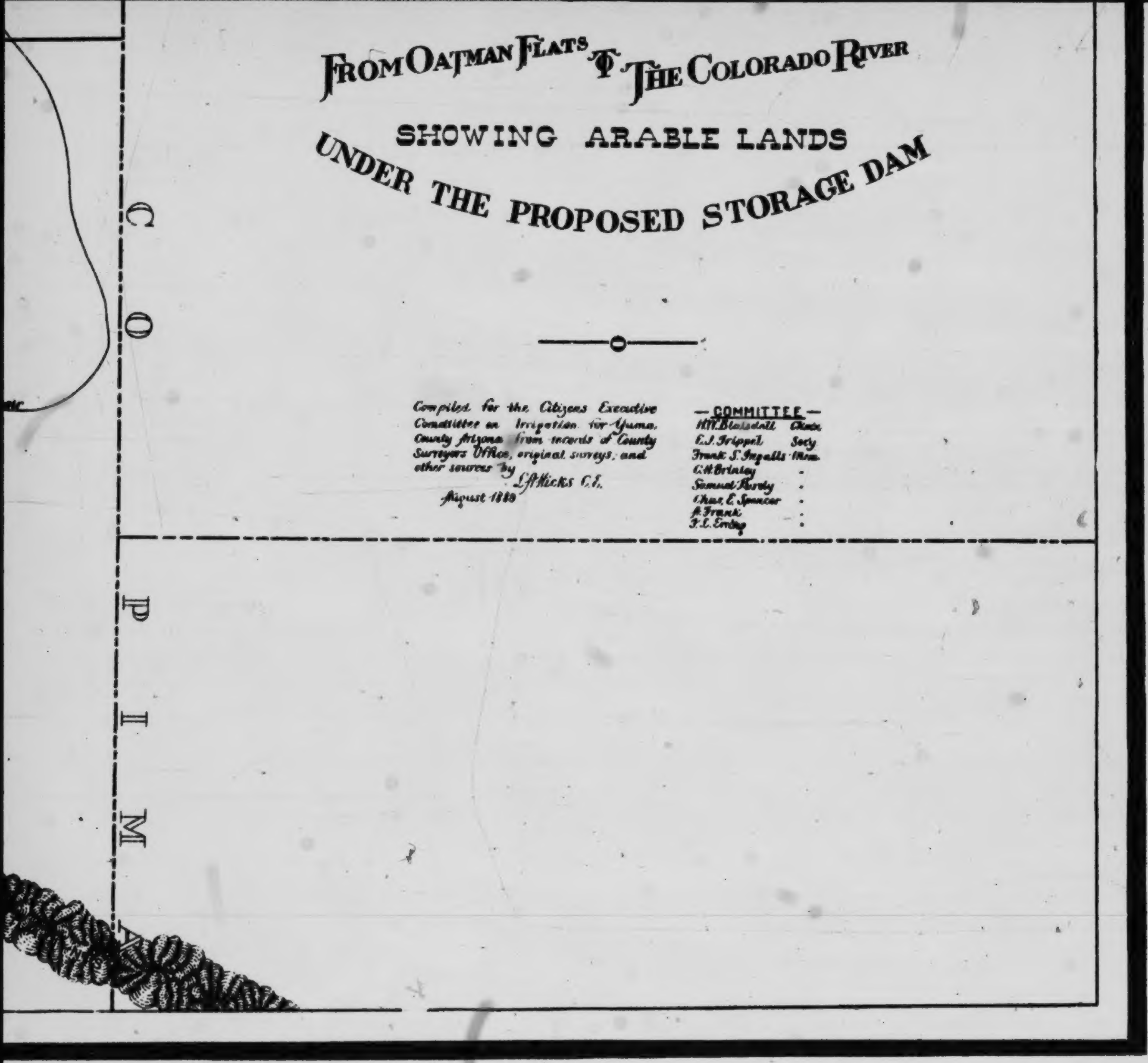
GILA RIVER VALLEY


CALIFORNIA
BAJA
Latitude
XXIV
XXIII
H
S
O
N


Valley
Antelope Valley
Vecna
XXIII
XXII
IX
X
HIGH LEVEL MESA
NORA
MOUNTA


ANTELOPE HILL
TACNA
S O U
Latitude 32°46'
Limit of irrigable lands with water at 15 ft. level in reservoir
Limit of irrigable lands with water at 100 ft. level in reservoir
K
C O U N T Y

Note— Below the junction of the 15 and 100 ft. lines, all lands shown can be irrigated at any stage of water in reservoir.



FROM OATMAN FLATS TO THE COLORADO RIVER

SHOWING ARABLE LANDS UNDER THE PROPOSED STORAGE DAM

Compiled for the Citizens Executive Committee on Irrigation for Yuma County Arizona from records of County Surveyors Office, original surveys, and other sources by

L.H. Hicks C.E.

August 1880

— COMMITTEE —

H.W. Blaisdell	Chm.
E.J. Trippel	Secy
Frank S. Ingalls	Treas.
C.H. Brinley	"
Samuel Purdy	"
Chas. E. Spencer	"
A. Frank	"
J.L. Ewing	"

deep and from 15 inches to 6 or 8 feet apart, owing to the kind of crop. In the bottom of these holes they plant their corn, wheat, pumpkins, and various kinds of melons. Into these holes, which serve as a basin to hold moisture, they pour the water. The quantity and quality of the products the Indians thus produce are remarkable. They do not, however, all depend on this kind of irrigation for a crop; some of them select low places in swags near the river which is sufficiently moistened by sepoge water from the river to grow their crops. I never saw better wheat grown in any country than I have seen in these swags.

The surface of the valley or bottom lands along the Colorado River seems to be from 8 to 20 feet above the ordinary stage of water in the river, and it is said that the river falls but a little over 2 feet to the mile. You can see that it would be very hard indeed to conduct the water from the bed of the river to the surface of the valley, I should think. I am not familiar with the science of the subject. However, in order to bring water from the bed of the river by canal so it can be utilized on the surface in the valley, the head of the canal must be located at least 12 miles above the lands to be irrigated. Owing to the soft sandy formation of the banks the channel of the river is continually changing, which will be a very serious obstacle in bringing water out with the ordinary canal or ditch. There is always abundance of sand and dirt floating in the water, and when the river is high there is so much floating that it seems to me that it would be very hard to prevent the sediment from filling a canal with only 1 or 1½ foot fall to the mile. But if they had any such experience with the canal that was constructed here in the latter part of the sixties, I have not been able to find it out.

The engineering of the location of the canal was certainly good. I doubt if there is a better place on the river for a head-gate. From the Arizona side there is a spur of nearly solid stone formation, extending out in a curve to nearly the center of the river, thus forming a basin in which I am informed no sediment has ever settled. In the arc of the curve of this basin the head-gate is located. A tunnel was made several hundred feet through a hill out to the foot of a mesa and on to the valley 5 or 6 miles below. I understand the canal was used successfully until the tunnel gave way near the head-gate, after which there was a temporary gate made lower down the river below the tunnel, that will conduct water into the ditch when the river is high. There have been several overflows over the canal and yet it stands intact, and with a very little work, removing some brush and other obstruction, it would conduct the water well. This canal brought water sufficiently high to be thrown out on the surface in less than 6 miles below the head-gate. Of course the canal, with a fall of only about 1 foot to the mile, had to have careful attention, keeping all obstructions removed, and occasionally had to be cleaned out; but I understand this did not have to be done more than once in twelve months.

I have said the head-gate and canal were admirably located, but there was some ridiculous judgment displayed in the work on the canal. The formation through which the tunnel was cut is of pebbles and a kind of cement-looking sand, and when dry presents a hard appearance but yields quickly to running water. Into this, without any kind of masonry work, the water was turned; the walls gave way, and thousands of dollars' worth of work was destroyed, and with it went the hopes of a dry arid valley being changed into a luxuriant farming section. If the proper masonry work had been done in the tunnel, there is no doubt in my mind but what the canal would have been a success, and to-day thousands of acres of this valley would be blooming fields.

Some of the whites have attempted to irrigate by pumping water by steam power, but while they can in that way get water into a ditch with sufficient fall and do excellent work, the experience with this mode of irrigation, so far as I have been able to learn, is that it is too expensive to be profitable, but some of the best posted people in the valley contend that there has never been a fair test made, and that it is the best plan and can be made successful.

PHŒNIX, ARIZ., *September* 4, 1889.

The committee met pursuant to the call of the chairman.

Present, Messrs. Stewart (chairman) and Reagan; also Director Powell.

STATEMENT OF T. E. FARISH, OF PHŒNIX.

The CHAIRMAN. What is your occupation?

Mr. FARISH. Commissioner of emigration.

The CHAIRMAN. What do you know of irrigation in Arizona? What has been its success and what are the opportunities for doing more?

Mr. FARISH. Do you wish me to cover the whole Territory?

The CHAIRMAN. Yes, or any part with which you are familiar.

Mr. FARISH. In this Territory, the report which I have written and which will be submitted to the committee will show that there are 250,000 acres of land now covered by irrigating canals, 187,500 acres of which have been reclaimed; that is to say, the land has been covered by the water; and 125,000 acres, about one-half, is in actual cultivation all the time. The report and the maps accompanying it will further show that that statement applies to the Salt River, and that in the Gila River Valley there have been works undertaken, and there canals are now in process of construction, where 30,000 acres are under cultivation. When those canals shall have been completed, there will be added 150,000 or 200,000 acres more.

Examinations made by Mr. Breckenbridge, our county surveyor, show that up at the head of the Salt River, where it enters into this county, and adjoining the Gila, there can be a reservoir constructed that will impound enough water to irrigate all the land lying north of the Gila River in this valley, and through the Salt River valley down to Yuma.

Senator REAGAN. Have you made an estimate of what that is?

Mr. FARISH. The figures are stated in the report which will be submitted to the committee. Mr. Evans has it. I do not remember the exact figures. As to the duty of water in this county, we irrigate alfalfa and grain, and it takes 3 acres of ground to 1 miner's inch.

The CHAIRMAN. Is 1 miner's inch one-fiftieth of a cubic foot per second?

Mr. FARISH. We calculate it to be one-fortieth.

The CHAIRMAN. Calculating it that way, a miner's inch will serve 3 acres.

Mr. FARISH. Three acres. In fruits and vines, 5 acres. The evaporation here is large during the summer months; but what it is during the winter I can not tell you, because the only data that has been kept so far has been at Tempe for the last two months. It was 4.2 evaporation in August.

Director **Powell**. Four and two-tenths what?

Mr. **Farish**. Four and two-tenths per cent., nearly half an inch.

Director **Powell**. In what time?

Mr. **Farish**. In twenty-four hours. At Walnut Grove—I only speak of what I have learned in corresponding with that point—where they have the big irrigation dam, it is about 3,500 feet elevation, and the evaporation is about a third of an inch. Here we have 1,180 feet, and I suppose about the same at Tempe, but at Walnut Grove they are 3,500 feet.

The **Chairman**. Is that the evaporation in twenty-four hours?

Mr. **Farish**. Yes.

The **Chairman**. You said that dams could be constructed to reclaim all the valley land between here and Yuma. Is there sufficient supply of water for that purpose?

Mr. **Farish**. I think so. Data will be furnished the committee showing the amount of water which flows to the sea unharnessed during the year. The data has been kept by the Arizona Canal Company, and it will show you that during several months of the season it is as high as 40,000 cubic feet per second. It would fill the dam to the top four times over. During the winter you can not cross Salt River at any time from four to six weeks in succession.

The **Chairman**. With a team?

Mr. **Farish**. With a team. Nor can you be ferried across; it is a mountain torrent.

The **Chairman**. What is the fall in the Salt River?

Mr. **Farish**. The fall is very small. It can not be large. Tempe is above this place. It is a little over 100 feet.

The **Chairman**. In 10 miles it is 100 feet?

Mr. **Farish**. It is not over 25 to 30 feet higher, and the difference between the altitude of Yuma and this place is about 1,000 feet.

The **Chairman**. What is the distance?

Mr. **Farish**. I think something over 186 miles. Then, in this county, up above Florence about 20 miles, there is a natural reservoir where you can impound a great deal of water. The Florence Canal Company is prepared to put in a dam to reclaim some 200,000 to 300,000 acres. The experience in this valley has been that the more irrigation the more land susceptible of cultivation. The policy among our farmers of late years has been, in the winter when water is plentiful, to flood the lands, to give them all the water they will stand. That creates a reservoir by absorption, which supplies the water during the dry season. There is another feature about it. There is more water now flowing through the Salt River during the dry months of June, July, and August than there was before a canal was dug in this valley.

Senator **Reagan**. How do you account for it?

Mr. **Farish**. By the ground absorbing the water. The water percolates back into the stream, and finds its natural channel. Then there is a good deal of land where you can grow alfalfa, fruits, and vegetables without irrigation.

The **Chairman**. That is without surface irrigation.

Mr. **Farish**. Yes; it has sub-irrigation. It is the natural slope which brings the water down and keeps the soil forever moist. My theory is that when the land is covered by raising the canal, really a high-land canal, and all the lands under it are in cultivation, there will be some lands in the lower part of the valley that will require drainage.

The **Chairman**. Drainage is often an important matter, because alkali may form on the land for want of drainage.

Mr. FARISH. I have not heard of any alkali forming. I do not believe there is any such thing existing in this county. Another feature of this county is this: Up here in the Verde there is in the lowest water season several inches of water that flows into the plain in sinks. There are traces here of old canals built by the ancients; canals as large as the Arizona Canal. By building a reservoir up that stream there could be 75,000 acres reclaimed under it.

The CHAIRMAN. Are the places suitable for reservoir sites upon public or private land?

Mr. FARISH. Some are located upon public land, and some are not.

The CHAIRMAN. I do not mean the location of the reservoir. Are there settlers upon the land?

Mr. FARISH. There are along this large canal of which I spoke, the one that would reclaim so much land, extending down to Yuma.

The CHAIRMAN. How many acres are located?

Mr. FARISH. Six thousand acres are located.

The CHAIRMAN. Located since last October?

Mr. FARISH. No; before. There are some 3,000 or 4,000 acres that have been in cultivation for the last two years.

The CHAIRMAN. Have you a law on the statute-book under which you can condemn land for purposes of reservoirs?

Mr. FARISH. No; we have not.

The CHAIRMAN. How are the other places for reservoirs?

Mr. FARISH. I think within this county that about covers all of it, because we do not want more.

THE CHAIRMAN. You spoke of several reservoir sites. Are they on public land?

Mr. FARISH. Yes; they are on public land. In Yavapai County there is the largest water storage concern that there is. I can give you the dimensions.

The CHAIRMAN. Does this all appear in your report?

Mr. FARISH. No; only for this county.

The CHAIRMAN. Has anybody made up a report for the whole Territory?

Mr. FARISH. No.

The CHAIRMAN. Has the surveyor-general any knowledge of it?

Mr. FARISH. There is no surveyor-general in the Territory. I can give you such information as has reached me as commissioner of emigration. If you wish me to go into Yavapai County I can do so. They have built a large storage reservoir there which is calculated to reclaim from 25,000 to 30,000 acres. There have been dam sites utilized at Date Creek and Bill Williams Fork, which are intended to reclaim about 50,000 acres. In Big and Little Cheyenne valleys there could be reclaimed probably 10,000 or 15,000 acres.

Senator REAGAN. Where are they.

Mr. FARISH. In Yavapai County. Along the Rio Verde there are reclaimed already 30,000 acres, which can be more than doubled by using the entire water supply. In other valleys there could be reclaimed some 25,000 acres. In Apache County there is under cultivation about 20,000 acres, and there could be reclaimed by water storage reservoirs on the streams making out from the mountains about 150,000 acres. In Graham County, along the Gila, it is estimated that there are about 30,000 or 40,000 acres under cultivation.

The CHAIRMAN. Is that below here?

Mr. FARISH. That is above here, one of the northern counties. That could be doubled under cultivation by utilizing all the water of the Gila.

In Cochise County there is under cultivation along the San Pedro 35,000 acres. This could be increased to 75,000 acres by proper utilization of the waters of that stream. In the valley and plain of the San Simon where waters reach into the valleys by different streams, by the utilization of those waters there could be reclaimed I do not know how much—15,000 or 20,000 acres. There are a good many gardens, and on the Whetstone there could be a reservoir for the reclamation of a large amount of land, and on the adjacent plains how much I could not tell you. The Sulphur Springs Valley contains, I think, by an actual survey, some 83,000 acres. The water underlies the surface from a depth of 15 to 20 feet. Wells have been dug all through that valley, and I believe by pumping all that land can be brought under irrigation. I simply give this as an off-hand opinion. But in 1879 when I first went over that valley there was not a hoof of stock on it, and now it is all eaten down. In the upper Gila Valley there is not a great deal of land susceptible of reclamation, probably not over 10,000 or 15,000 acres. In Pima County there are at least 8,000 acres—I have forgotten the precise number, but the possibilities there of water storage and irrigation are very great.

At Pantano there is a natural place for a reservoir, and there you could store water enough to reclaim 150,000 or 200,000 acres of land. There is enough water flowing down the Santa Cruz, where a reservoir could be constructed, to reclaim a large amount of land—from that on down to Tucson. The Santa Cruz River sinks some miles below Tucson, and is supposed to find its way back to the Gila at Florence. If its channel could be found, there would be a proper place to dig artesian wells. In the mountains near Florence there could be reclaimed by water storage by a reservoir above the Gila Buttes—15 or 20 miles above the canal—about 160,000 acres of land lying in Pinal County. By damming the Gila water with stone abutments, the river there having a channel 15 feet wide—the dam being 200 feet high—the water could be backed up 20 miles at that point, and you could impound water enough to reclaim from 300,000 to 400,000 acres of land. That, in connection with the big dam over on the Salt River, reclaiming the land of which I have previously spoken, and with the other reservoirs on the Lower Gila, which the map will show, and also those on the Rio Verde in this county, there could be reclaimed perhaps from Pinal County on to Yuma 3,000,000 or 4,000,000 acres of land. And of that land I wish to say here there is no better anywhere on the face of the continent.

The **CHAIRMAN.** What crops will it produce?

Mr. **FARISH.** Cereals, and fruits and vegetables of all kinds.

The **CHAIRMAN.** What kind of fruits?

Mr. **FARISH.** As fine lemons as you would wish. Along at Florence they have grown splendid olives. In this valley our olive trees are not far enough advanced to tell anything about; but they have grown them up there. We have planted out here some 22,000 orange trees, experiments in growing that have been successful. We think we have a field here for growing oranges. Peaches, pears, and apples are not so good in this part of the Territory. They grow to great perfection so far as size is concerned, but they lack flavor. We grow the crab-apple, prunes, and dates. Every variety of fig is a natural product here. The date is produced here, seven years from the seed.

Senator **REAGAN.** You mean that the tree bears in that time?

Mr. **FARISH.** Yes; and in bunches of from 5 to 25 pounds. And we grow wheat here—I should think about 1,800 to 2,000 pounds to the acre. The yield of barley is from 2,000 to 2,500 pounds to the acre, and sometimes as high as 3,000 and 4,000 pounds. Alfalfa is the principal crop. We cut that from three to four times a year, and we cut from 6 to 8 tons to the acre. Now, I think I have gone over the whole Territory, and any questions which you have to ask I would be glad to answer.

The **Chairman.** What advantage, if any, would it be to have the Government make surveys and designate the lines of ditches and sites for reservoirs, and make estimates of the cost of constructing the works, with an estimate of the amount of land that could be redeemed.

Mr. **Farish.** That would be a very great advantage, provided the work was not followed up by a restrictive clause that no entry could be made——

The **Chairman.** I did not ask you that question.

Mr. **Farish.** All right. It would be a very great advantage. I wanted to follow the one with the other, because I do not think it would be of any great advantage unless the arid lands were left where they were before the passage of such a bill.

The **Chairman.** You do not think the reservation of reservoir sites, the designation of lines of ditches, estimates of the cost of constructing them, the amount of land to be reclaimed, and with the land thrown open to settlers by proclamation, would be of any advantage?

Mr. **Farish.** I do not think they would be of any great advantage, because that clause is restrictive. You can not do that work under such circumstances through united enterprise. If the Government could build those reservoirs it would be all right. It could then say to anybody, come in. But you are restricted to a homestead entry of 160 acres.

The **Chairman.** How many men in this county cultivate well and to their highest capacity 640 acres of land?

Mr. **Farish.** I do not believe there are any.

The **Chairman.** How much land in this Territory could a farmer with his family cultivate to its highest capacity, and get the best results without hiring labor?

Mr. **Farish.** I understand your idea. But that question would not apply to all this Territory.

The **Chairman.** I mean the part that has to be irrigated.

Mr. **Farish.** You could not go to work and pass a general law, one that would be applicable to every portion of this Territory with equal force, because the products of the north are different from those of the south.

The **Chairman.** Let us take it by sections. Take the valley from here down to Yuma. How much land can a man cultivate, raise fruits and all-round crops, and get the best results from the land?

Mr. **Farish.** That would depend upon the kind of products. If grain, it would be one thing; if fruits it would be another. If alfalfa it would be another, because alfalfa requires nothing but three or four irrigations a year. But if a man wanted to get the highest products, and the railroad facilities were such as to give him a market, then, of course, horticulture would be his forte, because land planted in fruits would yield a higher percentage than anything else. Therefore, I would say that 15 or 20 acres would be as much land as he could attend to. If, however, it were in alfalfa he could attend to 320 acres.

The **Chairman.** Did you ever know a community to be wealthy and prosperous that cultivated but one crop?

Mr. **Farish.** You are now asking me about matters that I have not looked into. But, I do not think any community that cultivated but one crop was ever prosperous. To go back to my first remark, that law is restrictive so far as the prosperity of Arizona is concerned. I think the interest of the Territory is identical with that of the Government—to have the public lands made productive and made to bear their proportion of the burdens of taxation.

Mr. Farish filed at a later date with the committee the following data, compiled from the records of his office, that of Territorial commissioner of emigration:

RESOURCES, LAND VALUES, POPULATION, AND PRODUCTS.

The population of Arizona is rapidly increasing, especially in the southwestern and central portions of the Territory. The immigration into these sections aggregates 5,000 persons yearly, and the increase for the Territory for the last ten years will average fully 10,000 per annum. Our mining industries are being rapidly developed. Several large producing mines have been opened the present year, of which the Yuma copper mine, the Standard and Harqua Hala gold mines, are the most prominent. Large enterprises are being undertaken in irrigation that will more than double the arable land of the Territory in the next three years. The construction of a north and south railroad, connecting the Atlantic and the Pacific and the Southern Pacific by the way of Prescott and Phœnix, will open up a great mineral country heretofore inaccessible, create a home market for the lumber of the north, and give an outlet for the products of the Gila and Salt River Valleys in northern Arizona, New Mexico, and Colorado.

The returns from the different counties to the Territorial auditor for the present year show a total valuation of $27,231,424.47. But this does not represent the cash value of the property of the Territory, for no species of property pays on more than one-third its value.

In valuation on land the disproportion is even greater. Arable land with water that sells at from $20 to $75 per acre is assessed at from $5 to $15 per acre. There are assessed 5,985,358 acres in the Territory, about 5,000,000 of which is embraced in the grant to Atlantic and Pacific Railroad, and assessed at 20 cents per acre, which is being sold at from $1 to $10 per acre. The entire valuation on land is $3,285,212.60, on landed improvements, $1,931,440.83. There are assessed 552,718 head of cattle; the actual number in the Territory will fall a little short of 2,000,000. We market more than 300,000 beef steers yearly. These explanations are necessary to an understanding of the real property values of Arizona, which at a conservative estimate will reach $75,000,000. The expenses of the Territorial government, as estimated by the board of equalization for the ensuing year, is $180,000, which includes interest on bonded and floating debt, sinking fund, support of prison asylum, normal school, salaries of Territorial officers, and all incidental expenses.

The estimated population is by counties as follows:

Yavapai	16,000	Cochise	14,000
Maricopa	16,000	Pima	14,000
Apache	12,000	Pinal	8,000
Mohave	5,000	Yuma	3,000
Gila	5,000		
Graham	12,000	Total	105,000

The lands covered by canals and ditches is in—

	Acres.		Acres.
Apache County	6,900	Yuma County	40,000
Yavapai County	40,360	Pima County	7,500
Gila County	7,600	Cochise County	23,500
Pinal County	71,600	Mohave County	1,000
Graham County	47,000		
Maricopa County	321,000	Total	566,460

Of land requiring no irrigation the amount entered and occupied is estimated at 100,000 acres, lying principally in the counties of Apache, Yavapai, Graham, Pima, and Cochise, of which one-half has been cropped the present season. The number of acres of irrigable land cultivated this year is by counties as follows:

	Acres.		Acres.
Apache	6,900	Cochise	18,000
Yavapai	10,000	Mohave	1,000
Gila	7,000		
Pinal	17,000		256,900
Graham	35,000	Of non-irrigable land	50,000
Maricopa	150,000		
Yuma	6,000	Total	306,900
Pima	6,000		

This quantity will be increased the ensuing year by the addition of 75,000 acres, the most of which will be in the Gila and Salt River Valleys from Florence to Yuma.

The value of the agricultural product varies according to locality. In this valley the Salt River hay is baled at $5 per ton; in Yavapai and Apache Counties at $20 to $25. Barley is worth here 75 cents per hundred; in other counties from $1 to $2.50. Fruit here is worth from $20 to $40 per ton; in other counties from $40 to $200. Land in alfalfa or grain here gives a return of from $15 to $25 per acre; in other counties from $30 to $50. Fruit in this and the Gila Valleys give a return of $100 to $200 per acre, and in other localities more or less according to yield. The value of product from every acre of land cultivated in Arizona can safely be placed at $30, which will be largely increased in the southern valleys as the orange, fig, grape, apricot, and other fruit trees and vines now being planted come into bearing.

The value of the products of the Territory for this year is as follows:

Agricultural and horticultural	$9,207,000
Live stock, horses, sheep, and cattle	6,000,000
Gold and silver	4,431,500
Copper	2,000,000
Lumber, wool, etc.	1,500,000
Total	23,138,500

The great need of Arizona is railroad connections, roads that would make a market for her coal measures, and make available her extensive lumber forests that cover with juniper, spruce, and pine 20,000 square miles of her territory, extending from the Santa Rita and Chiracahua Mountains in the south, northwest to the Nevada line, in which are mountain parks, where wheat, oats, and all root vegetables can be grown without irrigation. There is a million of acres upon which crops can be grown without irrigation, which will be settled as soon as railroads make accessible markets.

In the Territory the amount of land that can be reclaimed through a proper system of reservoirs and canals, conserving the storm-water for irrigation, is very large, being variously estimated from 6,000,000 to 8,000,000 of acres, fully two-thirds of which, lying below the thirty-fourth parallel and not in the mountains, can be made available for the cultivation of those citrus and deciduous fruits that make horticulture most profitable in all semi-tropical countries.

Since the removal of hostile Apaches from our borders, Arizona has made rapid development, and none of the Western States or Territories has, apparently, a brighter future before them. She has all the conditions to support a dense population, and a citizenship that unrestricted will make those conditions available.

STATEMENT OF W. J. MURPHY, OF PHŒNIX.

The CHAIRMAN. How long have you resided in Phœnix?

Mr. MURPHY. Seven years.

The CHAIRMAN. What is your occupation?

Mr. MURPHY. Railroad builder and contractor.

The CHAIRMAN. Have you inquired into the effects of irrigation in this portion of the Territory?

Mr. MURPHY. Yes, some. I have made some observations of the result of irrigation.

The CHAIRMAN. State the amount of land that can be irrigated and the sources of water supply.

Mr. MURPHY. I am not familiar with the Territory outside of this county.

The CHAIRMAN. Then confine your statement to this county.

Mr. MURPHY. The amount of land now under cultivation is, in round figures, about 100,000 acres; that is, under irrigation. There are in this county, in the Salt River Valley, about a dozen canals, thirteen perhaps, with the combined capacity of about 2,000 cubic feet of flow per second. When the land is first irrigated, we estimate the duty of water here to be 60 acres per cubic foot, and requiring less water from year to year as it is irrigated until it reaches the minimum, when it will irrigate 150 or 160 acres. The canals now constructed would irrigate, in round figures, 200,000 acres.

The CHAIRMAN. Double the amount that is now under cultivation?

Mr. MURPHY. Yes, at the present time. But being irrigated a number of years, we think 50 per cent. can be added to that—another 100,000 acres—making ultimately reclaimed 300,000 acres where the canals are already completed in the Salt River Valley. There are now a half dozen completed canals in this county, in the Gila Valley, below the junction of the Salt and Gila Rivers, aggregating about 50 miles in length, and covering in round figures 50,000 acres. There are many projected canals in the Gila Valley; some partly built. The number of acres of land is variously estimated—probably aggregating, a low estimate, 200,000 acres—that is expected to be reclaimed in this county. The Gila River runs about 90 miles through this county before its junction with Salt River. I present for your observation a diagram showing the quantity of water in Salt River during the past twelve months. The lateral lines represent the number of cubic feet flow per second, and each of the vertical lines one day in each month. You can see at a glance the variable character of the water supply in this river. During four months it is only about 400 cubic feet per second, and in the last months of June and July not much above that, although perhaps 100 inches more. The yellow belt on the chart shows the season of growing grain, about six or six and a half months, beginning with the middle of November and ending with the middle of May. The quantity of water is always abundant during that season of the year. The canals now taking water out of the Salt River in this valley and aggregating 2,000 feet per second are represented by the lower red line, and it will be seen from this chart that during six months of the year there is not water enough to fill the canals; it will probably average about half enough. During the six and a half months included in the period from November to May there is more than water enough to fill the canals. In the month of March the main flow of water is 40,000 cubic feet, twenty times more than all the canals can carry. Therefore, if we had storage systems so that this water could be stored, it would irrigate at least 400,000 acres more of land. That is a low estimate. The main flow during those six and a half months is something over 8,000 cubic feet, nearly four times the amount of water that the present canals can carry. So that 800,000 acres of land could be added to the present quantity of land upon which grain crops could be raised, if the water were not used in summer to irrigate fruits. But taking the assortment of crops that would be grown here, such as alfalfa and grain, and the 300,000 acres which the present canals will reclaim, there could be added at least 400,000 more.

The land here is very fertile, with a grade of from 8 to 12 feet to the mile. It is very well adapted to the application of water, and requires practically no leveling for the purposes of irrigation. This map, you will see, is self-explanatory, and we file it with your committee.

The CHAIRMAN. Are you sufficiently well acquainted with the agriculture of the Territory to state the amont of wheat per acre that can be raised on irrigated land?

Mr. **MURPHY**. Our crops vary here as is the case in new countries. There is too much attempted. Some of our people who are beginners do not understand the proper methods of irrigating, and to some extent they damage their crops by excess of irrigation. So that, probably, their average land will not yield to exceed 1,500 pounds to the acre. I think it possible to produce here 2,500 pounds to the acre. We have had crops of 3,000 pounds to the acre.

The **CHAIRMAN**. What other cereals do you raise?

Mr. **MURPHY**. Barley, principally.

The **CHAIRMAN**. How much barley can you raise to the acre?

Mr. **MURPHY**. Certainly 3,000 pounds.

The **CHAIRMAN**. How much wheat and barley would be produced on the same land without irrigation?

Mr. **MURPHY**. None.

The **CHAIRMAN**. How much alfalfa can be produced to the acre where you have irrigation?

Mr. **MURPHY**. Certainly 8 tons.

The **CHAIRMAN**. Has the fruit production been of such a character here as to enable you to state how many oranges you can produce to the acre?

Mr. **MURPHY**. We have a few orange trees in bearing here; but I do not think we have sufficient data upon it to come to a conclusion.

The **CHAIRMAN**. And it would be the same as to lemons and limes? How is it with regard to grapes?

Mr. **MURPHY**. They grow luxuriantly, and we have a large crop.

The **CHAIRMAN**. What kind of grapes?

Mr. **MURPHY**. Raisin grapes, wine grapes, and table grapes. I am not familiar with the names; but they are such as are grown in southern California.

Mr. **HINTON**. Do the fruits ripen earlier here than in southern California?

Mr. **MURPHY**. Yes, about a month earlier than in southern California

STATEMENT OF WILLIAM M. BRECKENBRIDGE, OF PHŒNIX.

The **CHAIRMAN**. Did you make the survey that is shown by that diagram [indicating]?

Mr. **BRECKENBRIDGE**. Yes, I made a portion of it?

The **CHAIRMAN**. Where can water be stored and how?

Mr. **BRECKENBRIDGE**. There are several points; but the best point that I settled on was at the mouth of Tonto Creek, a little above the mouth of Mazatzan Cañon. The best point was 2,900 feet above this point [indicating the mouth of Tonto Creek and east thereof].

The **CHAIRMAN**. Describe that point.

Mr. **BRECKENBRIDGE**. I made a map of that. In this [indicating] is the dam site. This [indicating] is the proposed water storage of the Upper Salt River.

The **CHAIRMAN**. Explain that map; or does it explain itself?

Mr. **BRECKENBRIDGE**. Mazatzal range cuts through Salt River, and this [indicating] is a big cañon with mountains on each side, 1,500 feet high. The slope is one to one.

The **CHAIRMAN**. It is perpendicular, then, for 100 feet?

Mr. **BRECKENBRIDGE**. Yes; that throws the water back eastward

16 miles on the Salt River, where it boxes again in the Sierra Ancha. For the first 2 miles from the mouth of Tonto Creek, point of construction already suggested, the average width is 2,640 feet, and the average depth would be 180 feet, calling the proposed dam 280 feet high. The next 2½ miles opens out into a valley, the average width being 2 miles, and depth 140 feet. The river then narrows up at Steamboat Rock, 4½ miles above, so that it is only a quarter of a mile wide, with an average anticipated depth of 130 feet. Then above the Steamboat Rock passage for the next 10½ miles the average width is 2 miles, and the average depth, as marked here, will be 70 feet [indicating on the map]. I took them by sections, in short sections, and I tested them several times at different times in the day. Then, also, Tonto Creek, with a width of 1½ miles, could be made to obtain an average depth of 80 feet. There is ample space at a box cañon coming in from the south, where a waste-weir could be built, so that the river, when it arrived at a certain height, might run over that and not into the dam. That, I think, is about all. The contour lines outside of the water are indicated on my map.

The CHAIRMAN. Have you estimated the number of cubic feet per second that the proposed reservoir will contain?

Mr. BRECKENBRIDGE. Yes; I have estimated the amount it would hold in cubic feet. The report will be filed with you. It is a little over a billion cubic feet.

The CHAIRMAN. Enough to irrigate an immense body of land?

Mr. BRECKENBRIDGE. Yes; I have the figures. They are in the report which will be handed to you.

EXHIBIT B.

RESOURCES OF MARICOPA COUNTY.

The people of Maricopa County, Ariz., through the Phœnix Chamber of Commerce, by its chairman, H. E. Kemp, submits the following for the consideration of the committee:

The county contains 5,986,560 acres of land, 3,000,000 of which, including that covered by canals, can, by a judicious system of impounding the drainage and storm-flood waters, be reclaimed to cultivation and settlement. The report of William M. Breakenridge, county surveyor, to our board of supervisors, which is herewith submitted, shows that by building a dam in the Salt River, in the northeastern part of the county, enough water can be stored to reclaim all the desert mesa land lying north of the Gila River between Phœnix and the Colorado River at Yuma. Sufficient quantities of water annually flow through the Salt River to fill this reservoir several times. It is our belief also that, by the selection of suitable reservoir sites along the Gila, water enough can be stored to reclaim all the lands south thereof in this county. The Agua Fria, where it enters the Salt River Valley, in the dryest season carries a stream of several thousand inches of water. If properly utilized there is sufficient in this river to irrigate all the land, some 75,000 acres, lying between it and Cave Creek, and by a reservoir the land could be made available. In Maricopa County alone more has been done in reclaiming desert land than in any other portion of the Territory.

In the Salt River Valley the following canals have been taken from that river:

	Length.		Length.
Arizona	41	Utah	6
Grand	22	Farmers	5
Maricopa	14	Highland	22
Salt River Valley	18	Dutch Ditch	4
San Francisco	9	Monterey	4
Tempe	19	Griffin	3
Mesa	9		

These water-ways cover in the aggregate 250,000 acres of land, of which 187,500 have been reclaimed, and 125,000 acres are annually cultivated.

On the Gila are the following canals which have been completed:

	Length.	Acres.
Buckeye	30	20,000
Gila River	8	5,000
Enterprise	12	6,000
Gould & Bros	8	3,000
Palmer	23	12,000
Citrus	14	5,000

Besides these are the following canals now in process of construction: The Monarch Ditch, 8 miles long, which will cover 2,000 acres; the Gila River Irrigation Company, which takes the water at Black Butte, below the mouth of the Hassayampa River. This company has 12 miles of their canal completed. They propose to put in a dam 1,755 feet long and 75 feet high, and carry the water south and southwest, taking in the entire valley on the south and east sides of the river to the line of Yuma County, making a canal 75 miles long and covering 500,000 acres. The Gila Bend Canal Company starts from Gila Bend on the south side of the river. They have completed 22½ miles of the canal, which is to have a total length of 30 miles and cover 18,000 acres. Under this canal about 3,400 acres has been cultivated this season. The same company are building a large canal, taking the water about 2 miles above and running southwesterly a distance of 50 miles, intending to reclaim 80,000 acres, much of which has been filed upon.

Evaporation is very great in the valleys. During the summer months it will average about four-tenths of an inch every twenty-four hours; so that reservoirs should, wherever possible, be constructed in the higher altitudes. It is the general policy of our people to flood their land in winter, when water is abundant, which, by creating a reservoir of absorption, making frequent and heavy irrigations unnecessary during the months of June and July, when water is scarce. Since the first settlement of the valley of the Salt River the water has risen 30 feet nearer the surface. In some places fruits and alfalfa are now grown without irrigation. Another fact is noticeable; the water used in irrigation, except that lost by evaporation, percolates through the soil and finds its way back to the river. More water flows into the Gila from the Salt River in the dry season, covered by the months of May, June, and July, than before the first canal was built in the valley. Forty miner's inches of water is calculated to make a cubit-foot flow per second. One miner's inch is sufficient to cultivate 3 acres in grain or alfalfa, and 5 acres in fruits or vineyard.

The principal grain crops of our county are wheat and barley. The past season there has been produced about 40,000,000 pounds of barley and about 30,000,000 pounds of wheat. The yield of wheat is from 1,200 to 1,800 pounds per acre, and of barley from 1,800 to 3,000 pounds per acre. Sorghum and sugar cane are grown to a considerable extent for the sugar they contain and for feed. Corn is confined to a few hundred acres each year. Oats are native, and are cut in quantities every year for hay. Timothy, Bermuda, and blue grass do well, but alfalfa is the principal grass grown. Once rooted, it requires no attention except to irrigate it three or four times a year; grazed, an acre will support two and a half head of horses for one year, and from ten to twelve head of sheep or hogs. It can be cut from four to five times annually, and yields from 6 to 8 tons to the acre. The hay is very nutritious, and as a pasture for all kinds of stock can not be surpassed.

The mesquite and cottonwood are native trees, but the ash, cork elm, pepper tree, catalpa, willow, umbrella, lombardy poplar, North Carolina poplar, mulberry, palm, magnolia, locust, and tamarack have been introduced with marked success.

The cottonwood and North Carolina poplar grows from 18 to 20 feet in a season, fruit trees from 12 to 15, grape vines from 25 to 40 feet.

Up to five years ago very little fruit of any kind was grown in the county. Since then the planting of orchards and vineyards has increased every year, and no better section exists for the growing of nearly all citrus and deciduous fruits. In the lower Gila Valley lemons, oranges, figs, grapes, and pomegranates can be grown in great perfection. In other portions of the valley and through the valley of the Salt River peaches, pears, apricots, pomegranates, figs, French prunes, apples, oranges, almonds, quinces, dates, blackberries, and strawberries, and every variety of grapes grow in perfection.

There are now planted through the Salt River Valley 8,000 acres in vineyard and 3,000 in orchard trees. Of oranges, 200 acres are in cultivation. From experiments made the growing of this fruit will be a success. Olives have been planted in an experimental way. It is too soon to speak confidently as to the results, but as they have been successfully cultivated near Florence, in Pinal County, there seems to be no reason to doubt that good results will attend their culture in this county. Apricots, peaches, and kindred fruits bear heavily, yielding from 300 to 500 pounds per tree. Vineyards in full bearing give from 6 to 8 tons to the acre. Raisins have not yet become an export commodity with us. The Alexandria muscat, grown in this valley, contains a greater quantity of saccharine matter than elsewhere, and from experiments made in raisin-making we are justified in the statement that 3 pounds of this grape will make 1 pound of raisins, which is a more favorable proportion than in any part of this habitable globe. Another advantage which our county has in the prosecution of this industry over the raisin districts of Spain or California is that the drying and curing can be done in the open air without damage from rain or dew. Some experiments have been made in the manufacture of sherry wine with satisfactory results. All our wines have a strong sherry flavor, and expert viticulturists who have examined into the matter claim this to be the only port and sherry district in America.

The growing of early and late vegetables will also become a source of great profit. This is a country that produces fresh fruits and vegetables every month in the year. Where grown in the open air peaches, figs, tomatoes, and cantaloups can be gathered in December, and where the soil is a rich alluvial, varying in depth from 10 to 12 feet, and inexhaustible in its durable fertility.

The Indians occupying a reservation in this county have cultivated their land for two hundred years without apparent injury to the soil and without change of seed. After their crude method of farming they raise better crops of grain than are harvested in any of the wheat-growing districts in the Mississippi Valley.

That this portion of Arizona was once the home of a large population supported by agriculture is unquestioned. Near Gila Bend are found the traces of their old canals. All through the eastern portion of the Salt River Valley are the mounds covering their ancient dwellings and the lines of the canals that spread the life-giving waters over the arid soil. Frank H. Cushing, under the direction of the Smithsonian Institution, has spent sometime in exploring the old ruins of this county, and gives it as his opinion that at one time it contained a population of more than half a million.

We have in a brief way adverted to what has been done in the reclamation of desert land and the value of such land when reclaimed, in order to show you the importance of well-directed efforts to utilize every gallon of water that now flows to the sea. These lands, made productive through irrigation, will, in a high state of cultivation, support in easy independence three hundred souls to the square mile.

In Maricopa county we have of this quality of land 3,000,000 of acres that, if a liberal policy is pursued on the part of Congress, will be reclaimed and placed under cultivation in the next ten years; and on these lands, within the lives of young men now living, will be supported a population of one million and a half of souls. Within three years the arable area of the county has been doubled; the population and property values have increased in like ratio. Maricopa county has a population of 15,000 and property values amounting to $15,000,000, and is rapidly growing. If the laws respecting desert land entries are not repealed we are certain that every year will add to the quantity of land reclaimed in this county, but if entries are confined to homesteaders, then we are equally certain that such a policy would work most serious injury to our material progress, unless Congress should lend the nation's credit to the construction of the necessary canals and reservoirs. In our judgment any restriction would delay indefinitely the settlement of arid lands. Had they been open to settlement only under homestead law, it is fair to say that lands would have been reclaimed only where the ditches could be taken out at small cost, and that the lands under the Arizona, Highland, Buckeye and other canals in this county would have been desert to-day, for the capital necessary for their construction would not have been forthcoming had those advancing it been deprived of all advantages to be derived from filing upon lands their money was to reclaim.

The interests of the county, Territory, and nation at large are identical in this matter, and that is, to have these lands made productive and as soon as possible made to share their portion of the burdens of taxation and contribute their quota to the products of the country. While we would rejoice to see a family on every 40 acres, yet if it is going to take a hundred years to accomplish this result, as seems probable if restrictive legislation is persisted in, we submit that better results would follow could they be reclaimed in ten years, even if every settler owned a full section. The cost of conducting water upon land in this Territory is from $8 to $12 per acre. If the land owner is not to be peoned to the ditch owner, he should have an interest in the canal, otherwise he is always at the mercy of the corporation controlling the water. To expect community enterprise to construct waterways, costing from one hundred thousand to several millions of dollars, for the purpose of allowing each individual to enter a homestead, is chimerical and visionary. If done at all, it must be by capitalists, and capital entering a new country always asks large returns upon its investment. We invite your attention to this subject, and respectfully submit that the people of America will be best served by leaving the laws relative to desert entries as they were before the passage of the act creating the United States Irrigation survey.

GENTLEMEN: I beg leave to submit the following report in regard to water storage in Maricopa county. After a careful examination of the river I find that about 400 yards below the junction of Tonto Creek with Salt River, the river runs through a box cañon, the sides of which are nearly vertical for about 100 feet, and then slope back at about 1 to 1. It is about 201 feet wide at the river edge and the bed rock is very near the surface. At this point a dam could be erected, 200 feet high, that would back the water up Salt River to where the river cuts through the Sierra Aucha Mountains, a distance of 16 miles. The valley is wide, and as it is irregular, I herewith give you the dimensions in sections, commencing at the dam site and measuring up the river for a distance of 16 miles:

	Average width	Average depth.
		Feet.
First 2 miles	2,640 feet	180
Then 2½ miles	2 miles	140
Then 1 mile	1,320 feet	130
Then 10½ miles	2 miles	70
Besides, the water would block up Tonto Creek for a distance of 10 miles	1½ miles	80

Total on both streams in cubic feet, 93,689,128,000. Add to this 10 per cent. for the water that would back up Pinto Creek, Sallamay, and other streams and gulches, would give a total of 103,058,040,800 cubic feet; making the largest reservoir in the United States. Limestone and sandstone are in abundance, and about 600 feet below the proposed dam site a box canyon empties into the river from the south. The material that would have to be taken out of the side of the canal to build the dam would form a waste weir for the river into the said box canyon, so that no water from the river, after the reservoir was filled, need ever flow over the dam, thus obviating all wear by water on the dam.

There is plenty of timber on the Sierra Aucha Mountains for all building purposes 20 miles from the proposed site. A large limestone ledge crosses the river about 100 feet above the site, which would furnish all lime necessary, and there is plenty of timber in the vicinity for burning it. There are in the Salt River Valley, which would be covered by the proposed reservoir, 4,100 acres taken up by settlers, of which 678 acres are cultivated. On Tonto Creek there are 2,040 acres taken up, of which 224 acres are cultivated.

Total acres settled on	6,104
Total acres cultivated	902

The cost of building the proposed dam and reservoir would not exceed $1,500,000, and it would supply enough water to irrigate all the land in the valley from the Arizona canal dam to Yuma.

The present capacity of the canals in this valley is about 60,000 feet per second, covering a body of 240,000 acres of land, of which 160,000 are under cultivation. It would take over two years to empty the reservoir with the canals we have at present, running at their full capacity, and the water would irrigate all the cultivated land fifty times, allowing 3 inches of water in depth for each irrigation.

Very respectfully,

W. M. BREAKENRIDGE,
County Surveyor.

THE BOARD OF SUPERVISORS OF MARICOPA COUNTY.

STATEMENT OF LINCOLN FOWLER, OF PHŒNIX.

Senator REAGAN. What is your occupation?

Mr. FOWLER. I have had the management of some of the canals as director and foreman. I am also a lawyer ond real estate dealer.

Senator REAGAN. You have heard the course of this examination. Will you proceed, in your own way, and state what are the prospects for irrigation in this country?

Mr. FOWLER. I have lived here thirteen years, and the gentlemen who have preceded me have stated fully about the present system of irrigation. But I think there might be stated that very considerable bodies of land, perhaps to the extent of 200,000 acres, might be added to the available farming land of the county.

Senator **Reagan**. Of this county?

Mr. **Fowler**. Yes. In the western part of the county there is one point where a considerable underground river (perhaps as large as the Santa Cruz, which passes Tucson and has never been made available for irrigation), might be made to furnish water for quite a large tract of land. There have been no measurements made there for reservoir sites, but I have been to a very good place where one exists for that purpose. In the southern part of Pima County the Papago Indians have a system of irrigation from small streams that come down from the mountains, and in the flood-time they gather these waters together by damming and conducting them upon the land. In that way considerable tracts are irrigated by them.

Senator **Reagan**. Are those the perennial streams, or just the rain-water?

Mr. **Fowler**. Storm floods—storm water. Most of the year there is no water at all running in those places, except when a sudden fall of rain comes. That same system was used in this county by the ancient race which lived here. The people who occupied this country in ancient times have left behind them in many places traces of irrigation works. Those places are not now covered by canals. But the land seems to have been farmed in that way, and the farms of the ancients seem to have covered nearly as great an extent of country, supplemented by those provisions for storm water, as is cultivated here now. The remains of their buildings and canals seem to show that such was the case. It has been estimated that the valley at one time supported a population of from three to five hundred thousand persons.

The **Chairman**. Do you mean this valley?

Mr. **Fowler**. Yes.

Senator **Reagan**. State your authority for that estimate.

Mr. **Fowler**. One authority is Lieut. Hamilton Cushing, of the Smithsonian Institution. We have a number of sites for reservoirs where no permanent streams exist; but I believe they might be made available to supply large tracts of good land. This ancient people of which I have spoken, and which are now extinct in this country, used not only the permanent streams but seem to have used the storm-water system of irrigation in vogue among the Papagoes, and perhaps supplemented it by small reservoirs; of which, however, except in a few places, there is no direct evidence.

Senator **Reagan**. Are any of these ancient reservoirs in a condition to be seen? Are they still in a condition of preservation so that they will convey water?

Mr. **Fowler**. I am told that there is evidence of one in the neighborhood of Florence, but as to the extent of its remains I have no personal knowledge.

The **Chairman**. Have you information as to the manner of their construction and the material out of which they were constructed?

Mr. **Fowler**. Earth principally. There is one point in connection with the irrigation of this country that is very material. If we can add, as has been stated here, 400,000 acres to the cultivated land of this valley, it is likely that the added flow of the river, which will return to the river after this land has been cultivated, will make it possible to add 50 per cent. to that area at lower points on the river.

The **Chairman**. More than you could do now?

Mr. **Fowler**. Yes. It has been shown in the valley that during the last few years there is rising opposite Pima, La Tempe, and down the river for a distance of 10 or 12 miles from 5,000 to 10,000 inches of water. That is re-appearing in the neighborhood where eight or ten years ago in dry times the river might be dry when the ditches were full. That water rises from underground sources, and I take it that 400,000 acres added at this point will probably add 200,000 acres at points below, between the lower end of this stream and Yuma on the Gila River.

The **CHAIRMAN**. Mr. Fowler, you are a lawyer and have given considerable attention to the land laws, and such modifications as seem to you necessary for the proper reclamation and utilization of our public lands within the arid areas of the United States, will you give the committee the result of your study and observations?

Mr. FOWLER: I am gratified at the opportunity, and take this occasion to offer as part of my statement a bill I have prepared suggesting a mode of distributing the arid portion of our public domain. I will read it:

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That there is hereby granted unto the several States of California, Colorado, Nevada, and Oregon, and to commissions to be appointed by the President, by and with the advice and consent of the Senate, as hereinafter provided, for the use and benefit of each of the Territories, respectively, of Arizona, Washington, Idaho, Montano, New Mexico, Utah, and Dakota, the whole of the desert lands in each of the said States and Territories remaining unsold by the United States on the first day of January, anno Domini eighteen hundred and ninety, to enable the said States and Territories to construct the necessary canals, reservoirs, water-ways, and artesian wells for the reclamation of the desert lands embraced therein.

SEC. 2. That it shall be the duty of the Secretary of the Interior to make accurate lists and plats of all such lands, and transmit the same to the governor of each of the said States, and to the commissioners of each of the said Territories, after their appointment by the President, in which such lands may lie, and at the request of the governor of any of the said States, or the commissioners of any of said Territories, to cause patents to be issued to said State, or commissioners of said Territories, for the use and purposes herein mentioned, conveying to said State or Territory the fee-simple of said land.

SEC. 3. That the proceeds of the sale of said lands, whether from sale or by direct appropriation in kind, shall be applied exclusively so far as necessary to the reclaiming of said lands by means of canals, reservoirs, water-ways, and artesian wells.

SEC. 4. That in making out lists and plats of land aforesaid, all legal subdivisions, the greater part of which is dry and of desert character, and which will not without irrigation produce some agricultural crop, shall be deemed desert land within the meaning of this act, and shall be included in the said lists and plats; but when the greater part of the subdivision is not of that character the whole of it shall be excluded therefrom. In segregating large bodies of land notoriously and obviously dry and of desert character, it shall not be necessary to subdivide the same, but to run the exterior of such body of land.

SEC. 5. That upon proof by the authorized agent of any State or the commissioners of any Territory herein named, before the Commissioner of the General Land Office, that any of the lands purchased by any person from the United States prior to the first of January, eighteen hundred and ninety, were "desert lands" within the true intent and meaning of the act entitled "An act to provide for the sale of the desert lands in certain States and Territories," approved March third, eighteen hundred and seventy-seven, the purchase-money shall be paid over to the State or commissioner for the Territory wherein said land is situate; and when the lands have been located by warrant or scrip, the State or commissioner for the Territory shall be authorized to locate a like quantity of any of the public lands subject to entry, at one dollar and twenty-five cents an acre or less, and patents shall issue therefor. The decision of the Commissioner of the General Land Office shall be approved first by the Secretary of the Interior.

SEC. 6. That said commissions shall consist of five members each, three of whom shall be appointed by the President in the manner specified in section one of this act, who shall be citizens of the Territory in which such commissions shall act, and who shall hold their office for a term of four years and be subject to the "tenure of office" act of April fifth, eighteen hundred and sixty-nine. The salary of each of said commissioners shall be two thousand five hundred dollars per annum, payable quarterly, upon warrants drawn by the Secretary of the Interior, from the fund created by this act, known as the land reclamation fund. The Territorial governor and the surveyor-general shall, by virtue of their offices, be members of said commission, but shall receive no salary as members of said commission. The Territorial governor, by virtue of his office, shall be ex-officio president of said commission.

SEC. 7. That it shall be the duty of said commissions to receive from the Secretary of the Interior patents conveying the fee-simple of the desert lands in their respective Territories from the United States, and hold the same in trust for the benefit of said respective Territories, and issue like patents of the same to purchasers of scrip who shall have complied with the rules and regulations which the Secretary of the Interior shall prescribe as to the selection and location of said lands so purchased with said scrip. They shall prepare and transmit to the Secretary of the Interior lists of the lands located prior to January first, eighteen hundred and ninety, as provided in section five of this act. They shall establish districts of lands within their respective Territories lying contiguous to or being susceptible of irrigation by different watersheds situate therein, and shall apply the money arising from the sale of lands in each district to the aid of improvements in the canals, reservoirs, water-ways, and artesian wells situate within said district. They shall cause to be made a complete topographical and hydrographical survey of the Territories, and for that purpose shall devote so much of the general fund as may be necessary for that purpose. They shall deposit all moneys received with the Territorial treasurer of their respective Territories, taking his receipt therefor, and shall be allowed to draw from it upon warrants signed by the governor, as ex-officio president of the commission, and attested by their secretary, for the use and purposes herein specified. They shall sell at public auction, to the highest bidders, for lawful money of the United States, land scrip, after advertisement in three newspapers of general circulation within the Territory for thirty days prior thereto, at not less than one dollar and twenty-five cents per acre, the proceeds of such sales to be deposited with the Territorial treasurer, and to be known as the land reclamation fund. They shall make annual reports of the business transacted to the Secretary of the Interior, and shall at all times be subject to the rules and regulations and forms prescribed by said Secretary. When any of said Territories shall be admitted as a State, then the commission for said Territory shall render a final account of all business done by them, and shall surrender all books, records, and papers to the governor thereof, who shall review the same, and, if by him approved, said commission shall be by him dissolved.

SEC. 8. All land lying within an irrigation district shall have a vested and indefeasible right of use of water for irrigation, under the control of the boards of district and Territorial commissioners.

School lands already granted shall not be affected in manner of grant or sale by the provisions of this act, but shall have the same right to use of water for irrigation as other land in the same district, when sold, on pro rata payments.

This act shall not affect appropriations of water already made, but all appropriators shall be required to appear, upon due notice, before the Territorial commissioners and prove their respective rights, which, after determination by the commission, shall thereafter form the base of their title.

SEC. 9. All sales of land scrip under this act shall be to citizens of the United States and no others, and not more than eighty acres shall be sold to one person. The scrip may be located on any land of the district for which it is sold, and can not be used elsewhere. The commissioners shall not sell more scrip for a given district than the amount of land situate therein. The land scrip shall be issued to the purchaser, whose identity must have been verified before a court of record or United States land office, but the purchaser may be represented by an authorized agent to receive and locate the scrip, and for the purpose of voting at all elections provided for herein for the space of two years after location of scrip and no longer. Every purchaser shall locate his scrip within thirty days by filing at the land office of his district upon a definite tract, not exceeding the acres designated in the scrip.

The scrip shall be absolutely void if not located within thirty days and money forfeit to the fund to which it is paid. The scrip, or title under it, shall not be transferable, nor shall it be liable for any lien or debt for the period of three years after location. The purchaser shall be required to take up actual residence on the land within two years after the location of scrip and live continuously thereon for the space of one year, when the Territorial commission herein named shall, upon final proof being made by the settler, issue a patent to the settler.

SEC. 10. Within sixty days after the sale of scrip in a given district the commissioners of the Territory shall call an election, at which all those who have located scrip shall have the right to vote, for the purpose of electing a board of five commissioners, to serve the district for the term of two years, and a water-master, to serve for a like term. The Territorial commissioners shall call an election two months before the expiration of a term of a board of commissioners. The first board elected in a district shall hold office until the first day of January of the year following that ends with an even number. An election shall be called by the Territorial commission upon written application of ten per centum of the scrip locators, for the purpose of issuance of bonds of the district, recommended by the district board and approved by the Territorial board, and if at such election seventy per centum of all the votes cast shall be for the issue, it shall carry. The general laws of the Territory shall govern when an election shall be held, except as provided and regulated herein.

SEC. 11. All bonds issued by and under the provisions of this act shall be paid, principal and interest, by the levy of a tax annually upon the value of the land of the district for which the bonds have been issued. This tax shall be levied and paid after the same manner and by the same officers as those who collect other county taxes. The total amount of money necessary to be raised for each year shall be estimated by the Territorial commission, and said estimate furnished to each county board of equalization, upon which they shall base the levy for this purpose. All money collected for this purpose shall be paid in to the Territorial treasurer for the benefit of the district levied upon.

SEC. 12. The district commissioners shall give bonds in sum fixed by territorial commission, and may be removed for cause.

They may expend the money derived from sale of scrip and all other sources for the construction of such system of water-works for irrigation for their district as are first approved by the Territorial commission.

They shall distribute and regulate the water used for irrigation in their district justly and equitably through the water master, who shall be their executive officer.

Salaries of the officers of districts shall be fixed by the Territorial commission.

SEC. 13. The annual expense of maintenance shall be met by such just and equitable scale of rates per acre for the use of water as the district commission may fix, subject to approval by Territorial commission.

SEC. 14. Any bonds issued under provisions of this act shall never become a charge against the United States, any Territory or county.

Before the issuance of any district bonds the Secretary of the Interior shall cause the proceedings under which it is proposed to issue them to be reviewed, and, if found regular and according to law, shall cause the bonds to be approved, when the bonds shall be returned for issuance.

SEC. 15. That the Secretary of the Interior shall provide such forms, rules, and regulations as shall best subserve the purposes and provisions of this act.

SEC. 16. That this act shall take effect and be in force on the first day of January, anno Domini eighteen hundred and ——; and all acts and parts of acts in conflict therewith are hereby repealed.

The CHAIRMAN. Yours is one of the methods suggested. Objections are made to the plan, with which, Mr. Fowler, you are quite familiar. What have you to say as to these, and will you explain briefly how this measure, in your judgment, would work?

Mr. FOWLER. I think the objections are generally aimed at points of details. I shall not make an argument here as to whether or no the control of any portion of our public domain while in process of settlement should pass in whole or part to the several States and Territories wherein they are located. That is a question to be considered more appropriately in the wider forum of Congress. I offer my plan simply as a suggestion towards the important discussion on the reclamation of our arid lands, which your committee's beneficial labors, as well as the pressure of public development are sure to bring about. I pass, therefore, with the committee's leave, to a consideration of such objections to my proposition as I have heard made.

The first point is that such "segregated control and disposition" would be objectionable. This may be answered by a general statement that the varying conditions of the States and Territories would make it necessary to have a varied system from north to south, or from grain growing to fruit growing; that the people of a certain State or Territory named would probably be better qualified to handle its conditions than those of other or different localities. Should that, taken with the conditions specified in the latter part of section 1, be thought insufficient to compel the States that are to receive the land to do their duty in the premises, then in place of a direct grant of lands to the States there might be substituted control by commissioners, such as my bill contemplates.

This would furnish some definite pact between the General Government and that of each State as to such land disposition, by keeping the control directly under the Interior Department. It has been objected that the land subdivisions provided by this bill of mine are not small enough for the conditions of semi-tropical sections and districts like southern California or southern Arizona. It is also suggested that my bill is not sufficiently stringent in guarding against the opportunity offered under our present land laws for making quasi-fraudulent entries, ending in the transfer to speculative parties of large bodies of public lands which Congress has designed should be occupied as homesteads. All these are matters of legal details to be considered and provided for if shown to be reasonable.

In section 5 of my bill it is proposed that the Territorial commission or the State shall have the benefit of the value of all desert land already sold, also in line scrip. This is intended to furnish funds to commence or continue works of survey and hydrography, and to set the plan in operation. All water-district settlements in Territories would be practically incorporated for these purposes, as are California districts under the "Wright law," except that their source of life would be from Congress and through the Interior Department in place of the State.

This will be seen by section 7, which provides for the general powers of the commission. It is modeled largely from the "Wright law" of California, varied, of course, to suit the different conditions of working under the Interior Department. Appropriators under the bill would be required to prove their claims and appropriations. In many cases equities have already accrued from use and under intent of compliance with the desert-land law. In more cases those who hold them would no doubt be glad to turn over their interests at cost to a water district.

The general provision of usufruct of water is necessary to lay a ghost that has troubled California for many years in the shape of "riparian rights." School lands are untouched by this bill, except that they too should have right of irrigation upon pro rata payments. The rights of present appropriators form a very vexatious base for much litigation, and this act would effectually and at once bring it to a speedy close.

As section 9 of my bill is intended to especially promote the colonization of arid lands, many people of moderate means would by association or colonies send their agents to choose eligible sites for future settlements, and would be eager bidders for lands that would be occupied as soon as water could be brought upon them. Under the homestead law that is quite impracticable. This I believe to be one of the strongest and best features of the bill I suggest. I base my opinion on experience of over fifteen years in arid districts.

That the scrip I propose must be located within thirty days will keep the business of the district well in hand. That the scrip can not be used out of the district for which sold will prevent any chance of its having a speculative character. That the scrip locater may be represented for two years by agents will give colonies a chance for successful location at bottom advantages.

Section 10 is intended to convey, for the purposes of this bill, about the same general line of powers ordinarily vested in school districts or municipal corporations, except that so much of detail is unnecessary, for the reason that general laws would provide for nearly everything wanted, while for this especial line of duties it seems that, taken with the general instruction of the Interior Department and T[illegible]orial commission, it would be ample. But, of course, it can readi[illegible] be maed more rigid and detailed.

The bonds to be issued in pursuance of this plan will be for the primary purpose of improving and giving value to the land of a district; hence the land should be held responsible for their payment and improvements. Personal property, etc., should go free, so far as possible, from this tax. This would tend to promote small holdings, high cultivation, and induce a successful colony system.

Should this plan be modified in the case of the States to be benefited by having a State commission in place of a direct grant, then the States accepting would need to provide machinery for the levy of taxes in accordance with the grant; for, I take it, in matters of taxation Congress would not be authorized to go further than propose a grant on certain conditions. The several States would, if accepting the same, provide the method for tax levy and all details connected therewith. According to generally accepted theory, Congress may make such laws for Territories as they see fit for any purpose. The approval of the Territorial commission is inserted by me to provide uniformity of construction and to prevent any ill-advised steps being taken. The commissions are to be clothed with the power of distribution of water, with a water master as executive officer in each of the district boards. As the district boards will know much better about the annual cost of maintenance, they will name the rate per acre, with the same reserved power in the Territorial board. This provision is designed to definitely fix the validity and regularity of the issue, which under the California "Wright law" is provided for by the officers of the water district bringing the whole matter before a court of competent jurisdiction for judgment.

The Secretary of the Interior is to provide all the regulations and forms necessary to secure uniform and successful working of this act after the manner of other land laws. In summing up, then, I desire to say that under this proposed act the Government is protected from speculation either in water or land; first, by the water-works being owned by the community, and the land owned in small tracts being by right of purchase held not subject to debt as in the present homestead law, and the requirement that before title can be issued to the settler he or she must have resided on the tract at least one year. This term of residence being the last one of the three years is to render it possible for the settler to do so without evasion, for on the arid land of the west, which, as required by the desert-land law, must be of a character that will not produce an agricultural crop without irrigation, how can any settler support himself in advance of water to farm with?

It will be admitted by every one in the great majority of cases that two years after the commencement of work would be a short time to complete and put into operation an average system of irrigation and make the water available for the cultivation of the soil to sustain the homesteader. The era of land grants to corporations has passed, let us hope to never return, and callous would a public man be to the interest of his constituency who would invite its return; but what shall we term the gift of the water franchises of the arid region, that at the present can only be made available by the heavy investment of capital under terms that will make the intending settler subject to their exaction? Certainly protection and care is needed there.

It is not intended by this bill to interfere with rights already acquired, but to enable those who may need homes, even though now at a distance, to get them subject only to their own and governmental control. The central purpose of homes for the people without a rent-gathering landlord is purely American; the further idea of water for irrigation at first cost, and under the direct control of the people using it, has come to be the main drift of the later laws of our States where irrigation is most used, and forms largely the basic idea running down through all laws on irrigation from Rome through the Spanish, French, and Mexican system of community ownership with the land and water in inseparable and undivided control.

It is hoped that this brief presentation of a matter of such vast importance will assist all those seeking to solve the question of disposal by our Government of the 700,000,000 acres of arid land to actual settlers, thus perpetuating and continuing the grand work of free homes for a free people.

I think, Mr. Chairman, I have covered all the explanations I desire to make in regard to my proposed bill. I should like to add my concurrence to the statements of other gentlemen as to the great importance to all our people of the pending national survey for irrigation purposes. Such a survey is absolutely essential, and whether the General Government keeps entire control, or whether, as I propose, some of its administrative powers over the public lands west of the Powell meridian be delegated to commissions in States and Territories, the survey for irrigation purposes should be completed, and as rapidly as possible.

COPY OF CIRCULAR SENT TO COUNTY OFFICERS.

The following was filed by the secretary of the Territory. The circular was framed and published as the result of a correspondence with the governor of the Territory and Engineer Hinton, the committee's expert:

(1) The location of all streams, rivers, and irrigating canals. These can best be shown on maps, sketches, or tracings, prepared on a scale of 2 inches to the mile.

(2) List of canals and ditches, giving as nearly complete as possible—

(*a*) Name of canal or ditch.

(*b*) Name of owners or officers and their post-office addresses.

(*c*) Date when built or first in use.

(*d*) Streams from which the water is diverted.

(*e*) Number of acres irrigated, and of cultivated lands.

(*f*) Number of acres of good land so located that they could be irrigated by an increase of the water supply in the canals or ditches now constructed.

(*g*) Number of acres that could be irrigated by new ditches or canals and new reservoirs.

(*h*) The available sites for reservoirs, either in the valleys or mountains, and the probable size of such reservoirs.

In addition to the above you are requested to reply to the following questions:

(1) What is the average depth of snow in your mountains during the winter?

(2) When does the irrigation season begin and end in each valley?

(3) What is the elevation of each valley above the sea?

(4) How much water, in miners' inches or in cubic feet, per second flows through each stream in your country at the point where it can be used for irrigation during the irrigating season?

(5) How much water could be stored in suitable reservoirs during the rest of the year?

(6) How much water is required in each valley or locality to irrigate an acre of sandy soil for each crop—small grain, grass, root crops, corn, orchard grass, etc.?

(7) How much water is required to irrigate an acre of clayey or alkaline soil in each valley or locality for each crop mentioned above?

(8) How often and how long at each time is the land irrigated?

(9) How many acres of crops have been lost this year from lack of water?

STATEMENT OF J. M'MILLAN, OF PHŒNIX.

Senator **REAGAN**. How long have you resided in Phœnix?

Mr. **MCMILLAN**. Three years.

Senator **REAGAN**. What is your occupation?

Mr. **MCMILLAN**. Superintendent of the Arizona Canal Company.

Senator **REAGAN**. You have been in charge of the canals—managing them?

Mr. **MCMILLAN**. Yes.

Senator **REAGAN**. Directing the distribution of the water?

Mr. **MCMILLAN**. Yes.

Senator **REAGAN**. Will you state the plan of distributing this water to the persons who use it, who furnishes the water, and what those who use it pay for it?

Mr. **MCMILLAN**. We distribute it to the water-users through lateral ditches which we have built on every section line. It is measured to them and delivered to them with their land through divide boxes. They pay for the use of the water $1.25 an acre each year.

Senator **REAGAN**. What company furnishes the water?

Mr. **MCMILLAN**. The Arizona Canal Company.

Senator **REAGAN**. Is water furnished on that charge during any portion of the year when it is needed?

Mr. **MCMILLAN**. During the entire year.

Senator **REAGAN**. And is there a limit to the amount that you furnish to the users?

Mr. **MCMILLAN**. They can have all they require as long as we have it.

Senator **REAGAN**. You have heard the course of this examination. The committee would be glad to hear any statement you desire to make which will give us information upon the subject of inquiry, so far as it bears on this section of country.

Mr. **MCMILLAN**. The land is so level in this section that irrigation itself is very easy as compared with other localities. We are not troubled with arroyos or washes of any description. The slope of the land is about 10 feet to the mile, running to the southwest, largely, and hence the main laterals run to the south and our dividing laterals to the west.

Senator **REAGAN**. Do the ditches that carry the water out of Salt River carry it over the southern plateau to the Gila?

Mr. **MCMILLAN**. Nearly so, but they do not reach the Gila. I desire to say that as to the service of water on these new lands, we use in the neighborhood of half an inch to the acre on fresh lands each year. As lands become older they need less water.

STATEMENT OF W. E. PLATT, OF ST. JOHNS, APACHE COUNTY.

Senator **REAGAN**. You represent the board of supervisors of that county?

Mr. **PLATT**. Yes.

Senator **REAGAN**. Have they made a report with regard to irrigation?

Mr. **PLATT**. Yes.

Senator **REAGAN**. You have a written report?

Mr. **PLATT**. Yes.

Senator **REAGAN**. By whom prepared?

Mr. **Platt**. I prepared most of it myself.

Senator **Reagan**. State generally what the report shows, and then file it.

Mr. **Platt**. We are now attempting to irrigate about 12,000 acres of land, but we have scarcely water enough to water half that quantity so as to raise good crops. We have nearly 200,000 acres that we could water if we had a good reservoir. We have five or six reservoir sites already surveyed. They are shown in full in the report.

The **Chairman**. What streams of water pass through your county?

Mr. **Platt**. The Little Colorado and its tributaries.

The **Chairman**. Then you are away up adjoining Utah?

Mr. **Platt**. Yes, we are away up in the corner. We have an abundance of water when we do not need it. When we need it we have almost none. We have some five or six reservoirs in operation, which furnish all the water we have in the dry season. Our county grows almost everything except figs and oranges. We have every class of soil and can grow every class of vegetables.

The **Chairman**. Are you accessible to any railroad?

Mr. **Platt**. Yes; the Atlantic and Pacific passes through about the middle of the county, 50 miles from St. John. We have 111 miles of railroad in the county. Our taxable property is $2,500,000. We have about 12,000 inhabitants.

The **Chairman**. Are those reservoir sites on public land?

Mr. **Platt**. Partly. The railroad owns part of them.

The **Chairman**. Is there anything further you wish to say?

Mr. **Platt**. I believe not. You will find everything in detail in the report.

The following is the report referred to by Mr. Platt:

REPORT OF APACHE COUNTY; ITS IRRIGATION CANALS, RESERVOIR SITES, ARID LANDS, ETC.

Apache County is situated in the northeast corner of the Territory, and embraces a country of about 100 by 120 miles, exclusive of the Indian reservations.

The county now contains a population of only 6,000 to 7,000 people, but with sufficient water to cultivate the land that is otherwise available, it would afford good homes for many thousands more.

The climate is excellent and well adapted to the raising of all kinds of small grain, vegetables, and all kinds of fruits that can be grown in a semi-tropical climate.

The county is drained by the Little Colorado River and its tributaries. The Little Colorado heads in the White Mountains, in the south end of the county, and runs in a northerly direction 50 miles to St. Johns, thence in a northwesterly direction to the Big Colorado River, in Yavapai County.

From the head of the Little Colorado to the first settlement, Springerville, it is about 15 miles; there being in that vicinity several good sites for storing water, and some 8,000 acres of choice agricultural lands, unoccupied, that could be brought under cultivation. Springerville is one of the best farming districts in the county, the land being very productive.

In addition to the Little Colorado, the following tributaries of that river run into the Springerville valley from the mountains, through which a great deal of water flows during the spring, but runs dry about the time irrigation commences: South Fork Creek, Water Cañon Creek, and Nutriaso Creek. On each of these streams there are good sites for reservoirs. There are two reservoirs constructed and owned by private parties in this valley, which are very successful in storing water for irrigation.

A committee sent from St. John's surveyed and made estimates on the following reservoir sites between Springerville and St. John's, a distance of 35 miles, and make following report:

Reservoir site No. 1.—This place is 25 miles above St. John's, 3 miles away from the river, and would cost $1,500; has a small living stream running into it from the mountains; drains 100 square miles of the White Mountain slope.

There may not be sufficient water to fill this reservoir every spring, but, from reports of reliable persons, there would be ample water nearly every season. The embankment would be 300 feet long, 25 feet high, 70 feet thick at base, and 20 feet thick on the top. The reservoir, then, filled with water would cover 600 acres 12 feet deep. A natural ditch would convey the water from this reservoir 3 miles and empty into the Little Colorado, 22 miles above St. John's.

Reservoir site No. 2.—This site is 22 miles from St. John's, up the river, and 4 miles east from the Little Colorado, on "Coyote Wash." The work required would be masonry 495 feet long, 100 feet high, 100 feet base, and 20 feet on top; would cost about $50,000, and would cover 2,000 acres of land 50 feet deep on an average.

Rock and material for construction of dam is plentiful right on the ground. It is believed there is sufficient water passes down this stream every spring to fill this reservoir. At the same place by making only a wall 50 feet high the cost would be $12,000, and cover 1,000 acres 25 feet deep; no expense in conveying the water to the Little Colorado River from reservoir, and there are 1,500 acres of good land within 2 miles of the embankment that can not be irrigated from any other source. Eleven thousand acres of land could be better cultivated than at present from the above reservoirs, and 20,000 acres of good land within 10 miles of St. John's could use the surplus. Ten thousand dollars would make the necessary ditches to convey the water on the 20,000 acres near St. John's.

Reservoir No. 3.—The construction of a reservoir at this place, which is 16 miles above St. John's, would cost $5,000. An embankment 20 feet high, 60 feet wide at base, 20 feet on top, and 900 feet long would back the water over 700 acres at an average depth of 8 feet. The reservoir would be filled from the Little Colorado.

Reservation No. 4.—At the Salado Springs, 6 miles above St. John's, on the Little Colorado, is one of the finest places for storing water in the country. A wall and bank 70 feet high, with 100 feet base and 30 feet top, 600 feet long, would cost about $50,000; would back the water up the river for 10 miles, and would contain sufficient water to irrigate 60,000 acres of land during the irrigation season. About 1,000 acres of the land embraced in this reservoir site is claimed. There is always plenty of water passing down the river to insure the reservoir being filled. There are 25,000 acres of land between this place and 10 miles below St. John's, mostly vacant for want of water; and 8 miles farther down is a valley containing 13,000 acres of agricultural land not in use, and still farther down the river 17 miles another valley containing 60,000 acres of fair quality of land.

Reservoir No. 5.—This place is only 1 mile above St. John's, at a place known as the "Padre's Lake." An embankment 10 feet high and 1,000 feet long, costing only $2,500, would cover about 100 acres 6 feet deep. Said site is claimed by private parties, who hold it for speculation, as they have no land that could be irrigated from it, and the land embraced in this site is of no value for any other purpose, being a barren spot. A ditch necessary to fill it is now in use to convey water to the city lots of St. John's. There is abundance of water passes down the Little Colorado River during the thaw every spring to fill many such reservoirs, as described above.

Reservoir site No. 6.—This place is at the mouth of the Zuñi River, 20 miles below St. John's. The wall would be 700 feet long, 80 feet high, 120 feet wide on the bottom and 40 feet wide on the top, and would cost about $65,000. It would cover 7,000 acres 35 feet deep on an average. When full will hold sufficient water to irrigate 125,000 acres of land four times each season. The Zuñi River heads 100 miles east from said site, in the Zuñi Mountains. If this reservoir was made it would not be necessary to make all of the others mentioned above.

There is one reservoir about 2 miles above St. John's in successful operation, which has been in use three years. It is owned by the St. John's Irrigation Company. It covers about 50 acres 12 feet deep. Its original cost was about $4,000. It is the only source of water supply during the dry season for 3,000 acres of land near St. John's. It does not afford sufficient water for that much land, but would be ample for 1,500 acres.

With sufficient water for St. John's Valley, 20,000 acres of good agricultural lands could be brought under successful cultivation, most of said land being of a far better quality than is now in use.

The present population of St. John's is about 1,200.

There is a small reservoir in Coneto, which has been in use for ten years and irrigates 250 acres. One thousand acres more could be used in that vicinity with an increase of water.

In the western part of the county, on the Show, Low and Silver Creeks, there are many good places for storing water, and considerable good land that would be brought under cultivation if there was an increase of water.

They have one small reservoir near Snowflake, on Silver Creek, that covers 50 acres with an average depth of 4½ feet.

There are several places that would be good sites for storing water on the Rio Puerco of the West and other streams that empty into the Little Colorado, with abundance of land available for successful cultivation when water is brought upon it. There are also other locations or sites for reservoirs on the Zuni River and Little Colorado River that are not mentioned in the above report.

The amount of land under cultivation in this county at the present time is about 12,500 acres, over one-half of which is subject to drought and partial failure of crops every season.

The amount of land that could be successfully cultivated, and of good quality, is over 150,000 acres, and water sufficient to irrigate many times this amount of land passes down through the county every season.

Snow usually falls in the mountains from 8 to 12 feet each winter.

The irrigation season commences in some parts in February, and ends in October. In other parts irrigation commences in April and March and ends in September. The elevation of the county varies from 5,000 to 8,000 feet. Eighty-seven thousand one hundred and twenty cubic feet of water will irrigate one acre of sandy soil four times each season. One hundred and nine thousand nine hundred cubic feet will irrigate an acre of clayey soil four times in a season, which is the number of times necessary to irrigate for most crops.

STATEMENT OF WILLIAM A. HANCOCK, OF PHŒNIX.

The CHAIRMAN. What is your occupation?

Mr. HANCOCK. I am by profession a lawyer and civil engineer. I have lived in Arizona twenty-five years; was superintendent in charge of the construction of the canal intended for the irrigation of the Government farm at Fort McDowell in 1866, and was afterwards superintendent of the farm. I came to this valley in 1870 and have participated in the location and construction of nearly all the canals in the valley, and have been familiar with the whole valley for the past twenty years.

The CHAIRMAN. We shall be glad to hear what you can tell us about irrigation.

Mr. HANCOCK. We have now under the canals in the valley, from the junction of the Verde and Salt Rivers to Agua Fria, 235,000 acres of land susceptible of irrigation and cultivation. On the north side of the river the Arizona Canal with the older canals under it includes all the land practically susceptible of irrigation by the water from the Salt River. On the south side, if water is secured by storage, a new canal may be constructed above the Highland Canal that will cover something more than 50,000 acres to the east and south of the line of the Highland Canal and its possible extensions. This will make the area in this valley irrigable from Salt River approximate 300,000 acres.

If this entire amount of land was in cultivation it would require to properly irrigate it a flow of 150,000 miners' inches, or a stream equal to a discharge of 3,750 cubic feet per second. Such a stream would discharge in twelve months 116,640,000,000 cubic feet of water.

For the past twenty-five years the average natural flow of water in Salt River during the months of January, February, March, and April has been sufficient to afford the required water; so that, taking the average year, we should only need to secure by storage a supply of water sufficient for eight months, or 77,760,000,000 cubic feet. But during two years in the period named the natural flow of the river sufficient to afford the required water would not exceed three months in duration. To insure perfect success we must provide for the storage of sufficient water to supply the valley through the dryest year, or nine months, which would be 86,780,000,000 cubic feet. These estimates are made without any allowance for evaporation, seepage, or other wastage, and I think we do not need to make any. And, upon this point, suppose wastage from the causes named to be 33 per cent. of the water stored, that being the last-named quantity, 86,780,000,000 cubic feet:

one-third of it is 28,926,666,666 cubic feet. Now, to offset this we have the natural flow of the river during the nine months, and I will estimate this to be 50,000 miners' inches, or 1,250 cubic feet per second, and we have 29,160,000,000 cubic feet, or a little more than the wastage. These last are but approximate estimates, made without sufficient data to make them absolutely correct. I will say here, however, in support of the last proposition, that in September, 1868, the water in Salt River rose to the highest point ever attained in the twenty-five years that I have known it; and, further, that in twenty years out of the twenty-five years during which I have been here, some time in the summer, between the 1st of July and the 20th of September, the natural flow of water in Salt River has exceeded the required supply of 150,000 miners' inches, or 3,750 cubic feet per second, and such flow has continued from one to twenty days.

If the committee will refer to the chart furnished by the chamber of commerce they will comprehend what I mean when I say that if it had been made to illustrate the flow of Salt River for twenty-five years, instead of one year, it would have shown that the highest point reached by water was in September, instead of January, and that the average flow of the water during the months of July, August, and September produced by the summer rains would have been indicated by marks at least one-third the height of those for the months of December, January, February, and March.

Now, as to the reservoir site at the mouth of Tonto Creek. Contemplating the necessity for the storage of water for this valley twenty years ago, and when stationed for a time at Camp Reno in Tonto Basin, I examined the proposed site, and again with greater care nine years ago. I assured myself then that it would store sufficient water to successfully irrigate this valley.

The CHAIRMAN. I wish you would explain more fully the reservoir storage and dam site.

Mr. HANCOCK. I wish, for the benefit of the committee, the engineer in charge, and for the good of this valley and our people, to endeavor in a few words to show that, although hardly reconcilable in some respects, the statement made by Mr. Breakenridge proves that the Creator was not unmindful of the necessities of this valley when He placed upon Salt River above it the means of storing water for its irrigation.

I agree with Mr. Breakenridge in saying we may safely construct a dam 200 feet high, and that it will back the water up Salt River 15 miles and up the Tonto perhaps 8 miles; the basin is 4 and 5 miles wide in a part of its length, but is shallow except along the course of and near the beds of Salt River and Tonto Creek, but we may safely estimate that reservoir will equal a body of water 15 miles long by 2 miles wide and 100 feet deep. This is considerably less than the dimensions given by Mr. Breakenridge, and yet it will contain 83,635,200,000 cubic feet of water when full. This will be practically sufficient for the irrigation of the whole of this valley for nine months, even when we have 300,000 acres under cultivation, as the following estimates based upon the proposition that a constant flow of one-half inch miners' measurement, or 21.6 cubic inches per acre, will be required. Upon this basis the water required for one month is 9,720,000,000 cubic feet; for eight months 77,760,000,000 cubic feet, and we have for evaporation and other wastage the natural flow of the river during these eight months, and 5,875,200,000 cubic feet from the water stored in the reservoir.

Suppose the natural flow to be 750 cubic feet per second for these eight months, and we have 15,522,000,000 cubic feet, which added to the amount stored gives us 99,187,200,000 cubic feet, and from this subtract the amount required for irrigation, 77,760,000,000, and we have for evaporation and wastage 21,427,200,000, or practically 28 per cent. of the storage capacity, or equal to 1.4 inches per day for the mean surface of the reservoir during the eight months, supposing my estimate of its dimensions as I have given it above to be practically correct.

As to the probable cost of the reservoir: If the dam is built in the form of an arch up the stream, it will be, say, 250 feet long on the bottom with an average length, say, 425 feet, a width or thickness on the bottom of 130 feet, and 20 feet on top, and the average thickness is 75 feet, and this gives us 236,110 cubic yards, and at a cost of $4 per cubic yard it gives us $944,440. With all the material, except iron and possibly some timber, practically on the ground (for we find large bodies of limestone and gypsum in the near vicinity) this should be a liberal estimate, including the rubble which would be required to make it perfectly water-tight.

The cost of such a work and the means of raising the money to accomplish it are perhaps not within the province of the committee, but, nevertheless, as one of the Senators made some suggestion in regard to it, I will venture to discuss it.

The Senators will remember that a large portion of the land of this valley is already under canals, some of which were constructed more than twenty years ago, and those canals have from thence to the present time been used by the owners thereof in irrigating their lands. Large sums of money have been expended by the owners of these lands in the construction of their canals, and of some of them it is safe to say that unless their rights are encroached upon by subsequent appropriators, they have at all times, in the natural flow of the water in Salt River, an abundant supply of water. Perhaps 30,000 acres of the land in the valley is so supplied. From the owners of these lands we could not expect a contribution of $20 per acre for water rights under the reservoir. A much larger portion of the land is irrigated by means of subsequently constructed canals that do not afford an abundance of water at all times, but which, nevertheless, afford an ample supply to raise a crop of wheat or barley, or one or two crops of alfalfa, and in some years, when the rain-fall is greatest, even more than that. If the Senators can realize this condition of things they will understand how difficult it will be to induce private capital to invest in such an enterprise.

The CHAIRMAN. We realize the difficulty fully. Have you any plan to suggest to meet it?

Mr. HANCOCK. There is a proposition which I believe is practicable, although it does not commend itself to the judgment of all our people. It is this: Let Congress modify the Harrison act to such an extent that the legislature of our Territory may authorize our county board of supervisors to issue bonds to the extent of $1,000,000; let the whole valley of the Salt be created an irrigating district, let a board of commissioners be appointed who shall have the control and management of the construction of the reservoir, and of the reservoir and the water it will contain after the work of construction is completed; let the bonds be issued and turned over to them as they will be required, and with the money derived from the sale of them they construct the reservoir. We suppose these bonds to be payable in thirty years with interest at the rate of 6 per cent. per annum. Some means must be arrived at to make the sale of water rights and the use of the water pay the interest on these bonds and eventually pay the bonds; it must be made in some way from the land that is benefited by it. Is it not possible by some act of our legislature to make this a lien upon the 270,000 acres of land that will derive its permanent supply of water from the reservoir to the extent of $3.50 per acre? This would give us $945,000. The canal companies must receive the water from the commissioners, and not the individual farmers, and if the canals paid to the commissioners 50 cents per miners' inch per annum for the water, it would afford an income of $75,000 per annum, which would pay the interest on the bonds and the annual expenses.

If this proposition could not be made practicable, possibly some such scheme as several States adopted to construct levees on the Mississippi River could be made applicable.

The consummation of the proposition to store water for these lands will add $20,000,000 to the value of the land in the valley, and we can afford $1,000,000, or even $2,000,000, to accomplish it.

I will suggest another plan. Suppose we condemn all the existing water rights, and agree to pay for them, thus putting us all on an even footing, as though we never had secured any rights to the water. We can pay for the condemned rights with rights under the new and better system, and sell to the lands not properly supplied, and thus eventually pay for the cost of constructing the reservoir, and secure a fund to keep it in repair for a long period and pay all expenses for maintaining it.

The CHAIRMAN. All your suggestions are of value. Have you anything further to state?

Mr. HANCOCK. Yes. Where is outlying from this valley on the north, bordering on the Agua Fria River, and in one sense forming a part of this valley, from 75,000 to 100,000 acres of as fine land as any part of this valley; and here, again, on the Agua Fria, about 45 miles north of Phœnix, we have a natural place for a reservoir. At this point the course of the river passes between two perpendicular bluffs of solid rock. On the east side this perpendicular wall is 75 feet high, on the west it is but 30 feet high; from this height it inclines outward on an angle of 45 degrees for another 100 feet in height, when it again assumes the perpendicular to the height of 60 feet more.

The east side gradually slopes back for 900 feet or more until it rises to the height of 175 feet. A dam for a reservoir constructed here would be 300 feet at the bottom, and at the height of 175 feet it would be 15,000 feet long. This dam would back the water up the Agua Fria at least 10 miles and up Castle Creek from its junction with the Agua Fria, which is 4 miles above the site for a dam, probably 4 miles. At the junction of Castle Creek with the Agua Fria the reservoir would be approximately 100 feet deep. This reservoir would contain from twenty-five to thirty billion cubic feet of water when full. The Agua Fria and tributaries have the whole of the south and eastern slopes of the Bradshaw Mountains for a water-shed. One hundred thousand acres of land in this locality would require 24,000,000,000 cubic feet for six months, and as the summer rains on the Bradshaw range are sufficient to fill the reservoir as well as the winter rains, we shall have an abundant supply of water for the land. These lands are a portion of the public damain, and consequently no difficulty would be encountered in devising a plan for the construction of this reservoir with private capital. Probably $750,000 would be required to construct the dam and the canals to convey the water to the land.

The storage of water for this valley is the storage of water for the whole of the Gila Valley to Yuma. Already the irrigation of the lands in this valley has increased the flow of water in the Gila below in the dry season. The strata of the gravel, sand, and soil here act as a sponge, absorbing the water that we use in irrigating, and, holding it for a time, gradually let it flow on to the river below, where it is taken out and used again for irrigating the lands below us.

When this vast body of water shall be stored and poured out upon this valley constantly through the dry season it will afford to the valley of the Gila a very much larger stream of water than they now get from our partial irrigation of this valley.

In some way all the lands to be benefited by this water storage should be called upon to share in the expense. I can not yet see just how it can be done. Some legislation must be had to enable us to do it. With my twenty-five years' experience here I should be able to devise some proper practicable plan, or at least to make some practicable suggestions. From what I have learned of the plan adopted for constructing the levees on the Mississippi. it would be good here. If some plan could be devised by which Government aid could be had without delay, it would be better.

Adjourned.

ON TRAIN FROM PHŒNIX, ARIZ.,
September 5, 1889.

The committee met pursuant to call of the chairman.

Present: Messrs. Stewart (chairman) and Reagan; also Director Powell.

STATEMENT OF W. E. GUILD, OF FLORENCE, PINAL COUNTY.

The CHAIRMAN. You may state the condition of things in your county with regard to irrigation.

Mr. GUILD. Pinal County has an area of over 900,000 acres of land that are subject to irrigation. With a proper storage reservoir at Butte Cañon, on the Gila River 15 miles above Florence, this land could all be brought under cultivation.

The CHAIRMAN. Describe your reservoir sites and how the water supply is.

Mr. GUILD. This reservoir site at Butte Cañon in its narrowest place is 140 feet wide.

The CHAIRMAN. Has it been surveyed?

Mr. GUILD. Yes.

The CHAIRMAN. Have you the survey?

Mr. GUILD. Yes; I have the survey and maps, with the report of the surveyor and other reports. Here is the report of the engineer [producing]. I wish to say this, that this report is a mere synopsis, and that a complete report will be filed with the committee in the course of three or four weeks.

Our people raise in this valley, as a general thing, two crops a year; that is, two crops of potatoes, or a crop of barley and a crop of corn, or a crop of beans on some land. In planting the crops of potatoes they plant in March, and they will mature the last of June or first of July; and then they plant another crop in August, and they mature in October. In barley they seed in October, and it matures in June. They plant their corn in July, and it matures again in October.

The **CHAIRMAN**. At Florence, where you reside, is the land and climate suitable for raising grapes?

Mr. **GUILD**. I do not think there is a country that surpasses it in grape culture. The susceptibility of the soil there for raising grapes is extraordinary. There we have raised the finest grapes I have ever seen.

The **CHAIRMAN**. What other fruits do you raise; have you tried other kinds?

Mr. **GUILD**. We have fine orchards there of peaches, figs, dates, pomegranates, almonds and olives.

The **CHAIRMAN**. And those fruits can be raised all along through the valley.

Mr. **GUILD**. Yes. All the small fruits can be raised there, but the experiments in citrous fruits have not gone far enough to speak accurately with regard to them. But there is no country where the fig grows to such perfection as there. They raise three crops a year. In that report there is stated the amount of land that is under irrigation in that county, and it is 10,000 or 15,000 acres.

STATEMENT OF GEORGE W. BROWN, OF FLORENCE.

The **CHAIRMAN**. State your occupation.

Mr. **BROWN**. I am the editor of the Enterprise, a Republican newspaper. For information with regard to figures I shall have to refer you to the report. I heard the testimony of Mr. Guild, and from my own observation I can say he has given exact and correct information. There are some parties in the vicinity of Florence who are cultivating citrous fruits—the orange and lemon—and they give good promise. In the mountains near Florence, above, the orange and lemon have matured. There it is much higher than at Florence.

The **CHAIRMAN**. What is the height?

Mr. **BROWN**. About 1,500 feet. There is a large amount of land there that can be brought under cultivation by a reservoir at Butte Cañon.

The **CHAIRMAN**. Have you gauged the water?

Mr. **BROWN**. It has not been gauged accurately; but the river flows the year round.

Mr. **GUILD**. The water averages from 2½ to 12 feet in depth, and is in width 60 feet.

The **CHAIRMAN**. All the year?

Mr. **GUILD**. Yes. That would be the average for the year.

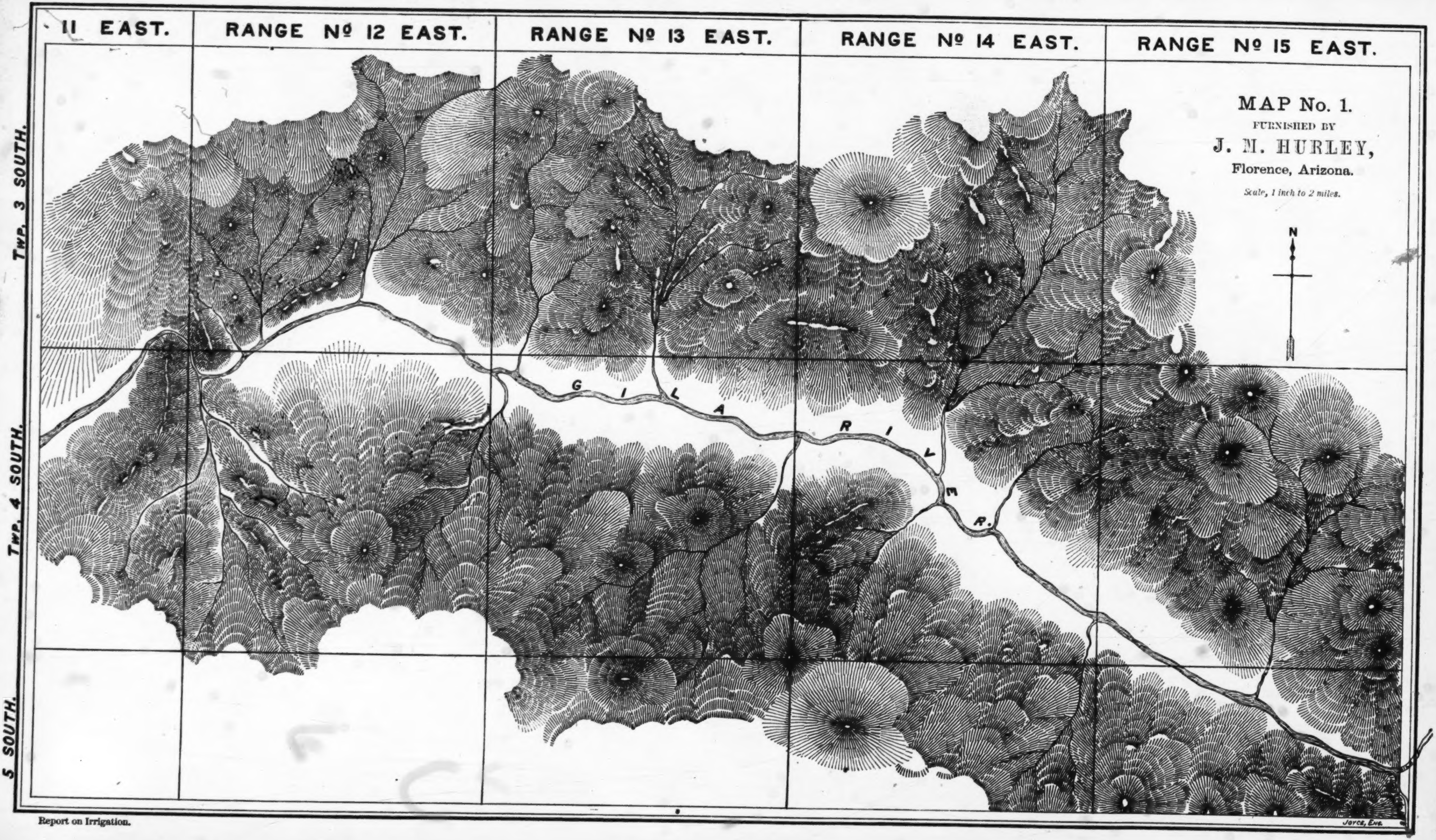
Mr. **BROWN**. There is more water in the canal at Butte than could be used. At that point it sinks in the sand and disappears. By constructing reservoirs at Butte and impounding the flood water we can have water enough to fill perhaps five times as many canals as we have in operation at this time, and do it the year round without any diminution of the flow.

The **CHAIRMAN**. What is the duty of water? How much does it take to irrigate an acre?

Mr. **BROWN**. I do not think that has been demonstrated there, because we have had such an abundance of water. There is no restriction upon its use; they allow it to flow all the time.

The **CHAIRMAN**. That will ruin the land.

Mr. **BROWN**. It has not done so up to this time. It is injurious, I know, but still the water of the Gila River at flood times carries down


11 EAST.
RANGE Nº 12 EAST.
RANGE Nº 13 EAST.
RANGE Nº 14 EAST.
RANGE Nº 15 EAST.
Twp. 3 SOUTH.
Twp. 4 SOUTH.
5 SOUTH.
MAP No. 1.
FURNISHED BY
J. M. HURLEY,
Florence, Arizona.
Scale, 1 inch to 2 miles.
N
G I L A R I V E R.

Report on Irrigation.

Joyce, Eng.

a sediment, a silt that fertilizes the land very much. Consequently, the more they cultivate and irrigate the land, the more fertile it becomes.

Mr. **GUILD**. I now present a set of photographs of the proposed reservoir site and dam at Butte, to accompany the map and report.

Mr. **BROWN**. So far as our climate is concerned it is very similar to the climate throughout the Gila Valley, with the exception that we do not have such extreme heat as they do in a lower altitude, although we have it hot enough.

The **CHAIRMAN**. Is it healthful?

Mr. **BROWN**. I think it is very healthful; one of the most healthful climates we have in this land.

The **CHAIRMAN**. Do you have consumption there?

Mr. **BROWN**. No. As far as my experience has gone, my health and that of my family has been better than it was in California, although I resided there a good many years.

STATEMENT OF J. H. STOUT, OF FLORENCE.

The **CHAIRMAN**. You may make a statement of what you know of this matter.

Mr. **STOUT**. I came out here last year for my health. I used to be the agent here for all the Indians in the Territory. I wish to say that the land is not better in Florence than it is in Phœnix, though the water is infinitely better. The water at Phœnix is brackish, and at Florence it is fresh. That is all I wish to say.

STATEMENT OF J. N. HURLEY, OF FLORENCE.

The **CHAIRMAN**. You may make a statement with regard to the irrigation about Florence.

Mr. **HURLEY**. The Gila River has two sections, the upper and the lower. The upper Gila River extends from the Black Range of mountains westward to the Buttes, some 400 miles; the lower, from the Buttes to the confluence with the Colorado River. These two sections, geographically, geologically, and climatic, you may say, are very different. In the upper portion a large area is covered with vegetation and timber growth, from mere brush of various kinds in the low lands to the most gigantic pines in the Black Range and Pinos Altos Mountains. In that portion of Arizona farming can be conducted without irrigation, having large rains in the summer season and heavy snow-falls in the winter. I have seen 3 feet of snow on a level. In the western portions all farming is conducted by irrigation, the rain-fall not having been sufficient to produce crops in any year from 1870. The upper portion of this lower section is the one in which I am interested. We have a large number of water-rights already established, and I file with you a map of the Territory, showing these water-rights at Mesa, Phœnix, and Florence. They are marked in red lines on the map. This map also shows the proposed reservoir site at Butte. That is marked in red. It also shows a proposed canal from that to the land that it covers. At Florence and in its vicinity we have water-rights that, including the Indian lands, are sufficient to irrigate, if properly cared for at this time, about 300,000 acres of land. Probably 50,000 acres of that are in the Indian reservation. Much of the land is not cultivated at this time, nor is it cleared up.

The gentlemen who have been examined filed a map showing this reservoir site at Butte, and I will file another that simply illustrates the same thing, but it will supplement the other. There can be constructed there a reservoir of large dimensions, at a distance of about 30 miles from Butte and the mouth of the San Pedro. This cañon varies in width from a quarter of a mile to a mile near Butte, and 4 miles long, with several cañons coming into it at various places. That reservoir will furnish water enough to irrigate a very large portion of the land that the gentlemen have referred to, south and west of Florence. The water-shed of the Gila River extends from Butte to the Black Range. Map No. 2, I file, shows this. In the Black Range and Pinos Altos Ranges there are unsurveyed lands with timber on them; but under existing regulations in the past years the timber has been cut off and destroyed, immense quantities of it, which is said to have been used in the construction of railroads, though taken ostensibly for mining purposes. There has been a large number of saw-mills running there, and they have destroyed vast quantities of timber. If that continues it will destroy our water-shed. Therefore the protection of this timber on the mountains is very desirable, the land not being fit for farming land. I would say that the Gila River has two annual rises; one in July and August, from the rains in the mountains, and one in February and March, from the melting snows in the Black Range of mountains.

The report submitted by Mr. Guild is as follows:

To the Special Senate Committee on Arid Lands:

SIRS: The undersigned committee, appointed by the board of supervisors to furnish data concerning the resources of Pinal County for submission to your committee, have been unable, through lack of time, to compile as complete a report as the importance of the subject demands, but beg leave to present the following statement of facts, with accompanying maps and photographic views, and to state that at a future date a more complete report will be submitted for your consideration.

We have the honor to be, with greatest respect,

RICHARD E. SLOAN, *Chairman.*
WILLIAM E. GUILD, *Secretary.*
JAMES M. HURLEY,
PETER R. BRADY,
WILLIAM H. BENSON,
JOSEPH H. KIBBEY,
GEORGE W. BROWN,
Committee.

FLORENCE, ARIZ., *August* 31, 1889.

POLITICAL ORGANIZATION.

Pinal County was originally formed from portions of Pima, Maricopa, and Yavapai Counties by act of the legislative assembly of the Territory of Arizona, approved February 1, 1875. In the year 1881 the Territorial legislature passed an act organizing the county of Gila from portions of Pinal and Maricopa Counties, leaving Pinal County bounded and described as follows, to wit:

Commencing at a point where the eastern line of range No. 1 east intersects the second standard parallel south, being the southeast corner of Maricopa County; thence east on the second standard parallel south to a point where such standard parallel south intersects the eastern line of range No. 18 east; thence north on the eastern line of range No. 18 east to a point where such line intersects the Gila River; thence down the Gila River to a point at the junction of the Gila River with the San Pedro; thence in a direct line to a point 250 yards east of the place where the Mineral Creek Mill stood in February, 1881; thence in a direct line to a mountain known as the "Water Shed," which lies about one-half mile east of Pinal Ranch; thence to a point where a direct line drawn from the Water Shed Mountain to where the mouth of Tonto Creek intersects the northern line of township No. 1 north; thence west on the north line of township No. 1 north to a point where such line intersects the eastern line of range No. 7 east; thence south on the eastern line of range No. 7 east to a point where such line intersects the southern line of township No. 2 south; thence west on the southern line of township No. 2 south to a point where such line intersects the Gila River; thence down the Gila River to a point where such river intersects the eastern line of range No. 1 east; thence south on the eastern line of range No. 1 east to a point where such line intersects the second standard parallel south to place of beginning.*

By reference to the map it will be seen that Pinal is one of the central tier of counties, which embrace the largest area of farming land in the Territory. It contains 5,368 square miles or 3,435,520 acres, one-third of which could be made productive by a systematic storage of the surplus water now running to waste.

The Gila River enters Pinal on her eastern boundary, flowing southwest for 20 miles, where it is joined by the San Pedro River, which enters the county at its southeast corner. From the point of conjunction the river flows in approximately a western course for a distance of 82 miles to the western boundary of the county.

The San Pedro Valley lies on both sides of the river of that name and is 40 miles long by an average width of 2 miles. Not more than 10,000 acres of this valley have been put under cultivation.

From a point on the Gila River 5 miles west of the mouth of the San Pedro for a distance of 25 miles no farming is attempted on either bank of the river, and could not be made profitable if so attempted, owing to the narrowness of the valley, which in this place takes the form of a gorge varying in width from 1,000 feet to 2 miles, its narrowest point being at the buttes 15 miles east of Florence. From this point the Gila Valley proper begins and widens out rapidly, embracing all of the western portion of the county.

This valley can be irrigated from a storage reservoir located at the buttes economically and with an unfailing supply of water.

It embraces an area of 921,600 acres of irrigable land, the title to 90 per cent. of which remains in the United States Government. This land would come into market immediately should the Government take measures to supply it with water.

The population of Pinal County at the present time is about 5,000, but with the whole of the Gila Valley under cultivation it would support an agricultural population of 50,000 people, with an equal number in her cities and villages.

The following shows the assessed valuation of property for the past three years, with rate of taxation:

Year 1887, assessed valuation, $1,701,802.48; rate per $100 valuation, $2.70. Year 1888, assessed valuation, $1,830,170.30; rate per $100 valuation, $2.63. Year 1889, assessed valuation, $1,813,135.62; rate per $100 valuation, $2.75½.

It is confidently asserted that should the whole of the Gila Valley be put under a moderate degree of cultivation the assessed valuation of property would be increased to $20,000,000 and the rate of taxation correspondingly lowered.

PRODUCTS.

But very few years have elapsed since the industry of the farmer in this valley was solely directed toward the production of the few simple requisites of home consumption, and if its horticultural possibilities were thought of at all they intruded as pleasant dreams only.

Beyond the production of hay and cereals little advance was made until a few years ago, when experiments in fruit-culture were undertaken in a small way and with varied results.

Sufficient is now known to form the basis of intelligent calculation of the desirability and value of the many species in cultivation for the guidance of those about to cultivate land.

The grape is especially adapted to this soil and climate, and it reaches almost perfection in quantity and quality of growth. Unusual saccharine qualities are developed, which are especially desirable for table use and in rasin-making. Nearly every variety of grape so far tested grows luxuriantly in this valley, and it is clearly evident that raisin-culture is destined to become a prominent industry of the valley. Two and often three crops of grapes grow in a single season, and ripe grapes have been picked from the vines in limited quantities early in January, but such incidents are rare. The fig thrives remarkably well, bears heavily, withstands neglect, and is a source of great profit to growers. From two to four crops per year are gathered. It bears the second season and sometimes the first from the cuttings.

The apricot, peach, plum, prune, nectarine, pear, early apple, quince, mulberry, date, pomegranate, cherry, and all the small fruits and berries are grown, while almonds, walnuts, and pecans thrive exceptionally well. Culture of the citrus fruits has been undertaken only recently, and at this time it promises to become a success.

---

*Section 12, paragraph 366, Compiled Laws of the Territory of Arizona.

Several orange orchards will be planted the coming winter, and it is believed that a little care during the first season will insure their growth.

The absence of fogs and nightly dews is a formidable obstacle to the existence of the destructive and unsightly scale bug, and the fruits of this valley are all bright and clean.

The season is several weeks in advance of that of southern California, which gives fruit-growers an appreciated advantage in the early markets. All the usual agricultural products of the temperate zone are easily produced here, the long seasons giving a succession of crops that double or treble the productive value of the land. Wheat and barley are largely produced, although they are amongst the least profitable crops under the irrigating system. A careful estimate of the cost of carrying through to a marketable condition a field of wheat or barely, including rent on the value of the land, fixes $13 as the average.

Wheat yields about 1,500 pounds per acre, and therefore costs 85 cents per cental, and barley yields about 1,800 pounds per acre, and costs 75 cents per cental, leaving a very slight margin of profit.

Alfalfa is the most productive and profitable forage plant in the valley, and produces, under different conditions, from 1 to 3 tons of hay per acre at each cutting, and from four to six cuttings per year.

It costs to produce a cutting of alfalfa after it is well established as follows:

Irrigating per acre	$1.25
Cutting	.50
Stacking	.75
Cost per acre	2.50

In exceptional instances as high as 4 tons of alfalfa hay per acre have been cut, and five or six cuttings made in a single season, but this is more than double the average.

The home market afforded by the adjacent mining camps has consumed the surplus products of the valley in past years, but the constantly increasing acreage coming into cultivation will encourage the exportation of the large fruit product that must form the principal industry of the valley.

MINERAL HILL.

Going northwest from the town of Florence the course of the Gila River is traversed for some miles over an alluvial soil well watered and under cultivation. After leaving the river the country becomes broken into small hills of alluvial wash and conglomerate; the foot-hills proper of the mountains are underlaid with granite, through which veins of quartz traverse in a northwesterly and southeasterly direction. This quartz is associated with a high grade of cuperiferous ore.

The heart of this district where the mines are situated is porphyry, which has been pushed up through the granite underly, forming hills of very precipitous and rugged character in which the mineral-bearing leads are situated, having a trend from northeast to southwest, are well defined and in place, and can be followed with ease by their croppings which are very prominent to a great distance. These croppings are of quartz and iron and in many instances project themselves above the surface several feet in height. The district is remarkable from the ease by which a lead can be followed, in many instances some thousands of feet. These croppings are of themselves valuable ore, and are an unerring index of what exists underneath the surface.

In all instances the formation and leads are solid and in place, requiring little or no timbering; their position is such that they can be attacked easily and economically by either tunnel or level. Both formation and leads are very near a vertical, having but a slight pitch or inclination; the surface is covered to some extent with brush and grass with a plentiful supply of scrub timber sufficient for all fuel purposes. Mineral Hill presents the appearance of an immense porphyry out-crop surrounded by a semicircle of granite and syenite reaching from the northwest to the southeast of the district, cut by gulches of varying depth, in the principal ones of which there is running water most of the year.

IRRIGATING STATISTICS.

Practically, in Pinal County there are two irrigation districts, the Gila, above Florence, and the San Pedro country. I inclose a pencil tracing showing the relative location of the various ditches in and around Florence, prepared by Joseph H. Kibbey, superintendent of the Florence Canal Company, to whom I am indebted for the following data concerning irrigation in this county.

Beginning just below the cañon, about 12 miles above Florence, the ditches occur in the following order:

Name.	Length.	Acres.	Name.	Length.	Acres.
	Miles.			*Miles.*	
On the north side—			On the other side—		
Moore's	3	300	Brash	4	400
McClellan	3	300	Florence	43	60,000
Sharp	3	160	Montezuma	6	1,000
Stiles	4	300	Pat Holland	7	1,000
The Swiss	2	200	Alamo Amarilla	7	1,000
			Brady	4	1,000
			Adamsville	4	1,000
			White	3	200
			Walker and Dempsey	3	300

All the above ditches are private property, except the Florence, Montezuma, and Alamo Amarilla, which are incorporated.

There are three private ditches on the Gila above Riverside and below the San Pedro, as follows:

Name.	Length.	Acres.	Name.	Length.	Acres.
	Miles.			*Miles.*	
Shields	2¼	480	Brennaman & Co.	1½	320
Winkleman	1½	480			

On the San Pedro, west side, and in their order up stream, are the following ditches:

Name.	Length.	Acres.	Name.	Length.	Acres.
	Miles.			*Miles.*	
Lattin	1	80	Bates	1½	160
Harrington	1¾	480	Pusch	2	640
Swingle	2	480	Dodson	2	320
Waterman No. 1	1½	320	Cook	1½	200
Waterman No. 2	1½	320	Brown	1½	160

These are all private ditches. About half of the land covered by the above ditches except the Florence is in actual cultivation. The Florence Canal Company has a capital stock of $500,000. The canal emerges from the river at a rocky point about 1½ miles below the cañon known as the Buttes. Eighteen miles of the main canal have been constructed and contracts for the remaining 15 miles have been made. Fifteen miles of laterals and service ditches are constructed. The main canal has a capacity equal to a flow of 440 cubic feet per second, and is so constructed that it can easily be enlarged and its capacity increased.

The company contemplates the building of storage reservoirs, one of which, at least, will be completed this summer. It will be situated about 15 miles south of Florence, will cost $100,000, and have a storage capacity of 8,000,000,000 gallons of water. There is a large catchment basin tributary to the reservoir, so that, with little trouble or expense, the reservoir can be filled at least once and possibly twice a year, independently of the river supply. There is in cultivation under this canal 6,000 acres.

The Florence Canal Company has in contemplation, as a part of its system, the construction of two reservoirs, one for storage purposes, about midway of the line of their canal, the other at the Buttes by means of a dam. This, however, will in no manner interfere with the construction of more extensive works that will furnish an abundant supply of water for a very large area of land not reached by their canal.

Adjourned.

The following statements were received and ordered filed:

REPORT FROM YAVAPAI COUNTY.

[Filed by the Governor, Hon. Louis Wolfley.]

In compliance with the request made by you in your letter dated June 3, 1889, the board of supervisors of Yavapai County issued a circular through the daily press, a copy of which is hereto annexed. The board regrets to say that not a single reply has been received by it from any individual or district directly interested in irrigation. The report of Lieut. A. O. Brodie, engineer in charge of the Walnut Grove Water Storage Company's property in this county, is herewith forwarded to you, with the prints accompanying the same. Will you please place them before the Senate committee?

Lieut. W. A. Glassford, United States signal officer, informs the board that all the information he is able to give has already been placed in your hands.

The lack of interest shown in this matter by the people of Yavapai County should not be taken as an indication of a lack of storage facilities nor of a scarcity of land which can be irrigated and be made valuable.

It is probably presumed that the natural advantages of Yavapai County and the necessities of the southern counties will cause the Senate committee to investigate for itself the vast possibilities which now lie dormant in our mountains and valleys.

The board of supervisors beg leave, through your excellency, to extend to the Senate committee a cordial invitation to visit the city of Prescott and county of Yavapai, and if this is accepted will place at the disposal of the committee every facility to enable it to investigate the subject-matter.

STATEMENT OF ALEXANDER O. BRODIE, OF SAHUARO, CHIEF ENGINEER OF THE WALNUT GROVE WATER STORAGE COMPANY.

[Made to the board of supervisors of Yavapai County.]

In reply to a communication from the clerk of your board of date August 7, 1889, containing copy of certain proceedings of the board, I have the honor to submit for your consideration the following remarks on water storage in this Territory, as exemplified in the successful establishment of a dam and reservoir by the Walnut Grove Water Storage Company.

This company has constructed on the Hassayampa River, 35 miles distant from Prescott, a dam of granite with outside walls 12 feet thick, the center being filled with loose rubble stone, covered on the upstream face with a skin of two thicknesses of 3-inch plank, a layer of tarred felt being placed between the two, the outside layer being thoroughly caulked and painted with paraffine paint, the joint along bed rock and at the ends being thoroughly cemented with hydraulic cement. This dam is 110 feet high, 135 feet thick at base, 12 feet thick, and 410 long on top line, and is built in a thoroughly solid and stable manner.

The water is carried through the dam for use by two 20-inch pipes placed in a tunnel cut through solid rock 80 feet below the top of dam, these pipes opening from a perpendicular tower, built out from the face of the dam, of 8 by 8 timbers well bolted together, with gates which can be closed at will, enabling the pipes to be cleaned. A waste-way has been cut through rock at the west end of the dam of dimensions 5 by 25 feet to carry off the overflow.

The batter, on the up stream face of the dam, is 68 degrees, with an apron or offset at 12 feet below the lower gate in the tower. About 9,000 yards of loose rock has been placed behind the dam and against the lower face as a precautionary measure.

The reservoir formed by the construction of this dam, when full, holds 4,444,534,864 gallons of water, covers an area of 527½ acres, and receives the drainage of about 500 square miles of territory, mostly in a mountainous country subject to heavy snowfalls in the winter and to heavy showers during the summer months. Floods will fill the reservoir full at least three times during the year. The water-shed being of mostly bare of granite mountains, the water from melted snows and rain-fall very quickly finds its way to the river and is impounded in the reservoir.

Under ordinary circumstances the Hassayampa is but an insignificant stream, but rises to grand proportions during a heavy freshet.

The primary object in the construction of this dam and reservoir was to hydraulic certain bars on the lower river, with the ulterior one of conducting the water stored out on the desert for irrigating purposes. The successful prosecution of the work has shown conclusively what can be done in the way of water storage in Arizona, as it is to be supposed that that which can be done on one small stream subject to freshets can be done on almost all others, reservoir and dam-sites being equally available.

This company is at present engaged in the construction of a service dam 14 miles below the reservoir, to which point the water is allowed to flow down the river-bed, when it is to be raised 32 feet into a flume.

I have not in my possession sufficient data from which to give the cost of construction of the main dam, but should judge that it would reach to nearly half a million dollars.

Any extended system of irrigation inaugurated in this Territory must almost wholly, from the nature of the country, depend upon water storage for its success. Artesian water may yet be found, though it is doubtful, while pumping water from wells for the purpose of irrigation is a costly experiment.

All streams flowing from the mountains to the plains are subject to heavy floods, the waters of which if stored in proper reservoirs would be sufficient to reclaim many thousand acres of desert land, utterly worthless without irrigation. Such a system inaugurated on the Agua Fria would reclaim land equal to any in the Territory. On this stream and its tributaries three large reservoirs could be constructed, from which the water would flow in the river-bed to the head of the necessary canal, at which point a small service dam would divert the water from the channel into the canal and thus to the land to be reclaimed.

Suitable sites could be selected on the Verde, the Salt, Tonto Creek, the Gila, and the San Pedro for reservoirs, which, if constructed and the water flowing in these streams during floods, now going to waste, impounded, would more than quadruple the amount of water now taken from them for irrigating purposes. Nearly all the available land in Arizona can be reclaimed by a proper system of water storage.

STATEMENT OF EDWARD B. MOSELEY, ASSISTANT SURGEON U. S. ARMY, OF FORT WHIPPLE, PRESCOTT.

In the popular mind the name of Arizona has been so long associated with torrid heat, lawless whites and hostile Apaches, venomous reptiles and poisonous insects, that anything that may be said in favor of this Territory as an agricultural region will be received with doubt and considered with prejudice. It is a fact, however, that large portions of this Territory have advantages in salubrity of climate and productiveness of soil so great that in time a great and prosperous community will live and flourish in what is now popularly known as the desert. These changes have already commenced, and, destined to rapid increase, have been effected by means of irrigation or the artificial application of water to the soil. It is the oldest system of tillage known to man. The water being at all times under the control of the cultivator, lands where this system is pursued support a dense population, for there is no failure or partial failure of crops. Through irrigation 9.000,000 acres of land in Algeria have within a few years past been reclaimed, and the arid belt of Arizona, long known as part of the Great American Desert, is rapidly being changed into a great farming and fruit region. Those who have not seen or studied irrigation have no idea of its advantages. Any farmer would consider the value of his land doubled if he could have the power to cause the rains to come to his fields in such quantities and at such times as he should direct. Almost exactly this power is held by the cultivator who lives in an arid region. He makes his own weather; he is almost independent of the clouds, as far as his own particular portion of the country is concerned. The water he uses is annually gathered from the sides of the mountains, scores and hundreds of miles away. This is an established fact. There are now thousands of acres, principally in the valleys of the Salt and Gila Rivers, bearing crops that rival in luxuriance those of the valley of the Nile. The amount of land which will be reclaimed in the counties of Maricopa, Pinal, and Yuma when the canals now in process of construction are completed, will probably approach 1,000,000 acres. How far the water-supply can be extended is a matter of much importance. In India and Spain one-third of the arable lands are cultivated by impounding the waters of the storm floods. Thus far, with the exception of the water-storage reservoirs built at Walnut Grove, Yavapai County, nothing has been done in this direction in Arizona.

The Gila and Salt Rivers during the flood season pass enough water into the Colorado River to increase the amount of reclaimed land three or four fold. In both these rivers are cañons which make almost natural storage reservoirs where, by building dams, the flood-water could be impounded and made to do its duty in adding millions of acres to the arable dominion of the Territory. On this subject I quote Lieutenant Glassford, of the United States Signal Corps, who says:

"The table of the average monthly rain fall shows the distribution to be plenty in the mountains and almost none in the so-called desert valleys. It should not fail to be noted in connection with the rain-fall that the points of observation are not on the tops of the mountains nor high up on their slopes, but in the most cases in valleys or cañons. It is no uncommon sight to observe heavy rains on the summit of ridges, and from them flows great volumes of water, while at the point the rain-guage is located perhaps not a sprinkle would fall. It is for this reason that the data only represents the least approximate quantity of the actual rain fall. Admitting that sufficient water falls upon the elevated plateaus of Arizona, it remains only to collect it in reservoirs and distribute it by canals to change the delusion of the mirage into the actual delights of the oasis. The observing traveler is also forced to note the jutting stone walls of cañons, forming natural abutments for storage dams, between which these mountain streams flow. By artificially completing these partial dams the immense supply of water that now pours in floods and later sinks in sandy channels would be preserved for the soil that only awaits its influence to bring forth abundant harvest."

The productions of these arid or desert lands when artificially supplied with water include every variety of vegetation, cereals, grasses, fruits, flowers, trees, shrubs, and vegetables known to the semi-tropical zone. There is not a month in the year when fresh vegetables and fruits can not be had in the Salt and Gila Valleys.

Grain yields from 2,000 to 3,500 pounds per acre; deciduous fruits from three to four years old an average of 300 pounds per tree; and all fruits ripen in this section from two to four weeks earlier than in Southern California. Grapes are especially a productive and profitable crop. In Yuma and Maricopa Counties they ripen several weeks earlier than in California, while the yield is fully as large. The climate is particularly adapted to the production of raisins, owing to the absence of rain, fog, and dew during the drying season, and many thousands of raisin-grape vines have been set out during the past two years. Alfalfa, being the most profitable, has supplanted all other grasses. Besides the large quantities grazed there is cut in the Salt River valley annually 60,000 tons, which is fed to cattle on the spot or shipped to supply the different towns and mining camps in the Territory. With additional railroad facilities this crop will be much increased.

Irrigation is no new thing in Arizona. The recent developments made by Mr. Frank Cushing, under the authority of the Smithsonian Institution and the patronage of Mrs. Hemingway, of Boston, proves beyond question that, centuries ago, the Salt River Valley contained a population of probably 300,000 souls supported by agriculture. There can be traced to-day upon the surface their ancient water-ways, through which in the past water was applied to the soil of that valley, and by farming support was furnished to over a quarter of a million people. The valley of the Gila shows the remains, if anything, of larger and more elaborate systems of irrigation. Thus is established that the agricultural resources of Arizona were recognized and utilized by a pre-historic race of industrious and progressive people. It has been estimated that in the valleys of the Colorado, Salt, and Gila Rivers there are fully 2,000,000 acres of arable land. These rivers carry an abundance of water to reclaim all these lands, but irrigating canals and storage reservoirs must be constructed.

It is gratifying to note that Congress has taken action on the subjects of irrigation and the reclamation of desert lands by making an appropriation to commence surveys for the establishment of locations for storage reservoirs and canals. This is a most important question, vitally affecting the future of Arizona. There are here fully 25,000,000 acres of land, the most productive on the continent, which, if they can be reclaimed, will make homes for 1,000,000 people. The remarkable fact that agricultural land is actually becoming scarce in the United States is at last becoming apparent, and the assistance of the General Government in bringing the so-called desert lands of the Southwest into a condition to support in comfort, by agriculture, a portion of the crowded population in the eastern portions of the country is greatly needed. Great advances have been made by the enterprise of the citizens of this region who have by their labors under great difficulties turned a portion of the desert into an oasis, but to fully develop the country is required the expenditure of large amounts of money in the building of storage reservoirs by means of which the lands already redeemed can be preserved from the effects of occasional mid-summer droughts, and many thousands of additional acres put under cultivation and made the homes of man. The establishment by the Government of the facts that the precipitation of moisture during the year is sufficient, if preserved and used for irrigation during the dry season, to make an absolute certainty of all crops that were put in and the location of the proper places for the dams to hold this great supply of water that now goes to waste would result in the erection of these works by capitalists from other sections of the country, foreign capital being now timid and the enterprise being too costly for the energetic and hard-working population who have settled in and, so far, remarkably developed the country by the canal systems which have been within their ability to perfect.

The Indian question, so long the bugbear which prevented the development of this Territory, now happily quieted by the successful exertions of the Army, would become entirely a thing of the past were the desert lands placed in a condition to support the population of agriculturists that would so rapidly flock to them were the internal improvements in the way of reservoirs and canals completed that have been so well commenced by the act of Congress in providing for the preliminary steps of survey and hydrographic engineering.

TUCSON, ARIZ., *September* 5, 1889.

The committee met pursuant to call of the chairman.

Present: Messrs. Stewart (chairman) and Reagan; also Director Powell.

STATEMENT OF F. H. GOODWIN, OF TUCSON.

The CHAIRMAN. Have you made any report with regard to irrigation in this Territory?

Mr. GOODWIN. Yes.

The CHAIRMAN. Have you it here?

Mr. GOODWIN. Yes.

The CHAIRMAN. Will you file it with the committee?

Mr. GOODWIN. With your permission, I will do so.

The CHAIRMAN. State generally what the report contains.

Mr. GOODWIN. It contains the opinion of our people as to the possibility of the reclamation of our arid lands, what the land produces when irrigated, and the fact that it has no value without irrigation. It also shows the feasibility of locating sites for reservoirs, and gives the results of fruit planting in the portions of the county irrigated.

The CHAIRMAN. What streams have you in this county?

Mr. GOODWIN. We have besides the Santa Cruz—our most important river—a small mountain stream in the southern portion called the Sonoita. It carries a good deal of water at flood seasons. There is also the Arivaca and the Babaquivari.

The CHAIRMAN. Is there much irrigation going on in the county?

Mr. GOODWIN. Comparatively little. We have probably 4,000 acres of land that could be irrigated, and have nearly that much under irrigation.

The CHAIRMAN. What crops do you raise here?

Mr. GOODWIN. Without irrigation we raise none; with irrigation we raise corn, barley, rye, wheat, alfalfa, lucern, potatoes, beans, and sorghum; in fact, all the grains, and all sorts of fruit from the peach to the olive, and all kinds of berries.

The CHAIRMAN. Do you raise oranges here?

Mr. GOODWIN. Yes; we have here, within 15 miles of this town, oranges growing nicely, but they are an experiment yet. We can not say that we grow oranges, but we know that the other fruits produce large crops.

The CHAIRMAN. Does your report designate the points where water could be stored?

Mr. GOODWIN. Yes; not so fully, though, as we intended, because the time given was short. We have surveyors, however, now looking for locations, and we propose to forward to your committee hereafter the information they obtain, if we are permitted to do so.

The CHAIRMAN. We would be glad to receive it. Are those locations for reservoirs on public or private land?

Mr. GOODWIN. On public land, as we understand it. One portion of the basin will probably cover land for which the United States has given a patent to an individual. We have thirty-six irrigating ditches covering 3,000 acres of land, aggregating 56 miles in length. There are several canals now in course of construction. Two of them are of considerable magnitude. One is at Santa Cruz and one near town. We expect to irrigate all this table-land that you see around here.

The CHAIRMAN. Has irrigation ever been practiced to a larger extent than it now is by the people who resided here before?

Mr. **Goodwin**. Yes; we find the ruins of their canals, ditches, and reservoirs everywhere. On my farm the lines of the old irrigation works traverse quite a considerable part of it. I sold my farm recently, however, and should not now speak of it as mine. The water taken on it is taken from the Santa Cruz, but evidently the water taken on it in past ages was water from the plain.

The **Chairman**. Have you any evidence as to the period of time when those ancient works were constructed?

Mr. **Goodwin**. No; though we know that it must have been in the stone age, as we find implements of stone—the axe and hammer, etc.

The **Chairman**. Are there any traditions among the Spaniards here as to the irrigating works?

Mr. **Goodwin**. None whatever. They were built by a race entirely unknown to the Indian tribes who now inhabit this country. The Mexicans have no traditions whatever on the subject. There are no remains except the hieroglyphics on the rocks and the stone implements to which I have referred.

Senator **Reagan**. Has anybody ever been able to interpret those hieroglyphics?

Mr. **Goodwin**. No. You find the hieroglyphics all around here, some of them on the edge of Tucson, half a mile from the city.

Senator **Reagan**. Then, from the ruins which you say exist, it is probable that this part of the county was once densely populated?

Mr. **Goodwin**. We hold that all this valley and all this table-land at one time supported a dense population. We have irrigating ditches that were originally created in 1690.

Senator **Reagan**. Does the land produce as good crops as it ever did?

Mr. **Goodwin**. Yes; I think better.

Senator **Reagan**. There is no failure of crops?

Mr. **Goodwin**. None, when we have water enough.

Senator **Reagan**. Have you made an estimate of the amount of land about this valley that can be irrigated?

Mr. **Goodwin**. Yes; we think about 2,000,000 acres can be irrigated. We take our estimates from the surveys made by the United States surveyors. Where the land has not been surveyed we take them by general measurement.

Senator **Reagan**. You think you have water enough to irrigate that much?

Mr. **Goodwin**. Yes. It was done before. The lines are plain to show where it was done. In very few instances can we trace the canal to its source—to the reservoir where it was filled.

Senator **Reagan**. What amount of wheat can you produce here from irrigated land?

Mr. **Goodwin**. Thirty to 40 bushels to the acre. Under favorable conditions we can produce 40 bushels.

Senator **Reagan**. State what you get of cereals and other crops?

Mr. **Goodwin**. We get 400 bushels of potatoes to the acre, 50 bushels of corn, 40 bushels of wheat, and 40 bushels of barley under ordinary cultivation. The yield would be greater with improved implements and conditions. I desire to state that we here hold that our country is peculiarly adapted to the growing of fruits—the peach, apple, quince, pear, pomegranate, and olive—in fact all the fruits that grow in tropical countries; and our fruit has as good flavor as any fruit ever eaten.

The following is the paper referred to by Mr. Goodwin:

REPORT ON PIMA COUNTY.

The citizens of Pima County, Ariz., have the honor to present to you the following facts and statistics in connection with the reclamation of arid lands in this county. Examination shows conclusive evidence that all level lands in southern Arizona have at one time been cultivated under a system of irrigation by storage of water in reservoirs, the remains of which, as well as of the ditches and canals conveying water onto these lands, are yet to be seen and can be traced for long distances. And at this day, when the farmer commences the cultivation of new lands, his plow turns up stone implements used by a long-gone race of men, who tilled the soil which we now use, seeking to reclaim again from the desert. The ax, hammer, lamp, and the hand-mill, etc., of stone, and the earthen vessels for household purposes are common and can be seen in almost every house. Beyond all question the whole of southern Arizona teemed with a dense population whose pursuits were wholly agricultural. The arid lands of our county were cultivated by a people who thoroughly understood the value of irrigation. Who they were we know not. The only record left by them is the remains of their canals and reservoirs and the hieroglyphics on the rocks, which doubtless, if they could be deciphered, would tell of a prosperous people. The skilled engineer of to-day finds in constructing his ditches and levels frequent occasion to utilize the labors of this long-forgotten people, who carried water where he now seeks to do the same.

The climatic conditions of southern Arizona are such now as doubtless they were then, that without irrigation agricultural pursuits can not be followed. This fact was recognized by the missionary fathers, who in the year 1690 settled in this valley. They, before building churches, taught the Indians how to build dams and reservoirs, three of which—El Cumoso, Missional, and Del Rey—are in use to this day, irrigating in part the same lands which have been under continuous cultivation for two hundred years. Much of this land has grown two crops each year during the whole period.

There are in the valley of the Santa Cruz River and on the table lands lying in the great basin between the Santa Rita Mountains on the south and the Rincon Mountains on the east, the Santa Catalina Mountains on the north and the Amole and Sierrita Mountains on the west, over 1,000,000 acres of arid land which are arable and can be brought under cultivation by making dams at points which are more fully shown by maps and measurements made by this committee for your information. We call your attention especially to the map of a proposed dam at a point about 25 miles southeast of Tucson, which alone, if built, will bring under cultivation more than 100,000 acres of good land which now lies idle and unproductive. All this land is now of practically no value, as no crop can be grown thereon without being irrigated.

Sites for reservoirs can be found at various points on the east and west sides of the Sierrita Mountains. There is a very fine site for a reservoir northeast of the United States military reservation at Fort Lowell, 7 miles from Tucson, at the Sabino Cañon, which has storage capacity for several billion gallons of water, sufficient to irrigate all the land lying to the east and north of Tucson, in the basin spoken of before.

This committee finds by consulting the best authority (United States surveys as far as made and by measurements where not made) that there are over 2,000,000 acres of the best of land in this county lying idle for the want of water to irrigate it. That this water can be stored there can be no doubt. The average rain-fall for five years, as shown by the report of Mr. E. R. Wetmore, in charge of the United States meteorological station at Tucson, is 11.71 inches in the valley. The precipitation on the mountains is more than four times as great as it is in the valley, where the station is established.

The probable cost of constructing dams, reservoir, and canals to bring these lands under cultivation will not exceed $1,000,000. The lands at present are of no value, but if by means of storing the rain-fall they can be irrigated they become at once valuable for all times. Our lands are adapted to the growth of all the fruits of the temperate and semi-tropical regions. The peach, pear, apricot, nectarine, pomegranate, apple, quince, fig, olive, and the plum do exceptionally well and produce the best of fruit, which ripens a month earlier than in California. The grape grows thriftily and often gives two crops per year, and ripens at a time when we have no rain, so enabling us to convert the grapes into raisins at a nominal expense. Under favorable conditions the product of lands well cultivated is as follows: Barley yields 50 bushels per acre, wheat yields 30 bushels, and corn 50 bushels per acre, potatoes 400 bushels, and beans 40 bushels per acre. Barley and wheat when sown for hay return an average of 2 tons per acre. Alfalfa (lucern) after being well set, can be cut six times per year, yielding in the aggregate 12 tons per acre. Hay is worth $12 per ton; grain 90 cents per bushel, and potatoes $1.20 per bushel.

If the Government will make the necessary surveys and withdraw from entry and settlement only the lands embraced in the basins of the proposed reservoirs, private enterprise will, we think, soon solve the problem of water storage in Arizona, increasing the value of lands from nothing to an assessed value of $50 per acre. (The lands in the vicinity of Tucson, under cultivation, being irrigated, are now assessed for taxes at $50 per acre.) Where lands are thoroughly cultivated experience shows that 1 miner's inch is sufficient to irrigate 6 acres of land, which, when planted to grain, beans, hay, or fruits, need to be irrigated once in thirty days. For alfalfa land should, to produce the best results, be irrigated every fifteen days, requiring 1 miner's inch for every 3 acres.

The castor bean grows here to be a tree reaching 6 inches in diameter and a height of 15 feet, yielding 2½ bushels of beans to the tree. The tree, when protected, lives four or five years.

There are in all 12,000 fruit-trees in bearing, producing the best of fruit, full in size and delicious in flavor. There are 3,000 grape-vines in bearing, with 1,500 cuttings one year old. The grape comes into bearing in three years from the planting of the cutting and in two years from the planting of the rooted vines.

The culture of fruit in this county is an entirely new enterprise, and from the success attained by the experiments made bids fair to become one of the chief industries of this section.

In the valley of the Santa Cruz, from Calabasas to Tucson, there is under cultivation about 3,000 acres, yielding—

5,628 tons of hay	
844,000 pounds of corn	$67,536
1,374,000 pounds of wheat and barley	12,675
300,000 pounds of potatoes	20,601
280,000 pounds of beans	6,000
300,000 pounds of vegetables	8,400
26,000 pounds of red pepper	15,000
	1,680
Total value of product	131,901

On the Rillito Creek, east of Tucson, 500 acres of land are under cultivation, producing—

850 tons of hay	$10,200
265,000 pounds of barley	3,975
80,000 pounds of beans	2,400
100,000 pounds of potatoes	2,000
Total value of product	20,575

At Crittenden, Redington, and other points lands are cultivated to some extent with the same results as reported above. There are thirty-six ditches, of a total length of 52 miles, used in irrigating these lands. The above products were grown from July, 1888, to July, 1889. The grain and potato crops were planted in 1888, the hay 1889, as our lands produce two crops a year, sowing grain in December and January and corn, beans, and potatoes in July and August, harvesting hay and grain in May and June, and other crops in October, November, and December, excepting alfalfa hay, which is cut each month from April to September. During the months of October, December, and January alfalfa fields are pastured, it keeping green and growing slowly during three months. This crop is destined to be the great hay crop of Arizona.

This committee has received protests from prominent men in all sections of the county against the repeal of the desert land act, so far as Arizona is concerned. Arizona being wholly arid, and having been largely benefited by the reclamation of arid lands under this law, we most respectfully ask you to lend us your aid in preserving this law.

We append the report of one of our best orchardists, which gives in detail the method of cultivation and the product of fruit-trees in this section.

Respectfully submitted.

FRANCIS J. HEUEY, *Chairman.*
JOHN A. BLACK.
BREWSTER CAMERON.
F. H. GOODWIN, *Secretary.*

SAN RAFAEL RANCH,
Lochiel, Ariz., August 14, 1889.

SIR: Yours of the 13th instant just received. In the next mail I will send you all the data I can. Will copy down number and varieties of trees in the large orchard; also the number and varieties I have, how many in bearing, age, etc.; all of interest that I can. If there is any part you do not wish to use, cut it out.

One nectarine tree had on it, by actual count of Colin and myself, eighty-four nectarines, every one perfect; one, thirty-two, and seven other trees from one dozen up to two dozen. The largest nectarines measured 8½ inches around, from stem end to blossom end, and 7½ inches around the other way. I did not weigh any; am very sorry I did not. I think there are some pretty large ones on the trees yet. If there are, will weigh and tell you.

Four peach trees have quite a good many on; two not many. The ones on the four trees I think will be very fine in size.

I think it will be very interesting to know of the success of fruit-culture, etc., in our county, and after all is reported and gotten together I would be much pleased to know the result of inquiries.

Respectfully,

ALICE F. CAMERON.

HON. F. J. HEUEY,
Chairman Citizens' Committee, Tucson, Ariz.

San Rafael Ranch.

[Orchard planted by Mr. Brewster Cameron, 1888.]

Varieties.	Total.	Dead.
Apple (summer, fall, and winter)	34	None.
Apricot (assorted)	15	None.
Cherry (early and late)	12	None.
Fig (white Adriatic)	2	None.
Nectarine (assorted)	9	5
Olive	6	None.
Peach (early and late)	24	4
Pear (assorted)	16	1
Pomegranate (assorted)	8	4
Prune (assorted)	10	2
Quinces	2	None.
American mulberry	2	None.
Almonds	3	None.
English walnut	10	1
White walnut (butternut)	2	2
Filberts	2	None.
Italian chestnuts	2	None.
Pecan	2	None.
Total	176	20

[Fruit trees planted 1889.—Alice F. Cameron.]

Apple (summer, fall, and winter)	38	None.
Apricot	2	None.
Fig	5	2
Olive	1	None.
Peach (assorted)	6	1
Pear	5	None.
Plum	4	None.
Russian mulberry	1	None.
English walnut	3	None.
Paragon chestnut (American)	2	1
Total	67	4
GRAPE VINES.		
Eastern:		
Brighton	2	
Concord	2	
Warden	2	
Wyoming red	2	
Total	8	None.
California:		
Muscat of Alexandria	10	
Black Prince	4	
Golden Chasselas	3	
Total	17	2
Planted in 1889	92	6
Planted in 1888	33	None.
Total	125	6

[Fruit trees planted in spring of 1888.]

Governor Wood, in 1889 bore 1 pint very fine large cherries	1	None.
Sweet cherry trees, Napoleon	1	None.
Sour cherry trees:		
May Duke	1	None.
Empress Eugenia, in 1889, bore over 1 pint of finest large sour cherries I ever saw, rich and good	1	None.
Bartlett pear	2	None.
Peach	6	None.
Nectarine	9	None.
Peach or nectarine	12	None.
Total	33	None.

The above peach and nectarine trees I raised from seeds sent to me by General Simon Cameron, of Harrisburg, Pa. I received the seeds in the fall of 1884 and planted them at once (in September). The young trees came up in the spring of 1885. I cut them back and transplanted them in 1888. In 1889, at four years of age, nine of these trees bore as fine nectarines as I have ever seen or tasted.

NOTES ON FRUIT.

The color of fruit, a dark purple red; flesh, greenish white, very delicious. Pit quite small. The other trees ripened their fruit from one to two weeks later. Fruit yellow, shaded bright dark red; flesh yellow white, very slightly tinged with green; very fine.

June bugs, and a small bug or beetle, gray with some red on it, were very destructive to this fruit, eating voraciously at the nectarines as soon as they could find the fruit begin to soften. On two nectarines there were twenty-three June bugs caught and killed.

Six peach trees are now in bearing, raised from seed sent me by General Cameron. The fruit is very smooth, and increases fast in size—promising to be exceedingly fine fruit. The trees have been kept trimmed to low, bushy heads. Each year they will be trimmed back half of the previous year's growth. Without an annual shortening-in, the peach is a short-lived tree. To prune them carefully and judiciously keeps them in bearing many years.

I do not know the names of the varieties of the peaches and nectarines of which I planted the seeds, the trees from which are now bearing. General Cameron said that it was exceedingly fine fruit.

In this locality I find the mulberry, apricot, nectarine and peach trees, and grape vines, make the most luxuriant growth. (The apricot trees planted this year, 1889, have made a growth of very nearly 6 feet. The grape vines have grown some 4 feet, some 8 feet.)

Next follow the apple and cherry, figs, pear, and plum. English walnuts and the chestnuts grow rapidly. For every tree and vine I had holes dug 3 feet in diameter and 2 feet deep.

The climate and soil are fine, and will, with most ordinary care, produce a good crop of fruit each year after the trees come into bearing. With good care, watchfulness, and careful pruning, the fruit-yield will be simply enormous.

In California grape vines are so trimmed that they are self-supporting, no trellises being used as a general thing, the vine growing thick and kept to within a few feet of the ground, the bearing branches each year spreading out and drooping over, so that some of the bunches of grapes rest on the ground and ripen there.

This system of culture, I am satisfied, will not do for Arizona. The rainy seasons for California and Arizona come at a different time of the year. Our rains come when our grapes begin to ripen, or rather before, but last up to and into September. The ground is hot and moist; this with the midday heat will, I believe, rot every bunch of grapes that touches the ground. I think vines will do better trained up about 5 feet or even less. Posts and smooth wire will make good trellises.

I irrigate my fruit trees and vines with a hose in midsummer once every two weeks. In spring and early fall once a month.

No rose plants, even of the most delicate and tender varieties, need any winter covering. I have a bed of thirty choice varieties which bloom with great profusion from early April to late November.

ORCHARDS IN COCHISE COUNTY.

Three years ago Mr. William Graeff, who resides at the foot of the west Huachuca Mountains, planted seventy-five fruit trees and about thirty-five grape vines. This year the trees were heavily laden with fruit, except the apple and pear trees, which are slower in growing to maturity in this country, as well as in the east or in California. He planted apple, pear, plum, apricot, cherry, and peach trees.

Among the grape vines he has the flame-colored Tokay, Muscat of Alexandria, Black Hamburg, Mission, and White Hamburg. These grape vines were laden with magnificent bunches of as fine grapes as I ever saw or tasted anywhere.

Mr. Graeff pipes his water for irrigation from a spring about a quarter of a mile from his orchard. The water runs into two large wooden troughs, or as he calls them tanks, from there into his orchard; the water of course can be turned off or on at will in the orchard.

The apricot and peach trees yielded particularly large crops. The fruit was of large size and of the finest flavor.

About five miles farther north along the same range of mountains is a fine orchard of Messrs. William Simmons and B. F. Heslep. These gentlemen set out their orchard two years ago. They bought their trees in California. At the time of planting these trees were two years from the graft. The orchard consists of two hundred trees of the following kind: One hundred peach trees; twenty cherry trees; twenty pear trees; twenty plum trees; twenty apricot trees; twenty apple trees. The orchard is irrigated by water run in through shallow ditches from a spring quite close by. The holes for the trees were dug 2 feet deep and nearly 3 feet in diameter.

Remembering that this orchard was planted only two years ago it is simply astonishing what an enormous crop of fruit was harvested this year.

Among the peaches the early Crawford, and a superb white flesh crimson covered peach, were the best of the early variety. No California orchardist could possibly show better specimens of fruit of the varieties these gentlemen planted.

The land on which this orchard is planted was very stony, not only small stones but in many places good-sized rocks. Many wagon loads of rocks were hauled away and many remain, though more will be taken off. The land is fine and rich since irrigated.

Among the trees bearing fruit this year the peach and apricot bore the heaviest crop.

I believed that grapes must be grown on trellises in Arizona, owing to our rainy season coming at a different time to that of California, but since visiting Mr. Graeff's place I am convinced that trellises are not a necessity, as Mr. Graeff has his vines tied to stakes. The body stem of the vines is about 24 inches high; from this height of stem the yearly growth sprouts out and hangs over, umbrella shape.

The fruits of these two orchards were sold in Tombstone, Bisbee, Harshaw, and other places. Every pound of fruit brought 8 cents, whether sold at home at the orchard or taken away to be sold, and ready sale was found for every pound.

STATEMENT OF A. J. DAVIDSON, OF TUCSON.

The **Chairman**. What is your occupation?

Mr. **Davidson**. I have been constructing ditches, and working in that line.

The **Chairman**. Are you an engineer?

Mr. **Davidson**. Yes; a constructing engineer.

The **Chairman**. Are you familiar with the water courses of this district?

Mr. **Davidson**. Yes; I have made them a study.

The **Chairman**. And with the quantity of water?

Mr. **Davidson**. Yes. Most of these streams are underground.

The **Chairman**. From where does the supply come for the streams in this vicinity?

Mr. **Davidson**. From the water-sheds of the mountains.

The **Chairman**. Describe generally, and in brief, the water-sheds that supply these streams?

Mr. **Davidson**. Stating it roughly, the Santa Cruz water-shed is 120 miles in length by, perhaps, 60 miles in width. The Rillito has a water-shed of about 75 miles to 80 miles in length by 30 miles in width. Then there are smaller streams also.

The **Chairman**. What is the general altitude of the mountains that furnish these streams.

Mr. **Davidson**. Ten thousand to eleven thousand feet.

The **Chairman**. Does snow fall on them?

Mr. **Davidson**. Yes; in the winter time.

The **Chairman**. What is the amount of precipitation generally?

Mr. **Davidson**. 11.77 inches in the valley.

The **Chairman**. I mean how much in the mountains?

Mr. **Davidson**. We have no witnesses on that point.

The **Chairman**. You say most of those streams are underground. Explain what sort of streams they are?

Mr. **Davidson**. For instance, the Rillito has an average fall of 20 to 21 feet to the mile. Our process of taking out that water is by commencing at the surface, at a grade of 3 feet to the mile, and tapping this underground stream. We get a great deal of this water underneath. It is a problematical question as to how much is water and how much gravel underground, but we know there is a good deal of water.

The CHAIRMAN. What amount of water did you get in your experiments?

Mr. DAVIDSON. As far as we have completed the work we have 6.4 feet of water. These underground streams are quite wide. For instance, by running a line of levels we find that the Rillito is 1½ miles in width underground.

The CHAIRMAN. At what depth is it?

Mr. DAVIDSON. We generally encounter this water at the dryest time at from 5 to 9 feet under the surface. It varies, of course.

The CHAIRMAN. Then you are engaged in getting that water to the surface?

Mr. DAVIDSON. Yes.

The CHAIRMAN. What effect does evaporation have on those streams, they being underground?

Mr. DAVIDSON. We consider that the fact of the streams being underground is an advantage. It is a wise provision of nature that they run below. We have constructed 1,300 feet of concrete aqueduct, and we propose to extend that by redwood aqueducts. We will then have supply leads running into those aqueducts.

The CHAIRMAN. You will go to the bedrock?

Mr. DAVIDSON. There is no bedrock.

The CHAIRMAN. What is beneath the stratum that furnishes the water?

Mr. DAVIDSON. It seems that there is not even a rudimentary bedrock; there is not the commencement of a bedrock.

The CHAIRMAN. No clay?

Mr DAVIDSON. No; only in spots.

The CHAIRMAN. What holds the water, then, from sinking down?

Mr. DAVIDSON. This entire country here seems to be underlaid with gravel and sand.

The CHAIRMAN. To what depth?

Mr. DAVIDSON. We do not know.

The CHAIRMAN. Have you sunk wells to see?

Mr. DAVIDSON. Yes; and as deep as we go we find the same material. We have gone 16 feet below the lowest water level that we have—that is as deep as we could go—and we found the same material—gravel and sand.

The CHAIRMAN. And water?

Mr. DAVIDSON. Yes, and water. That is the trouble about damming. There is nothing to pin a dam to at the sides or bottom.

The CHAIRMAN. You mean in the Rillito?

Mr. DAVIDSON. Yes. In the same work on the Santa Cruz we find the same conditions existing. When we encounter this water level we encounter this same material—gravel and sand. There is nothing, therefore, to pin a dam to, so that the only way to get water is to lead the water out.

Senator REAGAN. Do you mean lead it out from where it leaves the foot-hills?

Mr. DAVIDSON. No; lead it out into this channel.

Senator REAGAN. Where do you commence?

Mr. DAVIDSON. In the bed of the stream—out in the mesa, for instance, and running right along.

The CHAIRMAN. You go on in the stream until you get down deep enough to get water, then you cement your tunnel, and then run lateral tunnels.

Mr. Davidson. Yes.

Senator Reagan. You meant tunnels instead of ditches?

Mr. Davidson. Yes; we tunnel until we get into this water stratum.

Senator Reagan. How do you construct a tunnel, of what material?

Mr. Davidson. The last part of our tunnel will be a cylinder made of redwood with iron bands.

The Chairman. Have you sunk wells here to test it?

Mr. Davidson. Yes.

The Chairman. To what depth?

Mr. Davidson. From 5 to 9 feet in the river channel.

The Chairman. That is hardly a well.

Senator Reagan. Are your lateral tunnels made of wood?

Mr. Davidson. Yes.

Senator Reagan. How do you get the water into them?

Mr. Davidson. We put in percolating timbers, so as to let the water percolate into them.

The Chairman. Have you not bored at all?

Mr. Davidson. You can not well bore into these boulders. You could do so with the proper machinery, but we have no such machinery. These wells on the mesas are at the same water level with this stream, so that it is one moving stream underground.

The Chairman. How wide?

Mr. Davidson. A mile and a half in the case of the Rillito.

The Chairman. That is a vast amount of water?

Mr. Davidson. Yes. The same conditions, I was going to say, are encountered in the Santa Cruz as far as my work extended on the same work near Tubac.

Senator Reagan. Have you been successful in developing a considerable body of water in that way?

Mr. Davidson. We commenced the work, but were stopped by floods. We carried the work so far as to establish the fact beyond a doubt. Of course our work is incomplete as yet. It is like building a house; you can not reap the benefit of the work at first.

The Chairman. Is it true that the streams run underground in this Territory generally?

Mr. Davidson. Yes.

The Chairman. Is it true of the Gila also?

Mr. Davidson. I am not sure about the Gila, but of all the waters I have had to do with there are more underneath the surface than on the surface.

Mr. Goodwin. Fifteen years ago we commenced boring for an artesian well, some 200 or 300 yards from where we are now. We bored several hundred feet and encountered the same formation—sand and gravel. In regard to dikes for the catchment of water, in one of the places, as to which we will have the honor to report to you, the dikes of porphyry are about 30 feet apart. They jut up on the different sides of the stream.

STATEMENT OF E. L. WETMORE, OF TUCSON.

The CHAIRMAN. Have you been taking the record of the rain-fall?

Mr. WETMORE. Yes.

The CHAIRMAN. Will you please give us the particulars of it?

Mr. WETMORE. For the last twelve months the rain-fall, month by month, at Tucson is as follows:

Month.	Rain-fall.	Highest temperature.	Highest temperature.	Mean temperature.
	Inches.	°	°	°
1888.				
September	.10	103	....	....
October	.78	98	52	75
November	2.06	85	37	61
December	1.96	85	37	61
1889.				
January	1.74	77	30	54
February	1.06	77	29	53
March	1.98	81	44	63
April	.18	95	43	69
May	Trace.	96	44	70
June	.30	102	57	80
July	5.66	105	66	86
August	2.06	104	78	91

The rain-fall for the last twelve months has been 17.88 inches. I do not happen to have the lowest temperature for September, 1888.

The CHAIRMAN. Has there been any rain-gauging conducted on those mountains?

Mr. WETMORE. No. The rain-fall on the mountains is from two to three times as much as on the mesa.

The CHAIRMAN. Is there not more than that?

Mr. WETMORE. It may be more than that. There is no Signal Service report, except from Huachuca. At Pantana the rain-fall is about 20 inches.

The CHAIRMAN. Do you have any floods in this region?

Mr. WETMORE. Yes. The floods come in July, August, and September in the Santa Cruz and the Rillito, and permanent water runs during the months of January, February, and March on the Rillito in the winter from the snows of the Santa Catalina and the Rincons.

The CHAIRMAN. What time do you need to irrigate?

Mr. WETMORE. Principally in February and March and in July, August, and September. We have two planting seasons, winter and summer.

The CHAIRMAN. Do you raise two crops?

Mr. WETMORE. We raise two crops each year.

Senator REAGAN. What are your planting seasons?

Mr. WETMORE. One commences in September, October, and November, and from that time on until February for our wheat and grains. Our harvest season is in May and June. Then we plant again in summer for corn and such crops.

Senator REAGAN. What crops do you plant in July and August?

Mr. WETMORE. Corn, sugar-cane, and beans. We raise vegetables all the year round. There is not a month in the year that we do not have vegetables. Here [indicating some grasses] are some of the native grasses that grow in this Territory. These grow wild on the mesas during the rainy season, and only during that season. We have an average of 4.22 inches of rain-fall from October to the 1st of April, and 6 inches of irrigation will produce a crop.

Senator **REAGAN**. In addition to that?

Mr. **WETMORE**. In addition to that. In the summer we have an average during the three months of July, August, and September of 6.23 inches of rain-fall. A crop can be produced by artificial irrigation with 7 inches.

The **CHAIRMAN**. You say you have floods in the summer?

Mr. **WETMORE**. Yes; the rain-fall is generally over in from fifteen minutes to half an hour, and then it runs off to the river.

The **CHAIRMAN**. The summer rains might be stored?

Mr. **WETMORE**. Yes.

STATEMENT OF BREWSTER CAMERON, OF TUCSON.

The **CHAIRMAN**. We shall be glad to hear you, Mr. Cameron, with regard to irrigation in this locality.

Mr. **CAMERON**. I desire to say a few words with regard to these grasses. There are a great number of grasses in this country. The most valuable of them all is the white grama. That grows on a soil that is usually a little gravelly. That soil enables it to get a good root. It is very fattening for horses and other stock. They will fatten quicker on this grass than on any other grass known. The only difficulty about the growing of grasses here is that we do not have enough rain to irrigate them. They grow rapidly during the rainy season, but it rains for such a small portion of the season that we do not have the water for them. On the mesas the condition of vegetation is such that it would require ages almost to get it out.

The cattle frequently throw their tongues around this grass and pull it up. It formerly grew in great quantities, but the cattle pulled it up. Large quantities of this grass have been eaten out, and this country rendered a desert. If you would take the whole Territory of Arizona to-day, just as it stands, it would require 50 acres of land to support one head of cattle on the open range. Some conservative people think it would take 100. I am sure it would take 50.

In the places where the rain-fall is more than usual you will find that the grasses hold on very well. In those portions of the country you can support one head of cattle—one animal—on anywhere from 7 to 12½ acres, whereas with alfalfa you could support two cows probably on 1 acre. They generally cut five crops of alfalfa here and also get seed for another crop.

The rain-fall here is very rapid, and then it runs off. The consequence is that it ought to be carefully preserved, and if preserved, this country would support an immense number of people and immense herds of stock.

My brother and I own a ranch 100 miles southeast of here, on the Santa Cruz River. Going around the way the stream runs it is probably 130 miles. There are different points along that river that I have observed where large reservoirs could be constructed which would reclaim hundreds of thousands of acres. There is one place three quarters of a mile wide and 4 feet deep—just the catchment area that it has on that land. There is an area there 15 miles wide and several miles long.

The **CHAIRMAN**. The reservoirs would have to be constructed, I suppose, very strongly.

Mr. **CAMERON**. Yes, or the storms would wash them away. But there are places where reservoirs could be constructed strongly and well. We planted on our ranch some few years ago some peach trees, nectarines, and apricots, just from the seed. This summer the apricot trees bore very finely. The Mexicans also grow that class of fruit, and have done well with it. Fifty-one hundred feet above the sea, where our ranch house stands, we have planted olives, apricots, peaches, plums, quinces, and so-forth, English walnuts and almonds, all of which have done well. The first year I sub-irrigated, but the gentleman who made the irrigation ditch told me he made a bad selection of the material, and the fruit could get no water practically that year. The trees grew well, however, and as they did grow well in that high altitude, they would grow well here.

The **CHAIRMAN**. If you had Government surveys to designate the reservoir sites and set them aside, and estimate the cost of making reservoirs and ditches, are there many places in this country where private enterprise would utilize the water?

Mr. **CAMERON**. Yes, there are many. I will show you how that is. Some friends of mine called my attention to the fact that there was a great reservoir that could be built. I went East, and a gentleman from this city went with me. A gentleman to whom we appealed for a subscription subscribed $100,000, but on investigation it was found that it was not just what we had heard of it. I would be satisfied if the Government would make the surveys. I think the capital could be got to reclaim every acre of arid land in this country, if we had good surveys.

I am a member of the committee of this Territory to prepare a report for your committee. The engineer who was sent out to get information for submission to your committee came back and reported to us that there was a much better site out here than had been discovered before. Nobody has ever surveyed the place with a view of seeing what could be done in that respect. I think it is very important that the Government should survey these sites and reserve the land so that the minimum, not the maximum, may be taken and held by men who could crowd capital out, and prevent anybody from developing it. It is for that reason very important to have these surveys, so that some men can not come here for speculative purposes and keep back the development of this Territory for twenty-five or thirty years.

The **CHAIRMAN**. All the lands to be irrigated by these hydraulic works are withdrawn from sale, so that they can not be entered under the homestead law, or any other laws; but the President has power to open it to homesteads, which he would do, under the ordinary administration of law. Now what other laws do you wish changed besides the homestead law?

Mr. **CAMERON**. I was formerly receiver of the United States land office at this place, and ever since have been connected with many operations here. I have given much attention to this subject. I spoke to Major Powell in San Francisco about this matter, but he said that all the land within the basin of the river he had recommended to be absolutely withdrawn.

The **CHAIRMAN**. All that he designates are absolutely withdrawn.

Mr. **CAMERON**. All these mountains have lagunas in them, in which quantities of water could be stored, so that under the construction which the Commissioner of the General Land Office puts on that, every acre of land in this county is withdrawn.

(Mr. Cameron addressed the committee at some length in opposition to the repeal of the desert land act, asserting that such repeal would work great injury to Arizona.)

STATEMENT OF A. K. P. SAFFORD.

The **Chairman**. You have been governor of this Territory?

Mr. **Safford**. Yes; from 1869 to 1877.

The **Chairman**. Are you familiar with the Territory?

Mr. **Safford**. Yes.

The **Chairman**. Have you observed its capacity for irrigation?

Mr. **Safford**. Yes.

The **Chairman**. The committee will be glad to hear anything that you may have to say with regard to that subject in its relations to this Territory.

Mr. **Safford**. The largest river of this county is the Santa Cruz, which rises in Arizona, and comes into this county about 85 miles from here. It runs through a valley of as rich land as there is on the face of the globe. During the rainy seasons an immense quantity of water accumulates on the mountains, probably four or five times as much as in the valleys. There are frequent floods. By proper arrangements the water could be accumulated so as not only amply to irrigate all the lands in the valley above here, but it could be carried into the valley which we passed over.

The waters of the Santa Cruz sink, after passing about 9 miles from here north, and do not appear again until they reach Maricopa, near the railroad station. There the river comes out again. From the formation of the country you can tell where the water runs. Frequent experiments in sinking wells have shown the course of the water. When wells are sunk they sometimes find a running stream. I presume the water might be raised and do considerable irrigating, but if it were properly saved it could be gathered from the mountains. From here to the source of the river there is water enough, in my belief, to irrigate not only the valley above here, but tens of thousands of acres besides.

In addition to the Santa Cruz, there is the San Pedro River, which flows a distance of 150 miles and enters into the Gila. That flows through a very rich country, and, like the Santa Cruz, it is lined with mountains, where vast amounts of water can be accumulated and by which an immense area of country could be irrigated. The Rillito is another river that is susceptible of producing water enough to irrigate all the lands that you see here, if proper storage could be provided—the lands being all rich and excellent. You must have observed that it is also admirably calculated by nature for irrigation.

Another of the rivers is the Sonoita. That enters into the Santa Cruz some way up. That is a stream of considerable importance, and has a large water-shed. There is a valley, Babequivari, which is one of the richest in all the Territory. It is about 60 or 70 miles south. That, I believe, could be made cultivable by storage of water. In fact, I do not think there is any land in this county which could not be made cultivable if proper storage arrangements were made.

Senator **Reagan**. How much would that aggregate?

Mr. **Safford**. I suppose 2,000,000 acres. There is another feature I wish to call attention to. This valley here has been in cultivation for probably one hundred and fifty years, perhaps longer. We have no written history of the length of time that this valley has been cultivated. It had an old Spanish fort. That was one of the forts that the Spaniards made before the independence of Mexico was achieved. These lands were cultivated under the rule of Spain, and have undoubtedly been under cultivation for one hundred and fifty years. The soil is as rich to-day as it ever was, without any fertilizer whatever, except what it got from irrigation. Some of it now rents for $33.33 an acre.

I have had experience in agriculture in many States of the Union. I was born and raised on a farm, and after having had considerable experience in this Territory, and in other States of the Union, I can say that I know of no country so prolific as the Territory of Arizona. I lived for many years in Illinois, yet I know of soil nowhere that will produce crops from year to year for an entire number of years without fertilization, except this soil.

STATEMENT OF W. H. BARNES, UNITED STATES TERRITORIAL JUDGE.

The **Chairman.** We shall be glad to hear anything that you may desire to state with regard to irrigation, especially with reference to its application to this Territory.

Judge **Barnes.** I will say one word with reference to reservoirs. We have a town here of eight or ten thousand people, and there is not a well in it. Everybody must get water from our water system. The river here falls 18 to 24 feet to the mile. The water which you see here flowing comes from a redwood box 2 or 3 feet square, running underground for a quarter of a mile. It keeps along underground until it comes to the gravel, and you may put full pressure on all the faucets of this town, and that fact will make no appreciable difference in the supply of the water. That shows what is done with underground water.

It has been asked, "What is below this water?" We do not know. The more demands we make on the water the more water comes. A mile and a half below here a railroad company, with plenty of resources of money and machinery, sunk a well about 33 feet and encountered a force of water which they could not overcome. They put in a steam-pump, and finally put in two pumps, but could not overcome it. That well waters the machine-shops, the engines, the depot, this hotel that we are now sitting in, and a large part of the town besides. They could not go any further with all the means they could employ. They could not overcome the flow of the water that came at that depth. Of course, by means of a pipe and machinery for the purpose they could go on indefinitely, but with an open well they got all the water they wanted.

These mountains here have an immense rain-fall. The Government ought to ascertain what the fall of water is on these mountains. I believe that for 10 inches of water that falls in this valley 60 inches falls on the mountains. All over these mountains you will find rain-fall, but not a drop of that water has ever got to the river on the surface; it comes at such remote intervals.

STATEMENT OF ALEXANDER TRIPPEL, OF GLOBE, GILA COUNTY.

The **Chairman.** Have you anything to present with regard to irrigation in Gila County?

Mr. **Trippel.** I have a short report which I am instructed to hand to you.

The **Chairman.** Do you wish to say anything in addition to that?

Mr. **Trippel.** Yes. In order to save time I wish to make a brief statement of the contents of the report. Gila County is the central county of Arizona and is surrounded by mountains. It has not any large irrigation schemes to present. It only desires me to say that one-half of the county is embraced in the Apache Reservation. The eastern half of the county is embraced in the San Carlos Reservation. The eastern part of our county has about 200,000 acres of arable land which is susceptible of irrigation by the San Carlos River and by a number of little mountain streams.

At the present time irrigation is carried on to a small extent under the direction of the War Department and the Indian Bureau. I should say that there are about 2,500 acres irrigated. This whole mass of land is reserved by the Government for about 4,000 Apache Indians. The western half of the county is entirely devoted to mining. It is mountainous country. It is made up of high and sometimes inaccessible mountains. The arable land of that western part would not aggregate more than 15,000 acres, although there is a good deal of mining land and mesa land. This 15,000 acres is in small patches along the creeks.

Irrigation is carried on to the extent of about 800 acres by small ditches, but there is no site that I believe could benefit Gila County in the least. There is, however, one great enterprise now proposed of which you may have been informed in Phœnix, which proposes to dam up the Salt River to the height of 200 feet right at the county line. This dam will float all the agricultural land of Gila County and would destroy all communication between South Gila and North Gila. It would be impossible to make any road across. It is a question which is probably novel in this irrigation scheme, but it will certainly loom up—whether one community can be benefited by such dams, to the ruin of other communities. In this case a lake would be formed of from 16 to 20 miles in length in the Salt River and 10 to 12 miles on Tonto Creek, so that the lake would cover all the farming land and go from mountain to mountain. The question involved in this matter is presented to you in the report for your consideration.

So far as underground water is concerned, I have noticed right around those mountains that the water-sheds are delivering any quantity of underground currents. They are inexhaustible. But we have no living streams outside of Salt River and some small streams.

Our people are very anxious regarding the act of Congress withdrawing all lands susceptible of irrigation. Of course while there are no sites which would warrant the turning of them into reservoirs for the benefit of Gila County, yet technically you could make such sites. They may not be economic and may not be needed, yet, in an engineering sense, sites could be made, and so all those lands that are now in the possession of homesteaders and others under the land laws are apt to be withdrawn from them. The uncertainty of this is so great that people begin to be in doubt whether they will do any more work or not. It would actually withdraw the lands which are irrigated by springs or by wells.

(This witness also addressed the committee in opposition to the repeal of the desert-land law.)

The report referred to by Mr. Trippel is as follows:

The undersigned, a committee appointed by the board of supervisors of Gila County, Ariz., and instructed to present to the committee such facts as may be of importance in the course of your investigations and relating to said county of Gila, respectfully submit the following, to wit:

Upon a careful examination of the subject, what, if any, measures and undertakings to irrigate and reclaim desert lands in Gila County not embraced in the White

Mountain Indian Reservation, could be submitted, we find that not sufficient arid land lying without the reservation limits is susceptible to irrigation to warrant Government work.

The most of the tillable land in Gila County is within the Indian Reservation in the San Carlos and Gila Valleys, and has been computed at 200,000 acres, or 300,000 acres for the whole reservation, a portion of which is in Graham County, and kept from the citizens and preserved exclusively for the questionable benefit of 3,000 or 4,000 Apache Indians.

The balance of agricultural and mesa lands susceptible of irrigation forms a narrow strip lying along the Salt River and Tonto Creek, not probably to exceed 12,000 acres in the aggregate. These two narrow valleys, each being about 16 miles in length and not over 2 in width, are surrounded on all sides by high and, except in a few certain places, inaccessible mountain ranges which extend north and south, east and west the entire length and breadth of that portion of the county not embraced within the Indian Reservation; a portion of the lands situate in these valleys are now irrigated by small ditches, and the configuration of the country is such that within the county and for its benefit no larger storage reservoirs would be warranted.

Another small acreage is in the valley of Pinal Creek, extending north from Globe and being about 10 miles in length by 1 in width, but which has no surface water, but could be irrigated by raising the water by means of underground dams.

Gila County is chiefly a mining country, mountainous, being situated within the great mountain ranges of central Arizona, with good grazing, but little agricultural land.

In this connection, we would respectfully call your attention to the late act of Congress withdrawing all entries of land under the homestead, timber, desert, and pre-emption or water-right acts, which, with a strict and literal construction, would prevent the further settlement of most, if not all, the arable land in our county, inasmuch as the act withdraws all land susceptible of irrigation by ditches or canals. The effect of such interpretations will cause a complete stagnation in the progress of this Territory, and especially Gila County, keeping in suspense every industry dependent on agriculture and forbidding immigration. The act does not discriminate but excludes every acre worth having from being entered, as long as the technical feasibility of the construction of a storage reservoir exists, without regard to whether a site for such reservoir may be hereafter found warranted or not. It is obvious that a law so forbidding to all progress, all increase of population, and so sweeping in its effect, will be destructive to the material prosperity of the Territory at large.

We would also respectfully submit the question, whether storage reservoirs or other water-works should be constructed for the benefit of one community or one county when, as a consequence, such an undertaking would be the destruction of another community or county. This question seems to us one of the greatest importance when justice to, and equal rights of, all citizens are considered.

We do not desire to submit to your honorable body a mere abstract question touching the right of eminent domain, but beg to present a case coming near to us when applied to Maricopa and Gila Counties.

Your committee has, no doubt, received from the authorities in Maricopa County the plan and official report of the county surveyor of the Salt River storage reservoir to be constructed in Gila County, intended to dam Salt River to a great height, and by which a very large tract of arid land in Maricopa County could be reclaimed. We do not wish to underrate the great importance and the inestimable benefit which would accrue to Maricopa County exclusively by the construction and operation of such water-works, but we are compelled to state that a corresponding damage, nay, almost an entire destruction of the integrity of Gila County, of its future material prosperity, of its communications between one part and the other, of any possibility of a railway through the county, which is so essential to its mining industries, and the flooding of nearly all its agricultural land would follow this undertaking, and we would respectfully ask whether the Government would sanction the principle of creating prosperity in one county upon the ruin of its neighbor.

The official report of the surveyor states that some 10 miles in the Tonto Valley and 16 miles up Salt River, together with a number of miles on Pinto Creek, all being in Gila County, would be flooded by means of this dam, and he estimates that about 6,140 acres of arable land, of which 902 are now cultivated, would be covered with water. This statement of the acreage now under cultivation is erroneous, as about 1,500 would be a more proper figure.

That report also fails to state that the whole flooding and entire damage would be in Gila County; that the creation of such a lake would virtually make ordinary communication between North and South Gila impossible; that the only feasible location of a north and south railroad to Globe, whose route has already been surveyed and 40 miles of track built, would be obliterated. The topographical features are such that not even a good wagon road through the mountains to the east of this lake, except at an enormous expense, could be built, and even then the distance would be doubled.

The report further fails to mention the Verde River or any of its numerous tributaries as equally advantageous streams for water storage reservoirs, which, if examined, will be found to contain several sites for dams which would answer exactly the same purpose as the Salt River Dam, and could be constructed at probably less cost, and canals from which would irrigate precisely the same section of country, and whose construction and maintenance would interfere with or damage no one.

Another objection to this scheme of damming Salt River lies in the utter separation of the lands on the head of Cibuqu Creek from the mining regions surrounding and lying south of Globe. These lands contain large coal deposits, which at some not distant future day will be of great value and immense importance to the mining industries, especially of southern Arizona. This great lake, if constructed, will cut off all possible railway connection between these lands and Globe and the country lying south of Globe, except by road via Phœnix and Tucson, or to Deming, N. Mex., via Albuquerque, which are routes so circuitous that their construction would never be justified. We would also add that at the present time both southern and northern Gila rely exclusively upon the agricultural resources of the Tonto and Upper Salt River Valleys for all supplies of hay, grain, etc. This lake, flooding, as it will, the farming region of the county, leaves the remainder of the county practically without a farm, and from the mountainous character of the county and isolated as it is from adjoining farming sections, our people will be left without sufficient supplies of home agricultural products, and outside markets, owing to the great distance and almost insurmountable mountain roads, can offer nothing but at an enormous expense.

Under these circumstances the citizens of Gila County, to an unanimity, protest against such a wholesale destruction of a whole county, merely to benefit another adjoining county. Were it merely a matter of compensation for damage done, such may be adjusted, but the plan proposed conditions a material political disintegration of Gila County, affecting its communications and thereby destroying all hopes of future prosperity.

In presenting these facts as concisely as practicable, we feel satisfied that your honorable body will treat these grave questions with the consideration they merit, and that future Congressional legislation will duly recognize such important factors in the problem of an equitable limitation upon the schemes for the reclamation of large tracts of desert lands.

We remain, respectfully, your obedient servants,

ALEX. TRIPPEL,
Chairman.
J. H. HAMILL.
E. H. COOK.
F. T. POWERS.

Approved August 31, 1889.
[SEAL.]

PATRICK SHANLEY,
Chairman Board of Supervisors of Gila County, Ariz.

Attest:

CHAS. T. MARTIN,
Clerk of the Board of Supervisors, Gila County, Ariz.

STATEMENT OF C. H. MURRAY FIRST LIEUTENANT FOURTH CAVALRY, OF FORT LOWELL, NEAR TUCSON.

The CHAIRMAN. You have been stationed some time in Arizona?

Mr. MURRAY. I have, and studied somewhat the question of water supply.

The CHAIRMAN. Please give us your conclusions.

Mr. MURRAY. Wherever in Arizona a sure supply of water can be obtained for irrigation the element of chance is almost eliminated from agriculture. Unfortunately, except in very limited areas, it is impossible to obtain a regular supply without the aid of storage reservoirs. Streams that during the rainy months would water large areas, practically disappear in dry seasons. If the water wasted in the rainy months could be held for use during the dry, thousands of acres now arid could be made very productive. This can be done by building a system of large storage reservoirs, since most of the mountain ranges of this Territory contain numerous cañons admirably adapted to the construction of such reservoirs.

In determining the water supply of a mountain range in Arizona, it is manifestly incorrect to base the estimate upon the charts of rain-fall. These charts are based upon statistics collected in towns, which, as a rule, are distant from the mountains, and for that reason are in centers of small precipitation. In the mountains, rain falls much oftener than in the towns (plains). Not only does it fall more frequently, but, usually, with a violence resembling cloud-bursts. If, in the mountains, statistics could be carefully kept for several years they would probably show that the annual rain-fall of Arizona has been greatly underestimated.

Adjourned.

The following papers and reports were read and ordered filed:

REPORT FROM COCHISE COUNTY,

CONTAINING STATEMENTS OF ITS GEOGRAPHICAL POSITION, CULTIVATED LANDS, CROPS RAISED, LANDS SUSCEPTIBLE OF CULTIVATION, MILES OF CANALS AND DITCHES, RAIN-FALL AND STATISTICS, RESERVOIR SITES, WATER-WAYS, AND WATER SHEDS.

[Prepared under the direction of the board of supervisors by its special committee.]

The following information gathered under the direction of the board of supervisors of the county of Cochise, Ariz., by Hon. M. A. Smith, Delegate in Congress, H. G. Howe, civil engineer, and Hon. T. J. White, a member of said board, is respectfully submitted for the consideration of your committee, with the earnest hope that it will receive the careful perusal which characterized the actions of the above-named gentlemen while studying the questions, a report of the results of which study, and after a very recent personal examination of the country mentioned, is herewith laid before you.

B. S. COFFMAN,
Chairman.
FREDK. CASTLE,
Clerk.

Cochise County is situated in the southeast corner of Arizona, is 83 by 84 miles square, and contains 6,972 square miles, an area five and one-third times greater than the State of Rhode Island, three and one-fourth times greater than Delaware, and one and one-half times greater than the State of Connecticut.

It is situated on the continental divide between the Pacific Ocean and the Gulf of Mexico. The highest altitude along the Southern Pacific Railroad from San Francisco to New Orleans, being at Dragoon Summit, is an altitude of 4,614 feet, the average altitude being about 3,800 feet above sea level. Cochise County is watered by the San Simon Creek on the east, which stream rises in New Mexico and runs northwesterly through Cochise and into Graham County, and empties into the Gila River at Solomonville. The Sulphur Spring Valley, running through the central portion of the county, heads in Graham County. The waters flow southerly into Mexico and form the headwaters of the Sonora River, which empties into the Gulf of California. The San Pedro River, near the westerly line of the county, rises in Mexico and flows northerly through the county and joins the Gila River a few miles below Dudleyville.

The San Simon Creek drains a water-shed of 36 miles in width and 40 miles in length, or an area of 144 square miles, which waters flow through Cochise County at the northeasterly corner. The soil in many places being sandy, this stream runs under ground and comes to the surface at points only where the bed-rock comes to the surface, which points show an abundance of water.

This valley lies between the Pelloncillo range upon the northeast and the Chiricahua and Pinaleno ranges of mountains upon the west. Nearly if not quite all of this great valley could be irrigated, and valuable crops raised, could the waters flowing through it be but saved.

The Sulphur Spring Valley drains an area 30 miles in width by 90 miles in length, or an area of 2,700 square miles. This valley like the San Simon having a sandy soil, the waters flow under the surface, forming a broad underground stream a few feet below the surface throughout the greater portion of the valley. This valley lies between the Pinaleno, Chiricahuas, and Pedrogosa ranges upon the east, and the Mule, Dragoon, and Gallure Mountains upon the west. The vast majority of this great valley is also capable of raising anything, could the waters flowing through the same be saved.

The San Pedro River has a water-shed of 25 by 28 miles in Sonora, Mexico, and in Cochise County a water-shed of 25 miles in width by 80 miles in length, or a total, including Mexico, of 25 by 108 miles, or 2,700 square miles, of which 2,000 square miles are in Cochise County, which waters flow through Cochise County.

This valley, similar to the others above described, has a large underground current which comes to the surface only where the waters are raised by beds of clay or bed-rock coming near the surface. It is bounded upon the east by the Ajos, Mule, Dragoon, Limestone, and Gallura ranges of mountains and upon the west by the Catalina, Rincon, Whetstone, Mustang, Huachuca, and Cananea ranges of mountains. In this preliminary examination, the time being so short, it has been impossible to give the volume of water flowing in the different valleys; but from the many wells sunk along the bottom lands and upon the low table lands, and in the adjacent draws or flat washes leading into the valleys has demonstrated the fact that at no great depth from the surface there is an abundance of water. There is no known point in either of the above-mentioned valleys where the whole flow of waters comes to the surface. There have been no measurements taken to show the volume of these underground streams.

In addition to the streams described in this statement, there are many large springs, which do not feed permanent streams, whose waters properly used would be of great benefit in the irrigation of orchards and vineyards, as they are located in the mountains and higher table-lands. Many of them are now used by the settlers along the foot-hills for domestic purposes, some utilized by the laying of pipes to troughs for watering the cattle that graze along the table-lands and foot-hills, and others carried in ditches for the irrigation of orchards and vegetable gardens.

RAIN-FALL.

From reliable sources, taken for several years throughout what is termed the arid region of the United States, the following statistics are taken, showing that this portion of Arizona, and more especially Cochise County, has a greater rain-fall than many portions of California, Colorado, Montana, New Mexico, or Wyoming:

	Inches.		Inches.
Drum Barracks, Cal.	8.74	Fort D. A. Russell, Wyo.	14.09
Fort Yuma, Cal.	3.91	Fort F. Steele, Wyo.	15.38
San Diego, Cal.	9.31	Santa Fé, N. Mex.	14.91
Monterey, Cal.	15.71	Albuquerque, N. Mex.	8.11
Fort Garland, Colo.	14.86	Fort Filmore, N. Mex.	8.42
Denver, Colo.	13.77	Fort Selden, N. Mex.	8.40
Fort Lyon, Colo.	12.56	Fort Craig, N. Mex.	11.06
Fort Snow, Mont	6.95	Fort Bayard, N. Mex.	14.32
Fort Benton, Mont.	13.26	Fort Huachuca, Ariz.	15.60
Fort Sanders, Wyo.	11.46	Camp Grant, Ariz.	15.08
Fort Laramie, Wyo.	14.45	Camp Bowie, Ariz.	15.26

From the above list it will be seen that this county has a larger rain-fall than most of the above named stations, an average rain-fall of over 15 inches, of which nearly 50 per cent. falls during the summer and early in the fall, the next largest percentage being in the fall and winter, the smallest being in the spring. Frosts are rare, and in the valleys all the precipitation comes in the form of rain. As the limit of successful agriculture has from a great many observations been set at 20 inches, it will be seen that this county lacks about one-fourth the water to successfully carry on agriculture without irrigation, which per cent. must be provided for by some system of storage reservoirs or underground irrigation for vineyards and orchards.

RESERVOIR SITES.

In examining the San Pedro Valley there are but two points where reservoirs can be built to an advantage:

First. On the lower portion of the valley, at a point where the foot-hills come close together, with solid rock upon each side and bottom. This is known as the Nigger Ben place, and is about 15 miles below or north of the town of Benson, where a dam 350 feet in length and 40 feet high will overflow an area of a mile square and average 10 feet deep, or a storage capacity of 278,784,000 cubic feet. The area of bottom land and low table-land that could be irrigated by the construction of this dam would be in Cochise County over 3,000.

The second reservoir site on the valley, 1¼ miles above Charleston and 26 miles above Benson, where the foot-hills come down to the river forming solid rock banks for over a hundred feet high, where a dam 60 feet in height and 400 feet long would store over 300,000,000 cubic feet of water.

There are several places along this valley where there are broad stretches of almost level bottom-lands where underground dams (that is, trenches at right angles to the valley cut to bed rock or clay and filled with concrete) could be placed, that would raise the underground current to such a point that thousands of acres could be brought under cultivation without irrigation and save the expense of ditches and the great loss by evaporation.

Storage.—With this system of underground storage reservoirs, ditches from these dams can be taken out much higher up on the bottom lands, thus bringing under cultivation hundreds of acres that can not now be irrigated from the main channel of the river.

This system of underground damming would only expose for evaporation the narrow channel of the river, which would be but a small percentage above that of the present stream.

There are several points along the San Pedro River upon the west side where stronger reservoirs could be built.

One is at what is known as Page's Cañon, which drains from the southerly portion of Happy Valley, where there is running water the entire year. At this point the cañon is narrow, and walls solid. A dam 160 feet in length and 75 feet high will here store over 200,000,000 cubic feet of water and bring under cultivation over 20,000 acres that can not now be cultivated, owing to the sinking of the water below the cañon.

There are large flats to the east and west of Benson, where the soil is first-class, and could be irrigated by storage reservoirs built in the V-shaped washes that drain a vast portion of the country lying north of the Whetstones and west of the Dragoons Mountain ranges, which washes, or small cañons, carry large bodies of water during the rainy season. A series of dams, one above another, would store an immense body of water, enough to irrigate hundreds of acres of land, but the evaporation would be so great that but a small part of the water would be available for the early summer months when irrigation is needed most. If the water stored were to be used immediately after the rainy season during the early fall months this system of storage would warrant the expense, but the spring and winter rain-fall being so small there would be but little water left for use when needed most for growing crops.

This portion of the county gives the best indication, from its surroundings, for the sinking of artesian wells, with which these large areas could be irrigated with but a very small loss from evaporation.

The mountain ranges, especially the Chiricahua and Huachucas show several points where storage reservoirs could be built, but the amount stored would be so small compared with the expense of the dams, and the feeders to supply the reservoirs so small, that the quantity stored would be exhausted before the cultivated crops would be matured.

MILES OF CANALS AND DITCHES.

In the San Simon Valley there has up to the present date been but little done in the way of irrigation by taking out water in ditches; a few have been taken out for the raising of alfalfa—about 2 miles of ditch.

In the Sulphur Spring Valley there have been not over 4 miles of ditches taken out, most of which is used for small gardens.

Some portions of the San Pedro Valley show old ruins, and the remains of pottery and of old ditches are yet to be seen. They show that this valley was inhabited a long time ago. The valley is now quite thickly settled, there not being a mile of the bottom lands but what has been settled upon, and there is now over 45 miles of main ditches and laterals now in use along the river bottom.

All of the main ditches are supplied from the main stream by building dams in the river at the most available points, all of the dams built to date being simply temporary dams that at almost every freshet are carried away and have to be rebuilt sometimes two or three times a year.

The dams are usually built of brush and earth, with some stone, if stone can be had; some are built by filling sacks with sand and laying them across the stream, thus throwing the water from the main channel to the head of the irrigating ditch.

KIND OF CROPS RAISED.

The soil along the San Pedro River produces all the different varieties of vegetation, cereals, grasses, fruits, and vegetables known to a semi-tropic zone. Of cereals there are raised corn, wheat, oats, and barley; of grasses, alfalfa, blue-grass, timothy, etc. Of fruits the following are being produced: Peaches, cherries, pears, apples, quinces, apricots, nectarines, figs, plums, grapes, strawberries, and all the small fruits, and it is noticed that the fruits have a finer flavor than many of the fruits raised in the lower altitudes of Arizona.

The foot hills on each side of the mountains are covered with nutritious grasses most of the year, which render it valuable for grazing purposes. San Simon Valley, as well as Sulphur Spring Valley, is covered with luxuriant grass growth, which makes them the finest cattle-ranges in Arizona. In Sulphur Spring Valley there are no running streams, but water is abundant and near the surface, and in some places gives the appearance of wet lands.

LANDS IN CULTIVATION.

In the San Simon Valley there are not to exceed 300 acres under cultivation; in the Sulphur Spring Valley and adjacent foot hills there are about 2,000 acres under cultivation; in the San Pedro Valley and adjacent table lands there are under cultivation about 6,000 acres.

LANDS SUSCEPTIBLE OF CULTIVATION.

There are in San Simon Valley, 60,000 acres; in Sulphur Spring Valley, 200,000 cres; San Pedro River Valley, 50,000 acres.

All of which is submitted.

STATEMENT OF F. W. OURY, C. E., OF TUCSON.

[Referred by Mr. Goodwin.]

To the Committee on Data and Statistics for Pima County:

I have the honor to submit the results of my examination of the sites for dams to which you have sent me. Accompanying this are maps and diagrams to which I respectfully refer for the better understanding of this report.

Location.—The sites for the proposed dams are located on the water-course commonly known as the Pantano Wash. Dam No. 1 is situated at the junction of the Cienega and Davidson's cañon, about 23 miles southeast of the city of Tucson, where still stand the ruins of the Cienega station on the old overland stage route. About 5 miles down the cañon, where the Southern Pacific Railroad track leaves the edge of the wash to go on to the mesa, is the site for Dam No. 2. Dam No. 3 is still farther down, about 2 miles from the preceding one.

Water supply.—Water runs throughout the year as far down as Dam No. 2, but in such small quantities as not to be a very important factor as a source of supply. Hence, it must depend on the freshets which come along this water-cou[illegible] caused by the rain-fall over the country which it drains and which occur during the rainy seasons, summer and winter.

Drainage.—The Pantano Wash rises in a range of low mountains about 50 miles southeast of Tucson, known as the "Canelas," and runs, with innumerable bends and crooks, in a northwesterly direction, until it empties, near Fort Lowell, into the Rillito Creek; thence westerly until it reaches the Santa Cruz River. It thus drains a portion of all the mountains in eastern and southeastern Pima County, with the exception of the Patagonias. We shall refer, however, only to that portion of the water-shed, the water from which flows into the Pantano Wash above the points selected as sites for dams.

It will be seen from the accompanying map that the western slopes of the Whetstones and Mustangs, the eastern portion of the Santa Ritas, the southwestern slopes of the Rincons, all of the Empire Mountains (altogether about 60 miles of mountain ranges), besides a vast area of high rolling lands, would contribute their surplus of rain-fall.

A cursory glance at the eroded condition of the banks of this stream will convince a person at once that vast bodies of water run down this cañon. Great dykes of hard rock have literally been cut through by the water, large cotton-wood trees have been uprooted and carried down the stream, railroad ties, bridge timbers, iron bolts, and even steel rails are to be found miles away from where they were originally placed. So great was the damage done to the track of the Southern Pacific Railroad yearly that the company had, for the sake of economy, at great expense to elevate its road beyond the reach of the waters from this wash. At a point where the cañon is over 200 feet wide water marks from a recent freshet still remain which are 20 feet above the lowest point of the channel. These are conclusive proofs of the fact that enormous quantities of waters flow to waste annually, whereas if it could be properly stored in a system of reservoirs it would be sufficient to irrigate thousands of acres of land which are now worthless, and which would forever remain so unless reclaimed by the waters from this cañon, because the topography of the country would not permit its being brought from any other stream or wash.

Dams.—No. 1.—At this point a large dyke of hard volcanic rock crops out on the left bank, continues on the surface until it reaches the bed of the creek, then sinks beneath the sandy bottom, to appear again on the right bank of the main channel. At the extreme right end of the dam is also to be found solid rock, so that this dam, if constructed, would have three natural and solid abutments upon which to rest, namely, one on each end and one in the middle. Besides, the indications are such that bedrock can not be far distant from the surface of the sand. Therefore at this point a very strong dam could easily be built and, as we shall see afterwards, at a comparatively moderate cost.

The total length of this dam is 1,052 feet, and its greatest height is 67.5 feet. Its heights at different points are as follows: Commencing from the left, the first 200 feet in length, would average 20 feet, the following 50 feet would be about 45 feet high, the next 200 feet, being the main channel of the wash, would reach a height of 67 feet, while the remaining 600 feet would average no more than 35 feet.

In addition to the main dam, a small one would have to be built. Its length is 150 feet, and its average height through that distance would be about 6 feet.

Above the site of dam No. 1, along the Cienega Cañon and for a short distance up Davidson's Cañon, the waters have worn through the sediment which they had previously deposited, which averages 150 feet in width and 15 feet in depth. The fall of the Cienega Cañon in this locality is about 40 feet per mile; that of Davidson's Cañon about 50 feet per mile. The dam, then, being only about 34 feet above the broad basin of the cañons, would back the water along the Cienega Cañon for about 4,400 feet, and up the Davidson Cañon for about 3,700 feet. The basin of the former cañon averages about 2,000 feet in width; that of the latter about 800 feet. Hence, to speak generally, this dam would create two rectangular sheets of water, one 4,400 by 2,000, and the other 3,700 by 800, or, more accurately, as found by survey, the water would cover in the Cienega an area of 9,160,073 square feet, or 210.3 acres to an average depth of 26.47 feet, taking into account the deep channel already spoken of. In the Davidson Cañon a lake would be formed containing an area of 2,784,340 square feet—63.92 acres—having an averege depth of 20.50 feet.

Therefore the capacity of this reservoir would be equal to 299,580,795 cubic feet, or 2,241,019,947 gallons; in other words, it would take a ditch with an average width of 8 feet and an average depth of 2 feet, running at the average velocity of 35.6 feet per minute, 365 days to empty the contents of this reservoir, it having been once filled and no more water coming into it during the time that it is being emptied. Again, this amount of water if spread out over a level plain would cover 82,529 acres, or 515 one quarter sections, 1 inch deep. It has been mentioned that the waters have deposited sediment in the basins of both the Cienega and Davidson's Cañon; in fact, the soil in these basins is nothing more than this sedimentary deposit. There are places where the water has cut through it for a depth of over 20 feet, and it still continues down some feet deeper. This, too, must have been deposited within a comparatively recent period, since in the Davidson Cañon, at a depth of over 10 feet, where the water has worn down to the solid rock, there are to be found Indian mortars, familiar to all Arizonans. They are holes cut in the rock for the purpose of grinding acorns and mesquite beans. From this can be formed an idea of the amount of mud that the water carries.

Here, then, would be a serious difficulty which would have to be overcome. How could the débris and sediment be handled that would inevitably be deposited by the water if its velocity were checked by a dam? It could not be done by any system of sluice-gates; since now that the stream is unobstructed the water has only sluiced out a channel of an average width of 150 feet and something more than a mile long. The most that could possibly be done by sluice-gates would not be half this amount, and that portion of the area which would not come within reach of the strong currents caused by the gates would undoubtedly fill up. In this case at least two-thirds of the area of the reservoir could not be acted upon by the said currents; so that the only way to get rid of this débris would be by dredging, an operation which, as every one knows, is quite an expensive one. Next is to be noted that the track of the Southern Pacific Railroad, which runs along the north bank of the wash, crosses the site of this dam at a point which would be 30 feet below the top. Now, as the grade of the road up this cañon is about 40 feet per mile, the waters from the reservoir would cover three-fourths of a mile of track, besides rendering it useless for some distance on both sides of the dam.

If the dam were built so as not to interfere with the railroad its height would have to be reduced at least 35 feet, and this in turn would diminish the capacity of the reservoir to about one-third. Or if in order to prevent this interference it should be proposed to dam Davidson's Cañon alone, its cost would nearly equal the one above referred to and have only one-fifth the capacity.

Dam No. 2.—This dam, too, would have solid abutments upon which to rest, and although bed-rock is not seen upon the surface in the bed of the stream it is evident that it is only covered by the sand. The span, besides, being so short, this dam could be made not only the strongest, but the least expensive. It will be seen from the diagrams that its total length is 418 feet and its greatest height is 43.43 feet, and as the banks on both sides are so steep the dam will average a height of 40 feet through its entire length. The fall of the wash at this point is something more than 40 feet per mile; hence, the dam would back the water up stream not quite 1 mile. The basin also is comparatively narrow, and therefore would not make a very large reservoir. According to surveys the water would cover an area of 2,923,658 square feet, or 67.12 acres, to an average depth of 22.37 feet. Therefore its capacity would be 65,391,298 cubic feet, or only about one-fourth as much water as that caught by Dam No. 1. This is a small quantity of water, but it will be seen hereafter how this dam is an indispensable accompaniment to the success of the large dam, No. 3.

Dam No. 3.—The banks of the Pantano Wash after leaving the point for Dam No. 2 are of a gravelly nature, more or less strongly cemented together. At places where the current of the main channel cuts into the sides a hard conglomerate, somewhat of the nature of "caliche", is exposed. At no point, however, do we find croppings of solid rock. Dam No. 3 would not have the natural rock supports of dams Nos. 1 and 2. It is doubtful, too, whether bed-rock would be reached in the construction of this dam, hence we can anticipate a loss by seepage underground. However, if a puddle wall of clay or some other good material were built through the sand until it reaches the conglomerate, to which reference has been made, and which is quite impermeable to water, this loss could be, if not altogether stopped, at least very greatly diminished. The red sandy clay from which the Indians make their "ollas" and which abounds in the mesas in the vicinity, would be a most excellent material with which to built such a puddle wall.

The total length of this dam is 2,640 feet, or exactly one-half mile, and its greatest height is 73.96 feet. For 600 feet it would have an average height of about 50 feet, and for the remaining distance its height would average nearly 70 feet. It would back the water up the cañon a distance of 7,500 feet, the average width of the basin being about 3,000 feet. As found by our surveys, this reservoir would extend over an area of 22,400,017 square feet, or 514.23 acres, having an average depth of 33.53 feet; that is, it would contain 752,169,384.8 cubic feet of water. It will be noted that this amount is over twice as much as that which the other two reservoirs would hold. It would take one year to discharge this amount of water through a ditch 12 feet wide by 4 feet deep and running at a velocity of 29.42 feet per minute; or if this quantity of water were spread 6 inches deep over a level plain it would cover 34,484.26 acres, or 53.88 square miles, that is to say, it would flood a strip of level land 25 miles long by 2⅛ miles wide, 6 inches deep.

It has already been said that enormous torrents of water, running at an almost incredible velocity, and carrying destruction in their course, pass down this wash. Therefore, if the velocity of the water is not checked in some manner, a dam as long as this one would be at a disadvantage against this element, and a most ponderous structure would have to be built in order to resist the rush of water. In fact, since we have already seen that it would not have a natural rock foundation upon which to rest, it is even doubtful if it could be done at all. Here then is the necessity of Dam No. 2 in connection with this one. It is a well-known law of hydraulics that if water passes from a narrow channel into a broader one, or into a large body of still water, its velocity is checked in proportion to the difference in the cross sections of the channels, and consequently its energy diminished. Dam No. 2 may be easily built strong enough to resist the most powerful current. Hence it could be used to check the velocity of the water, and when it reached Dam No. 3 its force would be greatly reduced. Furthermore, it must be remembered that when reservoir No. 3 is once filled its waters would reach within 1,000 feet of Dam No. 2. Here again the current would receive an additional check by impact, so that by the time it reached the dam its velocity would be practically *nil*. Therefore the strength of this dam need not be such as to resist the force of any very great rush of water, but merely a little more than sufficient to sustain the quiet pressure.

The two dams can be made to act together in the following manner: The water charged with débris and sediment would come into No. 2, where its velocity would be diminished; consequently, the heavy material, such as gravel, sand, and the coarser particles of mud, would at once be dropped. Thus, none of these substances would flow over, and only the lighter sediment in suspense would reach Dam No. 3; in other words, the reservoir of Dam No. 2 would act in the capacity of a large settling pond for Dam No. 3.

Even after the water deposits its heavier burden it would contain a considerable quantity of fine sediment, the disposal of which would have to be provided for. This could easily be done by a proper distribution of sluice-gates along the bottom of Dam No. 3. It is so long that by making openings at proper intervals through which water can escape the currents so caused would be sufficient to scour the entire basin of the reservoir. This sluicing could be done whenever there should be a surplus of water, and this would happen once a year at least, that is, during the summer rains.

It will be observed that this arrangement renders it impossible to dispose of the accumulation in Dam No. 2 by sluicing. In no case, however, could this method be employed with any degree of success in this dam, it being too short to admit of the distribution of a sufficient number of gates. The only practicable way then would be by dredging, and since the area of this reservoir is comparatively small this could be done to advantage.

Building material.—A short distance above Dam No. 2, and in fact all along the banks of the wash, are to be found large deposits of a rock from which could be made the finest quality of lime. Granite and a compact species of limestone, very well adapted for building purposes, abound in the vicinity. Sand and gravel can be obtained from the bed of the stream. Hence, lime-kilns and quarries could be established, near at hand, which would supply at a moderate cost all the materials requisite in the building of masonry structures.

Evaporation.—In no portion of the United States, perhaps, is evaporation so great as it is in Arizona. During the five warmer months it will probably reach three-tenths of an inch per day, and through the remaining cooler season no more than one-tenth of an inch, thus averaging yearly one-sixth of an inch per day; in other words, it would amount to about 5 feet over the entire surface yearly.

It must be remembered, however, that summer, during which time evaporation is very much greater than in winter, is precisely the period when freshets are more frequent. The summer rains commence in the latter part of June and end in September; the winter rains commence in December and last until April. These, too, produce freshets, and it is to be noted that since it is the product of the gradually melting snows the water does not come in such large bodies, nor does it carry such a great quantity of sediment in suspense. Hence, we see that the only months through which the reservoirs would be without receiving occasional supplies of water are October, November, April, May, and a portion of June, months during which Arizona enjoys her proverbially mild and delightful weather, and in consequence of which the evaporation would be comparatively small.

Besides, we have already said that there is running water through the entire year as far down as Dam No. 2. This is a stream 4 feet wide, 3 inches deep, and running at the average rate of 1 mile per hour. Consequently it carries 126,720 cubic feet per day, or 45,252,800 cubic feet per year; in other words, this amount would cover the whole surface of reservoir No. 3, 2.02 feet deep. Therefore, this stream alone would supply enough water to make up for nearly one-half the yearly evaporation from the reservoir.

Lands.—The slope of the wash, as has been said, is about 40 feet per mile; that of the adjoining land is twice this. Hence, the mesa being 73.96 feet higher than the lowest point of Dam No. 3, in a little less than a mile the water can be brought on the mesa lands for irrigating purposes. The dotted line on the map showing catchment area, represents points on a level with the bottom of reservoir No. 3; that is to say, it is the boundary line, north of which the lands can be irrigated by water from this reservoir. Thus we see that the strip of lands bounded by the Santa Cruz River on the west and the Pantano Wash on the east, besides the bottom lands of the Santa Cruz River for 12 miles above Tucson, could be placed under its waters. The country embraced between the Santa Cruz River and the Pantano Wash is composed of what is known as mesa lands. On these plains grasses and weeds of many species flourish with only the moisture derived from the small amount of rain that falls on them, showing that the soil, a red, sandy loam, is very rich, and, it being compact as well as fertile, requires less water than any other to raise a crop. A few of our enterprising citizens have demonstrated, by great labor, what can be done with these lands, if only water could be obtained.

OTHER POINTS EXAMINED.

Madera Cañon.—This cañon heads in the highest point of the Santa Rita Mountains and drains the northern slopes of the west half of these mountains. Until it empties into the Santa Cruz River, where it spreads out into a wide flat plain, it is a narrow gorge with a great fall. Consequently no point is to be found in this cañon at which a dam, if constructed, would create a large reservoir. Adjoining this wash is a mesa, upon which this stream could be thrown, but as I found its slope to be about 150 feet per mile, and the nearest distance that its banks came together to be about three-fourths of a mile, I regard it impossible to construct a reservoir for irrigating purposes.

Sabino Cañon.—This cañon is much the same in character as the preceding one. Just before it empties into the Rillito Creek its basin becomes broad, but its banks are so low and so widely separated that it would be impracticable to dam it with the view of holding water for irrigation. Farther up, when it gets into the mountains, it becomes very narrow and has a steep slope. It is nothing more than a mountain gorge, such as are to be found in all high mountains, and which every one knows it is impossible to dam so as to catch any great quantities of water.

Puertisitos.—This is situated in the Altar Valley 9 miles north of the boundary line between Arizona and Mexico. The slope of this valley is such that a dam, the highest point of which would be 41.68 feet, and whose total length would be only 920 feet, would back the water up the valley nearly 1¾ miles, the average width of the basin being about three-fourths of a mile. It would cover an area of more than 800 acres to an average depth of about 15 feet.

The catchment area of this dam, however, would consist only of about 8 miles of the lowest portion of the Baboquivari range of mountains, together with about 25 square miles of rolling mesas, so that it can readily be seen that water enough does not come down this portion of the valley to fill the reservoir which this dam would create. Besides we have been informed by Mr. Aguirre, who has for many years resided about 2 miles above this point, that a natural lake, upon which he has located, and which covers about 300 acres with water to an average depth of about 3 feet, catches all the water that runs down the main valley. Once only does this gentleman remember that this lake has overflown, and that, too, over a very small section. Therefore this site is unsuitable for a dam.

STATEMENT OF LEONARD WOOD, FIRST LIEUTENANT AND ASSISTANT SURGEON, OF FORT McDOWELL.

Referring to proposed surveys for the purpose of irrigation of desert land in this and other sections of the West, I have the honor to forward the following notes, made mostly from memory, relative to possibilities in the way of storage of water and irrigation in this particular section:

The Santa Cruz River rises in Sonora, a few miles south of the line, about 35 miles south of Fort Huachuca, Ariz., and crosses the boundary near the town of Calobasas. From this point it flows nearly northwest to the town of Tucson, passing through a rich valley, in which are seen the remains of settlements and systems of irrigation constructed by an unknown people, and also the ruins of settlements founded by the Jesuits and Dominicans in the sixteenth century. This stream, like many others in this arid region, sinks in places, rising again where the bed-rock or impenetrable clay, forming the true bed of the stream, approaches the surface. During the entire year there is in many places a constant surface-flow, and during the rainy season a constant surface-flow throughout the entire extent of this portion of the stream. Attempts on a comparatively small scale have been made at or near Tucson, which have demonstrated the existence of a large subterranean stream and the possibility of bringing it to the surface by means of a dam founded on the bed-rock or strata forming the true bed of the stream. It is believed that a suitable dam at such a point as could be selected would enable enough water to be collected and stored during the rainy months, in addition to that brought to the surface, to irrigate a large portion of this valley. The soil is of excellent quality and of great depth near the stream; at a distance, where the bottom land slopes upward, the soil becomes lighter, but is suitable for fruit and vegetables.

In the neighborhood of the head of the Santa Cruz, and separated from it by a low divide, is the San Pedro River, which flows through a country similar to that bordering on the Santa Cruz. This stream is a surface stream throughout that portion of its extent with which I am familiar, and could, I believe, be stored up in sufficient amount to irrigate many thousand acres of land. Several prosperous Mormon and other settlements are already established on its banks. Its general direction is the same as that of the Santa Cruz. The volume of water carried is much larger and more constant. Both streams empty into the Gila River.

Between these two streams are the Huachuca Mountains, the western portion being situated on the Huachuca military reservation. All the cañons in these mountains have streams fed by springs higher up the range. These springs are constant, and during the winter and rainy season the flow of water is large and forms good sized streams, which run out on to the flats and become lost. The amount of water coming from each of these cañons would, if stored up, irrigate several thousand acres of land. The cañons are narrow and deep and favorable for the construction of dams.

Leaving this section of Arizona in the vicinity of Huachuca Mountains and Tucson, and considering that portion near Phœnix, including a portion of the Salt and Verde Rivers, I shall refer first to the Salt River, and second to the Verde.

The Salt River is formed by the White and Black Rivers, rising in the White Mountains in the neighborhood of Fort Apache, Ariz., and for the greater portion of the course flows through cañons and narrow valleys until it reaches the western end of the Superstition Mountains, about 12 miles southeast of this Post (McDowell). Here it runs out into the eastern portion of that vast tract of country, more or less level, which stretches off toward the Colorado River and upper portion of the Gulf of California. Along the banks of this river, throughout its extent, are evidences of a dense population existing at some former time; also traces of great systems of irrigation, etc. Around and about Phœnix there are at the present time many thousand acres of land under irrigation, supplied by a system of canals taking water from this river. At present, even in the present comparatively undeveloped condition of this extensive section of country, the want of sufficient water is beginning to be felt, and unless some means are taken to store up a portion of the immense volume of water which flows down this stream in winter the limit of development must soon be reached. The amount of water carried by this river during the winter months is very great, rendering it unfordable for weeks at a time, and in places it is half a mile wide with a maximum depth of 10 feet or more. For 25 miles previous to its emergence from the Superstition Mountains it passes through a cañon formed by these mountains and the Mazattelle Mountains. This cañon is of great depth in many places, and in others it widens out and has opening into it numerous large cañons extending for miles up into the mountains on either side.

There are several places where the cañon comes down between mountains of considerable height which border on the river, making a comparatively narrow passage of from 300 to 500 yards in width, where a dam could be constructed which would cause a backing up of the water in the cañon and an overflow into adjoining depressions and cañons joining the river cañon at right angles, thus storing up an immense body of water for use during the dry season when the flow in the river is at a minimum.

The Verde, rising in the Francisco Mountains, joins the Salt River at a point about 6 miles below the point of exit of the latter river from the Superstition Mountains, and its waters go to form a portion of the supply used in irrigation about Phœnix and the adjoining sections. This river passes through the center of the Fort McDowell Reservation, and a small portion of its water is used to irrigate the land under cultivation thereon.

At a point 12 miles north of the post it emerges from a long, narrow, and deep cañon with features somewhat similar to those of the Salt River Cañon. It presents as favorable places for the construction of dams, etc. Like the Salt River, it carries an immense volume of water during the winter season, which, if only partially stored up, would irrigate an immense area. The country which would be irrigated by a system of this kind is one of the richest in soil of any in the United States, and with water its productive capacity would be almost unlimited.

Snow never falls and frost is very rare.

The Gila River runs through this section of country about 20 miles south of the Salt River. The two rivers join a short distance below Phœnix and flow on to the Colorado, the combined streams being called the Gila River.

STATEMENT OF W. A. GLASSFORD, SECOND LIEUTENANT, SIGNAL OFFICER, SIGNAL CORPS, U. S. ARMY, OF PRESCOTT.

RAIN-FALL IN ARIZONA, AND ITS EFFECT ON IRRIGATION AND WATER STORAGE, WITH DESCRIPTION OF SOME FAVORABLE POINTS FOR STORAGE RESERVOIRS.

General features of Arizona.—No portion of the Union probably presents such favorable conditions for the artificial catchment of water for agricultural and other purposes as does Arizona. In its great area, nearly double that of the six New England states, are presented physical features peculiarly adapted to the construction and maintenance of an immense system of irrigation based on the storage of water by artificial reservoirs, and the supply of which it will be the endeavor of the writer to show is abundantly provided for by rain-fall.

Were it possible to obtain a birds-eye view of the Territory, the observer would see spread out before him an area equaling Italy in size, consisting of a series of mountainous plateaus, ranging in height from 7,000 feet in the northern part of the Territory, to a few hundred feet in the southwestern portion. Of these plateaus those of the north will be found interspersed with mountain chains and deep cañons. In some places volcanic cones rise over 5,000 feet above the plateaus, while cañon gorges are cut as deep below. To these characteristics the plateaus of the southwestern portion of Arizona present strong contrasts, consisting as they do of level valleys, mesa or table lands, gradually sloping off towards the Gulf of California. Some of these are basins of what have been, at comparatively recent periods, immense inland seas. In places the loss of altitude is so rapid that immense cañons have been cut by erosion through the mountain chains and plateaus, and immense basins have been formed along the water-sheds of all the permanent streams.

These cañons and basins are of great depth and area, and present unrivaled facilities for the construction of a system of artificial reservoirs similar to that established by the British Government in India, where the Himilayas present much the same characteristic features. The streams, which in the north flow through cañons whose precipitous sides tower thousands of feet above the surface of the water, as they reach the southern mesas roll sluggishly along, with barely sufficient fall to prevent their sinking in the sand.

It is in the valleys along the latter portions of the rivers of Arizona that are to be found rich alluvial lands unequaled in fertility and productiveness.

The areas of these lands in Arizona are variously estimated from 6,000,000 to 10,000,000 acres, or an area surpassing all of Massachusetts, Connecticut, and Rhode Island, or Belgium, and nearly equaling Switzerland. The vastness of these areas can scarcely be realized from the mere mention of the figures, but their extent can be appreciated when it is remembered that the entire area of such land susceptible of reclamation on the Rhone in southern France is less than 400,000 acres; Spain does not equal this, while the famous Deltaic provinces of lower Egypt possess but about three times this area, and India, the oldest settled of all lands, has but about five times as much as France under cultivation through irrigation.

Irrigation and water storage in Arizona.—The almost level and uniform surface of these lands in Arizona makes this reclamation by diversion of water upon them easy when the water is obtainable. Many streams are now used for irrigation by diverting the water by canals. The lands thus reclaimed are close along the banks of streams, where the diversion is accomplished by gravity. So prolific and various are the productions of the land already reclaimed that canals and ditches have increased so as to go far to exhaust the available permanent flowing streams. This is especially observed when the stage of supplying streams is at the minimum, occurring during years of scanty rain-fall.

The utilization of water for arable land has forced in some places an approach to the exhaustion of the water supply that can be depended upon during years of extreme drought, at least gone far to alarm the rights held by prior appropriators. Above the existing canals is more land, and in some localities vast quantities, that only want the water brought upon it. This conducting of water to higher levels involves in most cases the necessity of either very long canals, because taken from a point higher up the stream, or storage dams by which a higher level for the exercise of gravity is obtained without increasing the length of canal. We thus see that an increase of the amount of water by storage projects is favored by two considerations: First, to widen the area of land possible to be reclaimed; and, second, to secure sufficient water during seasons of drought. Such storage being necessary to the general welfare, the question of the practicability of impounding water naturally arises.

The solution of this question is found primarily in an accurate determination of the depth of the annual rain-fall, with both the maximum and the minimum that may be expected in the district under consideration; also any peculiarities of its distribution.

This preliminary investigation is obviously that of the meteorologist and belongs to the signal service, a task it has long been engaged in, and an evidence of its activity will perhaps become apparent from the array of data in this Territory, the last in which savagery has been subjugated. Having reliable data upon the above points, the next subject of investigation is, what amount of waterflow becomes available, due allowance being made for evaporation, the selection of reservoir sites, and proportioning their size to the area of the catchment basin after a study of the drainage area in every particular. These latter questions are for the engineer.

The presentation of this paper and data will, it is hoped, go far to show that the meteorologist has been and is performing his functions, and that the engineering questions, it is believed, are ready to be actively entered upon.

The writer, under the stimulus of encouragement from General A. W. Greely, Chief Signal Officer, has collected climatic data recorded in the past, and established new stations in considerable number.

The results of this labor are partially presented in this data and discussion of rain-fall in Arizona, which follows:

Annual precipitation in Arizona.—The chart presenting the average annual precipitation embraces all stations in Arizona and includes a few outside near the boundary line and headwaters of the Gila in New Mexico. The average annual depth of rain-fall is found by taking the aggregate of the monthly averages, which latter are derived by adding the records of each month and dividing by the number of months of the same name taken.

In the southwestern and western portions of Arizona the precipitation is quite scant, being from about 2 to 6 inches, some places being perhaps as little as recorded at any place on the globe.

Rising into the more elevated districts of the eastern half, central, and northern parts, characterized as plateau and mountainous, the annual average ranges from 10 to 20 inches, and at a point just over the line in Utah is over 36 inches, and at the headwaters of the Gila 33 inches. It is proper to note in considering these averages that the points of observation are not on the tops of the mountains, nor even high on the slopes, but in most cases in valleys or cañons.

It is no uncommon sight to observe heavy rains in the mountains, or at the summits of ridges, while down their steep slopes flow great volumes of water, although at the spot where the gauge is located frequently not a sprinkle would fall. It is for this reason the data represents perhaps the least approximate quantity of actual precipitation.

The distribution of the rain-fall throughout the year is peculiar, there being distinctly two rainy seasons—one in the winter, the other in the summer. These dual wet seasons are very advantageous in renewing the supply to the streams in close succession. This peculiarity of Arizona rain-fall is particularly favorable in contrast to districts where there occurs a single rainy season, and balances largely any deficiency in quantity. Much of the precipitation occurs in the high plateau and mountain districts in the form of snow, which continues to lie on the northern slopes till late in the spring, while upon the higher mountains it does not disappear till late in June.

It is a noteworthy feature of the climatology of Arizona that with the disappearance of the last snows upon the mountain summits commences the summer rains. This fact affords quite a sure means of forecasting the beginning of the summer showers, which can be turned to advantage in husbanding, if necessary, water accumulated in storage reservoirs. It appears that the winter precipitation, though not so great, nor as sure to be relied upon as that of summer, has been observed never to fail to flood the streams each year, and besides its influence is prolonged in the melting of the snow.

This being followed by the mountain rains of the summer, it appears a natural provision largely balancing dearth of quantity.

The general character of the surface where the rain occurs being steep, rocky, and without thick forest growth, conduces to pass the greater portion of the water that falls down into the valleys at once. Especially is this true of the mountain sides where we have every reason to believe the fall of rain is quite great. At the summits, the rains of summer are of almost daily occurrence, and generally in the afternoons, often extending into the night.

The precipitation of midsummer is quite local in character, while that of winter is more uniform over the face of the country, irrespective of topographical features. One is caused by mountain influences, the other by the proximity of approach of great storms, in low pressure areas, that pass over the country.

The amount of rain-fall as a general rule, as instanced in the Atlantic States, is greatest in those districts that are situated toward the point from which the prevailing wind blows. The contrary, however, of this phenomena is found in Arizona and in the neighborhood of mountain ranges. The prevailing wind over Arizona is southwesterly, and it is on the leeward side of ranges that the greatest pluvial effort is often found. Striking local instances may be observed in the records presented, when studied in connection with the location and topography. The record at Goodwin and Fort Thomas is a very noteworthy local instance, the former being under the flow of the wind from off Mount Turnbull.

The winter and summer rainy seasons.—The winter rains and snows generally occur within the months of December, January, and February. Sometimes they begin in November and rarely extend into March. The averages presented in the charts and in the table for these three months show quite well, however, the amounts that may be depended upon. The winter precipitation is largely in the form of snow, especially over the mountains and plateaus, and much remains unmelted till late in June, especially that falling on the north side of the higher mountain slopes. For this reason the ill effects of the nearly rainless period intervening between the end of the winter and the beginning of the summer rains is largely compensated by the melting snows which feed the streams.

The line of demarkation between the end of the summer and commencement of the winter rains is not so well defined. The summer rains, as above intimated, seem to begin as the snow disappears from the highest mountains, and continue during most of July, August, and September. Arizona is perhaps favored in having no mountains with summits above the perpetual snow line. To this absence the writer attributes the cause, at least a partial one, of the summer rains in Arizona. If the tops of the highest of the Sierra Nevada and Cascade Mountains could be cut off at their perpetual snow line, it is believed that there, too, the summer rains would prevail.

Contrasting Arizona with the Pacific coast States, if she has not so great an amount of rain-fall it comes differently distributed, and experience may prove the dual rainy seasons of Arizona have not unequal advantages with the single but greater one of those States.

The discussion of the cause of these different phenomena was touched upon in "Rain-fall of the Pacific Slope and the Western States and Territories," published by the United States Senate, in a letter transmitted by General A. W. Greely, Chief Signal Officer, and its repetition in this paper would perhaps be out of place.

The total amount of the summer rains is considerably in excess of that of winter, but comes in almost daily showers. It is rare that they occur as general rains over the whole face of the country, but instances are not lacking when the rain has fallen in down-pours and occasionally the term cloud-burst is not inappropriately descriptive. On the other hand, the winter precipitation is heavy and general while it lasts. It comes like that of the Pacific States, with storms conventionally known as cyclonic or low barometric areas, and the intervals between their occurrence are likewise characterized as cloudless. The variability of the winter rains in Arizona is about the same as that of the seasonal rains in California, that is in quantity and frequency, in a ratio to the intensity and recurrence of barometric disturbances. The effect of the rain-fall is obviously of an intermittent character. High and low water occurs in the streams during the rainy seasons, and during the periods of drought some streams become feeble rills or disappear altogether, except over some places where a solid rock stratum brings it to view. This disappearance of the streams is due to the great quantity of detritus, sand, and silt that has washed into the beds of the streams, on account of the sudden down-pours, and the steepness of the mountain sides.

This feature has given Arizona a reputation for drought and sterility largely undeserved. These conditions resulting in intermittent and for part of the year underground streams, with large volumes in winter, show the need of storage reservoirs to conserve the supply.

The most casual observer of the streams in Arizona during the winter is impressed with the fact that enough water pours down these rivers to water many times as much land as is possible of reclamation. These rises in the streams force us to repeat that the rain-gauge records show only a fraction of the actual precipitation that can be relied upon for water storage. It is during the summer only that the so-called cloud-bursts or down-pours of torrential rain occur. They are not frequent, however, but some are severe.

The maximum and minimum rain-fall.—The greatest and the least depth of precipitation is given for each month and year in tabular form; also in the charts is shown the greatest and least annual rain-fall for such stations as have a record of at least two years, or long enough to warrant its presentation as an approximate type. The minimum amount for any year is a very important item, too, in the consideration of water-storage systems, as it determines the water expectations of the most scanty precipitation seasons. When these amounts are viewed in connection with the great drainage areas, steepness, and character of the slopes there appears little or no doubt but the fall in years of drought even is sufficient for the most extensive reservoirs. The maximum annual rain-fall needs little mention, as it does not appear so great as to cause alarm. The greatest fall occurring within any number of consecutive hours, however, is more important, and the following table gives the aggregate number of excessive monthly, daily, and hourly rain-falls reported at regular stations of the Signal Service in Arizona during the periods of observation, and the average interval of their occurrence:

Station.	1	2	3		4	5		6
			Yrs.	*Mos.*		*Yrs.*	*Mos.*	
Fort Apache	0	2	5	0	9	1	1	10
Fort Bowie	0	0			0			5
Fort Grant	0	3	3	4	6	1	8	10
Fort McDowell	0	1	5	0	0			5
Fort Thomas	0	0			1	8	0	8
Fort Verde	0	0			0			12
Maricopa	0	0			0			3
Phoenix	0	0			0			9
Prescott	0	2	6	0	0			12
Yuma	0	0			0			13

In the table above column 1 represents rain-falls of 10 inches or more a month; 2, rain-falls of 2.50 inches or more a day; 3, average interval of occurrence; 4, rain-falls of 1 inch or more an hour; 5, average interval of occurrence; 6, length of record.

Practical examples of water storage in Arizona.—Arizona has but two complete projects for water storage for purposes of irrigation; one is a small reservoir at Woodruff in the northern part of the Territory. The Mormons operate it with marked success, as the flourishing villages in that community exemplify.

A more important project for water storage is found at Walnut Grove, near Prescott. This latter reservoir was principally built to hydraulic the placer or gold gravel deposits on the Hassayampa Creek, several miles below the basin in which the water is impounded.

This project may be looked upon as a type of what may be accomplished for irrigation works depending upon water storage for supply.

A careful estimate of the catchment basin of this reservoir shows it to be about 150 square miles. The few records of rain-fall within this area shows it to be much less than the recorded precipitation at Prescott, a few miles distant, where the least occurring during any year is 10 inches. The Walnut Grove reservoir is said to be capable of impounding 3,000,000,000 cubic feet of water. It is learned on good authority that this reservoir is full and was kept so during the scant rains of 1888. This actual exemplification shows the practicability of like storage systems on the Gila, Salt, Verde, and other streams, the only question apparently being the overcoming the abundance of water that sometimes occurs.

Proposed sites for surveys for storage reservoirs.—My own personal observations, supplemented by those of others, may not be inappropriate in this paper. During the past winter the writer, while on leave of absence, was engaged in surveys in southern Arizona, and examined especially the region about Florence, of which, through the kindness of Dr. J. M. Hurley, is presented a map with observations showing perhaps one of the most favorable spots in the country for water storage. The water-shed of the Gila River may be divided into two sections, the upper and the lower, the upper section extending from its source in the mountains of New Mexico, where the rain-fall, as shown by the tables, is phenomenally great, westward down its course to what is known as the Buttes, just above Florence, and a place where the mountains come together. At this point the bluffs are precipitous and the river flows through a narrow gorge not over 200 feet wide at the bottom. The lower Gila River extends from the Buttes down its course, and in a general westerly course for near 200 miles, to its confluence with the Colorado River at Yuma.

The topography, geography, geology, and productions of these two divisions are very dissimilar in many respects. A large portion of the upper Gila water-shed is very mountainous, the elevation varying from 2,000 to 10,000 feet. Some places show distinct traces of volcanic origin, the surface of the country being badly broken up. The soil is rich, consisting of decomposed granite, volcanic matter, and vegetable decomposition. Much of the more elevated portion is covered with a thick growth of timber, varying with the altitude from mere brush to the most gigantic pines on the mountains. In this section there are abundant rains, being heavy, as shown by the chart, during the summer, and considerable snow in the winter. Farming in some places may, indeed, be carried on without the aid of irrigation.

The rain-fall data presented in this water-shed is perhaps surprising. It is, too, no unusual thing to see snow from 3 to 7 feet deep on a level on the mountains. The lower section of the Gila Valley consists of vast plains interspersed with small mountains mostly of volcanic origin. The elevation of these plains varies from about 150 feet, near the Colorado River, to about 2,000 feet, at the Buttes near Florence. The soil of these plains consists of red clay, sand, and decomposed granite, with vegetable matter washed from the mountains, it being perhaps the original bed of the ocean, that once covered this country. These plains are dry and barren, being covered sparsely with cacti, sage brush, and similar growth. In this section of the Gila Valley all crops are grown by the aid of irrigation. In extent this vast plain embraces thousands of acres, while the water supply as compared to the amount of land susceptible of cultivation is very limited, and unless ways and means are devised to store and save the immense floods of water from the upper Gila section, that semi-annually run to waste in the Gulf of California, there will be but a limited portion of these vast plains, of as good land as anywhere exists, ever brought under cultivation.

The canals taken from the Gila in the vicinity of Florence cover about 300,000 acres of land, including 50,000 acres on the Pima Indian Reservation. These canals nearly exhaust the water at ordinary stage, although they furnish a superabundance of water in the spring of the year in crop season, and also when the summer rains come early in the upper Gila, to make a second crop; but there occur usually two short periods in each year when there is a scarcity of water in all the lower valley, say, from three to six weeks in June and July and again about the same length of time in November and December; especially during the latter period is the amount needed usually limited.

When the water in the upper Gila gets low, immediately after it passes through the gorge at the Buttes, where the bed-rock comes to the surface, it largely disappears in the gravel bed that underlies the plains in the lower valley. Canals that are taken out immediately below the Buttes have a steady and constant supply of water, while those lower down get none in low water, except at a few places where the bed-rock comes to the surface. Notwithstanding this the entire volume of the river might be turned down to the lower sections if it were possible to raise the level of the water sufficiently through the agency of a reservoir. The many thousands of acres of the most valuable land in these lower plains before noted can be successfully brought under cultivation at a comparatively small cost to each acre by constructing a dam in the Gila River at the place above mentioned at the Buttes, some 10 miles above Florence.

A dam constructed there would store a sufficient quantity of water when the river is flush in the two rainy seasons to insure a steady flow of water in all the canals now in use in this valley, and allow a sufficient surplus of water to guaranty the construction of another canal to be taken out of the river at the Buttes on the south side of the river. The capacity of this canal can be as great as all other canals, and would water some of the finest land ever looked upon. This statement may seem an extravagant one, but upon examination of the accompanying map, showing the topography of the country above Florence, at and above the Buttes, it is readily seen that an enormous basin of water can be formed by constructing a dam at that place. It appears that a dam 150 feet high will back the water about 20 miles, giving probably an average depth of some 75 feet for the entire distance. The cañon of the river immediately above the Buttes widens out, and at a distance of one-fourth of a mile it is as much as one-half mile wide on the bottom, and much of the entire distance it is a mile or more wide. The sides of the mountain surrounding this basin are broken by side or lateral cañons that add greatly to the capacity of the basin. The conception of the capacity of such a reservoir can only be appreciated by the engineer and study of such spaces. No cross-sections of this basin have ever been made, as far as known, to calculate the vast volume of the basin, but the above statement it is believed is not overdrawn, and that an accurate survey will increase this estimate. There can be no doubt of the water supply being sufficient to fill this vast reservoir when a dam is once constructed, as a glance at the rain-fall data in the water-shed covering southwestern Arizona, a large part of western New Mexico and Sonora will prove. It is believed this water-shed will not only furnish water for this ideal reservoir, but will also supply many other reservoirs, smaller in capacity, that can be constructed at different places in the lower Gila River valley, and from which many thousands of acres of valuable land can be reclaimed.

The above facts seem to me so patent that it is respectfully urged that this place be investigated for early experiment and surveys in Arizona, under the Government, as there are few spots in the United States, and certainly few in Arizona, where so much can be accomplished with so small an expenditure of means. Indeed, to the person who has looked at the place with the object in view it appears as if nature had largely made this extraordinary place for the purpose.

A dam about 200 feet wide at the bottom and 100 feet high, though the height might be doubled, will, it is believed, accomplish the results heretofore outlined. At this place the best rock, almost in place, can be quarried for constructing the dam, and in the immediate vicinity good hydraulic lime can be burned, as is now done by the Mexicans for use by the cattle men for the purpose of constructing water tanks. With all these advantages, and many others not enumerated that will be found to exist when properly examined, the Government can not too early turn its attention to this extraordinary place, that it may be utilized while it is yet unencumbered by settlers or other claims, so that this, if the first experiment in the storage of water from large streams, may be a success beyond a question.

Some action in this direction by the Government is essential, as the work is of such magnitude that it deters private capital from undertaking it until prominent engineers have pronounced the proposition feasible beyond a doubt.

The Salt and Verde Rivers.—Having noted the advantages for the impounding of water on the Gila, it would perhaps be unjust to fail in mentioning the existence of quite similar facilities reputed to exist in the Salt, or Salido, and the Verde Rivers. Of these the writer has made less investigation, and consequently speaks in a general way, having traversed each river nearly from their sources to their confluence, which is 40 miles northwest of the Buttes of the Gila. The Salt and Verde Rivers are the third and fourth largest streams in size in the extreme southwestern portion of the Union. These rivers after a tortuous course of hundreds of miles through deep cañons and natural basins, whose areas are measured by hundreds of miles, at their junction debranch into a series of mesa lands, noted for their fertility and extent. Of these lands over a quarter of a million acres within the last few years have by the construction of irrigating ditches been rendered susceptible of raising every variety of semi-tropical fruits that have made California so justly famous, while villages and cities numbering some hundreds, and others thousands, of inhabitants have sprung into existence. That the amount of land that can be now cultivated is but a small moiety of what has been is proved by the fact that far outside the ditches, constructed by the white residents, are to be found the remains of prehistoric canals and acequias, which in places can be traced for miles.

These prehistoric works of irrigation were in their day probably rendered possible by the rivers mentioned occupying, in the vicinity of the military post of Fort McDowell, higher levels than they do at present, levels now made impracticable through the wearing away and lowering by natural causes of the river-beds. The above causes may have been aided by volcanic or seismic action; the evidence of the recent occurrence of the first is well shown by beds of lava-flow, into and across the canals of these prehistoric people, and evidences of earthquake changes abound on every hand. While these causes were lowering the levels of the streams, they were at the same time forming a system of over-drainage through and by which natural basins that were once the beds of lakes were provided with outlets that prevented the accumulation of any quantities of water. So excessive is this natural system of over-drainage that in the water-sheds of the Verde and Salt Rivers, the great magnitude of which an observant glance at any hypsometric map of these areas will reveal, there is not to be found a single lake of any extent, although the evidences of the recent existence of such bodies of considerable size are so common as to excite but little comment. Some of these basins on the rivers mentioned equal in area some of the smaller States, and only need closing of the outlets created by the action of the streams to be reconverted into immense lakes, whose catchment capacity would be such as to provide water sufficient to reclaim the millions of acres, which in southern Arizona slope gradually away to the southwest toward the Gulf of California.

How vast an amount of water under the present condition of affairs yearly finds its way without being utilized through the channels of these rivers to the sea may be realized when it is remembered that the average annual rain-fall on the water-shed of the Salt River is shown to be about 20 inches and that of the Verde ranging from 20 to 10 inches. Year after year sees the demand upon these streams for water for irrigation become more and more difficult to fill, not on account of scarcity of water so much as by reason of the waste that is permitted during the wet seasons.

The catchment to any considerable extent of the rain-fall annually occurring on the water-shed of the Gila, Salt, or Verde River would not only insure an abundance for all present requirements, but make possible the reclamation of a vast territory that otherwise will always remain desert.

The following tables and charts are in illustration:

No. I.

Average rain-fall, by months and years, Arizona.

Stations.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
	In.	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*
Antelope Valley, Ariz	1.93	.64	3.14	.00	.00	.00	2.14	.34	.10	2.08	2.53	2.96	15.85
Apache, Fort, Ariz	1.25	1.76	1.70	.80	.47	.77	4.14	4.58	1.58	1.43	1.11	1.76	21.33
Ash Cañon, Ariz	1.80	.05	2.61	......	......	.76	......	1.45	......	......	1.03	4.50	......
Bangharts, Ariz	......	......	......	......	......	......	2.28	......	......	......	......	3.01	......
Benson, Ariz	.38	.56	.54	T.	.08	.29	1.65	2.39	.91	.60	.31	.67	8.38
Bowie, Fort, Ariz	1.27	1.96	1.25	.17	.28	.75	3.31	3.01	1.26	.63	.74	1.38	16.01
Buchanan, Fort, Ariz	1.47	2.01	.20	.60	.18	.82	5.25	6.16	2.03	1.16	1.09	1.15	22.12
Burks, Ariz	.15	.52	.13	.08	.00	.00	.02	1.41	.57	.02	.41	.70	4.01
Casa Grande, Ariz	.46	.15	.36	.06	.07	.07	.31	.88	.30	.34	.32	.71	4.03
Cedar Springs, Ariz	2.16	1.27	1.40	.25	.15	.47	.68	.17	.62	......	2.55	2.50	......
Colorado, Camp, Ariz	.15	.07	.25	.08	.02	.00	.03	.25	.00	.30	.50	.20	1.85
Coolidge, N. Mex	.60	.90	.60	.40	.40	1.20	1.60	.80	.40	.90	.40	.70	8.70
Crittenden, Camp, Ariz	.68	1.15	.70	.26	.05	.31	6.01	4.88	.94	.23	.37	1.81	17.39
Date Creek, Ariz	.79	1.35	.82	.87	.13	.24	3.19	3.78	.29	.46	.64	1.20	13.76
Defiance, Fort, N. Mex	.89	.56	.68	.67	.52	.74	2.46	2.73	1.86	.70	1.10	.87	13.84
Eagle Pass, Ariz	1.84	1.80	1.01	.27	.10	.04	......	......	......	......	2.84	3.13	......
Eldorado Cañon, Cal.	.80	.27	.63	.38	.00	.00	.83	.00	.05	.14	.84	1.64	5.64
Flagstaff, Ariz	......	......	......	.75	.65	.30	......	......	1.00	4.20	2.38	......	......
Florence, Ariz	.88	.70	.94	.38	.07	.02	1.59	2.05	1.06	.72	.47	1.04	9.92
Globe, Ariz	2.15	1.11	2.33	.43	.00	.38	2.47	1.37	.65	2.39	3.61	2.18	19.07
Goodwin, Ariz.	2.41	1.82	1.04	1.30	.00	.69	3.35	6.78	3.80	1.39	1.19	2.81	26.58
Grant, Fort, Ariz	.90	1.18	1.00	.57	.25	.64	3.42	3.44	1.86	.75	.87	1.51	16.39
Harrisburg, Utah	.10	2.94	1.17	.93	2.20	1.00	2.07	.65	.30	.10	1.92	.06	13.14
Holbrook, Ariz	.50	.76	.66	.52	.16	.28	1.04	1.31	1.09	.82	.96	.69	8.79
Huachuca, Fort, Ariz	1.45	.92	1.94	.22	.30	1.06	7.96	2.73	.96	2.12	1.97	1.38	23.03
Huachuca Mountains, Ariz.	2.37	.05	2.61	.14	.00	.55	......	3.47	1.07	......	3.46	1.42	......
Hualpai, Camp, Ariz	.09	1.02	.00	1.62	.63	1.28	3.00	7.02	3.15	.45	.28	.87	20.89
Keno, Camp, Ariz	......	......	4.00	2.70	......	......	......	......	.00	.20	1.30	.00	......
Kanab, Utah	1.47	1.69	.56	.79	.42	.46	.92	.50	.54	.90	1.20	1.55	11.60
Lincoln Camp	17.05	3.95	12.30	3.99	.27	.33	......	1.79	1.27	.58	1.08	......	......
Lordsburg, N. Mex	.47	.24	1.01	.06	.09	.13	1.88	1.99	.89	.72	.58	.60	8.66
Lowell, Fort, Ariz	1.12	1.21	.83	.28	.06	.35	2.44	2.78	1.20	.06	.52	.88	11.74
Maricopa, Ariz	.44	.52	.70	.11	.10	.09	.40	.87	.36	.36	.30	.75	5.10
McDowell, Fort, Ariz	1.07	1.24	.75	.38	.14	.13	1.30	1.54	1.00	.37	.82	1.79	10.53
Mount Carmel, Utah	6.68	6.13	5.20	2.14	3.05	.03	1.08	1.75	.58	7.12	2.25	.70	36.71
Mojave, Fort, Ariz	.87	.75	.02	.35	.14	.52	.30	.60	.09	.30	1.21	1.12	6.87
Needles, Cal	1.68	.98	2.08	.10	.75	.00	.66	.03	.12	.83	.00	1.32	8.55
Pantano, Ariz	1.03	1.23	1.00	.16	.28	.53	1.59	2.87	1.50	.95	.42	1.09	12.65
Peoria, Ariz	1.56	.24	1.00	.01	T.	......	......	......	......	......	......	......	......
Phœnix, Ariz	.53	.88	.87	.30	.12	.09	.70	.95	.59	.27	.48	.80	6.67
Reno, Camp, Ariz	2.46	2.70	.88	.03	.00	.50	......	......	.02	1.00	3.50	.70	......
Rioville, Cal	1.14	......	......	......	......	......	......	.17	.16	.01	1.29	1.98	......
Skull Valley, Ariz	3.11	1.11	3.69	.30	......	......	......	......	......	......	......	......	......
San Carlos, Ariz	1.12	1.62	1.42	.19	.24	.30	1.80	2.62	.77	.77	.71	1.79	13.41
San Simon, Ariz	.18	.33	.65	.02	.11	.02	.61	1.41	.53	.30	.13	.40	4.69
Silver City, N. Mex	1.42	1.08	.90	.22	.48	.69	3.96	5.95	2.24	1.19	1.40	.75	20.28
St. George, Utah	1.43	.78	.65	.26	3.70	.03	.62	.66	.56	1.26	.50	1.12	11.57
Teviston, Ariz	1.20	.80	.80	.20	.00	1.45	.20	.00	.05	.16	1.14	1.08	7.20
Texas Hill, Ariz	.61	.39	.37	.06	.04	.00	.11	.61	.43	.76	.30	.48	4.16
Thomas, Fort, Ariz	.71	1.33	1.14	.26	.50	.56	1.79	2.41	.98	.67	.86	.42	11.63
Tombstone, Ariz	3.27	......	......	.00	.00	......	......	......	.50	.40	......	3.00	......
Tubac, Ariz	.81	.29	......	......	......	......	......	......	......	.00	.35	2.57	......
Tucson, Ariz	.62	.92	.61	.21	.08	.19	2.39	2.27	.99	.39	.51	1.13	10.31
Tularosa, Fort, N. Mex	2.24	4.94	1.38	.34	.55	.63	3.65	8.40	1.20	1.29	.38	7.08	33.13
Verde, Fort, Ariz	.90	.91	1.16	.59	.26	.25	.80	2.96	1.03	.69	1.07	1.36	11.98
Wallen, Ariz	2.43	1.59	.52	.25	.03	.03	5.32	4.90	.90	.00	.00	2.93	18.90
Whipple, Fort, Ariz	1.42	1.78	1.72	.95	.60	.18	3.08	2.91	1.12	.65	.91	1.16	16.48
Webster, Fort, Ariz	.40	1.00	.07	2.23	1.14	2.98	3.67	2.75	2.36	.80	1.87	.19	19.46
Wickenburgh, Ariz	1.07	1.10	.80	.52	.30	.02	.81	1.99	.66	.18	.51	1.87	9.83
Willcox, Ariz	.66	1.07	.95	.01	.12	.18	1.85	3.40	1.40	.83	1.27	1.17	12.91
Winslow, Ariz	......	.60	.60	.02	.01	.43	.25	.71	.84	.09	1.02	......	......
Williams, Ariz	.70	1.70	.95	.05	.07	.00	1.35	.14	......	2.30	4.60	3.80	......
Willow Grove, Ariz	.48	.88	.42	.59	.20	.03	3.05	2.37	.07	.33	.23	.35	9.00
Willow Springs, Ariz	2.04	......	5.77	......	.00	......	......	......	......	......	1.76	3.08	......
Wingate, Fort, N. Mex	1.12	1.62	.98	.89	.50	.71	2.44	2.41	1.25	1.05	.78	.95	14.60
Yuma, Ariz	.46	.42	.55	.08	.03	T.	.14	.41	.15	.18	.37	.42	3.23

No. II.

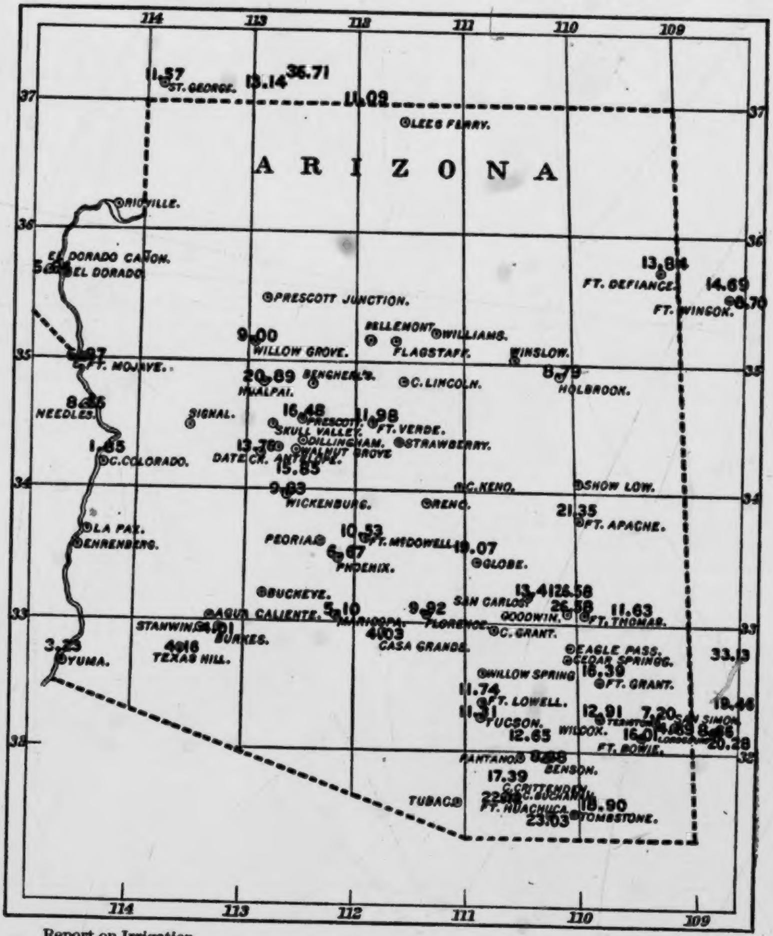
Average summer and winter rain-fall, Arizona.

Stations.	December, January, February	July, August, September.	Stations.	December, January, February.	July, August, September.
Antelope, Valley, Ariz	5.52	2.56	McDowell, Fort, Ariz	4.10	3.84
Apache, Fort, Ariz	4.77	10.30	Mount Carmel, Utah	13.51	3.41
Ash Cañon, Ariz	6.35	....	Mojave, Fort, Ariz	2.64	.99
Benson, Ariz	1.61	4.95	Needles, Cal	3.98	.81
Bowie, Fort, Ariz	4.61	7.58	Pantano, Ariz	3.35	5.96
Buchanan, Fort, Ariz	4.63	13.44	Phœnix, Ariz	2.30	2.24
Burke, Ariz	1.37	2.00	Reno, Camp, Ariz	5.86	....
Casa Grande, Ariz	1.32	1.49	San Carlos, Ariz	4.53	5.23
Cedar Springs, Ariz	5.93	1.48	San Simon, Ariz	.91	2.55
Colorado, Camp, Ariz	.42	.28	Silver City, N. Mex	3.25	12.15
Coolidge, N. Mex	2.20	....	St. George, Utah	3.33	1.84
Crittenden, Camp, Ariz	3.64	11.83	Teviston, Ariz	2.08	.37
Date Creek, Camp, Ariz	3.34	7.26	Texas Hill, Ariz	1.48	1.15
Defiance, Fort, Ariz	2.32	7.05	Thomas, Fort, Ariz	2.46	5.18
Eagle Pass, Ariz	6.77	....	Tubac, Ariz	3.67	....
Eldorado Cañon, Cal	2.71	.94	Tucson, Ariz	2.67	5.65
Florence, Ariz	2.62	4.70	Tularosa, Fort, N. Mex	14.26	13.25
Globe, Ariz	5.44	4.49	Verde, Fort, Ariz	3.17	4.79
Goodwin, Ariz	7.04	13.93	Wallen, Ariz	6.95	11.21
Grant, Fort, Ariz	3.59	8.72	Whipple, Fort, Ariz	4.36	7.11
Harrisburg, Utah	3.10	3.62	Webster, Fort, Ariz	1.50	8.78
Holbrook, Ariz	1.95	3.44	Wickenburgh, Ariz	4.04	3.46
Huachuca, Fort, Ariz	3.75	11.67	Willcox, Ariz	2.90	6.65
Hualpai, Camp, Ariz	2.88	13.77	Winslow, Ariz	....	1.89
Kanab, Utah	4.71	1.96	Williams, Ariz	6.20	....
Lordsburg, N. Mex	1.31	4.76	Willow Grove, Ariz	1.71	5.49
Lowell, Fort, Ariz	3.22	6.42	Wingate, N. Mex	3.69	6.10
Maricopa, Ariz	1.71	1.63	Yuma, Ariz	1.32	.70

No. III.

Greatest and least rain-fall, by months and years, Arizona.

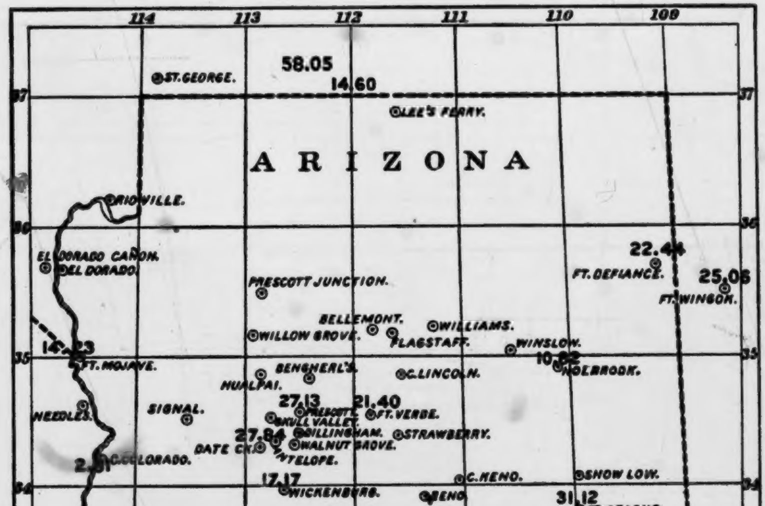
Stations.		Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
		In.	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*
Apache, Fort, Ariz.	Max.	3.90	3.43	4.44	1.77	1.31	3.27	5.83	9.33	5.41	4.68	2.63	5.52	31.12
	Min.	.18	.88	.03	.08	.00	T.	.14	1.20	.32	.00	.02	.22	12.41
Benson, Ariz	Max	.93	1.20	2.08	T.	.37	.86	2.97	4.33	2.92	2.89	1.11	2.50	......
	Min.	.00	.00	.00	.00	.00	.00	.58	.27	.05	.00	.00	.15	......
Bowie, Fort, Ariz..	Max.	4.24	5.40	4.48	1.00	1.50	4.21	7.90	7.44	8.19	3.58	1.79	6.41	25.20
	Min.	.00	.20	.00	.00	.00	.00	.50	.18	.01	.00	.09	.00	9.36
Buchanan, Ft., Ariz	Max.	2.35	2.92	.47	1.46	.55	1.96	9.24	10.60	4.76	2.33	2.84	2.58	25.82
	Min.	.54	.51	.00	.00	.00	.20	3.21	3.50	.74	.60	.00	.40	16.08
Casa Grande, Ariz.	Max.	.90	.40	1.08	.30	.24	.40	1.07	2.37	1.90	1.31	1.28	3.20	8.71
	Min.	.00	.00	.00	.00	.00	.00	.00	.60	.00	.00	.00	.00	2.02
Colorado, C'p, Ariz.	Max.	.30	.21	.50	.15	.05	.00	.06	.30	.00	.50	1.00	.20	2.61
	Min.	.00	.00	.00	.00	.00	.00	.00	.20	.00	.10	.00	.20	1.31
Crittend'n, C'p, Ariz	Max.	1.10	2.50	1.13	.39	.20	.68	11.72	5.55	1.55	.46	1.01	3.76	19.08
	Min.	.31	.19	.00	.00	.00	.00	3.17	4.07	.40	.00	.00	.40	15.53
Date Cr'k, C'p, Ariz	Max.	3.12	2.85	2.86	2.05	.63	1.49	7.24	8.30	.93	1.50	1.90	4.09	27.84
	Min.	.00	.70	.00	.00	.00	.00	.36	.84	.00	.00	.00	.06	13.60
Defiance, Ft., Ariz	Max.	2.86	1.71	3.30	1.64	1.51	2.35	5.77	5.24	3.47	1.73	4.30	1.59	22.44
	Min.	.02	.03	.00	.02	.00	.10	.90	.30	.49	.00	.15	.23	11.63
Florence, Ariz	Max.	2.88	1.15	2.83	1.55	.31	.07	4.53	4.28	2.75	1.29	1.37	2.12	13.49
	Min	.00	.00	T.	.00	.00	.00	.00	.13	.26	.00	.00	.00	5.35
Goodwin, Ariz.....	Max.	5.77	2.62	1.87	2.67	.01	2.06	3.39	14.45	10.40	3.70	2.40	5.20	27.93
	Min.	.20	.58	.02	.00	.00	.00	3.20	2.16	.02	.50	.41	.60	16.00
Grant, Fort, Ariz ..	Max.	2.48	4.62	1.04	3.11	1.16	1.47	9.00	7.41	4.65	3.06	3.38	5.93	25.67
	Min.	.00	.10	.00	.00	.00	.00	.67	.52	.00	.00	.00	.09	8.95
Harrisburg, Utah..	Max.	.15	4.50	2.10	2.10	2.25	......	3.60	.80	......	......	3.15	.10	......
	Min.	.05	.95	.10	.10	2.15	......	.90	.50	......	......	.70	.01	......
Holbrook, Ariz	Max.	1.00	1.18	1.24	.82	.20	.56	1.98	2.09	1.88	1.05	2.20	1.31	10.82
	Min.	.10	.29	.06	.10	.00	.05	.47	.74	.51	.50	.14	.40	6.92
Hualpai, C'p, Ariz.	Max.	.10	4.65	.00	1.97	1.18	3.60	4.91	6.40	4.10	.60	.50	1.70	......
	Min.	.00	.40	.00	.07	.10	.00	2.30	2.80	2.20	.30	.00	.20	......
Kanab, Utah	Max.	8.30	3.55	1.75	1.80	1.80	2.10	1.50	.50	1.25	4.40	3.20	6.50	14.60
	Min.	.00	.05	.00	.06	.00	.00	.00	.00	.00	.00	.00	.00	7.37
Lordsburg, N.Mex.	Max.	.92	.45	4.00	.20	.40	.30	3.17	3.45	2.35	2.55	1.50	1.46	13.09
	Min.	.00	.10	.00	.00	.00	.00	.75	.35	.00	.00	.00	.00	5.50
Lowell, Fort, Ariz.	Max.	4.74	5.23	2.90	1.09	.42	2.05	4.83	7.88	3.83	2.65	2.30	3.18	14.69
	Min.	.00	.00	.00	.00	.00	.00	T.	.34	.00	.00	.00	.00	6.21
Maricopa, Ariz	Max.	1.32	.60	2.83	.51	.41	.45	1.26	1.29	1.10	1.51	.70	2.97	11.96
	Min.	.00	.00	T.	.00	.00	.00	.16	.08	T.	.00	.00	.00	.38
McDowell, Ft., Ariz	Max.	8.35	4.37	.76	3.20	1.04	1.00	9.16	7.17	4.11	2.82	2.76	5.70	20.01
	Min.	.00	.00	.00	.00	.00	.00	.00	.06	.00	.00	.00	.00	4.94
Mt Carmel, Utah..	Max.	16.00	11.90	10.00	4.40	6.25	.08	3.25	4.25	1.50	18.75	4.50	1.40	58.05
	Min.	1.05	4.00	.50	1.25	.20	.00	.00	.00	.00	.20	.00	.00	22.50
Mojave, Fort, Ariz.	Max.	4.15	5.00	2.50	4.05	1.20	1.00	1.80	3.80	.83	2.00	6.16	5.69	14.35
	Min.	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	2.23
Pantano, Ariz	Max.	2.02	2.80	2.08	.88	.60	.99	4.51	5.74	1.50	2.80	1.83	4.70	13.86
	Min.	.00	.41	.00	.00	.00	.00	T.	1.63	.00	.00	.00	.00	8.96
Phœnix, Ariz	Max.	1.62	2.46	2.85	1.25	.65	.49	2.40	2.19	1.50	1.12	1.66	3.36	12.83
	Min.	.00	.17	.00	.00	.00	.00	.05	.02	.07	.00	.00	.00	3.77
San Carlos, Ariz ..	Max.	2.88	3.83	3.97	.84	.71	1.09	4.13	6.05	1.94	1.73	1.76	5.48	20.41
	Min.	T.	.93	.00	.00	.00	.00	.03	.40	.11	.00	.00	.00	8.19
San Simon, Ariz ...	Max.	.50	.78	2.21	.10	.34	.08	1.25	3.60	2.24	1.63	.35	1.03	......
	Min.	.01	.05	.00	.00	.00	.00	.00	T.	.00	.00	.00	T.	......
Silver City, N.Mex.	Max.	2.78	2.06	1.57	.48	1.37	1.92	9.62	8.69	3.89	3.21	3.81	1.65	30.82
	Min.	.02	.63	.32	.01	.00	.08	1.37	3.51	.27	.00	.00	.28	13.77
St. George, Utah...	Max.	2.44	.98	1.30	.52	10.00	.04	1.03	1.17	.98	1.36	1.03	1.30	......
	Min.	.85	.43	.01	.04	.00	.01	.22	.11	.20	.80	.23	.94	......
Tucson, Ariz......	Max.	2.02	2.50	1.77	1.09	.41	.99	5.72	6.32	3.83	1.50	2.06	3.90	16.66
	Min.	.00	.15	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	6.61
Verde, Fort, Ariz..	Max.	2.91	3.59	3.60	1.75	1.70	1.35	5.31	12.80	4.72	4.17	4.04	4.66	21.40
	Min.	.00	.00	.06	.00	.00	.00	.07	.26	.00	.00	.00	.00	4.80
Wallen, Camp, Ariz.	Max.	4.60	2.30	.67	.50	.10	.05	7.90	8.00	2.00	.00	.00	7.90	24.53
	Min.	1.10	.50	.30	.00	.00	.00	1.40	2.50	.20	.00	.00	.00	17.76
Whipple, Ft., Ariz.	Max.	5.09	6.55	8.00	2.86	1.82	1.24	7.98	6.34	4.88	1.75	3.18	5.58	27.13
	Min.	.00	.01	.00	.03	.00	.00	.61	.24	.00	.00	.00	.00	10.02
Webster, Fort, N. Mex	Max.	.....	1.51	.13	4.45	1.23	4.89	4.79	4.29	3.47	1.19	3.48	.30	29.73
	Min.	.....	.50	.00	.00	1.05	1.08	2.55	1.21	1.26	.40	.26	.08	8.79
Wickenburgh, Ariz	Max.	2.73	4.21	8.67	1.24	.64	.06	2.29	5.02	1.16	.58	1.69	5.27	17.17
	Min.	T.	.00	.00	.13	.00	.00	.09	.05	.04	.00	.00	.00	6.35
Willcox, Ariz......	Max.	1.25	1.83	1.95	.04	.48	.47	3.97	5.31	2.96	3.59	4.25	3.49	18.38
	Min.	T.	.31	.00	.00	.00	T.	.11	.52	.04	.00	.00	.00	11.15
Willow Grove, Ariz	Max.	.48	1.15	.42	1.02	.28	.07	4.67	2.73	.14	.33	.23	.35	......
	Min.	.48	.61	.42	.16	.12	.00	1.43	2.01	.00	.33	.23	.35	......
Wingate, Fort, N. Mex	Max.	8.30	11.25	4.95	2.70	3.00	3.15	7.60	5.90	3.60	4.60	4.10	2.75	25.06
	Min.	.10	.00	.00	.00	.00	.00	.26	.24	.00	.00	.00	.00	5.69
Yuma, Ariz........	Max.	1.35	1.72	5.01	.55	.44	.05	.55	2.23	1.09	1.11	2.43	1.96	7.77
	Min.	.00	.00	.00	.00	00	.00	.00	.00	.00	.00	.00	.00	.74


114
113
112
111
110
109
37
36
35
34
33
32
A R I Z O N A
11.57
ST. GEORGE.
13.14
36.71
11.09
LEES FERRY.
RIOVILLE.
EL DORADO CAÑON.
EL DORADO.
PRESCOTT JUNCTION.
BELLEMONT
WILLIAMS.
FLAGSTAFF.
WINSLOW.
13.84
FT. DEFIANCE.
14.69
8.70
FT. WINGATE.
9.00
WILLOW GROVE.
FT. MOJAVE.
20.89
HUALPAI.
BENCHER'S.
C. LINCOLN.
8.79
HOLBROOK.
NEEDLES.
SIGNAL.
16.48
PRESCOTT.
SKULL VALLEY.
11.98
FT. VERDE.
DILLINGHAM.
STRAWBERRY.
1.85
C. COLORADO.
13.76
DATE CR.
ANTELOPE.
WALNUT GROVE
15.85
9.83
WICKENBURG.
C. RENO.
RENO.
SHOW LOW.
21.35
FT. APACHE.
LA PAZ.
EHRENBERG.
PEORIA
10.53
FT. MCDOWELL
6.67
PHOENIX.
19.07
GLOBE.
BUCKEYE.
13.41
26.58
SAN CARLOS
26.58
GOODWIN.
FT. THOMAS.
11.63
AGUA CALIENTE.
5.10
MARICOPA.
9.92
FLORENCE.
C. GRANT.
STANWIX
BURKES.
4.03
CASA GRANDE.
3.23
YUMA.
TEXAS HILL.
EAGLE PASS.
CEDAR SPRINGS.
16.39
FT. GRANT.
33.13
WILLOW SPRING
11.74
FT. LOWELL.
11.31
TUCSON.
12.65
12.91
WILCOX.
7.20
SAN SIMON
19.46
16.01
FT. BOWIE.
LORDSBURG
20.28
PANTANO
BENSON.
17.39
C. CRITTENDEN.
C. BUCHANAN.
TUBAC
FT. HUACHUCA.
18.90
23.03
TOMBSTONE.

No. IV.—*Average annual rain-fall for Arizona Territory.*

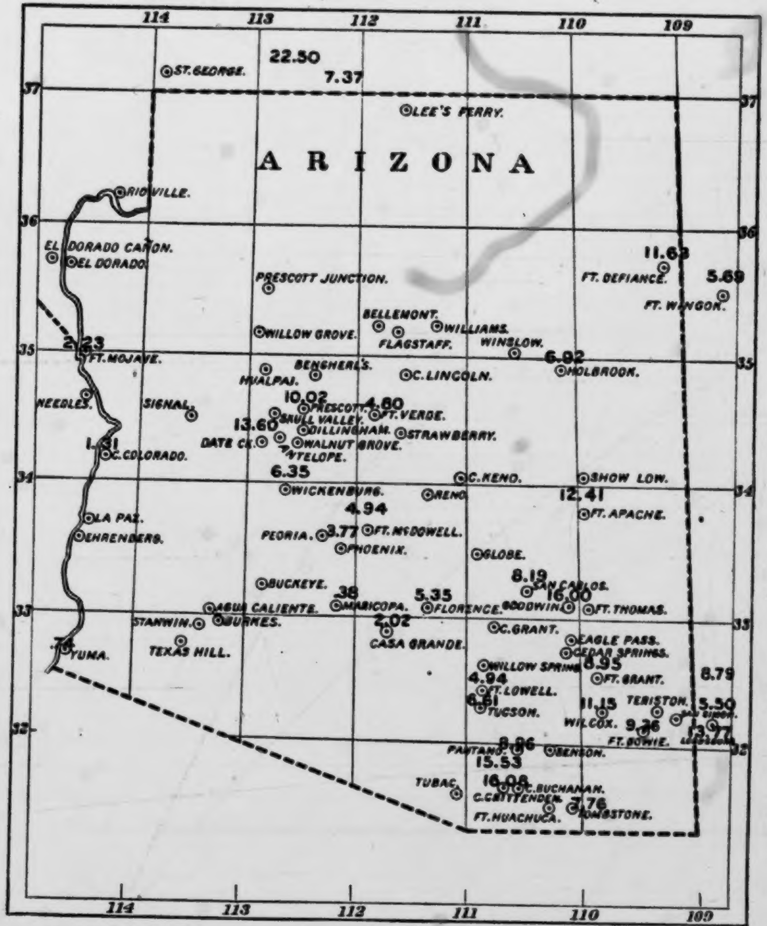
Report on Irrigation.

No. V.—*Greatest annual rain-fall, Arizona Territory.*



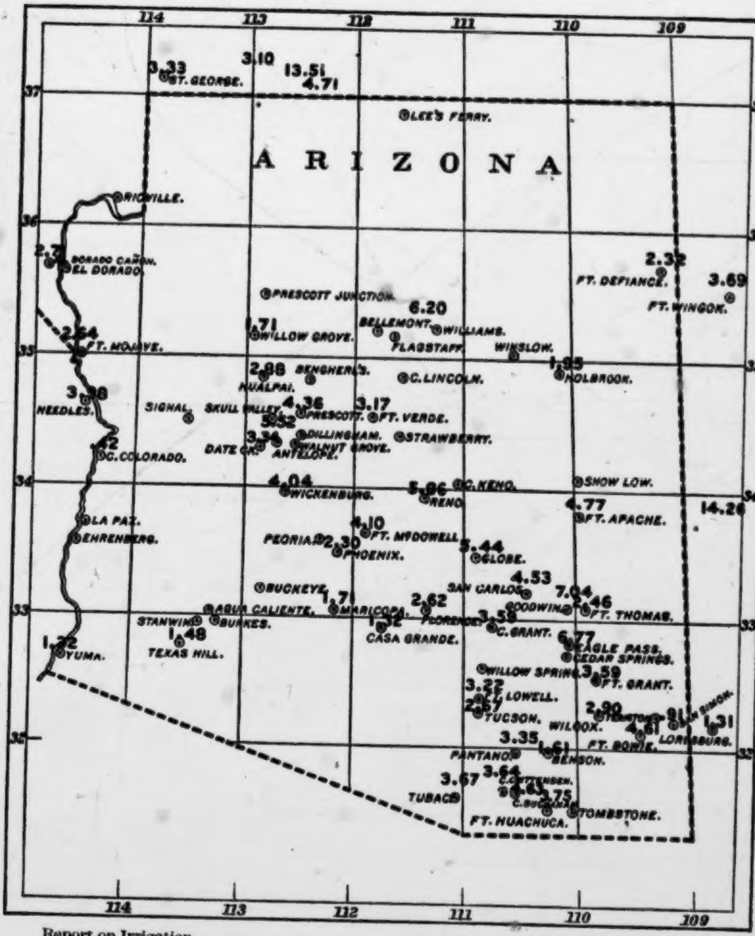
114
113
112
111
110
109
37
36
35
34
33
32
58.05
ST. GEORGE.
14.60
LEE'S FERRY.
A R I Z O N A
RIOVILLE.
EL DORADO CAÑON.
EL DORADO.
PRESCOTT JUNCTION.
22.44
FT. DEFIANCE.
25.06
FT. WINGON.
BELLEMONT.
WILLOW GROVE.
FLAGSTAFF.
WILLIAMS.
WINSLOW.
10.82
HOLBROOK.
14.23
FT. MOJAVE.
BENGHERL'S.
HUALPAI.
C. LINCOLN.
NEEDLES.
SIGNAL.
27.13
PRESCOTT.
21.40
FT. VERDE.
SKULL VALLEY.
27.84
GILLINGHAM.
STRAWBERRY.
DATE CK.
WALNUT GROVE.
ANTELOPE.
2.81
C. COLORADO.
17.17
WICKENBURG.
C. RENO.
RENO.
SHOW LOW.
31.12
FT. APACHE.
LA PAZ.
EHRENBERG.
PEORIA.
20.01
FT. MCDOWELL.
12.83
PHOENIX.
GLOBE.
BUCKEYE.
20.41
SAN CARLOS.
27.
FT. THOMAS.
AGUA CALIENTE.
11.96
MARICOPA.
FLORENCE.
13.49
GOODWIN.
C. GRANT.
STANWIN.
BURKES.
8.71
CASA GRANDE.
7.47
YUMA.
TEXAS HILL.
EAGLE PASS.
CEDAR SPRINGS.
WILLOW SPRING.
25.67
FT. GRANT.
14.69
FT. LOWELL.
16.66
TUCSON.
18.38
WILCOX.
TERISTON.
SAN SIMON.
29.73
25.20
13.09
LORDSBURG.
30.82
FT. BOWIE.
13.88
PANTANO.
BENSON.
19.08
25.12
C. BUCHANAN.
TUBAC.
C. CRITTENDEN.
TOMBSTONE.
FT. HUACHUCA.
24.53

No. VI.—*Least annual rain-fall, Arizona Territory.*

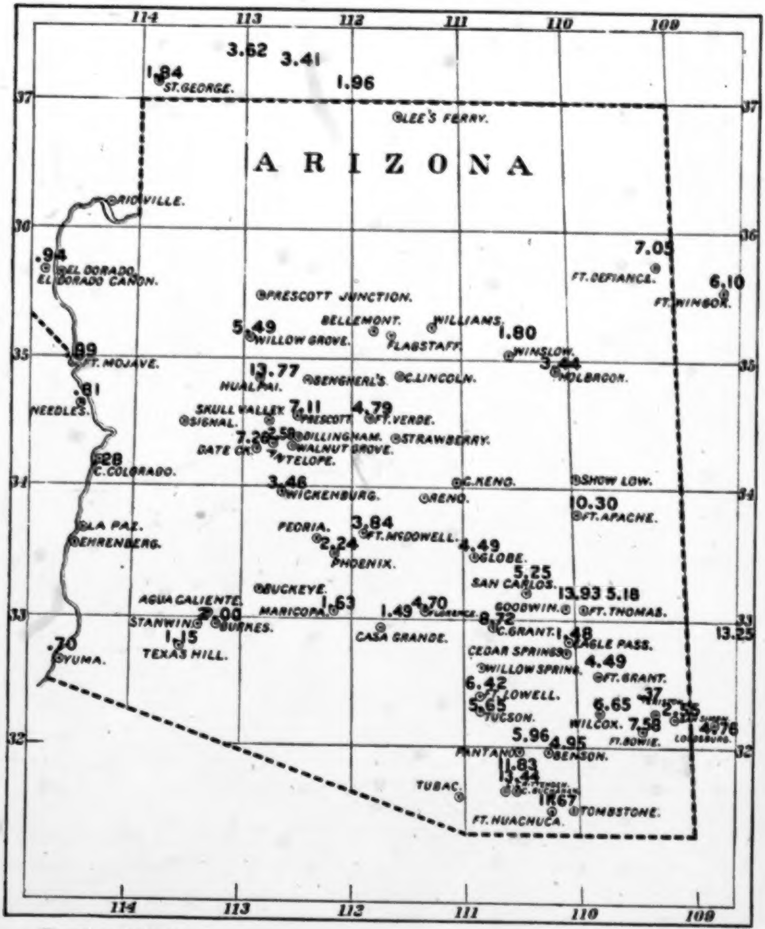

114
113
112
111
110
109
37
36
35
34
33
32
ARIZONA
ST. GEORGE.
22.50
7.37
LEE'S FERRY.
RIOVILLE.
EL DORADO CAÑON.
EL DORADO.
PRESCOTT JUNCTION.
11.63
FT. DEFIANCE.
5.69
FT. WINGON.
BELLEMONT.
WILLOW GROVE.
FLAGSTAFF.
WILLIAMS.
WINSLOW.
6.02
HOLBROOK.
2.23
FT. MOJAVE.
BENSHERL'S.
HUALPAI.
C. LINCOLN.
NEEDLES.
SIGNAL.
10.02
PRESCOTT.
4.80
FT. VERDE.
SKULL VALLEY.
13.60
DILLINGHAM.
STRAWBERRY.
DATE CK.
WALNUT GROVE.
ANTELOPE.
1.31
C. COLORADO.
6.35
WICKENBURG.
C. RENO.
RENO.
SHOW LOW.
12.41
FT. APACHE.
4.94
LA PAZ.
EHRENBERG.
PEORIA.
3.77
FT. McDOWELL.
PHOENIX.
GLOBE.
8.19
SAN CARLOS.
16.00
BUCKEYE.
.38
5.35
AGUA CALIENTE.
MARICOPA.
FLORENCE.
GOODWIN.
FT. THOMAS.
STANWIN.
BURKES.
2.02
CASA GRANDE.
C. GRANT.
EAGLE PASS.
CEDAR SPRINGS.
.79
YUMA.
TEXAS HILL.
WILLOW SPRING
8.95
FT. GRANT.
8.79
4.94
FT. LOWELL.
6.61
TUCSON.
11.15
WILCOX.
TERISTON.
5.50
SAN SIMON.
9.36
FT. BOWIE.
13.77
LEITENDORF.
8.86
PANTANO.
BENSON.
15.53
TUBAC.
16.08
C. BUCHANAN.
C. CRITTENDEN.
7.76
FT. HUACHUCA.
TOMBSTONE.

Report on Irrigation.

No. VII.—*Average rain-fall for December, January, and February.*


114
113
112
111
110
109
37
36
35
34
33
32
3.33
ST. GEORGE.
3.10
13.51
4.71
LEE'S FERRY.
A R I Z O N A
RICKVILLE.
2.71
DORADO CAÑON.
EL DORADO.
PRESCOTT JUNCTION.
6.20
2.32
FT. DEFIANCE.
3.69
FT. WINGOR.
1.71
WILLOW GROVE.
BELLEMONT.
WILLIAMS.
FLAGSTAFF.
WINSLOW.
2.54
FT. MOJAVE.
1.95
HOLBROOK.
2.88
BENGHERL'S.
HUALPAI.
C. LINCOLN.
3.38
NEEDLES.
SIGNAL.
SKULL VALLEY.
4.36
PRESCOTT.
3.17
FT. VERDE.
5.52
3.34
DILLINGHAM.
STRAWBERRY.
.42
C. COLORADO.
DATE CK.
ANTELOPE.
WALNUT GROVE.
4.04
WICKENBURG.
5.86
C. RENO.
RENO.
SNOW LOW.
4.77
FT. APACHE.
14.26
LA PAZ.
EHRENBERG.
4.10
FT. McDOWELL.
PEORIA
2.30
PHOENIX.
5.44
GLOBE.
4.53
SAN CARLOS.
7.04
2.46
GOODWIN.
FT. THOMAS.
BUCKEYE.
1.71
2.62
AGUA CALIENTE.
MARICOPA.
FLORENCE.
3.59
C. GRANT.
STANWIX.
BURKES.
1.32
CASA GRANDE.
1.48
TEXAS HILL.
6.77
EAGLE PASS.
CEDAR SPRINGS.
1.22
YUMA.
WILLOW SPRING.
3.59
FT. GRANT.
3.22
FT. LOWELL.
2.67
TUCSON.
WILCOX.
2.90
.91
SAN SIMON.
1.31
4.61
FT. BOWIE.
LORDSBURG.
3.35
1.61
PANTANO.
BENSON.
3.64
C. CRITTENDEN.
3.67
TUBAC.
4.63
3.75
C. BUCHANAN.
TOMBSTONE.
FT. HUACHUCA.
114
113
112
111
110
109

No. VIII.—*Averages for July, August, and September.*


114
113
112
111
110
109
37
36
35
34
33
32
3.62
3.41
1.84
ST. GEORGE.
1.96
LEE'S FERRY.
A R I Z O N A
RIOVILLE.
.94
EL DORADO.
EL DORADO CAÑON.
7.05
FT. DEFIANCE.
6.10
FT. WINGOR.
PRESCOTT JUNCTION.
BELLEMONT.
WILLIAMS.
5.49
WILLOW GROVE.
FLAGSTAFF.
1.80
WINSLOW.
3.44
HOLBROOK.
.89
FT. MOJAVE.
13.77
HUALPAI.
BENGHERL'S.
C. LINCOLN.
.81
NEEDLES.
SKULL VALLEY
7.11
PRESCOTT
4.79
FT. VERDE.
SIGNAL.
7.26
2.58
BILLINGHAM.
WALNUT GROVE.
STRAWBERRY.
DATE CK.
ANTELOPE.
.28
C. COLORADO.
3.46
WICKENBURG.
C. RENO.
RENO.
SHOW LOW.
10.30
FT. APACHE.
LA PAZ.
EHRENBERG.
PEORIA.
3.84
FT. McDOWELL.
2.24
PHOENIX.
4.49
GLOBE.
5.25
SAN CARLOS.
BUCKEYE.
AGUA CALIENTE.
MARICOPA.
1.63
1.49
4.70
FLORENCE.
13.93
5.18
GOODWIN.
FT. THOMAS.
2.00
STANWIN
BURKES.
8.72
C. GRANT.
1.48
EAGLE PASS.
13.25
1.15
TEXAS HILL.
CASA GRANDE.
.70
YUMA.
CEDAR SPRINGS
4.49
WILLOW SPRING.
FT. GRANT.
6.42
FT. LOWELL.
.37
6.65
2.55
5.65
TUCSON.
WILCOX.
7.58
4.76
FT. BOWIE.
LORDSBURG.
5.96
4.95
PANTANO
BENSON.
11.83
13.44
TUBAC.
11.67
TOMBSTONE.
FT. HUACHUCA.

Report on Irrigation.

IRRIGATION LAWS OF ARIZONA.

TITLE LXIII.—WATERS AND WATER RIGHTS.

CHAPTER 1.—*Riparian rights.*

[Approved March 10, 1887.]

3198. (Sec. 1.) The common-law doctrine of riparian rights shall not obtain or be of any force or effect in this Territory.

CHAPTER 2.—*Irrigating canals and acequias.*

3199. (Sec. 1.) All rivers, creeks, and streams of running water in the Territory of Arizona are hereby declared public and applicable to the purposes of irrigating and mining, as hereinafter provided.

3200. (Sec. 2.) All rights in acequias, or irrigating canals, heretofore established shall not be disturbed, nor shall the course of such acequias be changed without the consent of the proprietors of such established rights.

3201. (Sec. 3.) All the inhabitants of this Territory who own or possess arable and irrigable lands shall have the right to construct public or private acequias, and obtain the necessary water for the same from any convenient river, creek, or stream of running water.

3202. (Sec. 4.) Whenever such public or private acequias shall necessarily run through the lands of any private individuals not benefited by said acequias, the damages resulting such private individuals, on the application of the party interested, shall be assessed by the probate judge of the proper county in a summary manner.

3203. (Sec. 5.) No inhabitant of this Territory shall have the right to erect any dam, or build a mill, or place any machinery, or open any sluice, or make any dyke, except such as are used for mining purposes or the reduction of metals, as provided for in sections 6 and 7 of this chapter, that may impede or obstruct the irrigation of any lands or fields, as the right to irrigate the fields and arable lands shall be preferable to all others; and the justices of the peace of the respective precincts shall hear and determine the question relative to all such obstructions in a summary manner, and cause the removal of the same by order directed to the constable of the precincts or sheriff of the county, who shall proceed to execute the same without delay.

3304. (Sec. 6.) Where reduction works or other mining apparatus shall be placed upon lands previously held for agricultural purposes, or persons so holding such lands shall be entitled to remuneration from person or persons erecting or owning said reduction works or mining apparatus, the amount of remuneration shall be adjudged by three or five disinterested persons, or by the probate judge, as the parties interested shall agree; and in case such agreement can not be made, then the party injured may bring suit for damages.

3205. (Sec. 7.) When any ditch or acequia shall be taken out for agricultural purposes, the person or persons so taking out such ditch or acequia shall have the exclusive right to the water, or so much thereof as shall be necessary for said purposes; and if at any time the waters so required shall be taken for mining operations, the person or persons owning said water shall be entitled to damages to be assessed in the manner provided in section 6 of this chapter.

3206. (Sec. 8.) All by-paths or footpaths across any cultivated fields are prohibited, under penalty of a fine not to exceed $10 for the public acequia, to be assessed in a summary manner by the justice of the peace of the precinct; and if the person so offending shall not have wherewith to pay the fine, he shall be adjudged and sentenced to ten days on the public acequia.

3207. (Sec. 9.) All owners of arable and irrigable land bordering on, or irrigable by, any public acequia, shall labor on such public acequia, whether such owners or proprietors cultivate the land or not.

3208. (Sec. 10.) All persons interested in a public acequia, whether owners or lessees of land, shall labor thereon in proportion to the amount of land owned or held by them, and which may be irrigated or subject to irrigation.

3209. (Sec. 11.) It being impracticable to properly inclose the fields in this Territory, all animals shall be kept under a shepherd so that no injury may result to the fields; and if any damage should result, it shall be paid by the owners of the animals causing the same, to be assessed by the justice of the peace of the precinct in a summary manner, and paid to the person or persons whose fields may have been damaged.

3210. (Sec. 12.) In case a community or people desire to construct an acequia in any part of this Territory, and the persons desiring to construct the same are the owners or proprietors of the land upon which they design constructing the said acequia, no one shall be bound to pay damages for such land, as all persons interested in the construction of the said acequia are to be benefited thereby.

3211. (Sec. 13.) Immediately after the publication of this chapter, it shall be the duty of the several justices of the peace in this Territory to call together, in their respective precincts, all the owners and proprietors of land, irrigated by any public acequia, for the purpose of electing one or more overseers for said acequia for the corresponding year.

3212. (Sec. 14.) The manner of conducting such elections, and the number of overseers, shall be regulated by the justices of the peace of their respective precincts; and the only persons entitled to vote at said elections shall be the owners and proprietors of lands irrigated by said acequias.

3213. (Sec. 15.) The pay and perquisites of said overseer shall be determined by a majority of the owners and proprietors of the lands irrigated by said acequias, and paid by them.

3214. (Sec. 16.) It shall be the duty of the overseers to superintend the opening, excavations and repairs of said acequias; to apportion the number of laborers furnished by the owners, and proprietors; to regulate them according to the quantity of land to be irrigated by each one from said acequia, to distribute and apportion the water in proportion to the quantity to which each one is entitled according to the land cultivated by him; and, in making such apportionment, he shall take into consideration the nature of the seed sown or planted, the crops and plants cultivated; and to conduct and carry on such distribution with justice and impartiality.

3215. (Sec. 17.) During years when a scarcity of water shall exist, owners of fields shall have precedence of the water for irrigation, according to the dates of their respective titles or their occupation of the lands, either by themselves or their grantors. The oldest titles shall have precedence always.

3216. (Sec. 18.) It shall be the duty of each of the owners and proprietors to furnish the number of laborers required by the overseer, at the time and place he may designate, for the purposes mentioned in the foregoing section, and for the time he may deem necessary.

3217. (Sec. 19.) If any overseer of any public acequira after having undertaken to serve as such, shall wilfully neglect or refuse to fulfill the duties required of him by this chapter, or conduct himself with impropriety or injustice in his office as overseer; or take any bribe in money, property or otherwise, as an inducement to act improperly; or neglect the duties of his office, he shall be fined for each of said offenses in a sum not exceeding $100 nor less than $50, to be recovered before any justice of the peace of the county—one-half of which shall be paid to the county, and the other half to the person bringing suit for the same,—the said suit to be brought in the name of the Territory of Arizona; and said overseer, on being convicted a second time, shall be removed from his office by the justice of the peace of the precinct, and shall take such pay and perquisites as may be due him for services rendered.

3218. (Sec. 20.) Upon such removal, the justice of the peace shall order a new election to fill the vacancy thereby occasioned, which shall be conducted in the manner prescribed in the thirteenth and fourteenth sections of this chapter.

3219. (Sec. 21.) If any owner or proprietor of land irrigated by such acequia shall neglect or refuse to furnish the number of laborers required by the overseer, as required in the eighteenth section of this chapter after having been duly notified by the overseer, he shall be fined for each offense in a sum not exceeding $10 for the benefit of said acequia, which shall be recovered by the overseer before any justice of the peace in the county, and in such cases, the overseer shall be a competent witness to prove the offense or any fact that may serve to constitute the same.

3220. (Sec. 22.) If any person shall in any manner interfere with, impede or obstruct any of said acequias, or use the water from it without the consent of the overseer, except as provided in section 7 of this chapter, during the time of cultivation, he shall pay for each offense a sum not exceeding $10, which shall be recoverable in the manner prescribed in the foregoing section for the benefit of said acequia; and he shall further pay all damages that may have accrued to the injured parties, and, if such person have not wherewith to pay said fine and damages, he shall be sentenced to fifteen days labor on said public acequia.

3221. (Sec. 23.) All fines and forfeitures received for the use and benefit of any public acequia, shall be applied by the overseers to the improvements, excavations and repairs which may be necessary on said acequia, and for the construction of bridges where they may be crossed by any public street or road.

3222. (Sec. 24.) In all cases of conviction under this chapter, an appeal shall be allowed to the probate court, which appeal shall be taken and conducted as all other appeals from the decisions of the justices of the peace.

3223. (Sec. 25.) The regulations of acequias, which have been worked according to the laws and customs of Sonora and the usages of the people of Arizona, shall remain as they were made and used up to this day; and the provisions of this chapter shall be enforced and observed from the day of its publication.

3224. (Sec. 26.) All plants and trees of any description growing on the banks of any acequia shall belong to the owners of the land through which said acequia may run.

3225. (Sec. 27.) Any person owning lands which may include a spring or stream of running water, or owning lands upon a river where there is not population sufficient to form a public acequia, may construct a private acequia for his own uses, subject to his own regulations, provided it does not interfere with the rights of others.

3226. (Sec. 28.) All laws conflicting with the provisions of this chapter are hereby repealed.

[NOTE.—The foregoing chapter is compiled and taken from the Compiled Laws, chapter LV, page 528. There was no legislation upon the subject by the fourteenth legislature (1887), and this chapter remained unchanged.]

CHAPTER 3—*Ditch Crossings.*

[Approved February 7, 1887.]

3227. (Sec. 1.) Any person, corporation or company, owning or using any ditch or canal constructed for the purpose of conveying water, shall construct and maintain suitable crossings wherever said ditch or canal crosses any public highway, or usually traveled road of this territory; said crossing shall be maintained as follows:

From the bottom of the ditch in the roadway there shall be a uniform rise of not more than 1 foot in 3 to the top of the embankment; either side the ditch shall be graveled or macadamized with stone to a depth of not less than 10 inches from the top of one embankment to the other, and the macadamized or paved road across any of said ditches shall not be less than 14 feet wide; provided, that any person or persons, corporation or company may at any of said crossings construct and build a good and substantial bridge to be approved of by the road overseers of the district.

3228. (Sec. 2.) The road overseer of each of the districts in the several counties in this Territory shall have supervision of said crossings, and it shall be his duty to see that the several ditch crossings in his district are constructed and maintained as provided in the preceding section.

3229. (Sec. 3.) For neglect or refusal of any person or persons, corporation or company, whose duty it shall be to construct or maintain such crossings as provided for in section 1, for the period of ten days after being notified in writing by the road overseer of the district in which any such crossing needs construction or repair that such construction or repair is required, such person, corporation or company shall be guilty of a misdemeanor, and upon conviction thereof before a justice of the peace of any such precincts, shall be fined not less than $10 or more than $100 for the first offense; and of not less than $25 nor more than $250, and the costs of prosecution, for each subsequent offense; provided, that whenever such highway or road is constructed, after the construction of such ditch or canal, it shall be the duty of the road overseer of the district to construct and maintain such crossing at the expense of the road fund of the district, and if the same be at any time insufficient, the same shall be paid out of the general fund in the county treasury, to be chargeable to and thereafter collected from such road fund.

3230. (Sec. 4.) All funds collected under the provisions of this act shall be paid into the road fund of the district, wherever such crossings are situated.

3231. (Sec. 5.) This act shall take effect immediately.

[NOTE.—The foregoing chapter is taken from the Compiled Laws, chapter LV, page 541.]

ADDENDA TO NEVADA DIVISION.

STATEMENT OF LYMAN BRIDGES, OF SAN FRANCISCO.

[The following paper has been delayed. It was prepared originally for the Nevada Division, Mr. Bridges being at the time division civil engineer in the U. S. irrigation survey for the Lahontan Basin, which includes Nevada and part of the California Sierras.]

In laying our reclamation works for western Nevada the lakes lying at high altitudes upon the eastern slopes of the Sierras Nevada have to be first considered. Speaking of the physical and hydrographic geography and formation of the basin in which Nevada is situated, this series of lakes, though located in whole or part within the political or State line of California, belong in every natural sense as storage and drainage sources and systems to the eastern basin region. For that reason, then, a good deal of the work of the survey has been done in connection with the idea that these lakes must form the reservoirs from which, in connection with the Truckee Basin, the supply of water needed for the reclamation of the Carson Valley and the Sage Brush Plains around Wadsworth must be drawn.

During July the survey of the basin at Donner Lake has been continued, contours of the lake and its valley two miles east of and including the lake giving an elevation of 20 feet above the present Donner Lake. This will make a reservoir of over 5 square miles, with an everage depth of 40 feet, holding an estimated volume of 5,575,680,000 cubic feet of water in a natural land-locked basin. The elevation is 5,885 feet above sea level.

The outlet of the projected Donner Lake reservoir will be by a high-line canal along the benches on the north side of Truckee to the plateaus north and northeast of the city and to the east of Boca and Verdi, crossing Prosser Creek and the Little Truckee River. There can be selected reservoirs at that point in which we can store water enough to fill Dog Valley. This will ultimately become available for the valleys and plateaus north and east of Reno. A basin map of the Sierras is being prepared. It will show this system.

We have also located a place for a dam across the Truckee River about 1 mile above the Central Pacific depot. This will give a reservoir 3 miles in length along the Truckee Valley. Contours of this basin are being made, and we expect to get a reservoir by the projected dam holding fully 200,000,000 cubic feet of water, as Bear Valley, Squaw Valley, Deep Creek, Pole Creek, and others enter the Truckee River above its location. There can also be a connection from Donner Lake reservoir with this. The outlet from this reservoir will be on the south side of the Truckee River, along the benches and high foot-hills south of Truckee City, around the Marquis plateau and meadows into Marquis Creek, which flows into the Truckee River near Boca, about 10 miles below Truckee. This canal through Truckee and along the hill-sides may also afford an excellent water-power for mills, etc., for a mile or more before being used on the plateaus, and again entering the Truckee River offer an ample supply for Truckee meadows, or it can be carried by a higher-line canal to and around the Washoe Basin here in western Nevada.

This dam, with the reservoir it will create in the Truckee, taken in connection with Lake Donner, will store, the two together, nearly or quite 6,000,000,000 cubic feet; quite sufficient for the supply of all lands now under ditch or available therefor; as well as the reclamation of at least 1,000,000 acres more. This is now given over to the sagebrush and the few broad-horned steers that feed upon it. A careful study and survey of the other lakes—Independence, Webber, and Eagle—with reservoir sites as found, is also being made by my assistants. Lake Tahoe, by a dam at its outlet near Tahoe City, can readily be raised 8 feet. It has a drainage basin tributary to its supply of at least 5,000 square miles.

In my view of its utilization, Lake Tahoe should be held in reserve—the great storage reservoir which will meet extraordinary needs. Over one-third of its area is within the boundary lines of Nevada. A tunnel has been proposed to lead into the Carson Valley, by which the water thus stored can be drawn from its depths, at least 1,000 feet below its surface. As the site and route have not been fully decided upon, for obvious reasons it will be seen I can not state the location more definitely. We have run three lines across the Sierras between Lake Tahoe and Carson Valley, and have adopted the shortest and best location for a tunnel, which we find to be near the southeast portion of Lake Tahoe and the head of Carson Valley, all in the State of Nevada, locating a tunnel 10 by 10 feet, with a crown of 2 feet in center. The open cut from Lake Tahoe to the entrance of the tunnel will be 4,200 feet; the length of tunnel 17,331 feet, or 3.45 miles, the cut and tunnel having a grade of 2 feet per mile. The exit of the tunnel on the Carson Valley or east side is to be 1,500 feet above the valley.

The output of this tunnel can be carried both north and south along the foot-hills and carried to any portion of the upper Carson Valley, and thence into the Carson River. In addition to the great benefit to be derived from the placing of this water upon the Carson Valley lands, a magnificent water-power can be secured and utilized along the east side of these mountains, and dynamos charged so that this power can be transmitted to Carson and Empire where the Virginia City mills are located, and the water used over again in Douglas, Ormsby, Washoe, Lyon, and Churchill Counties, all of them in Nevada. It is a perfectly feasible and not an expensive project either. A dam will have to be located also at the outlet of Lake Tahoe on the west side at Tahoe City to raise the Lake 8 feet. The inlet to the canal and tunnel is located so as to receive 20 feet depth of water at high-water mark. This will give 200 square miles of surface water 20 feet deep; equal to 111,518,600,000 cubic feet. The lake will never be more than 12 feet lower than the present height. This grand reserve reservoir can be turned either into the Carson or Truckee basins. The elevation is 6,200 feet.

On the 4th of July last, at the chairman's (Senator Stewart) request, I met at Carson with the Senator, the State surveyor-general (Mr. J. E. Jones), and Commissioner H. Springman, of the State board of water and reclamation, as well as some other gentlemen. A conference and exchange of views was held. Many valuable suggestions were obtained pertaining to the water-sheds, water supply, water-courses, locations for reservoirs and canals on the eastern slope of the Sierras and within the State of Nevada.

The State of Nevada having appropriated $100,000 for water storage, which is immediately available, this committee and the citizens present requested me to locate a reservoir site for them. Commissioner H. Springmayer accompanied me for four days to the head of the Carson Valley, going well up toward the head of the three branches of the Carson River. We found Hope Valley, at the head of the West Fork of the Carson, an admirable location for a large reservoir. By making a dam 150 feet high we could secure a surface area of not less than 5 square miles, with an average depth of 50 feet. This dam we located at the foot of the Carson Valley and at the head of Hope Cañon, which has a granite ledge on both sides. For the first 100 feet in height it has a narrow gorge of 200 feet at bottom and 800 feet in width at top, with rock benches about 500 feet on either side above the first 100 feet. This is a land-locked valley about 5 miles in length, an average of 1 mile in width, 7,658 feet above the sea, and will hold 6,969,600,000 cubic feet of water, with average depth of 50 feet. This reservoir will require two outlets to be cut in rock on both sides, and the water can be then turned into the river below. This is the West Fork of the Carson River. It would conduct the water 6 miles down Hope Cañon to a diverting dam to be located about 1 mile above the mouth of the cañon, where a canal on the left or north side of the river would conduct the amount of water required along the foot-hills at the base of the mountain and north of the cañon at any desired height as far north as Sheridan or Genoa, and distribute it then down the foot-hills and into the valley until it reaches the West Fork of the Carson River. From this same diverting dam, 1 mile above the mouth of Hope Cañon, on its right bank, another canal can be constructed along the right bank of the West Fork of the Carson River, with a sufficient grade to conduct any portion of this water from the Hope Valley Reservoir across Diamond Valley 2 miles in length; this is located at the foot of Hope Cañon, with an elevation of 5,481 feet, then through Dutch Valley, with an elevation of 5,277 feet, and this also about 2 miles in length; thence into Long Valley, which has an elevation of 5,078 feet above the sea and about 200 feet above the head of Carson Valley. There are already three ditches running from Hope Cañon and conveying water through Diamond Valley to Dutch Valley, whose natural drainage is into Long Valley. One of these ditches can be enlarged into a canal, and the flood and natural water from the West Fork of the Carson can be secured to Long Valley, which is a good, natural, safe location for a grand receiving reservoir; all outside of any river channel.

With a dam 100 feet in height at a narrow neck of Long Valley about 1 mile above the head of Carson Valley nearly or quite 4 square miles of surface water with an average depth of 50 feet can be obtained. This will give 5,625,680,000 cubic feet of water for distribution by a canal on the east side of the Carson Valley, which will supply not only the Empire Mills, but also all that the 100,000 acres of land on the east side of the Carson River (that now has no water for irrigation) may require. A canal from the left side of this dam out on the benches at the head of the Carson Valley may be supplied from this same source. The east or main fork of the Carson River runs almost parallel with Long Valley for the 3 miles east before debouching into the Carson Valley proper. At Horse Shoe Bend, a point about 2 miles from its mouth, there is a narrow saddle ridge, where with an overflow dam across the East Fork or main river can be turned through a tunnel or cut of about 1,000 feet in length. This will turn the water through a 10 by 10 feet tunnel or cut 10 feet wide at bottom and with its slopes of 1 to 1.

We have found and located a number of other sites. Pleasant Valley, on the Middle Fork of the Carson, in Alpine County, Cal., 12 miles south of Hope Valley, which is about 3 miles in length and 1 mile in width, can be made from 40 to 50 feet in depth as a reservoir, with a water-shed of 50 square miles, and it has good rocky flanks at the lower end of the valley. This location is 3 miles above Markleville, Cal., and in it can be stored 3,345,408,000 cubic feet of water. Below this reservoir and above Markleville are the waters from Burnside Lake, Hot Springs Creek, Charity Valley, and other mountain creeks. At Markleville, 18 miles above Long Valley, the East and Middle Forks of the Carson unite, thus making the East Fork the main Carson River, so that by the diversion of the East Fork at Horse Shoe Bend Long Valley can receive the water of all the branches of the Carson to its full or maximum capacity. Twelve miles above the junction of the Main and East Forks of the Carson River Silver Creek joins the East Fork. Five miles farther southeast Wolf Creek empties into the East Fork. One mile above the mouth of Wolf Creek is a meadow where from 1 to 2 square miles surface of water can be stored with a depth of 40 feet. Two miles above Wolf Creek, at Silver King Valley, on the East Fork of the Carson, another reservoir can be located with a water surface of 2 square miles. Now, all the above-named reservoir sites in Alpine County are above 6,000 feet elevation. Other sites have been examined but found impracticable. The water-shed for the Carson River and its branches is fully 1,000 square miles.

The commission which the State of Nevada authorized to construct reservoirs and canals has made a formal request that I should make a plan and locate their reservoirs and canals, which I agreed to do. They promised to proceed with their work without delay. This reservoir at Long Valley, the one that they desire to use as the State reservoir, you will observe, is the grand receiving reservoir between the forks of the Carson River, and any dams built above by the United States or otherwise will be feeders, for this grand receiving reservoir owned by the State of Nevada. As to other reclaimable areas I desire to say that at Wadsworth, Nev., 34 miles below Reno, the Truckee River turns north and sinks into Pyramid Lake, 15 miles from Wadsworth. At a point on the Truckee 5 miles west of Wadsworth an admirable location for a diverting dam was found, which can be built of stone in rocky bluffs 116 feet higher than the water surface at the Wadsworth bridge. A dam and reservoir has also been located there, and our men are running levels for canals on either side of said river to conduct the water out on the plateaus and benches north, east, northeast, and southeast from Wadsworth. The bridge, which is now 30 feet high, can be filled up, and a 10 by 10 feet outlet and canal put in on each end of the bridge to guard against any possible flood or overflow or accident. This water can be extended along the benches if required.

I have made many inquiries and obtained memoranda in as many counties and districts of the eastern slope of California and of the State of Nevada as I have had opportunity. From the information thus obtained I can safely state that by the storing of the flood waters at the head of the Carson and Truckee Basins and other water-sheds along the eastern slopes of the Sierras at least 500,000 acres of fertile lands in California and not less than 2,500,000 acres of good arable lands in Western Nevada can be reclaimed and cultivated; all this in addition to the area now under cultivation. It will be seen that the aggregate amount of water in the reservoirs already selected is estimated at 133,229,968,000 cubic feet of water, and from the best information obtainable the reservoir can be filled annually from natural water-sheds. The demand for water in this State is at the rate of 1 cubic inch per acre, and is much in excess of that generally required in the State of California. The estimated amount for the reservoirs now located will furnish an acre-foot for 3,000,000 acres of land. I am convinced that we shall be able to find reservoir-sites that will hold an amount sufficient for another 2,000,000 acres of land; that is, having an acre-foot of water for each acre. This will make 5,000,000 acres that can be reclaimed in this division by the storage of water sufficient therefor. The waters of the Truckee and Carson and auxiliary springs have been carefully gauged daily, giving the velocity and quantity and discharge in cubic feet per second. A sample of the gauging of the Truckee River at Essex above the ditches and canals is as follows:

	Name.	Mean velocity.	Discharge.
			Cubic feet.
May 20	Truckee at Essex	2,630	2,336.67
22	......do	2,767	2,511.94
28	......do	1,983	1,716.25
June 20	......do	358,549	350.49
May 22	Dog Creek	....	6.89
24	Prosser Creek	....	312 52
June 21	......do	....	64.33

In concluding this imperfect statement, I wish to say that there is reason to believe that we can gain as much in the Humboldt and also in the Owyhee Valley region in Northern Nevada as I have estimated for the eastern California, Sierras, and western Nevada. Land under water will be worth from $10 to $30 per acre. It is now worth 50 cents or $1. The cost will certainly not exceed $1 in $4 of the increased value I have named.

STATEMENT OF CHARLES W. IRISH (UNITED STATES SURVEYOR-GENERAL), OF RENO, NEV.

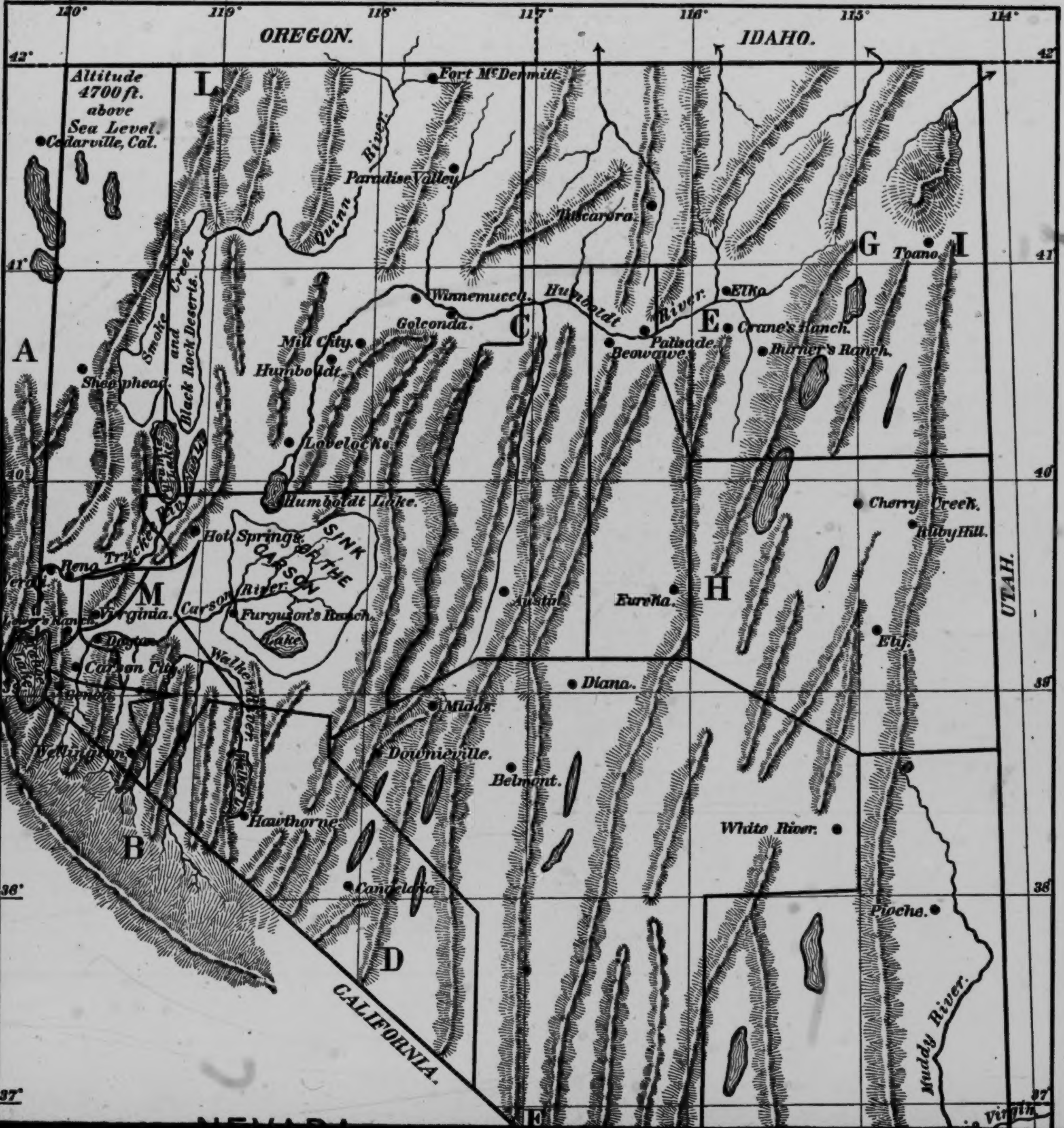
Under date of January 6, 1889, the surveyor-general of Nevada writes:

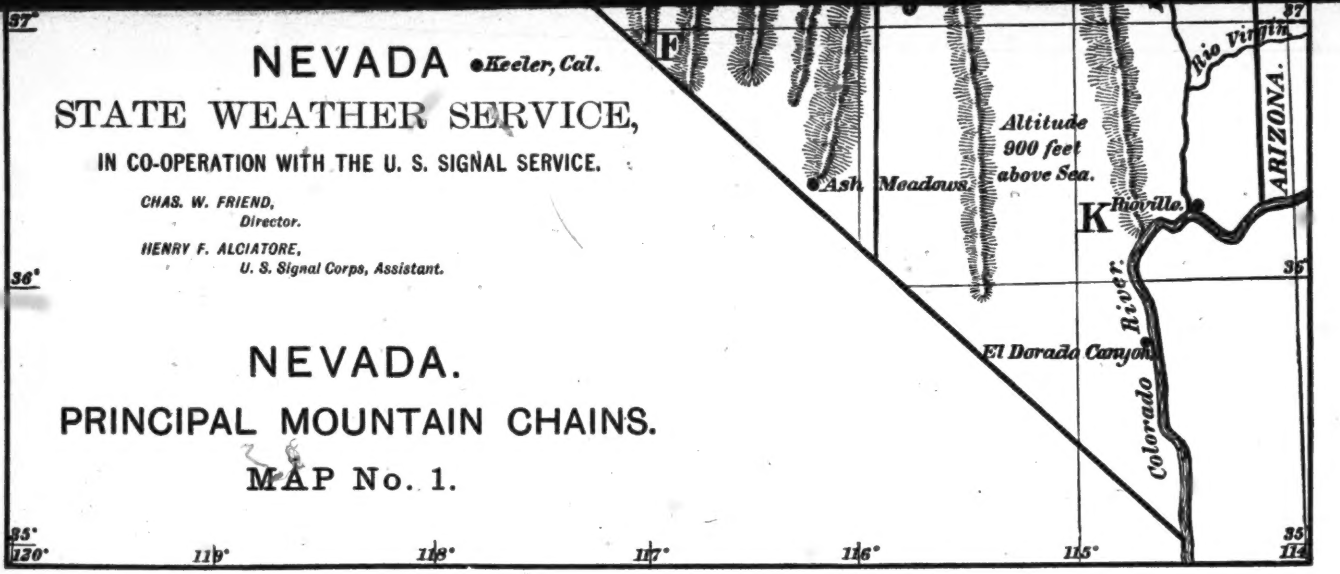
As to the improvement of the arid lands of the State through the means of water stored by reservoirs and distributed upon said lands by means of some system of irrigation conduits, the first question which I come to consider is the amount of annual rain-fall, which, of course, includes the snow-fall. Of the first the State does not receive enough rain per year in all parts to insure an agricultural crop, for the average, including the snow-fall, is, I think, not far from 8¼ inches.

It is concluded that about twice this amount is absolutely necessary for the purpose, and such amount indicates a precarious region for the farmer; its efficacy depending very much upon the kind of subsoil which receives it.

I think that the rain-fall proper can not overgo about 5 or 6 inches per year for the whole State, which, if I am correct, leaves the amount of water derived from the snow-fall to be about 2¼ to 3¼ inches. This estimate applies only to the valleys, for the reason that only in them have systematic observations been taken. It is, as will be seen further on, vastly different upon the mountains. It is the snow-fall which is of greatest value to the State, for the reason that, lodging upon the mountain tops, sides, and cañons, it becomes so much water stored away for future use through the preserving coolness of those elevated regions, from which it is let down by degrees to the plains below at the season when most needed by the farmer.

As to the observed amount of annual rain-fall as reported for this State, I must say that it, in my opinion, must fall far short of the truth, for the reason that all the observing stations are located upon the plains and valleys at the foot of the mountains, where the gauges catch but a very small part of the snow-fall, the important factor in this case, and also do not catch all of the rain.


OREGON.
IDAHO.
UTAH.
CALIFORNIA.
120°
119°
118°
117°
116°
115°
114°
42°
41°
40°
39°
38°
37°
Altitude 4700 ft. above Sea Level.
Cedarville, Cal.
L
A
B
C
D
E
G
H
I
M
Fort McDermitt.
Quinn River.
Paradise Valley
Tuscarora.
Toano.
Winnemucca.
Humboldt River.
Elko.
Golconda.
Palisade.
Crane's Ranch.
Beowawe.
Burner's Ranch.
Mill City.
Humboldt.
Sheephead.
Smoke Creek and Black Rock Deserts.
Lovelocks.
Humboldt Lake.
Cherry Creek.
Ruby Hill.
Hot Springs.
Sink of the Carson.
Truckee River.
Reno.
Verdi.
Virginia.
Carson River.
Furguson's Ranch.
Lake.
Austin.
Eureka.
Ely.
Dayton.
Carson City.
Tahoe Lake.
Genoa.
Walker River.
Diana.
Midas.
Downieville.
Belmont.
Wellington.
Walker Lake.
Hawthorne.
White River.
Candelaria.
Pioche.
Muddy River.
Virgin.
NEVADA.


NEVADA STATE WEATHER SERVICE,

IN CO-OPERATION WITH THE U. S. SIGNAL SERVICE.

CHAS. W. FRIEND,
Director.

HENRY F. ALCIATORE,
U. S. Signal Corps, Assistant.

NEVADA.

PRINCIPAL MOUNTAIN CHAINS.

MAP No. 1.

Keeler, Cal.
F
Ash Meadows.
Altitude 900 feet above Sea.
K
Rioville.
Rio Virgin
ARIZONA.
Colorado River.
El Dorado Canyon.
37°
36°
35°
120°
119°
118°
117°
116°
115°
114
37
35
35

Report on Irrigation.

I have made experiments for the purpose of determining the proportion in inches of water to be derived from freshly-fallen snow in this State, and find that it is 1 inch of water from 11 inches in depth of snow; this is the result of many averages.

Now it is rare indeed to have more than a few inches of snow to fall in the valleys, and a fall of 25 inches is rare indeed, but on the mountains it is quite different; there the snow falls to great depths.

The great snow-catchers of this region are the Sierra Nevada Mountains.

I have been at great pains to discover, in the absence of definite measurements, the depth to which the winter snows fall upon these mountains, and find that the average is not far from 18 feet over all their surface above 6,000 feet altitude.

It is sometimes as much as twice this amount and at times less, but it is safe to count upon about this quantity in ordinary seasons. This amount of snow will, when melted, give 19 inches of water over the area upon which it is lodged.

In the storing capacity of this giant mountain range is seen the great value it is to the people of the state. The more valuable for the reason that the region immediately eastward of it is about the driest in the State, and would be, without the vivifying stores of winter storms, retained by these grand old mountains, totally uninhabitable and useless to man.

All the mountain chains of the State are more or less nearly parallel with the Sierra Nevadas, and they in succession eastward, from this the northern range, are known by local names, as shown upon map (number 1) accompanying.

Upon said map I have represented the Sierra Nevadas from A to B, the great bulk of these mountains lying without the State, in California, but all the drainage of their eastern slopes falling within Nevada, giving rise to the Truckee, Carson, and Walker Rivers.

The next range eastward is shown at L, M, and is properly called the "Virginia Range," from the fact that Virginia City, the most important mining center in the State, is located upon it just under its highest peak, Mt. Davidson.

The Multiple range, shown at C to D, is known as "The Toy-ah-be." In altitude, and linear extent it rivals the Sierra Nevadas. The Toyabbe Mountains are the backbone of the State.

From E to F is the "Diamond Range," and from G to H is the "Ruby Range," an apparent branch of the former. The Rubies are, throughout their extent, very high mountains.

Lastly from I to K is the "Schell Creek Range." Between these principal lines are many lesser ranges, branches of, or lying parallel to, the main ranges already described.

I have not attempted to describe these lesser ranges nor show them upon the map. From careful examination of all sources of information I estimate that the surface area of Nevada's mountains (I mean as seen in plan) is 52,000 square miles, and that of this area 18,000 square miles catch and hold snow the year around.

Of the 18,000 miles of snow-catching area, all that portion which is in altitude above 6,000 feet will receive in average winters from 4 feet to 26 feet of snow, which will, I estimate, give an average of 16 inches of water, and this average, in my judgment, will hold good for the whole State, for the reason that the estimate does not include the large catchment area of the eastern slope of the Sierra Nevadas, where the yearly average depth of snow-fall is much greater, all of which drains into Nevada.

But all the snow caught by Nevada's mountains does not stay all the year upon their tops and sides, for the warm winds, which by their natural direction in proceeding from the equatorial regions toward the great easterly circulating belt along the forty-second parallel of latitude, fall into the valleys of Nevada and follow them throughout the extent of the State in a south to north direction and eat away the snow from all the subsidiary ranges, thus causing streams of water to run down the cañons from early spring until about the end of July, by which time nearly all of the snow which lodged below 6,000 feet altitude is melted away and the water from it has run down to the plains below, and has been absorbed by the soil or can be seen collected in a thousand shallow lakes of greater or less extent—natural reservoirs. With proper engineering, I believe that 90 per cent. of this, the first fruits of the winter storms, can be saved for the production of what are called here second crops, which in most cases will be limited to the foot-hills along the bases of the mountains, and matured in the months of September and October, by which time the greater part of this store of water will become exhausted, to be again replenished the succeeding spring. The remainder of the snow, which from its altitude is above the reach of the warm air currents spoken of, melts very slowly and much of it remains from year to year.

Map No. 2 is intended to give an idea of the distribution of the rain-fall throughout the valley portion of the State. The results as shown are from exact observations, and do not include the mountain snow-fall. It is seen from this map that the lowest portions of the State are both the driest and warmest, and, singular as it must appear to those who have but little understanding of such matters, these very dry regions are now the most fruitful; as, for example, the region from Reno and Virginia City eastward towards Austin across the "Sink of the Carson," and from Wellington and Hawthorne, by way of Lovelocks, to Winnemucca; also across the southern parts of the State, below Candelaria and Pioche.

The secret of this is in the fact that for the northerly region mentioned the drainage of the eastern slope of the Sierra Nevadas comes down to and covers all the "Sink of the Carson" region, from Pyramid Lake to Walker Lake, depositing an immensity of water over and above the yearly waste by evaporation and constant percolation, and for the further reason that the Humboldt River brings an immense quantity of water from the region bounded by "Burner's Ranch," Elko, Tuscarora, and Paradise Valley, down to its "sink," now called Humboldt Lake. In the southern region mentioned the reason for fruitfulness is in the fact that there is no winter season there. Winter being replaced by a season of light rains, during which the crops are put in, and the light rain-fall, aided by an immense underground supply of moisture, is sufficient to produce and ripen the crops before the hot and very dry summer sets in. When a water supply is available for the purpose, a continual yearly round of crops is produced almost without exception.

The source of the great under surface flow of the regions included in Nye and Lincoln Counties is seen in the great difference of altitude between the northern and southern portions of the State,* which amounts to about 3,800 feet, whereby all the water entering the strata of the northern portion is carried down a grade of about 7 feet per mile, to this region.

The substantial evidence of this is seen in the many strong flowing springs to be found in the two counties mentioned. Of three of these springs I have a close approximation to their capacity of flow for a period of twenty-four hours. They are all in the same vicinity. The one highest upon the mountain gave 472 cubic feet; the next in order lower down, 1,744, and the lower one, quite down to the base of the mountain, 3,860 cubic feet per twenty-four hours. From all that I have myself seen of the region in question I feel that it is the only part of the State which can be relied on to furnish a certain and continual supply of artesian water.

(Referring to Map No. 2.) In the northeast quarter is a region which I have marked as "Rain-fall unknown." I am sure that throughout this part of the State, from Fort McDermitt southeasterly, is the future wheat region of Nevada. I conclude this from my personal observation of its climate and soil and its natural vegetation. I feel certain that over a very large proportion of the region indicated wheat can be grown under about the same conditions as it is produced in northwestern Minnesota and northeastern Dakota.

This subject brings me to Map No. 3, upon which I have endeavored to show the regions of the State in which the crops there indicated can be grown with a certainty and success.

The climate of the region marked A is the least variable of any part of the State; the winters never very cold nor the summers hot. It contains the largest area of veritable desert land in the State, comprised in the Black Rock and Smoke Creek Deserts, areas which produce no vegetation whatever. I have verified the statement as to its range of crop products.

I have heretofore stated as to the region D. Its climate is much like that of western Minnesota, and a bountiful snow-fall, with very rare exceptions, is assured. Soil, climate, and snow-fall all combine to make it the wheat region of the State. Its average altitude is considerable, and having no deep valleys, its climate is the coldest of all the State; hence the snows are more lasting upon its mountains, and water from that source is plentiful. It contains the highest mountains to be found within the State.

The central region B contains high mountain regions and deep wide valleys, with a bountiful mountain snow-fall; hence water is very plentiful in spring and summer months, as evidenced in the broad shallow lakes to be found in all the valleys in the mid-summer season. Its climate is mild, and Indian corn can be raised within it.

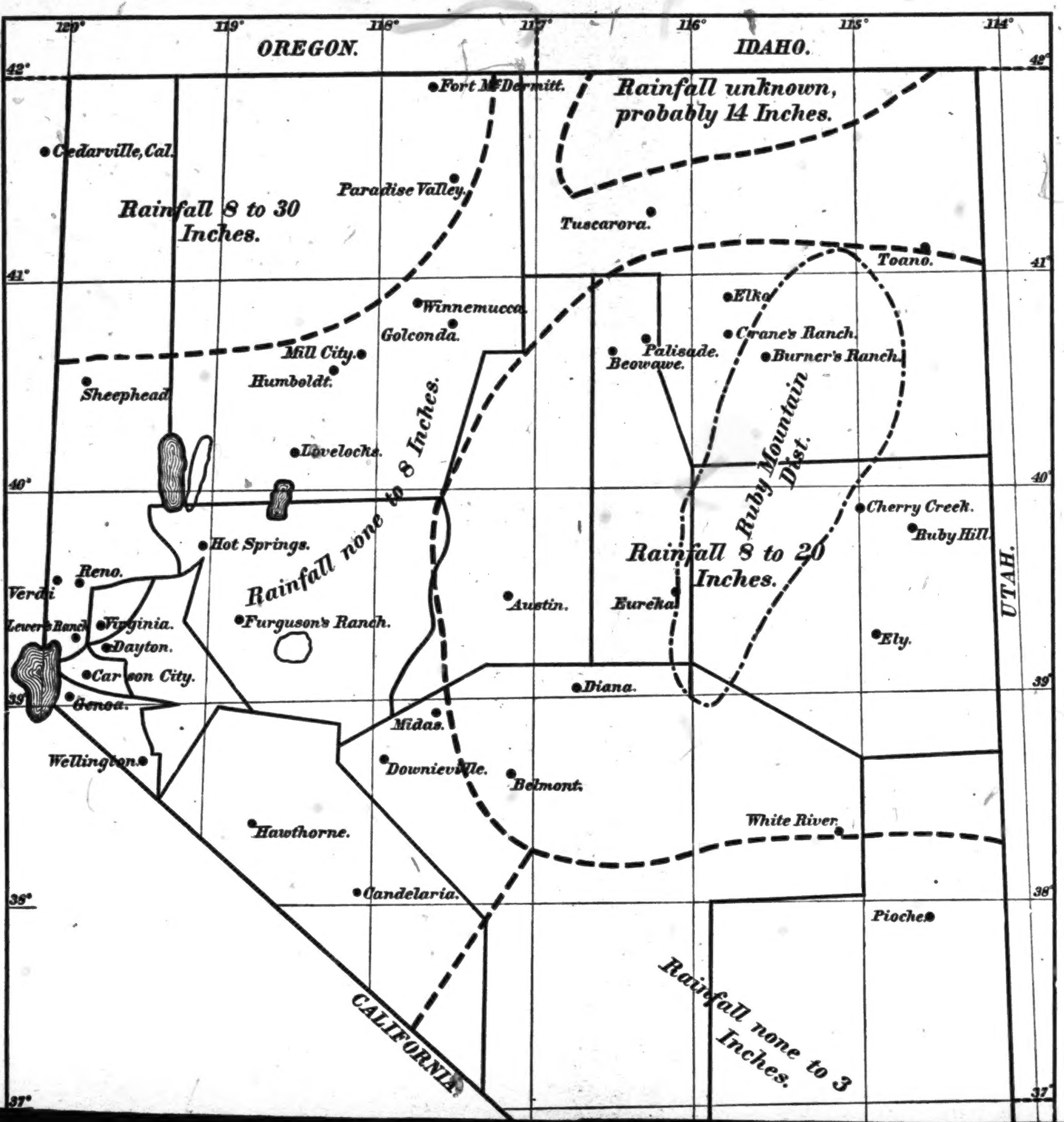
Experiment on a large scale has fully proven the statements on the map as to the variety of crops to be successfully raised within it. Its western portions, bordering on the region known as the Colorado Desert, are very dry and hot.

The region marked C has a greater range of productiveness than any other part of the State. Its climate much resembles that of the Gulf States, more particularly that of southern Texas, not subject, however, to such great variations of temperature. Its winters are warm and spring-like, and are the seeding season, and about all the rain-fall of the year comes down at this season and is small in amount. Here the semi-tropical fruits, which are produced in southern California, can be successfully cultivated, to which can be added cotton and sugar-cane. Thus herein, wherever water can be had by impounding or through artesian pressure, all the agricultural products of the middle Gulf States can be grown, and much more besides.

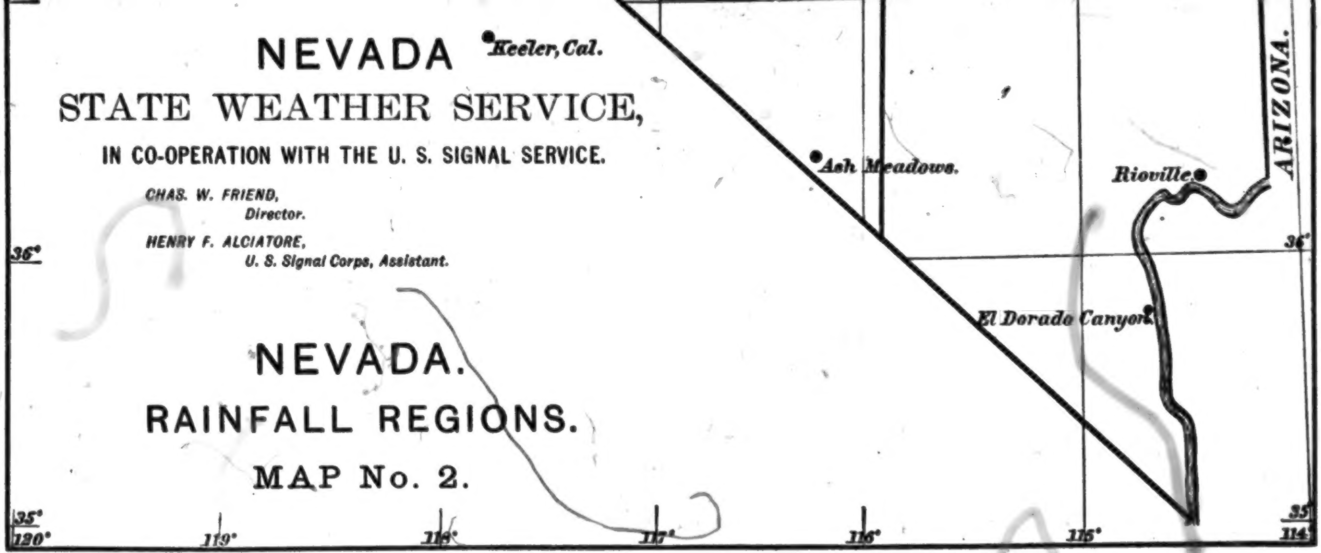
Cotton and Indian corn were produced in this and surrounding regions in pre-historic times, as I have proven by the discovery of corn-cobs among the relics of an-

---

*See Map No. 1.



OREGON.
IDAHO.
UTAH.
CALIFORNIA.
120°
119°
118°
117°
116°
115°
114°
42°
41°
40°
39°
38°
37°
Rainfall unknown, probably 14 Inches.
Rainfall 8 to 30 Inches.
Rainfall none to 8 Inches.
Rainfall 8 to 20 Inches.
Ruby Mountain Dist.
Rainfall none to 3 Inches.
Fort McDermitt.
Cedarville, Cal.
Paradise Valley.
Tuscarora.
Toano.
Winnemucca.
Golconda.
Elko.
Crane's Ranch.
Palisade.
Beowawe.
Burner's Ranch.
Mill City.
Humboldt.
Sheephead.
Lovelocks.
Hot Springs.
Cherry Creek.
Ruby Hill.
Reno.
Verdi.
Austin.
Eureka.
Lewer's Ranch.
Virginia.
Furguson's Ranch.
Dayton.
Ely.
Carson City.
Diana.
Genoa.
Midas.
Wellington.
Downieville.
Belmont.
White River.
Hawthorne.
Candelaria.
Pioche.


Keeler, Cal.
Ash Meadows.
Rioville.
El Dorado Canyon.
ARIZONA.
36°
36°
35°
120°
119°
118°
117°
116°
115°
35°
114°

NEVADA
STATE WEATHER SERVICE,
IN CO-OPERATION WITH THE U. S. SIGNAL SERVICE.

CHAS. W. FRIEND,
Director.

HENRY F. ALCIATORE,
U. S. Signal Corps, Assistant.

NEVADA.
RAINFALL REGIONS.
MAP No. 2.

Report on Irrigation.

cient dwelling places and of cotton packed in funeral urns along with the bones of the dead and also made into twine and coarse thread and woven into fabrics resembling very coarse blanket stuff. I am able to supply you with a small quantity of the cotton fiber which I procured from one of the ancient burial places west of the Colorado River near to the head of the "Vegas Wash." The urn in which this cotton was found contained human bones, and the urn, with its contents tightly packed within it, was closed with a lid, which was closely sealed with a resinous substance, thus securing it from the action of the air. I found other urns filled in the same manner but not sealed. The cotton which they contained was only slightly stained. As evidence of the antiquity of this relic of ancient agricultural art I will state that the jar from which it was procured was placed in a cave in a mountain side and with several others embedded in a smooth layer of adobe mortar, in which were impressions of the feet of those who made the deposit, tracks of barefooted man. The cave, after its use by man, became the habitation of bats, and they occupying it long enough to deposit manure to the depth of 3½ feet over these relics, forsook the cave, and, when I was there, evidently had not inhabited it for a long time.

I saw enough other evidence, besides the corn-cobs and this flock cotton, to lead me to believe that the southern portion of Nevada had, in times long since passed, been inhabited by a nation of farmers, who extensively tilled the soil, and that they did this by a system of reservoirs and irrigating ditches leading therefrom.

For further testimony as to the fruitfulness of Nevada soil, I have the honor to refer you to my annual report to the Commissioner of the General Land Office and accompanying letters from some of the most experienced of her citizens relating to this subject, dated July, 1889.

I am certain that Nevada can and will produce abundantly all of the crops which are raised in the region ranging in climate from Minnesota to Florida, together with all that flourish in and enrich southern California. The results stated above and as shown by the maps accompanying are not speculations at all, but the results of observation and personal examination; and while they are in a measure approximate, they are to a very great extent reliable.

I have been at some pains to state the amount of water in average seasons upon the surface of Nevada; I will in conclusion now state its quantity as far as the mountainous portions are concerned.

To the 16 inches stored above the 6,000-foot elevation should be added that which, falling below the 6,000-foot melts and runs down in the spring and early summer. The average depth of this snow is about 5½ feet, and I estimate its quantity of water from my average found for snow freshly fallen, viz, 1 inch of water to 11 inches of snow.

I think that it can be safely estimated that 9,000 square miles of mountainous surface will catch this amount of snow in average winters, thus giving 6 inches of water; this added to the amount falling upon the higher altitudes gives 22 inches of water, the greater part of which can be, by careful planning, made available for irrigation purposes.

There is not less than 4,800 square miles of the Sierra Nevada Mountains which shed water into Nevada. Of this area 250 square miles store annually 14 inches of water; 560 square miles store annually 19 inches of water; 1,330 square miles store annually 36 inches of water. All of which that is not lost by evaporation and percolation comes down into Nevada, giving rise to the Truckee, Carson and Walker Rivers. The remaining 2,660 square miles giverise toonly seasonal streams, which dry away with the summer heats.

I estimate the agricultural lands of Nevada at 21,000 square miles. This area will, I believe, be increased in the future by the addition of many square miles of foot-hills now classed as mountains. Be that as it may, the water supply of Nevada, as I have outlined, is sufficient to furnish each square mile of agricultural land in the State with 42 inches of water per annum.

As it is not possible to reach and improve all the agricultural lands of the State by irrigation from the mountains, it is seen that it is possible to supply much of such lands within reach with more than 42 inches per year; that quantity of itself being equivalent to a bounteous rain-fall in other regions.

I have for the past year carried on a series of experiments upon the amount of evaporation at this place, the town of Reno. I found the maximum for twenty-four hours for the day endng August 2, 1889, to be seventy-two one-hundreths of an inch. For the year 1889 it was as follows:

	Inches.		Inches.
January	1.94	August	16.21
February	2.13	September	13.91
March	3.91	October	9.99
April	4.53	November	3.03
May	11.26	December	1.18
June	14.15		
July	17.76	Total	100.00

Eight feet and four inches for the year 1889 was considered the driest and warmest which has been experienced since the settlement of the country.

The spring and early summer of 1889 were especially dry seasons. I am inclined to believe that 1889 will for a long time stand as the maximum dry year for Nevada.

In my opinion the evaporation is considerably greater for the central and southern portions of the State. From all that I can gather it was about 19 per cent. greater in those portions of the State for the year 1889 than here in Reno.

In order to give you an idea of the substantial and permanent nature of our water supply, and the consequent reliability of it if properly stored, and being stored, that it can be depended upon to tide the farmers using it over a number of dry seasons, I desire to call your attention to the water-shed of the Truckee River. I estimate it at 560 square miles, with an annual average of 14 inches of water stored in the shape of snow. The Truckee takes its rise in Lakes Tahoe and Donner and numerous mountain streams. The river, leaving Lake Tahoe, makes its way through a deep gorge in the heart of the Sierras, and emerging from them on their eastern face runs its course easterly for 12 miles across the "Truckee Meadows," and continuing that course cuts the "Virginia Range," traversing it for 21 miles, at the town of Wadsworth changing its course to north. It in 17 miles more falls into either of two large lakes.

Pyramid Lake is the larger and deeper of the two. The other lake is called Winnemucca Lake by the whites, and Mud Lake by the Pah-Ute Indians.

The river channel divides at a point 2 miles from the former and 5 miles from the latter. Now it has so happened that, by means of drift-wood and from other causes, one of these channels gets choked up, with the result that all of the water is shut off from one lake and turned into the other. The diverted flow will continue then for a longer or shorter time, lifting the surface of the receiving lake much above that of the other. This is seen in the many, and various, water marks along their shores.

Pyramid Lake is about 1,700 feet deep. Mud Lake is shallow, being, as far as I have been able to sound it, only 65 to 70 feet deep. From its shallowness it at times goes dry; but this happens only at long intervals of time.

I have taken great pains to ascertain the facts, and find that about fifty years ago it was entirely dry, so that the Indians used its bed for a road from one end to the other. There are Indians now living who remember having traveled along its bed many times.

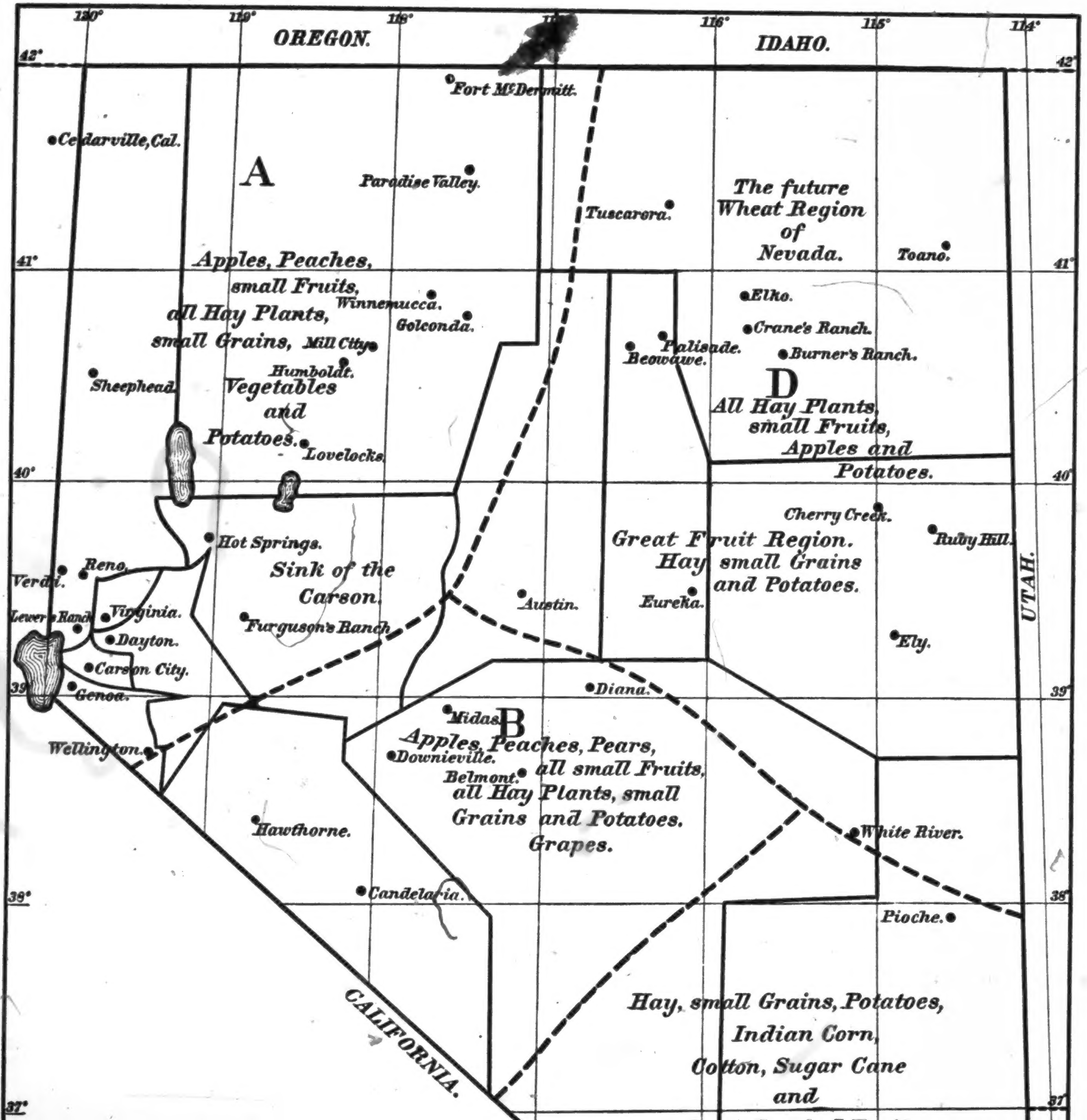
In 1844, at the time of General Fremont's first trip through this region, it was slowly filling, by reason of a great dam of brush and cotton-wood timber, which was pushed into the Pyramid Lake channel by a great freshet in the river some time before that date. The filling has continued to the present time; so that now, as before stated, the lake is about 70 feet deep, and completely covers all its bed. The length of this lake is 28 miles, and its average width 6¼ miles. Thus it is seen that in fifty years' time the Truckee River drainage has stored in Mud Lake, 2.4 cubic miles of water. But this is not all of its storage capacity, for within the fifty years spoken of it has again and again filled up Pyramid Lake, a much larger body of water, through a rise and fall of at least 25 feet; so that I am disposed to place the storage by the Truckee River for a period of fifty years in these two lakes at not less than 5 cubic miles of water, over and above all the losses by evaporation and percolation. This would be at the rate of 14,719,795,200 cubic feet per annum, which sum is the result over and above all losses by evaporation, percolation, and used by irrigation for the past twenty to fifty years. This amount of water would cover a square mile 7,795 feet deep each year if diverted from the lakes and so used.

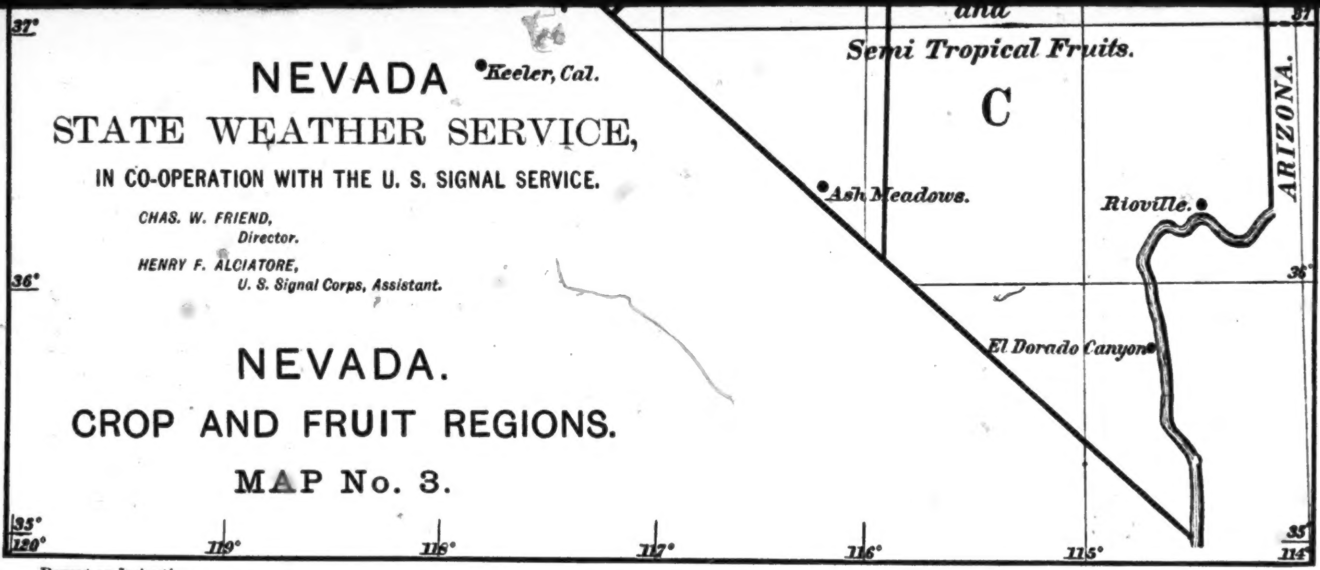
That irrigable lands may be taken by settlers and put under improvement, in this State, with proper facility and with safety to the appropriators. The land laws require a radical revision to that end. I am sure that a settler on the public lands here will require, at an average, three years' time in which to so improve and irrigate his selection, that he can take his family upon it to permanently reside. The homestead law should be so changed as to allow a selection to be made, and at least three years' labor upon it, to get water to it, before requiring a permanent family residence thereon, and also requiring that at the least, labor to the value of $5 per acre of land claimed, be done each year to that end, and that the land be fully improved, and under crop on the making of final proof, which change in the laws would accomplish much.

The proper safe-guards should be provided by law, to prevent the labor of the settler finally going into the hands of land sharks.

There is much valuable public land to be found in the mountain cañons, where very fruitful farms can be made and cultivated through aid of the early melting snows, which can not now be taken under the present land laws.

The legal requirement that homesteaders and pre-emptors shall take their lands in a compact body approximating a square in shape is in the way. In many cañons in Nevada's Mountains, farms of 160 acres can be made, but of very irregular shape, and will be as much as 2 or 3 miles long. The land laws should provide for the improve-


120°
119°
118°
116°
115°
114°
OREGON.
IDAHO.
42°
41°
40°
39°
38°
37°
Fort McDermitt.
Cedarville, Cal.
A
Paradise Valley.
Tuscarora.
The future
Wheat Region
of
Nevada.
Toano.
Apples, Peaches,
small Fruits,
Winnemucca.
Golconda.
all Hay Plants,
small Grains,
Mill City.
Humboldt.
Sheephead.
Vegetables
and
Potatoes.
Lovelocks.
Elko.
Crane's Ranch.
Palisade.
Beowawe.
Burner's Ranch.
D
All Hay Plants,
small Fruits,
Apples and
Potatoes.
Cherry Creek.
Ruby Hill.
Hot Springs.
Great Fruit Region.
Hay, small Grains
and Potatoes.
Reno.
Verdi.
Sink of the
Carson.
Austin.
Eureka.
UTAH.
Lewer's Ranch.
Virginia.
Furguson's Ranch.
Dayton.
Ely.
Carson City.
Genoa.
Diana.
Midas.
B
Apples, Peaches, Pears,
Wellington.
Downieville.
all small Fruits,
Belmont.
all Hay Plants, small
Grains and Potatoes.
Grapes.
Hawthorne.
White River.
Candelaria.
Pioche.
CALIFORNIA.
Hay, small Grains, Potatoes,
Indian Corn,
Cotton, Sugar Cane
and



NEVADA
STATE WEATHER SERVICE,
IN CO-OPERATION WITH THE U. S. SIGNAL SERVICE.
CHAS. W. FRIEND,
Director.
HENRY F. ALCIATORE,
U. S. Signal Corps, Assistant.

NEVADA.
CROP AND FRUIT REGIONS.
MAP No. 3.

and
Semi Tropical Fruits.
C
Keeler, Cal.
Ash Meadows.
Rioville.
El Dorado Canyon
ARIZONA.
37°
36°
35°
120°
119°
118°
117°
116°
115°
114°

Report on Irrigation.

ment of such cañon lands, for they otherwise will go to waste. I feel that there will be large bodies of land so situated, as that their improvement will be beyond individual effort; these can only be improved through the organized effort of a colony, hence, the land laws should provide for the colonization of such lands.

In conclusion, I have to say that any system of irrigation which does not provide for the impounding of the water in any useful quantity, large or small, will be useless to the people of this State.

Such plan should provide for the using of the water wherever found, in reservoirs, or by other means, and in quantities from ponds 20 acres in extent, and 5 feet deep, up to the largest areas which can be covered, and with dams to the highest limit, consistent with safety.

LAKES TAHOE AND DONNER FOR IRRIGATION PURPOSES.

STATEMENTS OF FRANCIS G. NEWLANDS AND R. L. FULTON, OF RENO, NEV.

The following papers having been forwarded to the committee by the Nevada State Board of Trade, it is ordered that they be inserted with the testimony taken in connection with Nevada:

PROPOSITIONS FOR THE USE OF LAKES TAHOE AND DONNER, MADE BY FRANCIS G. NEWLANDS.

Shortly after my coming to Nevada the prevailing subject of discussion in Reno was water storage, and the general sentiment was expressed that the Government only was able to give the necessary relief and aid. My judgment was that this community would have to take the matter in its own hands, first, because the Government is proverbially slow in such matters; second, because the political views of one of the national parties are opposed to the Government undertaking enterprises which can be undertaken by private capital, and that this sentiment, co-operating with the ignorance in the East of Western wants, might defeat measures for relief; and third, because I had reason to believe that most of the storage sites were out of the ownership of the Government and in the ownership of private individuals.

As to the State board of reclamation organized under the act of the last legislature, I found upon conference with its members that they were hampered with doubts as to their powers, as well as the question whether a proposed enterprise could be completed within the proposed limits of the appropriation made ($100,000), and also difficulties arising from the supposed onerous nature of the rates exacted by the law for the use of water.

I said that I was disposed to spend some time and money in securing a practical solution of the difficulty, and endeavored to ascertain the facts with reference to the title and ownership of the various reservoir sites on the Truckee. I was then brought in communication with Mr. Robert Fulton, the land agent of the Central Pacific, who has a greater familiarity with the topography of the country than any man I have met. The result of our investigations was that we ascertained that the outlet of Donner Lake was in the possession of Mr. Kruger, of the Truckee Lumber Company, and that he had recently constructed a dam there about 6 feet in height. We found the outlet of Lake Tahoe, consisting of 118 acres, was in the ownership and possession of the Boom Company, the principal stockholders of which were Leland Stanford, C. P. Huntington, the estate of Charles Crocker, and other persons interested in the Central Pacific Railroad Company. We immediately commenced negotiations with a view to the purchasing of these outlets, I agreeing that I would advance the money to perfect the dams, store the water, and turn over the completed works either to the State of Nevada or to the county of Washoe, or to the united ditch-owners on the Truckee, as might be deemed advisable. I communicated with Mr. Charles F. Crocker on the subject shortly prior to his departure for the East, by letter, Mr. Fulton taking the letter, and having also a personal interview with Mr. Crocker.

The following is a copy of the letter addressed by me to Mr. Crocker:

CARSON CITY, NEV., *September* 26, 1889.

MY DEAR CROCKER: You doubtless know that "irrigation" is the absorbing question in Nevada at present and that surveys have been and are being made by the United States Government of the various sources of water supply, with a view to the establishment of reservoirs for the storage of water, so that the supply may be continuous—not as at present, too abundant during the spring and early summer, when the snow is melting, and scanty when it is needed for the maturity of crops and for the second and third crops of alfalfa and other grasses.

The storage project to which I call your attention in this communication is that of the Truckee River, and I propose to show you how the Central Pacific Railroad, or the men who are interested in it, can greatly benefit this State and its people, and at the same time largely increase the revenue of the railroad. I shall probably give you some information of which you are already possessed, but it is necessary to a connected statement. The Truckee River takes its source in Lake Tahoe on the eastern side of the Sierras and flows past the town of Truckee, Cal., and the towns of Verdi, Reno, and Wadsworth, in Nevada, a distance of 97 miles, emptying into Pyramid and Winnemucca Lakes. It obtains about one-fourth of its flow from Lake Tahoe, the other three-fourths coming from water-sheds which empty into the Truckee below Tahoe, such as the Little Truckee, Prosser Creek, and the outlets of Donner, Independence, and other small lakes.

The sources of this river are almost entirely in California, but they can be of no benefit to it so far as irrigation is concerned, for the reason that the California lands adjacent to it are on the eastern slopes of the Sierra Nevadas, and are mountainous and precipitous. The water is not utilized for irrigation until the Nevada line is reached, and from that line to Wadsworth a strip of country 50 or 60 miles in length and from 2 to 15 miles in width is transformed from a desert into a fertile country, equalling in productiveness and surpassing in climate any irrigated district in California that I know of, except the San Gabriel Valley, in Los Angeles County. Within the reach of the Truckee River, by ditches which have been surveyed, lie 400,000 or 500,000 acres of land superior to any that has yet been irrigated. The only thing that prevents this land from being made of great value to the State and a great source of revenue to the Central Pacific, is the scarcity of water during the months of July, August, and September, when the crops are maturing. When the water is most needed it is scarce, and when it is least needed it is abundant and over flowing. During March, April, May, and June the snows melt and fill the river with an overflowing stream, of which a very small proportion is utilized, the balance pouring into Pyramid and Winnemucca Lakes, which lie in the sink of the desert and have no outlet. Some idea of the magnitude of this volume can be formed when I tell you that the area of these two lakes is (as I am informed) about 600 square miles, or over 360,000 acres, and that the depth of Pyramid Lake is in some places 160 feet, and in others even more. If this water to the depth of 4 feet could be led by ditches over fertile land, it would put under cultivation over 500,000 acres. As it is, the water rushes to these lakes and can not be utilized, for the lakes are below the level of the adjoining lands. In July, August, and September, when the water is most needed, the river runs almost dry, and the farmers of the 50,000 or 60,000 acres now under irrigation, fearful lest the drought may wither their crops, are engaged in a continual fight for the scanty supply that does come down.

Much has been expected from the United States Government, but the people are beginning to realize that it moves slowly and that little will be done beyond the ascertainment and survey of reservoirs, the enterprises themselves being left to private capital. We have already ascertained all that can be learned about the sources of the Truckee River. We know that a dam costing $10,000 can be constructed at the outlet of Lake Tahoe, which if raised only 10 feet high will store for the period of scanty supply a body of water in addition to that at present in the lake covering 175 square miles and 10 feet in depth, all of which, except that drunk up by the sun, can be utilized in the period of greatest scarcity, and capable of irrigating millions of acres, in connection with the utilization of the water which flows from other water-sheds into the Truckee during the flood season.

The title of the land on which this dam must rest is not in the Government. If it were the solution would be simple. But I was glad to find that it was in the name either of your father or yourself and that a dam was at present upon it, and that in some way it was in the possession of a boom company organized under the laws of California for the booming of logs down the Truckee River, and that the stockholders of this company were the gentlemen interested in the Central Pacific Company—Governor Stanford, C. P. Huntington, yourself, W. E. Brown, and others. I say that I was glad to hear this for I felt satisfied that the public spirit as well as the business policy of these gentlemen would prompt them in some way to utilize this land to the advantage of Nevada and its people and the consequent profit of the railroad in which they are interested and which traverses from one end to the other the State of whose products and supplies it is almost the only carrier.

Something can be done immediately in behalf of this community, and I appeal to you to do it before your departure—and that is to take measures to bring some of the gentlemen interested in your railroad in communication with a committee of the people of Reno on this subject. And I suggest also that orders be given to keep the gates of the present dam shut down during the coming winter and spring so that the water of the lake can be stored, and if the present dam is insufficient that a new one be immediately constructed. If necessary I will undertake to see that the money is raised for this purpose. All this can, I think, be done immediately. Measures for the more complete utilization of the waters can be devised hereafter when you are more at leisure. The people along the Truckee River will, I am sure, form a corporation to purchase the land at the outlet of Lake Tahoe at a reasonable price; or, if you would like to enter into an irrigation enterprise on a large scale, I suggest that you give the opportunity to the people of this State to subscribe to it.

I think that with the unremunerative rates which the competition of the Canadian Pacific and other trans-continental railroads has caused, it will be sound business policy to build up a country through which so much of your road passes and over which you have no competitors. I am sure that this can be done, and the best evidence of the sincerity of my opinion is that I am disposed to invest largely the funds of the estate of which I am trustee in a State from which it has received so much of its income. * * *

FRANCIS G. NEWLANDS.

Mr. Crocker was very much hurried making preparations for departure for the East, but expressed himself favorably in general terms to the immediate utilization of Lake Tahoe, and wished Mr. Fulton to make a proposition which could be submitted to the directors of the Boom Company. Mr. Fulton did not think it advisable to make a proposition then, as Mr. Crocker was hurried and had not time to entertain it. Subsequently I sent a copy of this letter to Senator Stanford, who was then at Sisson Springs, asking his immediate consideration of the subject upon his return to San Francisco. Meanwhile Senator Stewart arrived in Reno upon his return from the labors of the Irrigation Commission. Mr. Fulton and myself had an interview with him and enlisted his active co-operation. He proceeded immediately to San Francisco and had a conference with Governor Stanford and secured an opportunity for a conference with a committee of citizens of Reno, consisting of Messrs. Fulton, Martin, Wheeler, Foley, and Mayberry.

Shortly after Senator Stewart's arrival in San Francisco he sent me the following letter:

SAN FRANCISCO, *October* 7, 1889.

MY DEAR NEWLANDS: I have just had an interview with Governor Stanford in regard to the Lake Tahoe matter. He says that he will make any fair arrangement whereby the people in Nevada shall have a right to use so much of the waters of Lake Tahoe as they can appropriate. He wants the arrangement made, however, so that the people will have the benefit of it, and that it shall not be monopolized by a few individuals.

I saw Mr. Fulton after my interview with the governor, and told him that he had better have the committee come down, and we would then call on the governor and try to perfect an arrangement. The governor seemed to care more to have the water economically used than the money to be paid for the right. If ready money is necessary to perfect the arrangement—and it probably will—are you willing to advance it and hold the title for the use of the people of Washoe County or of the State of Nevada? I do not know exactly what form the case will take or what contract Governor Stanford will want, but I will do what I can to put it in the best shape.

Yours, very truly,

WM. M. STEWART.

FRANCIS G. NEWLANDS, Esq.,
Carson City, Nev.

I immediately replied as follows:

CARSON, NEV., *October* 9, 1889.

MY DEAR SENATOR: I received your letter of October 7 to-day and immediately sent the following telegram:

CARSON, *October* 9, 1889.

Senator WILLIAM M. STEWART, *Palace Hotel, San Francisco:*

All my efforts in the matter of irrigation have been for the benefit of the State of Nevada and not for personal profit. Will advance any money necessary to perfect arrangements and will start immediately to work upon necessary dams, holding the title for the people of Washoe County or State of Nevada subject to payment of my advances and per cent. interest. Telegraph me Fulton's address and keep me fully advised.

F. G. NEWLANDS.

I presume this is sufficiently explicit.

I have often observed the inability of communities to deal with practical questions. The business man can often solve in a few hours what it takes a community months and years to determine upon. When I first came to Nevada I was surprised to find how little accurate knowledge there was with reference to the subject of irrigation, and particularly of storage. In my talks with individuals I have been insisting that it would not do to wait for the Government to move, as it would be too slow and possibly would not move at all, and that the only course to pursue was for the community to act on business principles, as any individual would do, ascertain the facts, and then act quickly. But the old adage, "What's everybody's business is nobody's business," has proved true. The people along the Truckee River have struggled along for years without solving the question, which was of comparatively easy solution. So, after ascertaining the facts from Mr. Fulton, I determined to negotiate for all the available dam sites in the headwaters of Truckee River. I have secured that of Lake Donner, and wish to secure that of Lake Tahoe. I don't propose to wait for the community as to the construction of dams; I shall build them immediately. They will not be expensive. I shall then hold the property for the county of Washoe or the State of Nevada, as may be determined to be best, and shall turn them over in complete condition for storage upon reimbursement to me of my expenditures with 6 per cent. interest.

I propose to undertake the construction of the dams for the reason that otherwise time will be lost. The county of Washoe has no power to undertake such a construction, and the act of the legislature appropriating $100,000 is coupled with such onerous conditions as to rates for water as to make it undesirable to use in that agency.

I know you will do what you can to expedite matters. I am very anxious to get to work immediately upon these dams and hope there will be no delay.

I am glad that Senator Stanford has the disposition of this matter. I knew that his generous spirit would lead him to act with reference to it with an eye for the benefit of this community.

Very sincerely, yours,

FRANCIS G. NEWLANDS.

Meanwhile, Senator Stewart and Mr. Fulton telegraphed to the committee to come to San Francisco and hold a conference with Governor Stanford. At this conference Senator Stanford was very cautious; he did not express himself so favorably as to immediate action as he did in previous interviews with Senator Stewart. He expressed the general view that nature had adapted this lake to the use of the agricultural community on the banks of the Truckee River, but that he was desirous of moving cautiously, so that whatever might be done would be not to advance any monopoly or speculative interest, but the people of that community. The committee retired somewhat discouraged, fearing that excessive caution might delay the great enterprise and retard the proper utilization of the waters of Tahoe.

Shortly after Senator Stewart came to Carson and told me the result of further interviews with Senator Stanford; and also told me that he thought that Senator Stanford would turn over the outlet of Lake Tahoe for the benefit of the people of the State, provided the waters would not fall into the hands of speculators or be monopolized by existing ditches, and provided it could be done in such a way as to insure to the people generally the benefit of the enterprise.

Senator Stewart's idea was to have the State reserve large tracts of land in the vicinity of the Truckee River, to which the waters stored in Lake Tahoe and the storage reservoirs could be applied; then to have these storage reservoirs put in the hands of the State reclamation commission, of which Senator Evan Williams is chairman; then to connect the water with the land, and then sell out these tracts to colonies in small parcels of from 20 to 40 acres each, his opinion being that the interests of the State would be much more advanced by encouraging the ownership of small tracts, which would be more thoroughly cultivated than in large tracts, for what we need is population, and a population of workers. So we conferred with the State authorities to see whether any large grant of land could be secured for this purpose, and we found that the law was so framed as almost to prohibit the State itself from taking advantage of its own grant.

We found that of the grant of 2,500,000 acres of land to this State, 2,000,000 have been selected by private applicants, and that a balance of 500,000 acres only remains; that under existing laws an applicant might apply to the State for 640 acres of this grant, and upon making the deposit required by law the State would then, as his agent, select the land designated by him and make application to the Federal Land Office for the listing of the same to the State. The price fixed is $1.52 an acre.

Section 15 of this act reads as follows: "It is hereby made the duty of the State land registrar to select as portions of the several grants of land to this State all lands for which money has been deposited under the provisions of this act."

So you will observe that the act provided only for the selections where the deposit was made, and such deposit could be made only by individual applicants for title. We found then that the State was powerless either to reserve or select for itself any portion of its grant. This was a very discouraging view of the situation. Senator Stewart was anxious to secure the title of the Tahoe outlet immediately. He was satisfied that it could only be secured by showing to Governor Stanford some reasonable scheme for its utilization which would redound to the advantage of the people of the entire State, and he found that the law of the State itself held it in chains.

I suggested that a number of individuals could combine together, make applications under the law, make the deposit required and hold the lands for such a projected scheme, not for themselves but for the benefit of the State—the legislation to be shaped at the coming session—and I said that I would advance whatever moneys were necessary to make such deposits. We have now under consideration the selection of from 25,000 to 30,000 acres of land with a view to setting them aside for the benefit of this State or of this county, and of developing a colonization scheme which will increase the wealth, the population, and the prosperity of the State.

When that land is secured and the certificates of purchase are so placed as to secure to the State or to the county of Washoe the benefit of the enterprise, I have no doubt that Governor Stanford will take some measures for the utilization of the storage of Lake Tahoe, either by conveying this land to the State commission of reclamation, or by leasing it perpetually, or by placing it in charge of some one who will act disinterestedly for the owners as well as for this community.

Whilst these negotiations were pending I purchased for $18,000 the outlet of Lake Donner. The facts connected with this purchase have been made public, and it is hardly necessary for me to repeat them. I hold this land subject to reimbursement of the cost and interest at 6 per cent. for the people of the State or of Washoe County, or of the united ditches of the Truckee, as may be deemed advisable. A dam is already raised 6 feet high, and we propose to raise it 6 feet more. This will bring it to the meander line. We propose also to dig down 4 feet, thus giving a height of 16 feet, or 32 square miles of water 1 foot deep.

I was disposed to purchase the lands of riparian owners along the lake if they could be secured reasonably, and raise it 6 feet higher still, but the rapacity of some of these riparian owners has been aroused and they are exceedingly unreasonable in their demands. I do not propose to submit to them, and I trust this community will not. I propose to go on with the enterprise and perfect it so far as I can, and within a short time the question will come up as to what disposition you wish to be made of them. Shall these reservoir sites and these lands be turned over by me to the State commission of reclamation appointed by the State legislature, or shall I hold them until they can be turned over to the county of Washoe under legislation to be secured at the next session? Or shall I turn them over to the united ditches of the Truckee. There is much to be said in favor of each of the propositions. The advantages in favor of turning over these enterprises to the State commission of reclamation are the following: They can be immediately turned over; that commission has $100,000 appropriated for such purposes. The difficulties which have heretofore laid in the way of the commission's entering upon these enterprises have been: First, doubts as to their powers; second, doubt as to the wisdom of obtaining property in California which will be subject to taxation there; third, the supposed onerous nature of the rates to be exacted for the use of water under the law. The commissioners have insisted until recently that it would be their duty to demand a dollar an acre for every acre which received any benefit from this storage. It was thought this would impose a very onerous obligation upon the people of Washoe; assuming that we should succeed in developing only the Donner Lake storage, it would involve the payment from the 25,000 or 30,000 acres of this county now under cultivation of a sum almost equal to the purchase money. In other words, the owners of irrigated lands would be compelled to pay to the State every year the entire amount expended by the State in the enterprise.

This, I understand, is the construction of the law placed upon it by Mr. Evan Williams, chairman, but some gentlemen in this county, among them Mr. Foley, differ with Mr. Williams as to the construction of the statute, and insist that the exaction of $1 an acre applies only to new lands placed under irrigation; but as to old lands covered by existing ditches, the commissioners are under section 8 of the act authorized to fix rates according to their discretion, and that hence they can fix a nominal rate of 10 or 20 cents an acre, which would work no injustice to the owners of land in the Truckee meadows now under cultivation.

All these questions will require time to determine, and possibly an application to the courts will be necessary. My judgment is that in the district of the Truckee, situated as it is all within one county, it is better to intrust the control of these storage reservoirs to the county itself or to the united ditches; otherwise you will find difficulty in having speedy action when energy is required. The members of the State commission are four in number, and live in different parts of the State; they had all-important business interests; it requires three to make a quorum. The fact that we have only been able to secure the presence of one commissioner to-night shows how difficult it will be to secure the attendance of a quorum when some emergency may demand it.

But as to the ownership of the county, it is admitted that under the existing law the county has no power to acquire such properties, and it will be necessary to shape legislation one year hence to that end. As to the acquisition of these storage reservoirs by the present owners of the ditches on the Truckee, this will meet with the opposition of Governor Stanford and may defeat the acquisition of Lake Tahoe. It will be necessary to overcome his objections by a negotiation and by satisfying him that this measure will advance the general good.

For my own part I incline to the view that the ownership of the storage reservoirs should be vested in the united ditches of the Truckee, through the intervention of some corporation or trustee holding for them. These ditches are about forty in number. The stock in them is for the most part in the ownership of the farmers whose lands are irrigated. No community of interest could be devised which would include a greater number of those to be benefited than would this plan. It would secure the old settlers against loss of their crops, and as the storage was gradually extended these ditches would be enlarged so as to take in new lands within their reach, and when these were all put under cultivation new ditches could be constructed to lead the surplus waters to the high lands above the Truckee meadows. And such ditches should be allowed to appropriate water from the river, both the natural flow and the flow acquired by storage, subject, of course, to prior rights, for it must be remembered that the great cost of these enterprises would not be in the storage of water as much as in the construction of long and expensive ditches running along a precipitous river bank and requiring in places flumes, tunnels, and distributing reservoirs. I am told that the lowest sum for which the cheapest of these ditches—the one projected by Alvaro Evans—can be constructed is $100,000, with a capacity for supplying not more than 4,000 acres of land. Other ditches which have been projected will cost from $250,000 to $300,000 each, thus involving an outlay for water of from $25 to $40 per acre. It will be readily seen that these measures can only be worked out gradually, and as the growth of the community warrants. These views have been most admirably expressed in a letter written by Mr. Robert L. Fulton to Mr. W. H. Mills, the general land agent of the Central Pacific, a man of large and comprehensive views, who will doubtless bring them to the attention of Governor Stanford and Mr. Crocker. I trust that this letter will be published, as it does away with many exaggerated views which I, in common with most others, have indulged as to the area of additional land which can be covered by stored waters, and deals with the whole subject practically and in detail.

It has been suggested that, as I am not purchasing these properties for my personal benefit, I should put the nature of my trust in some legal form; whilst nobody impugns the possibility of my acting in anything but good faith as long as I live, the suggestion is made that I might die, and then there would be a difficulty in enforcing the trust. This is an objection, and I will be glad to take some action which will do away with it. We are about to shape the title to these reservoir sites for all time, and we must carefully consider the plan and the mode, and were I to express my trust in plain and unequivocal terms, acting upon present information, the terms of the trust might prove to be inadequate, and yet could not be changed. It seems to me, therefore, that there is no other course for me to pursue, save as I have done—to acquire the properties and wait until a plan for turning them over can be properly formulated. If I live I know that you will trust me in the matter, and should I die you may rest assured that my executors will not wrong you.

As I have already stated, I have given but little attention to the legal questions involved. I have been too busy with the practical ones. I always give full force to questions that are raised as to legal power, but I have seen great enterprises fail from too great attention to legal obstructions, and in reaching out for a great enterprise my disposition is to fix my eye on the goal and to jump all intermediate fences. I believe that we are on the road to a solution of all the practical difficulties, and when they are solved you may rest assured that the legal difficulties will also disappear.

USE AND CONTROL OF WATERS FROM THE EASTERN SIERRAS, BY ROBERT L. FULTON.

[This letter was written to the land commissioner of the Central Pacific Railroad.]

Heretofore the entire water supply of Lake Tahoe has been used in the interest of concerns located on the upper end of the stream, without any reference whatever to the ten thousand people who have settled on its banks lower down, on lands made fruitful by its waters and their hard labors, and it is to secure, if there is any earthly way to do it, some modification of this arrangement that we importune Governor Stanford and his associate owners in the Donner Boom and Lumber Company.

The people of Washoe County, in which the entire agricultural resources of the Truckee basin lie, know very well that the complete control of its waters can not be transferred to them, for they are aware that the Truckee Lumber Company has a right to water sufficient to furnish power to turn the wheels of their saw-mills and furniture factory, but they believe that the interests of the farming communities on the Truckee could be much better served than at present without in any way decreasing its usefulness to the others who use its waters.

The most rigid economy should be exercised in saving all that falls from the clouds, as well as in its use after it is stored. Last winter and the one before the ice men whose ponds lie on the river complained to the men who have charge of your dam at the outlet that they had too small a flow of water, and insisted that they must have a regular and constant stream flowing through their ponds. The water was allowed to run full head for some time with no further examination or consideration, and what would have been of immense benefit here in maturing crops at a critical period, went to add a few tons in weight or a fraction in quality to the crops of the few ice companies that have their ponds on the main stream. The large ponds of the Prosser Creek, Boca, and Mountain Companies are on side streams and only the newer works are on the river proper.

I have carefully computed the area of its surface, and find the lake to cover 190 square miles and the catchment outside of water to cover 291 square miles. On the south end of the lake the natural course of the streams has not been interfered with, but on the north and east sides it has been diverted. The Virginia and Gold Hill Water Works are supplied by water saved in reservoirs on the west side of the ridge and conducted through a tunnel to the eastern slope and thence in pipes and flumes to their works. The Carson and Tahoe Lumber Company's flume is largely fed from streams that nature originally sent into Tahoe. The change throws the water into the valley south of Carson City. The same is true of the Sierra Nevada Wood and Lumber Company's flume, which carries a large stream into the valley north of Carson.

Making allowance for these diversions on the eastern side for the very narrow limits of the ridge on the north and the break made in the western wall by the Truckee River flowing through it, I do not think it possible to save more than an average of 2½ feet a year.

The highest the lake was ever raised in one year was 3 feet 7 inches, and the average, allowing for the drain that would be made by the interests that would have to be considered, and that need more or less water in the stream all the time, would certainly not exceed 30 inches. If it could be that amount regularly it would be better, but where it is 3 feet one year and 1 foot the next it can not be used economically. There will not be much gained by trying to hold water over for a dry year, the evaporation being so great, and the waste continues day and night. Much of the basin extends toward the east, where the annual deposit of moisture is small, and what does not fall can not be saved. * * *

Major Powell estimates that a foot of water in a reservoir will irrigate an equal amount of land. If he has a square mile of water 1 foot deep he can raise a crop on 640 acres. This might do in a fruit orchard or a grain field, but it will take that much a month on the alfalfa fields of this county. No one figures on using less than three-quarters of an inch, miner's measure, to the acre, and very few on less than an inch. This corresponds very closely, I find, with the estimates made in Spain and elsewhere, according to the reports of General Greeley of the Weather Service, who gives the figure at 5 inches a year. Of course, our farmers raise two and three crops a year, and after the last one they irrigate for pasture until heavy frosts come.

A little calculation will show that the flow of an inch to the acre will be considerably over a foot deep for each month it runs, and that is allowing nothing for seepage or evaporation on the way from the reservoir to the field, which in this case would be from 50 to 80 miles. The Truckee is so steep and full of large bowlders that all the water that comes down gets well aerated, and the evaporation is considerable.

It seems very plain to me, therefore, that if this country was all open, the best that Lake Tahoe could be made to irrigate with the water saved up would not be outside of 50,000 acres. This is beside the natural flow, which was long since appropriated under the laws, and all we can figure on owning is what we can save out of the surplus floods of winter and spring.

There are now about forty ditches, all of them taking their water from the river, and furnishing enough to irrigate, in ordinary years, something like 25,000 acres of land. In such a dry year as this a reserve of water would have added 30 per cent. to the crops on this land, without adding 5 per cent. to the expenses, because all the work of irrigating, harvesting, etc., had to be done as thoroughly for half a crop as for a whole one. To insure a community like this against a failure of even one of its staples is worth a large amount of effort. If the alfalfa crop could have been increased by 10,000 tons this season it would have affected every interest that has a representation in Nevada. Beef cattle would have been shipped in to fatten on it, and trade, industry, transportation, and everything else would have had its share.

It seems to me that the first consideration in any system of water storage should be to prevent a famine in works already constructed. No new settler can have any greater claim on the country, the Government, or the philanthropist than those who came in first and pioneered the country when no one believed it would ever be worth living in. Of all the ditches on the map not one was built by capital for the sake of the investment. Every one was built by the owners of land to cover the fields they were tilling for their own and their families' support. Many of them worked with a rifle within reach to protect themselves from the treacherous Washoe or Piute, and I claim they are entitled to as much consideration as the pioneers of Kentucky or the forty-niners. All these ditches are owned and operated to this day, directly by the farmers who use the water, except the Steam-boat ditch, which proved too much of an undertaking for the farmers who united to build it. It was sold by the sheriff and is now owned by an estate that offers it for sale for a third of its cost. This and the one used to supply the Reno Water-Works are the only ones not owned by the actual users.

I mention this fact to show you and Senator Stanford that if it was deemed best to sell the control of the outlet to these ditch companies it would be put to the highest possible use, and in case there was a surplus there is a large field beyond their present termini to which they could be carried and the entire waters of Tahoe used to make new homes for citizens. Very fine lands could be reached by extending the Orr ditch and enlarging it to carry water for Spanish Spring Valley. Settlers could take water from the end of the Highland ditch and construct a canal of their own into Prosser Valley and higher up in Spanish Springs than the Orr ditch can reach. Another colony could carry the water of Steam-boat ditch across the valley to fertile lands east of Steamboat Creek. There is a fine tract of land to be covered below the present Steamboat ditch and another below the Orr ditch, but neither can furnish the water until the supply in the river is increased and their carrying capacity multiplied. There is a large opportunity for bringing water and land together to the east of Wadsworth, but it has never been surveyed, so I can not give the data. The water should be used higher up on the stream first for the seepage is so great that with large bodies of land well soaked on the upper waters of a stream there can never be a scarcity below. This has been carefully estimated in Colorado, and the result showed that it was far better for the people on a stream to have farmers come in above them and irrigate than to have all to themselves, as the water was held back and worked its way into the stream again throughout the whole season instead of rushing by in a flood.

IRRIGATION LAWS OF NEVADA.

AN ACT to regulate the use of water for irrigation and for other purposes; for settling the priority of rights thereto, and to punish the unlawful interference with such rights; to provide for the condemnation of land for reservoirs; for recording claims to water rights, and the appointment and duties of water commissioners.

The people of the State of Nevada, represented in Senate and Assembly, do enact as follows:

SECTION 1. That the lands now irrigated, or which may hereafter be irrigated in the State of Nevada, are hereby divided into the following irrigation districts: District No. 1 shall consist of all the lands irrigated from the Truckee River and its tributaries. District No. 2 shall consist of all the lands irrigated from the Carson River and its tributaries. District No. 3 shall consist of all the lands irrigated from the East and West Walker Rivers and their tributaries. District No. 4 shall consist of all the lands irrigated from the Humboldt River and its tributaries. District No. 5 shall consist of all the lands irrigated from the Owyhee River and its tributaries. District No. 6 shall consist of all the lands irrigated from the Rees River and its tributaries. District No. 7 shall consist of all the lands irrigated from the White River and its tributaries. District No. 8 shall consist of all the lands irrigated from the Muddy River and its tributaries. Other irrigation districts may be formed from time to time by the governor, on petition of the parties interested, comprising territory not within any of the above-established irrigation districts.

SEC. 2. There shall be one water commissioner for each of the above-named districts and for each district hereafter formed, who shall be appointed by the governor whenever his service may be required, to be selected by him from the persons recommended to him by the several boards of county commissioners of the counties in which the water districts may extend, and the water commissioners so appointed shall hold office for the period of two years, or until their successor is appointed and qualified. The governor, by like selection and appointment, shall fill all vacancies which may be caused by death, resignation, or continued absence from the district, removal or otherwise, and the governor may at any time remove any water commissioner for failure to perform his duties or for any other cause.

SEC. 3. That within twenty days after his appointment, and before entering upon the duties of his office, such water commissioner shall take and subscribe to an oath to faithfully and impartially perform the duties of his office, which oath shall be deposited with the clerk of the court having jurisdiction over his district.

Sec. 4. It shall be the duty of said water commissioners to divide the water in the natural lakes or streams of their districts among the several ditches taking water from the same according to the prior rights of each respectively, in whole or in part, and to shut and fasten, or cause to be shut and fastened, the head-gates of any ditch or ditches heading in any of the natural streams or lakes of the district, which in time of a scarcity of water makes it necessary by reason of the priority of the rights of others above or below them on the stream.

Sec. 5. Every person who shall wilfully open, close, change, or interfere with any head-gate or water-box without authority shall be guilty of a misdemeanor, and on conviction thereof shall be fined in any sum not exceeding five hundred dollars, or imprisoned in the county jail for a term not exceeding six months, or both such fine and imprisonment. The water commissioners, or their assistants, within their districts, shall have authority to arrest any person or persons offending, and take them before the nearest justice of peace in the county, to be dealt with as in other cases.

Sec. 6. The water commissioner herein provided shall be entitled to pay at the rate of five dollars per day for each day he shall be actually employed in the duties of his office, not to exceed ninety days in any one year, to be paid by the county in which his irrigation district may lie. Each water commissioner shall keep a just and true account of the time spent by him in the duties of his office, and shall present a true copy thereof, verified by oath, to the board of county commissioners of the county in which his district may be, and said board of county commissioners shall allow and pay the same out of the county treasury, and where irrigation districts shall extend into two or more counties then said water commissioner shall be paid for his services as follows: In District No. 2, Douglas County shall pay ——, Ormsby County shall pay ——, Lyon County shall pay ——, Churchill County shall pay ——. In District No. 3, Esmeralda County shall pay ——, Lyon County shall pay ——, Douglas County shall pay ——. In District No. 4, Humboldt County shall pay three-sevenths ——, Lander County shall pay one-quarter ——, Eureka County shall pay one-quarter ——, Echo County shall pay three-sevenths ——. District No. 6, Lander County shall pay ——, Nye County shall pay ——. Said water commissioner shall have power, in case of emergency, to employ suitable assistants to aid him in the discharge of his duties; such assistants shall take the same oath as the water commissioner and shall obey his instructions, and each shall be entitled to four dollars per day for every day he is actually employed, not to exceed thirty-five days in any one year, to be paid upon the certificate of the water commissioner in the same manner as is provided for payment of water commissioners.

Sec. 7. Said water commissioners shall not begin their work until they shall be called by three or more owners or managers or persons controlling ditches in their several districts by application in writing, stating that there is a necessity for their action, and they shall not continue performing services after the necessity therefor shall cease.

Sec. 8. For the purpose of hearing, adjudicating, and settling all questions concerning the priority of the appropriation of water between ditch companies and other owners of ditches drawing water for beneficial purposes from the same stream or its tributaries or lakes, within the same irrigation district, and all other questions of law and questions of right growing out of or in any way involved or connected therewith, jurisdiction is hereby vested exclusively in the several district courts as follows: For district No. 1, in the district court of the State of Nevada, Washoe County; for district No. 2, in the district court of the State of Nevada, Ormsby County; for district No. 3, in the district court of the State of Nevada; for district No 4, in the district court of the State of Nevada, for either Humboldt or Elko Counties; for district No. 5, in the district court of the State of Nevada; for district No. 6, in the district court of the State of Nevada, Lander County; for district No. 7, in the district court of the State of Nevada; for district No. 8, in the district court of the State of Nevada. All lakes, streams, and reservoirs not herein enumerated shall be for all purposes attached to and belong to the irrigation district in which the greater portion of its waters is, it being the intent and meaning hereof to add to each irrigation district all waters not hereinbefore enumerated, the majority of which lie within their respective areas, for the purpose of acquiring rights to the appropriation and use thereof and adjudicating the same.

Sec. 9. In order that all parties may be protected in their lawful rights to the use of water for beneficial purposes, every person, association, or corporation owning or claiming any interest in any ditch, canal, or reservoir within any water district, shall, on or before the first day of September, eighteen hundred and eighty-nine, file with the county recorder of the county a statement of their claim under oath, entitled of the proper county, which statement shall contain the name or names, together with the post-office address, of the claimant or claimants claiming ownership as aforesaid of any such ditch, canal, or reservoir, the name thereof (if any), and if without a name the owner or owners shall choose and adopt a name to be therein stated by which such ditch, canal, or reservoir shall thereafter be known; the description of such ditch, canal, or reservoir as to location of head-gate, general course of ditch, the name of the natural stream or lake from which such ditch, canal, or reservoir draws its supply of water; the length, breadth, depth, and grade thereof as near as may be; the time, fixing a day, month, and year as the date of appropriation of water by original construction, also by the enlargement or extension, if any such thereof have been made, and the amount of water claimed by or under such construction, enlargement, or extension, and the present capacity of the ditch, canal, or feeder of reservoir, and also the number of acres of land lying under and being, or proposed to be, irrigated by water from such ditch, canal, or reservoir; or if such waters have been appropriated for other beneficial purposes than irrigation, a statement of such purposes. Said statement shall be signed by the proper party or parties and filed with the recorder of the county wherein the right claimed is situated, which shall be recorded by him in a book kept for that purpose.

SEC. 10. Upon the filing of such statement the recorder shall indorse upon the back thereof the date of filing, and shall prepare an index of the same in a book to be provided for that purpose by the county commissioners, which said index shall contain the date of filing, the name of the party, association, or corporation, the name of the ditch, the stream from which the water is taken by such ditch, canal, or reservoir, the location of the head-gate, the date of the appropriation of the water by construction, enlargement, or extension. Said index shall be prepared alphabetically by reference to the name of the ditch, canal, or reservoir.

SEC. 11. For filing and indexing such statement the recorder shall receive the same fees as for recording deeds, to be paid by the party or parties filing the same.

SEC. 12. That hereafter every person, company, or corporation constructing, enlarging, or extending any ditch, canal, or reservoir for beneficial purposes, and intending to use or appropriate any water from any natural stream or lake within any water district for such beneficial purposes, shall file with the county recorder of the proper county before the commencement of the construction, enlargement, or extension of such ditch, canal, or reservoir, a statement showing the stream or streams from which the water is to be taken; the point or place on said stream at or near which the water is to be taken out; the line or commencement of said ditch or ditches as near as may be; the use or uses to which said water is to be applied; the dimensions of said ditch or ditches, and each thereof, giving width on bottom and top, slope of banks, and grade of ditch, and likewise of any and all enlargements thereof, which statement shall be filed and indexed as is provided in section 9 of this act; and from the time of filing any such statement water sufficient to fill such ditch or ditches and subserve the use or uses aforesaid, if a lawful and just use, shall be deemed and adjudged appropriated: *Provided*, That nothing herein contained shall be permitted to interfere with a prior right to said water or to any thereof: *And provided further*, That such person or persons or corporation shall, within sixty days next ensuing the filing of such statement, begin the actual construction of said ditch or ditches, and shall prosecute the work of the construction thereof diligently and continuously to its completion: *And provided further*, That the beginning of all necessary survey of such ditch or ditches shall be construed as the beginning of said work of construction.

SEC. 13. The water of every natural stream not heretofore appropriated within this State is hereby declared to be the property of the public, and the same is dedicated to the use of the people, subject to appropriation as herein provided. The provisions of this act shall apply to all cases where the water of natural streams or lakes is appropriated for beneficial purposes, whether the water be conducted through ditches, canals, flumes, or tunnels, and shall apply also to cases where for irrigation purposes the water is stored in reservoirs, and the owner or owners of any ditch, canal, flume, or tunnel through which water is conducted for irrigation purposes, and also the owners of reservoirs, may conduct the water therefrom into and along any of the natural streams of the State, but not so as to raise the waters thereof above high-water mark, and may take the same out again at any point desired; but due allowance shall be made for evaporation and seepage, the amount to be determined by the water commissioner of the proper district, subject to review and determination by the court having jurisdiction over priorities in such districts.

SEC. 14. Whenever any person or persons, association or corporation, interested as owners of any ditch, canal, or reservoir in any district, shall desire a determination of the priorities of rights to the use of water from any stream or streams from which they draw the water for their ditch or ditches, canals or reservoirs, they shall present to the district court having jurisdiction over the rights in such water district, or to the judge thereof, a petition or application in writing, moving or praying said court to proceed to an adjudication of the priorities of rights to use of the water for irrigation, between the several ditches, canals, or reservoirs, in such district, on the stream or streams named in such motion, petition, or application. The said motion, petition, or application shall state the names of the ditches, canals, or reservoirs claiming water from said stream or streams as appears from the final statements in the recorder's office, together with the names of the persons, associations, or corporations interested therein, taken from said statements, and shall set forth the nature of the claim or claims of the applicant or applicants, and such motion, petition, or application shall be entitled "In the matter of an application for an adjudication of the priorities of rights to use water for beneficial purposes in water districts. District No. ——, on ——" (stating the stream or streams). Upon the filing and docketing of such application, the court or judge thereof shall, without unnecessary delay, by an order to be entered of record upon such petition or application, appoint a day for commencing to hear and take evidence in such adjudication, at which time it shall be the duty of the court or judge thereof to proceed and hear all evidence that may be offered by or in behalf of any person, association, or corporation interested in stream or streams in such district, in any ditch, canal or reservoir, either as owner or consumer of water therefrom, in support of or against any claims of priority of appropriation of water made by means of any ditch, canal, or reservoir, or by any enlargement or extension thereof in such district, or on such stream or streams, and consider all such evidence, also the arguments of the parties or their counsel, and shall ascertain and find from such evidence, as near as may be, the date of the commencement of such ditch, canal, or reservoir, together with the original size and carrying capacity thereof as orginally constructed; the time of the commencement of each enlargement or extension thereof, if any, with the increased capacity thereby occasioned; the time spent severally in such construction, enlargement, or extension, and re-enlargement, if any; the diligence with which the work was in each case prosecuted; the nature of the work as to the difficulty of construction, and all such other facts as may tend to show the compliance with the law in acquiring the priority of right claimed for each such ditch, canal, or reservoir, and determine the matters put in evidence, and make and cause to be entered a decree determining and establishing the several priorities of right, by appropriation of water of the several ditches, canals, and reservoirs in such water district in such stream or streams, concerning which testimony shall have been offered, each according to the time of its said construction and enlargements and extensions, with the amount of water which shall be held to have been appropriated by such construction and enlargement or extensions, describing such amount by cubic feet per second of time (which shall also be the measurement for the sale of water), if the evidence shall show sufficient data to ascertain such cubic feet, and if not, by width, depth, and grade, and such other description as will most certainly and conveniently show the amount of water intended as the capacity of such ditch, canal, or reservoir. In such decree such court or judge thereof shall receive from the clerk, on payment therefor, a certificate, under seal of the court, showing date or dates and amount or amounts of appropriations adjudged in favor of such ditch, canal, or reservoir, under and by virtue of the construction, extension, and enlargement thereof severally, also specifying the number of said ditch, as determined by said court, with reference to priority and of each priority to which the same may be entitled by reason of said construction, extension, and enlargements; provided, that any party or parties claiming any right to the use of water for beneficial purposes in such district and on such stream or streams by reason of being owner of or interested in any ditch, canal, or reservoir, who is not mentioned in the petition or application, and shall become parties to such proceedings and shall have their rights adjudicated therein. The court, or judge thereof, may, instead of taking the testimony orally or in open court, refer the matter to a referee, with such powers as in other cases. The testimony may be taken at any place ordered by the court, or judge thereof, or by the referee.

SEC. 15. The holder of the certificate provided for in section fourteen, shall exhibit the same to the water commissioner of the district when he commences the exercise of his duties, and such water commissioner shall keep a book in which he shall enter a brief statement of the contents of such certificate and which shall be delivered to his successor, and said certificate, or statement thereof in his book, shall be the warrant of authority to said commissioner for regulating the flow of water in relation to such ditch, canal, or reservoir; said certificate shall be recorded at the same rates of charges as in case of deeds of conveyance in the records of each county into which the ditch, canal, or reservoir, to which such certificate relates, shall extend; and said certificate, or said record thereof, or a duly certified copy of such record, shall be prima facie evidence of so much of the decree as shall be recited therein in any suit or proceeding in which the same may be relevant.

SEC. 16. Upon the order of the court fixing the time of such hearing being made, the clerk shall make a certified copy of such order, which order shall contain the names of all parties alleged in the application to be interested in the matter, which shall be thereupon served upon each of the parties therein named, in the same manner as summons. It shall be the duty of the clerk also to give public notice of such application in a newspaper, if any printed and in circulation, in each county wherein such water district is situated, which shall be published at least twenty days, and which said notice shall contain the date of the filing of said petition or application, the name or names of the parties filing the same, a copy of the order made by the court of hearing, and shall notify all parties interested as owners in any ditch, canal, or reservoir, on such stream or streams, in such water district, as well as the persons named in the petition or application, to appear at said court, or before the judge thereof, at the time appointed and stated in the order; and all persons interested as owners or consumers may then and there present his or her or their proofs for or against any priority of right of water by appropriation sought to be shown by any party, by or through any ditch, canal, or reservoir (either as owner or consumer of water therefrom), and in case any party mentioned in the petition or application can not be personally served in any county embraced in such water district, the published notices above provided shall be deemed sufficient service of notice: *Provided further*, That in addition to such publication the clerk shall mail such published notice to each party mentioned in the petition or application, directing the same to the address of the parties, as stated in the sworn statement on file. Proof of the proper publication shall consist in the sworn certificate of the publisher of the paper in which notice is published, to which shall be attached a printed copy taken from such paper.

SEC. 17. Any person or persons who shall willfully cut, dig, or break down or open any gate, bank, or embankment or side of any ditch, canal, or reservoir, flume, pipe, tunnel, or feeder in which such person or persons may be joint owners or which is the property of another or in the lawful possession of another or others and used for the purpose of irrigation, milling, manufacturing, mining, or domestic purposes, with intent maliciously to injure any person, association, or corporation, or for his or her own gain or with the intention of stealing, taking, or causing to run or pour out of such canal or reservoir, feeder, pipe, or flume any water for his or her own profit, benefit, or advantage, or to the injury of any other person, persons, association, or corporation lawfully in the use of such water or of such ditch, canal, tunnel, feeder, pipe, or flume, he, she, it, or they so offending shall be deemed guilty of a misdemeanor and on conviction thereof shall be fined in any sum not exceeding $500, and may be imprisoned in the county jail not exceeding six months, or both, at the discretion of the court.

SEC. 18. Any party or parties representing any ditch, canal, or reservoir, or any number of parties representing two or more ditches, canals, or reservoirs which are affected, in common with each other, by any portion of the decree rendered by the district court, by which he, she, it, or they may feel aggrieved, may have an appeal from said district court to the supreme court, and in such case the party or parties joining desiring an appeal shall be the appellants, and the parties representing any one or more ditches, canals, or reservoirs affected in common adversely to the interest of appellants shall be appellees. The party or parties in such appeal shall, within sixty days after the date of the decree is entered under this act, file a notice of appeal in writing stating that such party or parties appeal to the supreme court of the State from the decree rendered in the case or any part thereof. When only a part of the decree is appealed from, the notice of the appeal shall so state and shall also in that case specify the portion or part of the decree appealed from. Upon filing of such notice of appeal the cause shall be deemed to be appealed to the supreme court of the State: *Provided, however*, That the party or parties appealing as aforesaid shall, within sixty days as aforesaid, enter into an understanding to be approved by the district court, or judge thereof, and to be given to all parties in said suit or proceedings other than the parties appealing, and to be in such an amount as the court or said judge shall order, conditioned that the parties giving the said undertaking shall prosecute their appeal to effect and without unnecessary delay, and will pay all costs and damages which the parties to whom the undertaking is given, or either or any of them, may sustain in consequence of such appeal.

SEC. 19. The notice last aforesaid shall be entered of record, and the appellant or appellants shall cause a certified copy thereof to be served on each of the parties or their attorneys, if they have one, as in other cases.

SEC. 20. The appellant or appellants shall, within six months after the appeal be allowed as aforesaid, file in the office of the clerk of the supreme court of the State a certified transcript of the proceedings had in the case in the district court, containing the pleadings and the statements of the parties filed therein and all evidence of record offered on the hearing of the cause, or so much thereof as shall affect the appropriation of water claimed by the means of construction, enlargement, or re-enlargement of the several ditches, canals, and reservoirs mentioned in the order allowing the appeal; such statement to be served, filed, and settled in the same manner as statements on motion for new trials.

SEC. 21. The supreme court in all cases heard before it under this act shall, when it can properly be done, render such decree as the court or judge below should have rendered. It may either reverse or modify the decree of the court below. If reversed in whole or in part it may direct the court below as to its further proceedings therein.

SEC. 22. No claim of priority of any person, association, or corporation, on account of any ditch, canal, or reservoir, as to which he, she, it, or they have filed or refuse to offer evidence under any adjudication herein provided for, shall be regarded by any water commissioner in distributing water in times of scarcity thereof, until such time as such party shall have, by application to the court having jurisdiction, obtained leave therefor and made proof of the priority of right to which such ditch, canal, or reservoir shall be justly entitled, which shall only be granted upon terms as to notice to other parties interested, and upon payment of all costs, and upon affidavit or petition, sworn to, showing the rights claimed, and the ditches, canals, and reservoirs, with the names of the owners thereof, against which such priority is claimed, nor until a decree adjudging such ditch, canal, or reservoir has been entered, and certificate, such as mentioned in section fifteen thereof, shall have been issued to claimant and presented to the water commissioner.

SEC. 23. No person, association, or corporation representing any ditch, canal, or reservoir shall be permitted to give or offer any evidence before said court until he, she, it, or they shall have filed a statement of a claim, in substance the same in all respects as is required to be filed under the provisions thereof.

SEC. 24. The district court or judge thereof shall have power to order, for good cause shown, upon terms just to all parties, and in such manner as may seem meet, a re-argument or review, with or without additional evidence, of any decree made under the provisions of this act, whenever said court or judge shall find from the cause shown for that purpose by any party or parties feeling aggrieved, that the ends of justice will thereby be promoted, but no such review or re-argument shall be ordered unless applied for by petition or otherwise within one year of the time of entering the decree complained of.

SEC. 25. Persons desiring to construct and maintain reservoirs for the purpose of storing water shall have the right to take from any of the natural streams of the State and store away any unappropriated water not needed for immediate use, for domestic, irrigation, or other needful purposes; to construct and maintain ditches, canals, flumes, and tunnels in the same manner provided by law for the condemnation of lands for right of way for ditches, provided no reservoir with embankment or a dam exceeding 10 feet in height shall be made without submitting the plans thereof to the county commissioners of the county in which it is situated and obtain their approval of said plans.

SEC. 26. The owners of reservoirs shall be liable for all damages arising from leakage or overflow of the waters therefrom, or by floods caused by the breaking of the embankment of such reservoir.

SEC. 27. Every witness who shall attend before the court or judge thereof, or before the person appointed to take testimony, in the causes provided for in this act, under subpœna by request of any party, shall be entitled to the same fees and mileage as witnesses in civil cases in the district court, and shall be paid by the party requiring his testimony. All other costs of the proceeding shall be paid by the parties claiming water, as may be adjudged by the court or judge.

SEC. 28. Whenever, in actions for proceedings, for the determination of water rights, it may become necessary to divide the water of any stream or ditch between the different claimants, it shall be divided, as far as possible, by periods of time, instead of fractional parts of the water.

SEC. 29. Said water commissioners shall so divide, regulate, and control the use of the water of all streams within their respective districts in such manner, as near as may be, as will prevent unnecessary waste of water; and to that end such commissioners shall so shut and fasten the head-gate or gates of all ditches so that no more water will flow into said ditch than is actually required and will be used for the purpose or purposes for which such water was appropriated; and any person may resort to any court of competent jurisdiction for such relief as he may be entitled to.

SEC. 30. Whenever testimony shall or may be taken in any district created by this act for the purpose of procuring decree as to appropriation of water and priorities thereof, any testimony theretofore taken upon the hearing of any former application or petition under this act may be introduced and shall be received as evidence.

SEC. 31. This act shall in nowise be construed as impairing or abridging any rights already vested in any person or persons, company or corporation, by virtue of the law heretofore in force.

SEC. 32. All acts and parts of acts inconsistent with this act are hereby repealed.

SEC. 33. This act shall take effect and be in force from and after its passage.

No. X. Assembly joint memorial and resolution relative to encouraging the sinking of artesian wells, and the assistance, by other means of irrigation, for the arid lands situated within the State of Nevada.

To the honorable the Senate and House of Representatives of the United States in Congress assembled:

Your memorialists, the legislature of the State of Nevada, respectfully represent, that—

Whereas the said State of Nevada did, upon its admission to the Union, receive and acquire five hundred thousand (500,000) acres of land for purposes of internal improvements, under the act of Congress approved September fourth, one thousand eight hundred and forty-one; and

Whereas the said State of Nevada did, upon the adoption of its constitution, pledge and dedicate and transfer the land covered by said grant, and all proceeds therefrom, to the school fund of said State and for school purposes inviolably and forever; and

Whereas by act of Congress approved July fourth, one thousand eight hundred and sixty-six, the said appropriation by the constitution of the State of Nevada to educational purposes of the said lands so granted for internal improvements was approved and confirmed; and

Whereas at the time of said transfer, appropriation, and dedication, as aforesaid, the agricultural interests of the State of Nevada, together with the possibilities of production of its soil, were entirely misunderstood or not understood at all, owing to the prominence then claimed for and given to its great mining industry; and

Whereas the events of later years have conclusively shown that a large percentage of the neglected public lands within the said State are susceptible of a high state of cultivation where irrigation can be had, and will return large and profitable crops of great variety; and

Whereas there now remains of the public lands within said State, including those heretofore granted and pledged for educational purposes, about five hundred thousand acres, which are partially unsalable from the fact that the labor and expense necessary to join water with said land is above and beyond individual effort; and

Whereas the said State of Nevada has now, by existing law, done its utmost to encourage and further the good purposes of this memorial and resolution; and

Whereas such aid as your memorialists pray for will add largely to the income of said school fund of said State, to the proceeds derived by the national Government from sale of lands within its borders, and will add taxable property for all purposes, as well as materially increase the population of said State; and

Whereas by recent enactment and appropriation for hydrographic surveys the Congress of the United States has recognized the necessity of reclaiming lands of the character described within the arid regions, of which this State forms a part, and the fact being that any expenditure within this State for internal improvements could only be made profitably for the purposes herein written; and

Whereas, in so far as it may be proper for us so to do, we pledge the State of Nevada to aid and encourage the reclamation or sale of said lands to the limits of its capacity: Therefore,

Resolved by the assembly, the senate concurring, That we earnestly petition the Congress of the United States to make such appropriations as it may deem proper to the State of Nevada, and to all other States and Territories where the conditions of soil, climate, and rain-fall are similar to those found within said State; or that the Congress of the United States do make to this State, as well as to other States and Territories in like condition and situation, a grant of a sufficient portion of the public lands as yet unappropriated and within said State or Territory, which said grant and land, and all proceeds therefrom, shall be by said State or Territory held and used solely and entirely for the uses and purposes hereinabove written, viz: To encourage the sinking of artesian wells upon public lands, in assisting settlers in good faith to conduct waters now running to waste to and upon portions of said land.

Resolved, That we earnestly urge upon Congress immediate consideration of this memorial.

Resolved, That the governor be requested to forward a certified copy hereof to our Representative in Congress and each United States Senator from the State of Nevada, with the request that they use all honorable means to secure an early and favorable consideration therefor.

Passed February 6, 1889.

AN ACT defining and prohibiting the unlawful diversion and waste of water.

The people of the State of Nevada, represented in senate and assembly, do enact as follows:

SECTION 1. Any person or persons who shall, during the irrigating season, divert and conduct the water, or portion thereof, of any river, creek or stream into any slough or sloughs, dam or dams, pond or ponds, and retain, or cause the same to be held or retained therein without making any other use of such water, or who shall, during the irrigating season, divert and conduct the water, or portion thereof, away from any such river, creek or stream, and run, or cause or allow the same to run to waste on sage-brush or greasewood land, such diversion shall be deemed an unlawful use and waste of water.

SEC. 2. Any person or persons, company, corporation or association who shall, during the irrigating season, divert and conduct, or any person or persons aiding, abetting or assisting any such person or persons, company, corporation or association in diverting and conducting, during the irrigating season, the water, or portion thereof, of any river, creek or stream into any slough or sloughs, dam or dams, or pond or ponds, and retain, or cause the same to be retained therein without making any other use of such water, or who shall, during the irrigating season, divert and conduct the water, or portion thereof, away from any river, creek or stream, and run, or cause or allow the same to run to waste, contrary to and in violation of the provisions of this act, shall be guilty of a misdemeanor, and upon conviction thereof, in any court of competent jurisdiction in this State, shall be punished by a fine not exceeding five hundred dollars or by imprisonment in the county jail of the county not exceeding six months, or by both such fine and imprisonment.

Approved February 28, 1889.

CHAP. CXII.—AN ACT to provide for the storage of water, to encourage milling, mining, and internal improvements, and to reclaim the arable desert lands and develop the agricultural resources of the State of Nevada, and to provide funds for the payment of the same.

Whereas the State of Nevada has received from the General Government a grant of two million acres of land in lieu of the sixteenth and thirty-sixth sections, previously granted to the State of Nevada, the proceeds from the sale of which are to be placed to the credit of the school fund of the State; and

Whereas under an act of Congress approved September 4, 1841, and an act approved March 21, 1864, a grant of 500,000 acres of land was made to the State of Nevada for internal improvements; and

Whereas the selection of said lands are not confined to any particular section of unappropriated land; and

Whereas the greater portion of unappropriated lands in the State of Nevada is known to be desert, waste, and actually valueless and without sale, unless water, for the purpose of irrigation, can be brought upon them, and the land properly and systematically irrigated, crops of all kinds can not be successfully raised; and

Whereas the permanent settlement, growth, wealth, and independence of the State and people, as well as the sale of school lands, depend upon the reclamation of these desert lands: Now, therefore,

The people of the State of Nevada, represented in senate and assembly, do enact as follows:

SECTION 1. A board of reclamation commissioners is hereby created, to consist of four members, to be known as the "board of reclamation and internal improvements," for the storage of water and reclamation of arable desert lands in this State. Said board to consist of J. F. Clark, of Humboldt County, Evan Williams, of Ormsby County; J. R. Bradley, of Elko County, and Herman Springmeyer, of Douglas County. The said J. F. Clark, of Humboldt County, and Evan Williams, of Ormsby County, to hold the position for the term of four years, or until the election of their successors, and the said J. R. Bradley, of Elko County, and Herman Springmeyer, of Douglas County, to hold the position for the term of two years, or until the election of their successors. The State of Nevada is hereby divided into seven internal improvement and reclamation districts, of which Douglas, Ormsby, Esmeralda, Lyon, and Storey, shall constitute the first district, Washoe County, the second district, Churchill County, the third district, Humboldt County, the fourth district, Elko County, the fifth district, Lander, Eureka, and White Pine Counties the sixth district, and Nye and Lincoln Counties the seventh district. At the general election in eighteen hundred and ninety, and at each general election thereafter, there shall be elected from the State at large two reclamation commissioners, one who shall serve for the term of two years, and one for the term of four years, from and after the first Monday in January next succeeding such election.

The office of said board shall be in the State capitol building, at the seat of government. The board shall adopt rules and regulations for the transaction of its business.

SEC. 2. The board of reclamation shall invite, receive, and procure information and statistics in regard to all public lands within this State, and the waters running therein, which are or may become possible of reclamation, by means of conducting upon them the unappropriated waters running through natural or artificial channels within this State, and shall report the same, together with an approximate estimate of costs and result of such proposed reclamation, at each biennial session of the legislature.

SEC. 3. The board of reclamation shall also invite, receive, procure, and publish facts and statistics regarding the natural water-courses of this State and several districts, including source, supply, water power, and other matters relating to the value of said waters, or the most practical methods of utilizing the same, either for milling, mining, manufacturing, or agricultural purposes, in order that said information may be offered for the attraction of dormant capital and the encouragement of individual enterprise.

SEC. 4. It shall be the duty of the surveyor-general, *ex officio*, to furnish the board of reclamation, within a reasonable time, maps, profiles, and estimates to determine the cheapest and most economical and valuable routes for canals, reservoirs, and other improvements for irrigation and milling purposes; and also to furnish maps, plans, and estimates for the purpose of building reservoirs, dams, etc., connected with the storing and preserving of waste water.

SEC. 5. The board of reclamation shall have the power to divide the State into districts, and to appoint a superintendent for each reclamation district within the State, which they may establish and define, whose duty it shall be to superintend the building, constructing, and maintenance of the canals, dams, and other like works within his district as so defined.

SEC. 6. The work of building and constructing any and all canals, dams, and other improvements shall be done by contract, if done by private parties the contracts to be let to the lowest responsible bidder. The work done by contract shall be let in lots of one or more sections, said sections not being more than one mile in length, as indicated by the maps, profiles, plans, and specifications prepared by the surveyor-general and adopted by said board.

SEC. 7. The board of reclamation commissioners of the State are hereby authorized and directed to employ a competent civil engineer to ascertain and report the number of irrigating ditches in each reclamation district, the capacity of the same in inches, and amount heretofore appropriated and used through said ditches.

SEC. 8. Any irrigating ditch now constructed and hereafter carrying more water than reported by said civil engineer, the owner or owners thereof of said ditch shall pay to the reclamation fund of the State, for such additional water, such sums or rates as the board of reclamation commissioners shall designate; which sum so paid shall constitute a part of the reclamation fund, and shall be available for demands against said fund.

SEC. 9. Whenever the board of reclamation commissioners deem the reorganization or division of any district advisable for internal improvements contemplated by this act, they shall have power to make such changes and establish such additional rules for the government thereof as will not conflict with prior rights as now recognized by law.

SEC. 10. The board shall have power to purchase or rent such lands for reservoirs, sites, or ditches as they may deem best, whether within or without the boundaries of this State.

SEC. 11. The board of reclamation commissioners, on petition of ten or more persons interested in irrigation ditches in any district in this State petitioning for the issuance of bonds of said district for reclamation purposes, said board shall, at the next general election, submit the question, together with amount of bonds to be issued, to the voters of said district; and, if carried at said election, the said board shall issue and dispose of said bonds under such rules and regulations as they may adopt, the proceeds thereof to be placed in the reclamation fund of the district, and made available for reclamation purposes.

SEC. 12. The board shall advertise for and receive bids upon the work to be done as soon as the surveyor-general can have surveys, maps, plans, specifications, and estimates of the same in readiness for adoption by the board and inspection by bidders, and shall fix a time when they will open bids and award contracts, which shall not be done on less than four weeks' notice thereof, which said notice shall be given for said time by publication in one newspaper in the reclamation district where the work is to be done, or by posting notices.

SEC. 13. The terms of contracting may be to pay monthly, as the work progresses, on the estimate of the surveyor-general or engineer of the amount of work done, seventy per centum of its contract value, reserving to the district or State thirty per centum of the value thereof to insure its faithful completion according to contract, when full payment shall be made, including the retained per centum.

SEC. 14. The board shall fix a definite day for the final completion of any canal, dam, or other improvement, and require all contracts to be done and completed on or before that day, and shall in any agreement reserve the right of forfeiture to the State or district of any retained per centum, and to award the contract of any person or persons who, in the opinion of the surveyor-general, confirmed by the board, fails to make such monthly progress as will insure the completion of any such work so undertaken or contracted for on the day named.

SEC. 15. The board of reclamation shall, upon organization as herein provided, be authorized, empowered, and directed to construct a canal, ditch, or other proper work at, from, or upon the most desirable and practical point on any river or water-way in the State, or that can be procured—the said point to be hereafter selected by said board—to connect with, and to be connected with, for the purpose of milling or irrigating the arable lands situate, lying, and being in the accessible vicinity of such selected river or water-way; and the said canal, ditch, or other work shall be built or established upon a grade or plan in accordance with the configuration and necessities of the shortest and most feasible route and safe carriage of the requisite volume of water required to irrigate the lands within the scope of said ditch or work.

SEC. 16. The total cost of said canal, ditch, or work shall not exceed one hundred thousand dollars, and the cost thereof is hereby limited to that sum.

SEC. 17. The board of reclamation shall audit and certify to the State board of examiners the several amounts that may become due from time to time for work and labor done, services or material furnished in and about the location and building of canals and other works of reclamation that may be carried on, built, and completed under the board, and when approved by the State board of examiners, the controller shall audit the same and draw his warrant upon the State treasurer for the several amounts of such claims, to be paid out of the reclamation fund of the State or district.

SEC. 18. The elective members of the board shall be paid their necessary traveling expenses, and they shall receive no other compensation for their personal services.

SEC. 19. It shall be unlawful for any State officer, or any member of the board of reclamation, to be interested, directly or indirectly, or to take or have any interest or profit, in any manner, in any work of constructing any canal or other improvement for reclamation under this act, and upon conviction shall be fined in any sum not less than one thousand dollars nor more than ten thousand dollars, or imprisonment in the State prison not less than one year nor more than five years, or both such fine and imprisonment.

SEC. 20. The annual rent for water within the scope of any canal, ditch, or work created and built by the board of reclamation shall be one dollar per acre per year. Said rental of water shall be held as a lien against said lands.

SEC. 21. The annual rent of water shall be collected in the same manner and by the same officers as taxes are now collected, and paid into the State or district treasury without fee or abatement and accounted for as the water rent, and placed to the credit of the reclamation and internal improvement fund; and it is hereby enacted that all lands sold by the State under the provisions of this act shall be supplied with the necessary water for reclamation whenever in the judgment of the board it is practicable to do so, and the right of way for the secondary ditches is hereby reserved by the State, and shall be reserved and excepted by the surveyor-general and State land register, from every patent issued by the State, to take up, convey, and deliver all waste water over and across any lands sold and conveyed by the State to any person or persons.

SEC. 22. One hundred thousand dollars is hereby appropriated for the construction and building of any canal, ditch, dam, or other work or works mentioned in this act, and in no case shall a contract or contracts be entered into that shall in the aggregate exceed the sum of one hundred thousand dollars for the construction and building of said canal or work.

SEC. 23. The money herein appropriated shall be taken from the State school fund and placed to the credit of the reclamation fund, herein credited, and in its place shall be deposited one hundred bonds of one thousand dollars each, bearing interest at the rate of four per cent. per annum. Said bonds shall run for twenty years, but shall be redeemable by the State at its pleasure after two years. Said bonds shall be signed by the governor and State controller, and countersigned by the State treasurer, and authenticated with the great seal of the State, and shall state in substance that the State of Nevada owes to its school fund one thousand dollars, the interest on which sum, at four per cent. per annum, it agrees to pay until said bond is redeemed for the benefit of the common schools of the State. Said bonds shall be lithographed, as is usual in such cases, and deposited with the treasurer of the State. The interest on said bonds shall be paid semi-annually, on the first day of January and July, on the written order of the State board of education to the State controller, directing him to draw his warrant for the amount of such semi-annual interest on the reclamation interest and sinking fund herein created.

All sums derived from the interest on said bonds shall go into the general school fund for the support of the common schools of the State, and for the regular and prompt payment of which the faith and credit of the State is hereby pledged.

SEC. 24. There shall be levied and collected for the fiscal year commencing January first, A. D. eighteen hundred and ninety-one, and annually thereafter, an ad valorem tax of two cents on each one hundred dollars of all the taxable property in the State, and all sums derived from this tax shall go into the reclamation interest and sinking fund for the payment of the interest and redemption of bonds herein authorized by this act.

SEC. 25. The reclamation fund is hereby made a permanent fund, into which all revenue arising from the last-mentioned section, and from the water rent aforesaid, in section fifteen, and from any other source provided by law, shall be paid and shall be devoted as follows: First, to the payment of interest on bonds; second, to the redemption of the principal sum of the bonds at or before maturity; third, to the reclamation of new districts that may be hereafter created; fourth, to be transferred to the general fund of the State.

Approved March 3, 1889.

CHAP. LXXXVII.—AN ACT to amend an act entitled "An act to encourage the sinking of artesian wells," approved March 5, 1887.

The people of the State of Nevada, represented in senate and assembly, do enact as follows:

SECTION 1. Section one of said act is hereby amended so as to read as follows:

Section one. Every person, firm, company, corporation, or association, that shall, after the passage of this act, commence the sinking of artesian wells, for stock or agricultural purposes, shall be entitled for sinking such artesian well, where flowing water is obtained, the following specified sums: For the first two hundred feet, one dollar and twenty-five cents per foot; for the third one hundred feet, one dollar and fifty cents per foot; for the fourth one hundred feet, two dollars per foot; for the fifth one hundred feet, two dollars and twenty-five cents per foot; for the sixth one hundred feet, two dollars and fifty cents per foot; for the seventh one hundred feet, three dollars per foot; for the eighth one hundred feet, three dollars and fifty cents per foot; for the ninth one hundred feet, four dollars per foot; for the tenth one hundred feet, four dollars and fifty cents per foot; for all depths exceeding one thousand feet, five dollars per foot for each and every foot below the said one thousand feet. And an additional bounty of one thousand dollars for every well sunk to the depth of one thousand feet or more: *Provided*, That such well shall furnish twenty thousand gallons of water each twenty-four hours, flowing continuously for thirty days, said sums to be paid in the manner provided for in sections four and five of this act: *Provided*, That no bounty shall be paid on any well which does not furnish seven thousand gallons of water in each twenty-four hours, flowing continuously for thirty days: *And provided further*, That no two wells shall receive a bounty if located within the same county. Where two or more wells within the prescribed limit apply for a bounty, the well which first furnished the amount of water required by this act shall be entitled to the bounty allowed by this act.

SEC. 2. Section six of said act is hereby amended so as to read as follows:

Section six. The sum of ten thousand dollars is hereby appropriated out of any money in the general fund of this State for the payment of bounties herein provided for.

Approved March 7, 1889.

SESSIONS OF THE COMMITTEE.

Page.
Salt Lake City, Utah, August 19, 1889 5
August 20, 1889 55
Carson City, Nev., August 22, 1889 129
San Francisco, Cal., August 26, 1889 189
Tulare, Cal., August 30, 1889 273
Bakersfield, Cal., August 31, 1889 288
Los Angeles, Cal., September 1, 1889 317
On train near San Bernardino, Cal., September 2, 1889 336
at Riverside, September 2, 1889 339
Riverside, Cal., September 2, 1889 341
Santa Ana, Cal., September 2, 1889 350
San Diego, Cal., September 3, 1889 354
Yuma, Ariz., September 4, 1889 400
Phœnix, Ariz., September 5, 1889 442
on train, Arizona, September 5, 1889 449
Tucson, Ariz., September 5, 1889 450

INDEX.

A.

Page.

- Agricultural College, Utah ... 24
- Alkali in water, influence on soil ... 237, 239
- Ancient inhabitants, references to ... 158, 458, 504, 505
- Apache County, Ariz., irrigation in ... 443
- Altitudes, in arid region:
  - Ashley Valley, Utah ... 68
  - Dragoon Summit, Ariz ... 407
  - Higher plateau, Arizona, of ... 408, 432
  - Julian, Cal., at ... 386
  - Mesa Grande, Cal., at ... 386
  - Mountains of California, the ... 355
  - Nevada, plateau of ... 130
  - Pahranagat Valley, Nevada, in ... 140
  - Redding, Cal., at ... 190
  - Sacramento, Cal., at ... 190
  - San Diego, Cal., at ... 390
  - Sierras Nevada, the ... 191, 299
  - Silver Lake, Utah, at ... 37
  - Utah Valley, in ... 68
  - Walker Ranch, Nevada, at ... 173
  - Water-shed in high ... 193
- Annual assessment for irrigation in Utah ... 97, 100, 101, 102, 103, 104
- Arid lands, special references to ... 5, 24, 42, 49, 63, 64, 69, 77, 92, 143, 234, 237, 443
  - Cultivated by irrigation ... 292
  - Nevada, report on ... 164
  - Powell, John W., on ... 43, 203
  - Public domain, arid portions of ... 436, 437, 438
- Arizona, mention of ... 31, 33, 72, 235, 382, 400, 407, 408, 412, 415, 421, 427, 433, 436, 439, 445, 451, 457, 458, 463, 465, 470, 472, 473, 474, 476, 477, 480, 483, 484, 486, 488, 490
- Arizona, canals and ditches in, names of:
  - Adamsville, at ... 455
  - Alamo Amarilla, at ... 455
  - Arizona, the ... 424, 445
  - Bates, the ... 455
  - Brady, the ... 455
  - Brash, at ... 455
  - Brennaman & Co., the ... 455
  - Brown's ... 455
  - Cook's ... 455
  - Colorado, on the ... 413
  - Dodson's ... 455
  - Florence, at ... 455
  - Gila, on the ... 432
  - Gila Bend Canal Company, the ... 432
  - Great Colorado, the ... 412, 413
  - Harrington's ... 455
  - Highland, at ... 445
  - Lattin's ... 455
  - McClellan's, at ... 455
  - Monarch, the ... 432
  - Montezuma, the ... 455
  - Moore's, at ... 455
  - Pat Holland's ... 455

Page.

Arizona, canals and ditches in, names of—Continued.
- Pusch, at 455
- Salt River Valley, in 431
- Sharp's, at 455
- Shield's, at 455
- Stiles, at 455
- Swingles, at 455
- Swiss, the 455
- Walker & Dempsey's 455
- Waterman No. 1 455
- Waterman No. 2 455
- Winkleman, at 455
- Yuma County, in 414

Artesian water and wells, references to 38, 66, 67, 69, 70, 71, 75, 93, 116, 118, 138, 196, 231, 232, 237, 283, 284, 322, 333, 344, 349, 358, 391, 393, 415, 425, 479
- Basins of 75, 166, 232, 346
- Belts of 170, 299, 343
- Boring of, the 170, 196, 232, 236
- Dakota, supply of, in 76
- Débris of, the 208
- Deep, their character 71, 305
- Depth of 30, 315
  - average, the 69, 170
  - Carson River, on 171
  - Salt Lake Valley, in 73
- Deposits of 166
- Drainage of, the 208, 235
- Driving of 40, 73, 391, 393
- El Paso, Tex., at 270
- Exhausting supply of 76
- Flowing 29, 30, 73, 75, 170, 270, 322, 29, 30
- Indian, at 332
- In Nevada 134, 166, 170
- Irrigation by means of 57, 67
- Larnark, Colo., at 270
- Millard County, Utah, at 73
- Montague, Cal., at 270
- Paris, Cal., at 392
- Pressure of 504
- Reservoir, made by 76
- Rim of basin, the 75
- Rock foundations for 76
- Rosser, Nev., at, description of 171
- Siete Posos, in Cal. (seven wells) 376
- Size of, in Nevada 170
- Storage of water, by 242
- Supply of, by 75-284
  - in Colorado 76
- System of 78, 133, 134, 139, 238
- Tabular statement of 393
- Utah, in 41, 57-72, 75-76, 117
- Utah in, capacity of 29, 30
- Water, value of 70, 235, 237, 238. 241, 305, 350, 387
- White Plains, at 269

B.

Basins, relating to:
- Baja California 376
- Acres in 56
- Big Cottonwood, at 37
- Carson, near 499, 501
- Catchment, the 455
- Colorado, in 376, 377, 378, 381
- Drainage of Salt Lake, at 41, 42
  - of Sevier Lake, at 42
  - of California, in 419
- Draining into the Colorado 55
- Fertile, when 58
- Great areas of 42-67, 70, 105

Page.

Basins, relating to—Continued. 34
- High mountains, among 498
- Lattontan, the 58
- Little, in high mountains 87
- Natural, Pauquitch Lake, at 55
- Brim of, the 42
- Sevier Lake, at 169
- Storage in 498, 499, 501
- Truckee of 419
- Total area of Cottonwood Flat 446
- Tonto, The 60
- Upper Sevier Lake, in 41
- Utah, in 499
- Washoe County, in 359, 360, 370

Bay of San Diego

C.

California, irrigation ditches in: 303
- Anderson's, at 301
- Ash, the 221, 223
- Basin group, a 298, 300
- Beardsley, the 396
- Buaga, the 303
- Buena Vista, the 396
- Busca, the 223
- Canada, the subgroup of 224
- Calimuga Ballona group of 298, 301, 309, 310, 314, 315, 316, 397
- Calloway, the 302, 303
- Castro, the 220
- Chochilla River, from 302
- Cotton Ranch, at 222
- Cucamonga Plains group, the 218
- Deer Creek, on 301, 302
- Dixon's, at 301
- Edwards, the 301
- Emery, the 302, 303
- Farmers, the 303
- Frazer, the 220, 227, 273
- Fresno, the 303
- Gates, the 301
- Goose Lake, at 303
- Henley, the 301, 303
- James, the 301
- Johnson, the 302
- Joice, the 301
- Jones, the 221, 222
- Jumpa Plains and valley subgroup, the 219, 277
- Kaweah River, from 299, 304
- Kern County, system of 302, 303
- Kern Island, on 218
- Kern Valley Water Company, the West Side 219, 277, 280
- Kings River, from 277, 280
- Lakeside, at 224
- Los Angeles group, the 224
- Lower San Gabriel group, the 224
- Lower Santa Ana River group 221
- Lytle Creek Springs and Town Springs subgroup, the 301, 302
- May, the 301
- McCaffery, the 298, 300
- McCord, the 303
- Meacham, the 220
- Mercer River, from 479, 480
- Miles of 220
- Mokelumne River, on 396
- Mora, the 233
- Moor, the 277
- Mussell Slough, the 220
- North Cañons, group and names

Page.

- California, irrigation ditches in—Continued.
  - Old River, the 220
  - Open Cement, in 322
  - Old South Fork, the 302
  - Panama, the 302
  - People, the 277, 280
  - Pioneer, the 301, 314
  - Pomona group, the 222
  - Poso Creek, the 218
  - Pottinger, the 301
  - Plunkett, the 303
  - Railroad, the 301
  - Rincon group, the 222
  - Riverside, at 216, 217
    - Mesa groups, the 221
    - Water company, the 342
  - Santiago Creek group, the 224
  - San Bernardino Valley, in 222
  - San Diego and San Diequito Rivers, the 220
  - San Fernando Valley group, the 223
  - San Gabriel River subgroup, the 223
  - San Jaciento River group, the 221
  - San Joaquin Valley, in 218
  - San Joaquin River, from 219
  - San José subgroup, the 223
  - San Juan Capistrano group, the 224
  - San Louis Rey River group, the 220
  - San Pasquel subgroup, the 223
  - Santa Ana Cañon group, the 221
  - Santa Ana River, from 221
  - Santa Ana subgroups 221, 223
  - Santa Margarita River group, the 221
  - Settlers, the 280
  - Sierra Madre Cañons group, the 223
  - South Cañon, the 222
  - Stanislaus River, on 220
  - Stine, the 302, 303
  - Supply and names, summaries of 220
  - System of, the 349
  - Tuckey, the 301
  - Tule River, on 220
  - Tuolumne River, on 220
  - Warm Creek and City Creek subgroup, the 221
  - Wible, the 301
  - Wilson, the 303
- Canals for irrigation, and relating to 11, 25, 28, 46, 48. 56, 69, 71, 77, 79, 86, 87, 90–94, 118, 161, 265, 358
  - Acres irrigated by 16
  - Acres irrigated by, Salt Lake, at 15
  - Area under, in Utah 56
  - Built with bowlders 159
  - Cash value of stock 16
  - Claims, on 97
  - Companies, in Utah 89
  - Common law, riparian rights, under 246
  - Concrete lining for 61–211
  - Construction of 55, 78, 79, 97, 98, 99, 100, 101, 103, 239
    - Waterways as 436
    - Co-operation in 55
    - Combination of individuals, the 15
    - Private capital by 148
  - Cost of, the 15, 16, 155
    - California, in 49
    - Ditching and checking in Kern County 311
  - Largest of the ancient 159
  - List of, in Utah 79, 86, 87, 90
  - Lining ditches 159
  - Lowering ditches, at Utah Lake 61
  - Machine-plow for making 93

Page.

Canals for irrigation—Continued. 16
  Mountain sources for, the 72
  New, in Utah 59, 88, 89, 90, 99, 100, 108, 109
  Owners, names of, in Utah 108
  Owned by a corporation, when 79
  Primary owners, the 12, 49 99
  Private owners, the. 163
  Right of way reserved for 57
  Streams owned by the people of Utah 46–105
  Supply by small 27, 271, 347, 349, 458
  Systems of 53
  Waste of water in 158
  Water, Utah subdivision of 305
  Works in Kern River Valley, Colorado
Cañons in arid regions, names of 18, 29, 33, 36, 37, 38, 43, 44, 51, 52, 58, 59, 64, 116
44, 66, 64
  Bear River, on 449, 450, 451, 455, 490
  Butte, at 95
  Cheeny, at 480, 481
  Cienega, at 321
  Cottonwood, on the 65
  Creek, on the 480, 481, 482
  Davidsons, at 52
  Deep, the 89
  Deep Creek, at 151
  Dry, the 96
  Dry Creek, at 89
  East, the 42, 111
  East Fork, on 98
  Gebo, the 409, 410
  Gila, on the 95
  Head of South Eden, at 500
  Hope, the 95
  Laketown, at 89
  Line Creek, the 96
  Little Cottonwood, the 482
  Madera, at 42
  Marysvale, at 430
  Mazatzan, at 188
  McDermit, at 95
  Meecham, the 332
  Nine Mile, at 95
  North Eden, at 414, 420
  Oatman, the 119
  Ogden, at 120
  One Horse, the 188
  Oregon, in 479
  Pages, at 103
  Parleys, at 120
  Plain, on the 84
  Providence, at 39, 118
  Provo at 484
  Puerisitos at 188
  Queen River, on 332
  Red Rock, at 461, 484
  Sabino, at 270
  Sacramento, on the 485
  Salt River, on the 340
  San Antonio, at 112
  Sevier, at 113
  Soldier, the 117
  Spanish Fork, on 382
  Temescal, at 95
  Tufts, at 185
  Willow Creek, on 52
Capitalist timidity, in irrigation 19
Cattle companies, accounts of 94
  Bear River Land and Stock Company 52, 104
  Pittsburg Cattle Company 160
  Cost of raising

Page.

- Cattle companies—Continued.
  - Fattening with alfalfa 175
  - Horses, raising 316, 397
  - Sheep, raising 316, 397
  - Stock companies 27
  - Stock-men 34
  - Stock-raising, on 32, 53, 114
  - Stock-ranches 397
- Cayote holes 323, 333
- Chambers of commerce:
  - Phœnix, Ariz 431
  - San Diego, Cal 266
- Channels, for water:
  - National 63
  - Natural 107
  - St. John 287
  - Willow Creek 186
- Chloride of sodium, in water 74
- Cities, mention of and reference to:
  - Albuquerque 467
  - Brooklyn 391
  - Cairo 378
  - Carson 129, 151, 177, 178, 499, 510, 513
  - Charleston 479
  - Chicago 235
  - Fresno 215, 217, 218, 227, 228, 229, 230, 232, 239, 240, 243, 247, 266, 272, 352
  - Johnstown 362
  - Los Angeles 44, 210, 235, 242, 254, 269, 320, 321, 329, 381
  - National City 360, 370, 375, 376
  - New Orleans 146, 477
  - New York 43, 44
  - Oakland 218, 330
  - Ogden 45, 46, 64
  - Pasadena 230, 231, 266, 323, 325, 328, 381
  - Philadelphia 74
  - Phœnix 409, 422, 427, 428, 430, 431, 434, 442, 445, 448, 451, 474, 476, 485
  - Prescott 409, 427, 456, 457, 489
  - Reno 145, 148, 498, 501, 502, 503, 505, 506, 507, 508, 509
  - Riverside 231, 241, 266, 341, 344, 347, 348, 355, 390, 416, 455
  - Rome 381
  - Sacramento 251
  - Salt Lake 5, 11, 14, 15, 19, 24, 28, 35, 36, 41, 55, 66
  - Santa Ana 350, 351, 352, 353
  - Santa Cruz 459
  - San Bernandino 210, 232, 233, 241, 242, 267, 370
  - San Diego 210, 267, 354, 356, 357, 358, 376, 379, 385, 386, 390
  - San Francisco 74, 138, 189, 215, 235, 254, 269, 292, 315, 377, 378, 379, 402, 418, 471, 477, 498, 509, 510
  - Santa Fé 404
  - Stockton 214
  - Truckee 269, 498, 508
  - Tucson 425, 435, 459, 460, 462, 466, 469, 470, 476, 480, 483, 484
  - Washington 44, 71, 72, 129, 138, 293, 296, 309, 376, 406, 415
- Climate, in arid regions—
  - Average temperature, table of 52, 68–106, 234, 415, 416–451, 457, 504
  - California, table of annual temperature 204
  - Dry counties in, of Utah 66, 69
  - Foreign localities, temperature of 204
  - Hot counties, in 66, 71
  - Moist counties, in 66, 72
  - Nevada, of 139–179
  - San Diego County, of 389
- Colorado Desert, account of 243, 376–380, 381
- Cloud-bursts, their effects 43, 185
- Congress, references to 44, 47, 49, 50, 77
  - Act of 47
  - Act of, special 50
  - Government supplied 52
  - Powers of 37
- Cowboys in Utah 51

Page.

Countries, mention of foreign:
.... 379
- Africa 24
- Arabia 486
- Belgium 378
- Egypt 246, 361
- England 139, 147, 209–369. 397, 486
- France 147, 148, 241, 229, 246, 336, 361, 387, 397, 457
- India 14, 7209–229, 397, 486
- Italy 148, 317, 376, 377, 380, 381, 484
- Mexico 147, 148, 209, 282, 361, 397, 433, 457
- Spain 486
- Switzerland ....

Counties in arid region, names of, 187, 501
- Alpine 424, 427, 428, 442, 443, 444, 445
- Apache 66, 70, 77
- Beaver 64, 65, 69, 80
- Box Elder 66, 67, 84, 85
- Cache 132, 187, 499
- Churchill 425, 427, 477, 478
- Cochise 234, 248
- Colusa 23, 24, 53, 58, 66, 67, 89
- Davis 132, 187, 499
- Douglas 131, 132, 133, 154, 155, 178, 184
- Elko 66, 68, 71, 86
- Emery 87
- Escalante 134
- Esmeralda 132, 133
- Eureka 227, 235, 236, 244, 273, 274, 281, 297, 299
- Fresno 66, 69, 72, 87, 88
- Garfield 473, 474, 476
- Gila 408, 424, 427, 475
- Graham 132, 133, 150, 151, 152
- Humboldt 330
- Inyo 66, 70
- Iron 66
- Juab 66, 69, 71, 104, 105, 106
- Kane 236, 281, 290, 291, 292, 293, 294, 295,
- Kern 296, 297, 298, 299, 307, 309, 310, 311, 312, 314, 315, 316, 317, 330, 394, 397, 398
  97
- Lake 132
- Lander 131, 134, 139, 140, 141, 504
- Lincoln 210, 218, 222, 223,
- Los Angeles 224, 265, 266, 267, 297, 308, 317, 318, 322, 323, 325, 327, 335, 382, 390, 416, 508
  134, 187, 499
- Lyon 408, 415, 431, 433, 434, 452, 457, 472, 475
- Maricopa 203, 287, 297
- Merced 66, 69, 70, 73, 104
- Millard 212, 214
- Modoc 408
- Mohave 409
- Mojave 66, 67, 89
- Morgan 235
- Napa 134, 139, 504
- Nye 187, 499
- Ormsby 480
- Pima 408, 409, 425, 427, 432, 435, 449, 452. 453, 454, 457
- Pinal 66, 68, 72
- Pi Ute 66, 67, 93, 94
- Rich 14, 15, 39, 65, 66, 67, 69, 70, 96, 97, 98, 99, 100, 102, 103
- Salt Lake 210, 221, 222, 230, 231, 238, 266, 321. 336, 338, 339, 382, 390
- San Bernardino 221, 233, 297, 308. 357, 370, 376, 381, 382, 383, 385, 388, 389, 390
- San Diego 50, 51, 52, 66, 72, 104
- San Juan 22, 66, 68, 71
- San Pete 238
- Santa Clara 58, 59, 66, 69, 71, 107, 108, 109, 110, 112
- Sevier 212, 214
- Siskiyou 234
- Solano 228
- Stanislaus ....

Page.

- Counties in arid region, names of—Continued.
  - Summary, of Utah 80, 81, 89
  - Summit 66, 67
  - Tehama 234
  - Tooele 66, 69, 112
  - Tulare 273, 274, 275, 276, 277, 279, 280, 281, 283, 285, 287, 297, 299
  - Uintah 68, 71, 114, 116, 117
  - Utah 23, 30, 38, 40, 66, 68, 116
  - Wasatch 66, 68
  - Washington 66, 69, 71, 72
  - Washoe 132, 145, 146, 149, 499, 507, 509, 510, 511, 512
  - Weber 19, 20, 66, 67, 89, 118, 119, 120, 121
  - White Pine 133, 178
  - Yavapai 408, 424, 427, 428, 443, 452, 456, 457
  - Yolo 234
  - Yuma 407, 408, 409, 410, 412, 416, 420, 422, 425, 432, 457
- Creeks in arid region, names and mention of:
  - Alder 118
  - Ashley 68, 114
  - Battle 117
  - Beaver 80
  - Bench (surplus of) 119
  - Bennett 118
  - Berritts 120
  - Big 101, 113
  - Big Rock 321, 325
  - Big Spring 94
  - Birch 84, 107
  - Birch Hollow 94
  - Bisbing 94
  - Bishop 335
  - Blake 86
  - Blue 45
  - Box Alder 113
  - Box Elder 63, 64, 80
  - Braffits 94
  - Brown 120
  - Brush 67
  - Buffalo 150
  - Burch 118, 119, 120
  - Buse 118
  - Butler Farm 88
  - Cache 233, 234
  - Caliente 300
  - Canfield 120
  - Canon 54, 89, 90, 409
  - Carrizo 379, 409
  - Castle 448
  - Cave 431
  - Cedar 107, 409
  - Chalk 67
  - Cherry 84, 178, 409
  - Cibica 409
  - Cibuqu 476
  - City 34, 35, 84, 96
  - Clarkston 84
  - Clay 112
  - Clear 84, 112
  - Clover 113
  - Coal 86
  - Cole Canon 120
  - Cold 118
  - Cold Water 119
  - Cottonwood 90, 94, 150, 331
  - Dalton 90
  - Date 424
  - Deep 45, 70, 90, 113, 498
  - Deep Canny 84
  - Deer 218, 274, 275, 281

Page.

Creeks in arid region, names and mention of—Continued.
120
- Dixon 95
- Dry 112
- Dry or Fish 113
- East 88
- East Fork 88
- East Fork Sevier 94
- Edar Valley 150
- Eight Mile 319
- Elizabeth 96
- Emigration Canon 94
- Falula Spring 86
- Ferron 113
- Fifteen Mile 150
- Flat 121
- Four Mile 121
- Gertisoa Canon 86
- Gooseberry 86, 90
- Gordon 117
- Grove 489
- Hassayampa 95
- Head of Woodruff 120
- Herd House 84
- High 117
- Hobble 86, 88
- Horse 95
- Hollow north of Cottonwood 501
- Hot Springs 86, 87
- Huntington 117
- Independence 78
- Indian 50
- Johnson 30, 31, 32, 43, 105, 106
- Kanab 150
- Kelly 94
- Lake Town 90
- Line 96, 99, 100
- Little Cottonwood 90
- Littleton and Milton 90
- Loss 89
- Lost 444
- Low 87
- Manmoth 150
- Martin 498
- Marquis 120, 188
- McDermit 94
- Meadowville 120
- Mice 113
- Middle 118
- Middle Fork 121
- Middle Fork Canon 95
- Middle Fork Woodruff 119
- Mile 90, 96, 101, 102, 103, 120, 121, 242
- Mill 101
- Miller Fork 86
- Moab 90
- Morgan City 119
- Mud 86
- Muddy 78, 107
- North 88
- North and Birch 94
- North Eden 118
- North Ogden Canon 443
- Nutriaso 319, 321
- Oak 93, 94, 111
- Otter 96, 103, 10
- Parleys 409
- Perito 90
- Peterson 88
- Pine

Page.

Creeks in arid region, names and mention of—Continued.
Pine Kanyon 94
Pinal 409, 475
Pinto 434, 475
Pleasant 107
Poison 88
Portage 81
Pole 498
Poso 218, 300
Prosser 147, 498, 508, 513
Putah 233, 234
Raccoon 409
Randolph, Big 93, 94
Randolph, Little 93
Rebel 150
Recapture 50
Red Butte 96
Rice 118
Rillito 463, 480, 484
Rock 184, 325
Rock Canon 117
Rocky Mouth 98
San Diego 363
Salem 117
Saleratus 93, 95
Salina 42
San Simon 477
Show 444
Silver 444, 501
Six Mile 93
South Dry 98, 100
South Eden 94
South Fork 443
South Hollow 98
South Montezuma 51
Spring Lake 117
Thimble-berry 120
Thistle 68
Three Mile 64, 80
Tonto 409, 430, 431, 434, 446, 452, 457, 474, 475
Town 107
Twin 107
Uintah 118
Virgin 43
South Mill 90
Steamboat 514
Strawberry 117
Strong's Cañon 118, 119
Summit 84, 117
Swan 93, 94
Sweet Water 359
Talula Spring 94
Taylor's Cañon 118
Temescal 381
Warm 241, 342, 344
Water Cañon 443
Water Fall 118
Wells & Sage 93
West Fork Pahreah 89
Western 84
Wester 120
Wheeler's 67, 119
Whitney 290
Willard 80
Willow 150, 154, 184, 185
Wilson 86
Woodruff 93, 94, 95
Wolf 118, 501
Woolf 120

Page.

Crops in arid region, mention of:
.... 14, 17, 18, 81, 89, 99, 100, 102, 103, 104, 108, 109,
Alfalfa 116, 118, 159, 160, 175, 176, 186, 212, 233, 234, 243, 278, 283, 284, 287, 290,
291, 307, 310, 311, 312, 314, 315, 316, 324, 328, 333, 338, 340, 344, 380, 384,
388, 394, 397, 418, 422, 423, 426. 429, 430, 432, 454, 459, 470, 479, 508, 513
Barley 17, 163, 316, 324, 343, 350, 353, 401, 403, 418, 426, 430, 432, 449, 454, 459
.... 453, 460
Cereals, all 14
Clover 17–71, 77, 97, 98, 99, 102,
Corn 384, 410, 418, 421, 432, 449
103, 104, 108, 110, 114, 116, 152, 310, 316, 350, 379,
Egyptian Corn 307, 311
Grasses 72, 77, 91, 108, 114, 165, 175, 408. 411
Hay 67, 72, 77, 91, 100, 101, 108, 109, 111, 114, 175, 312, 314, 383, 394, 403, 408, 453
.... 24
Mortgage on 17, 99, 100, 102, 103, 104, 110, 428
Oats 31
Seasons 67, 72, 77, 86, 89, 93, 94,
Small grains 97, 98, 99, 100, 104, 109, 110, 114, 116, 117, 312, 317, 323, 383, 385, 422, 429, 443
.... 17, 26, 24,
Special references to 32, 56, 71, 72, 77, 89, 91, 93, 106, 114, 116, 117, 130, 157, 165, 402, 480
.... 123, 284, 285
Water, effects on 17, 19, 100,
Wheat 102, 103, 104, 110, 111, 114, 274, 312, 316, 344, 401, 403, 418, 428, 430, 432, 454
average yield, if irrigated 162
average of, in Nevada 58

D.

.... 76, 436, 504
Dakota, mention of 33, 37, 322
Dams for irrigation purposes 155
Acres under 434
Arizona Canal, of 368, 369
Ban, in France, the 47
Bear Lake, lien against 370
Bear Valley, at 15
Built by county, Utah 483
Building material for 37
Capacity of 484
Catchment area of, at Puertisitos 362
Conemaugh, the, Pennsylvania 96, 159, 360–376, 456, 462
Construction and cost of 156
Cost of, Squaw Valley, in 185
Cost of, Willow Creek 361
Dale Dike, at 461
Del Rey, at 40
Diking the Jordan 360, 361, 362
Earth, with 42
East Fork, cañon at 461
El Cumoso, at 154
Elko County, in 68
Green River, on 369, 370
Habra, Algiers, at 17, 65
Height and length of 112
Joseph Canal, at 498, 499
Locations for 362, 370
Masonry in 461
Mission, at 14
Mountains, in 361
Nethertrees, Paisley, England 364
Overturning, danger of 42
Panquitch Lake, at 369
Perair, at 375
Probable duty of works 480, 481, 482, 483
Proposed works, description of 39
Provo Cañon, at 37, 413
Raising of water, by means of 33
Rio Virgin River, at 474–476
Salt River, proposed works, objections to 210
San Diego, in ....

Page.

Dams for irrigation purposes—Continued.
- Solid, value of 52
- Squaw Valley, at 156
- Sweetwater, at the 337, 359, 360, 369, 370, 371, 372, 373, 390
- Tahoe, Lake, timber at 148
- Terrasse, at 369
- Ternay, at 368, 369
- Utah Lake, at 25, 29
- Walnut Grove 423, 457, 489
- Weber River, at 54
- Willow Creek, at 154, 184, 185, 186
- Wing 305, 309

Desert land act 394, 463, 471, 474, 475

Districts for irrigation purposes:
- Agriculture in 21
- Armagosa, the 335
- California, in 240, 246, 248, 249
- Coso, the 335
- Darwin, the 335
- Death Valley, in 335
- Highlands, the 232
- India, irrigation 396
- Lyons 335
- Madora, the 227
- Madeira, the 229
- Mairwara, the 398
- Monroe, the 109
- Pamment, the 335
- Paso del Norte, at 409
- Poso, the 293, 310, 311, 312, 314, 315
- Redland, the 232
- Rialto, the 232
- Riverside, at 232
- Roseta, the 379
- San Bernardino, at 232
- State Range, at 335
- Smithfield irrigating, the 84
- Turlock, the 227, 229
- West Side, the 227

Ditch owners in Utah, references and names of:
- Allan, Edward 88
- Allrid, W 79
- Anderson, O 89
- Assay, Aaron 88
- Barney, H 89
- Bennett, B 79
- Cannonville Company 88
- Christain, J. W 79
- Christian, O 89
- Church, A., Brothers 88
- Church, Haden W 88
- Clark, J 89
- Clove, Neils P 88
- Cox, W. J 79
- Crosby, J. W 88
- De Long, Albert 88
- Dotson, W. L. H 79
- Emerson, H 79
- Farrer, J 79
- Fletcher, K. A 89
- Frayer, F 79
- Frothingham, W 79
- Gale, H 79
- Gillis, J 79
- Gilling, W 79
- Goulding, Daniel 88
- Goulding, John 88, 89
- Goulding, Joseph U. G 88
- Greenwood, W 79
- Griffiths, R 79

Page.

Ditch owners in Utah, references and names of—Continued. 79
Harris, F 89
Hatch, O 88
Hatch, Meltiah 88
Hatch, O. S 88
Hencock, Cyrus 89
Henderson, William J 79
Hutchings, G 88
Ingram, Joseph 79, 88
Jones, J 79
Jones, J. H 79
Josephs, J. F 79
Josephs, J. H 88
Kanana Stock Company 79
Lang, J 88
Langford, Thomas F 88
Leflere, William D 88
Levey, John L 88
Lewman, Welham 89
Lewman, William 88
Littlefield, Samuel 88
Littlefield, Emu 89
Littlefield, D. O 89
Littlefield, Lucy 79
Martin, P. S 79
Mathews, E. C 88
McEwen, Mathew 79
McGeary 79
McKnight, J 88
Meacham, Samuel 88
Meacham, Morrison 89
Meacham, S. H 79
Merchant, C 79
Miller, C 79
Mumford, G 79
Murdock, J. R 79
Nowers, W. G 79
Olsen, A 79
Owen, G. E 79
Parkinson, T 79
Patterson, R 79
Patterson, E 89
Pearce, E 88
Pollock, John F 88
Pollock, William W 89
Porter, Mary 79
Puffer, O 89
Relief Society 79
Shepherd, M. M 88
Stevens, Abraham A 79
Tinktell, A 89
Thompson, E. H 88
Thompson, John O 88
Thompson, James B 88
Thompson, Joseph E 88
Thompson, Lucy D 88
Thompson, Willis A 88
Thompson, William S 79
Warby, C 79
Warby, J 88
Watson, Reese & Co 88
White, Henry J 86
Wilcox, Edward 86
Wilcox, James H 89
Wiley, James & Co 89
Williams, Hyrum 89
Workman, A 89
Zion Co-operative 54, 64, 65
Dry washes ....

Page.

E.

Eminent domain, law of 246
Engineers, mention of 44, 45, 47, 50, 55, 77, 96
  Blowers, R. B 234, 235, 239
  Breakenbridge, W. M 431
  Bridges, Lyman 188
  Brodie, A. O 456
  Dixon, W. L 306
  Dutton, Clarence E., U. S. Army 42
  Gilbert, Prof. E. K 75
  Hall, W. H 216
  Harding, H. Y 321
  Hinton, R. J 77, 189, 290, 326, 345, 407, 410, 430, 441
  Irish, C. W 178
  Jones, J. E 129, 151
  Newell, F. H 107, 108
  Newman, G. O 344, 345, 346
  Smith, Fewsen J 96

F.

Farms, in arid region:
  Annual production of, under, irrigated 21
  Average size of 20, 21, 26
  Agricultural purposes, value of, for 22, 35
  Bennett's 140
  Dry farming 23, 56, 65, 67, 72
  Farm wages 26
  Largest, irrigated, in Cache Valley 20
  Smallest, Cache Valley 21, 26
Fibers:
  Cotton 71, 158, 316, 378, 416, 417, 504
  Kentucky hemp 378
  Manilla 378
  New Zealand 378
  Indian 378
  South American 378
  Wild hemp 378, 402, 417
  Flumes for irrigation purposes 33, 322, 342, 347, 512
  Canal, the, use of 305
  Carson and Tahoe Lumber Company, of 513
  San Diego, at 267, 268, 354, 376
  Sierra Nevada Wood and Lumber Company, the 513
Forts, United States, mention of:
  Apache 485
  Douglas 75
  Huachuca 489
  Lowell 461, 476, 480
  McDermit 188, 504
  McDowell 445, 484, 485, 491
  Mojave 129
  Thomas 488
  Whipple 457
  Yuma 379, 380, 412
Fruits, small:
  Blackberries 316, 388, 432
  Currants 388
  Cherries 388
  Gooseberries 388
  Melon 338
  Raspberries 316, 410, 421
  Strawberries 316, 388
Frémont, John C., mention of 316, 388, 432
Freshets 74
51
Fruit trees, under irigation 18, 69, 70, 240, 317, 383, 432, 453, 465
  Almond 71, 316
  Apple 18, 383, 388, 425
  Apricots 71, 316, 355, 389, 402, 416, 417, 471
  Banana 403

Page.

- Fruit trees, under irrigation—Continued.
  - Crab-apple 425
  - Cherry 316, 383
  - Date 378, 400, 402, 416, 417, 425
  - Fig 388, 389, 400, 402, 403, 404, 416, 417, 425, 432
  - Guavas 388
  - Japanese persimmon 388
  - Lemon 340, 341, 352, 384, 400, 402, 403, 404, 416, 417, 425, 430
  - Lime 400, 402, 403, 404, 416, 417, 430
  - Mulberry 316
  - Nectarine 316, 471
  - Olive 71, 355, 388, 389, 403, 416, 417, 425
  - Oranges 316, 317, 333, 340, 341, 352, 355, 400, 401, 402, 403, 404, 416, 417, 430, 432, 450
  - Peach 18, 71, 315, 316, 355, 388, 400, 402, 416, 417, 425, 471
  - Pear 355, 402, 425
  - Pecan 316
  - Plums 316, 383, 388, 403, 416, 417
  - Pomegranate 316, 388, 402, 403, 416, 417, 432
  - Prune 425
  - Temperate zone, of the 383
  - Walnut 316

G.

- Geological Survey, report of 209
- Government aid to irrigation 50, 53, 57, 92, 93, 106, 117, 376
- Governors, references to:
  - Arizona, of, Louis Wofley 456
  - Idaho, of, George L. Shoup 45
  - Utah, of, Arthur L. Thomas 577
- Grant, General U. S., reference to 44
- Guadaloupe-Hidalgo treaty 245
- Gulf of California 131, 376, 377, 378, 379, 380, 409, 412, 415, 477, 485, 486, 491

H

- Hand-book to Arizona, Hinton's 410
- Hawai Station, Mojave Desert, in 333, 334
- Head gates and other works:
  - Calloway Canal, on 315
  - Flood, for 311, 377
  - Head of canals, at 305, 309, 310, 421
  - Inlet Tower, Sweetwater 374
  - Pioneer Canal, of 314
  - Sluice-ways 413, 481, 483
  - Supply for 185
  - Sweetwater Dam, at 374
  - Waste tunnel and way, for 185, 305, 413
- Hills, mention of:
  - Alabama 334
  - Purple 412
  - Mineral 454
  - Steam-boat Rock 436
- Homestead law, mention of 471, 506

I.

- India, tanks of 148
- Indian reservations, mention of 43, 52, 66, 68, 72, 104, 117, 451, 458
  - Apache, the 474
  - Colorado River Agency 420
  - Fort McDowell, at 485
  - Huachuca, at 485
  - Pima, the 490
  - Southern Utes, the 52
  - Uncompahgre Agency, the 43
  - Uintah, the 43
  - White Mountain, the 408, 474, 475

Page.

- Iowa, mention of 72
  - Ex-Governor Stone 44
- Islands, names of:
  - Antelope 74
  - Australia 246, 379
  - Kern 299, 300, 305
  - Rock 419
  - Stevenson 413
- Irrigation, character and effects of 20, 32, 35, 47, 53, 54, 56, 63, 79, 93, 96, 97, 98, 99, 117, 157, 193, 194, 203, 205, 235, 238, 239, 279, 280, 281, 282, 291, 292, 293, 296, 413, 414
  - Acequias, for 495
  - Alkaline water, effect on 237
  - Alkali soil for 14
  - Analyses of water for 242
  - Ancient, in Nevada 158
  - Ancient works for 491
  - Antelope Valley, plans for 331, 336
  - Arizona, area for 425, 426
  - Artificial streams for 12
  - Boutwell's Bear Lake plan 18
  - California, area for 46, 162, 190, 192, 224, 248, 266
  - Climate, effects of 217, 305
  - Colorado, in 46
  - Colorado Desert by catchment basins, of 319
  - Conduits, mountains, by 198
  - Commission, a, for 509
  - Cost per acre 159, 211, 306
  - City sewage, use of, in 224
  - Cuca Monja Plains, on the 222
  - Custom of, on Indian reservations 420, 421
  - Dams, by 132, 134
  - District organizations, for 249
  - Drainage, relation to 240
  - Duty of water 193
  - Elko County, Nev., in 133
  - Enlarging, existing lakes, for 78
  - Etiwanda, in 231
  - Europe, in 209
  - Facilities for 141, 191, 400
  - First experiments, in 24
  - Flooding, by 56
  - Florence, at 451
  - France, in 209
  - Fresno Canal, from 273
  - Gauge system, of 230, 242
  - Government interest in 204
  - Humboldt River, Nevada 133
  - Italy, in 209, 395
  - Kern County, in 294, 298, 305, 306, 308, 309, 310
  - Lakes Tahoe and Donner, proposed use of 507
  - Lakes used for 37
  - Mexican method of 384
  - Mountain streams for 57
  - Ontario, at 231
  - Papago Indians, by 435
  - Pipe system for 339, 340
  - Pomona, at 230
  - Public ownership and control of water for 303
  - Quality of water for 236
  - Quantity required for 157
  - San Bernandino County, in 199, 225
  - San Diego County, necessity for 201
  - San Gabriel Valley, in 223
  - San Fernando Valley, in 223
  - Seasons, for 18, 28, 29, 41. 45, 47, 48, 63, 66, 67, 68, 69, 70, 71, 72, 77, 80, 84, 86, 89, 91, 99, 100, 101, 102, 103, 104, 107, 108, 110, 111, 118, 124, 135, 239, 240, 469
  - Sevier River, from 57
  - Small ditches, by 475
  - Sources of, in Utah 119, 120

Page.

Irrigation, character and effects of—Continued.
  Spain, in 209
  Springville, Utah, at 117
  Statistics of 454
  Storage dams, reservoirs, water, for 132, 134, 136, 199, 406, 486
  Storm waters, for 435, 461
  Streams used for 56, 64
  Submerged dams, by 381
  Sub-irrigation, systems of 35, 196, 322
  Systems of 20, 38, 93, 107, 298, 461
  Temperature, suited to 204
  Tunnels, by 381
  Underground waters, by 56, 474, 475
  Value of land increased by 55, 65, 213
  War Department, under 471
  Water for, character of 241, 465
Irrigation companies, names of:
  Arizona Canal, the 423, 442
  Ashley Consolidated, the 114
  Boom Company, the 507, 509
  Brooklyn Company, the 110
  Corporations, relating to 12
  Deep Creek Company, the 90
  Ditch Company, a 514
  Donner Boom and Lumber, the 512
  Enterprise Bottom, the 90
  Florence Canal, the 423
  Fresno Canal, the 273
  Gila River, the 432
  Joseph Irrigating, the 110
  Line Creek, the 90
  Loss Creek, the 90
  Munroe Irrigation, the 110
  Morgan City, the 90
  Mountain Companies, the 513
  North Morgan Mill Race, the 90
  Precipice, the 266
  Promontory Stock Ranch the 81
  Riverside, the 344, 346, 350
  Salt Lake County, the 15
  San Diego Flume, the 390
  Settler's Ditch, the 280
  St. John's, the 444
  South Gila Canal, the 419
  South Round Valley, the 90
  Stockholders' System in Utah 12
  Swan Creek, the 93
  Truckee, Lumber, the 507, 512
  Vermillion and Extension, the 109
  Walnut Grove Water Storage, the 456
  Weber Canal, the 90
  Wells, the 108

L.

Lakes, names and mention of:
  Bear 23, 41, 42, 43, 46, 48, 49, 54, 92, 94
  Biglar 215
  Birch Creek 78
  Blue 78
  Bonneville 75
  Box Elder 64
  Buena Vista 300, 314
  Carson 130, 131
  Catharine 36, 37
  Catherine 96
  Clear 215, 233
  Crystal 269
  Dog 36, 96
  Donner 147, 148, 498, 163, 498, 499, 506, 507, 508, 510, 511, 512

Page.

Lakes, names and mention of—Continued.
- Eagle, 132, 326, 429
- Elizabeth, 326
- Elsinore, 381, 382
- Fish, 42
- Fresh water, 14
- Goose, 215, 300
- Great Salt, 31, 32, 36, 41, 42, 44, 51, 56, 64, 67, 69, 73, 96
- Oscillations of, 74, 75
- Humboldt, 131, 154, 504
- Independence, 147, 148, 499, 508
- Kents, 78
- Kern, 300, 302, 314
- Little, 334
- Martha, 36, 96
- Mary, 36, 96
- Mud, 506
- National, 39
- Owens, 331, 332, 333, 334
- Padrés, 444
- Panquitch, 42, 87
- Phoebe, 96
- Puffers, 78
- Pyramid, 130, 131, 148, 501, 504, 506, 508
- San Joaquin Valley, in, 242
- Scipio, 70
- Sevier, 41, 42
- Silver, 36, 37, 96
- Small Lakes in Utah, 87
- Tahoe, 129, 130, 138, 147, 148, 149, 163, 498, 499, 506, 507, 508, 509, 510, 511, 512, 513, 514
- Tulare, 237, 242, 299, 300, 314
- Twin, 36, 37, 78, 96
- Upper Sevier, 60
- Utah, 14, 17, 19, 18, 25, 29, 30, 31, 32, 34, 35, 36, 38, 39, 40, 42, 51, 52, 54, 56, 60. 68, 72
- Walker, 130, 131
- Webber, 147, 148, 499
- White, 39
- Winnemucca, 506, 508

Land, reference to:
- Acreage irrigated and cultivated, 18, 38, 39, 41, 45, 47, 51, 58, 67, 69, 70, 71, 77, 86, 90, 113, 114, 116, 117, 173, 187, 189. 202, 214, 350, 427, 428, 480
- Acreage irrigable, 30, 38, 40, 42, 43, 134, 154, 157, 161, 192
- Acres under Utah Lakes, 31, 41
- Adjoining streams, irrigable by, 134, 315
- Alfalfa, 309, 310, 313
- Alkali in and effects of, 14, 176, 240, 241, 280
- Arable, areas of, 20, 22, 23, 26, 30, 35, 38, 39, 40, 43, 47, 51, 64, 66, 67, 68, 69, 70, 71, 77, 80, 81, 89, 97, 104, 112, 114, 132. 133, 139, 145, 150, 151, 154, 157, 167, 173, 192, 211, 233, 382, 383, 385, 387, 388, 409, 410, 427
- Average crop on irrigated, 165, 173
- Barren, 31
- Base of mountains at, 50
- Bench, 20, 25, 46, 63, 176
- Bottom, 20, 410, 411
- Bunch grass, 165
- Buena Vista, Slough of, 288
- Cache Valley, in, 21, 22
- Cañon, 43
- Cost of agricultural, 22
- Cottonwood Flats, on, 418, 419
- Covered by ditches, 427
- Desert, 159, 382, 504
  - Armargoza, the, 140
  - Black Rock, the, 504
  - Colorado, the, 212, 214, 219, 318, 320, 358, 376, 382, 504
  - Great American, the, 457
  - In Los Angeles County, 319, 320, 321, 382, 504
  - Mojave, 214, 379
  - Sevier Lake, at, 59
  - Smoke Creek, of, 504

Page.

Land, reference to—Continued.
  Fertilizing débris, of 20
  Foot-hills, of 23, 176, 479
  Gila Bend Flat, of 419
  Valley, classification of 410
  Government policy 49
  Government urged to grant 143, 144, 145
  Granite 172
  Hay, for 45, 114
  High Plains, on 410, 411, 412
  Marsh, extensive 45
  Meadow 132, 148, 175, 215, 290, 334, 498, 499, 506, 511, 512
  Mesa, the 42, 50, 357, 370, 383, 386, 410, 411, 483, 491
  Miner's water on public 45
  Mississippi Bottom 140
  Mussel Slough, the 280
  Nevada, settlers for 161
  Opened to occupation in Kern County 307, 308
  Orchard 114
  Pasture 114, 316
  Plateau 42, 130, 498
  Pre-emption of 43, 47
  Price in Utah of farming 17, 22
  Public, areas of 43, 169, 228, 506
  Reclaiming, cost of 156
  Reclaiming Humboldt Valley
  Reclaimed by storing water 319
  Reservation of, by Government 29, 43, 47, 48, 49, 50
  Reservoir sites for 49
  Rocky 176
  Sage-brush in Nevada 165
  Sage-brush plains 498
  San Juan, Utah, of 52
  San Juan, settlers on 45, 58, 66, 157
  San Joaquin Valley, in 202
  Smoke Creek Desert 504
  Speculation in 20
  Still Water Basin, of 174
  Surveyed 57, 58, 78
  Suitable for cultivation 58, 480
  Squatters' right on 17, 47, 50
  Table of cultivable, with increased water 117
  Tillable, in Gila County 475
  Timber 233
  United States, laws and grants, of 21, 243, 281
  Value of, irrigated 16, 17, 22, 163, 201, 272, 290, 292, 312, 348, 349
  Washington colony, the 227
  Wheat 153, 233, 313, 504
  Yellow Bank, the 79
Laws on irrigation, Arizona, statutes of:
  Acequias, public and private rights in 495
    when taken out by private persons 495
    not to be interfered with 496
  Animals to be controlled by shepherd 495, 496
  By-paths prohibited over fields 495
  Community ownership of ditches 495
  Conveyance of waters, incorporation for 497
  Convictions, appeals allowed on 496
  Crossing of roads by ditches 496, 497
  Customs of Sonora in force 497
  Damages, how assessed 496
  Dams, not to impede irrigation 495
  Elections, order and conduct 496
  Exclusive right to water, when 495
  Fines for refusal to labor 497
  Funds, road-making, for 497
  Inhabitants, right to construct acequias 497
  Justices of the peace, their duties 496
  Laborers, when required 497

Page.

Laws on irrigation, Arizona, statutes of—Continued.
- Land-owners required to labor 495
- Overseers, pay and duties of 497
- Reduction works, when prohibited 495
- Riparian rights, not recognized 495
- Scarcity of water, how met 496
- Trees on ditches, owned by 497
- Water regulations in force 497

Laws on irrigation, California, statutes of: *
- Acquisition of lands and water 253, 254, 260
- Agents, power to appoint 251
- Assessments, how made and paid 252, 254, 255, 256, 258, 260
- Assessors and deputies, qualifications and duties of 251, 254
- Board of equalization, duties 259
- Board of supervisors, powers of 250
- Bonds of district, mode of issue, classes, and sale 253, 259, 264, 265
- Bonds, official amount of 251, 253, 254, 259
- Boundaries, changes of 250, 260, 261, 262, 263, 264
- By-laws, when framed and published 252
- Canvass of votes, how made 251, 252, 258, 259, 261, 263
- Certificates, when issued 255, 256, 260
- Collector of taxes, election and duties of 251
- Compensation of officers 254, 258
- Construction of works 251, 257, 258
- Contracts, how made and enforced 257
- Directors, election and duties of 252, 257, 258, 259, 261, 262, 263, 264
- District for irrigation purposes, its powers 250, 260, 261, 262, 263, 264, 265
- Divisions of district 250, 251, 255, 260, 261
- Elections, how held and what for 250, 251, 252, 258, 259, 263
- Electors, qualifications of 251
- Freeholders, right to form district 250
- Interest on bonds, amounts of 253, 255, 259
- Newspapers, advertising in 250, 254, 255, 257, 261, 263, 265
- Oaths, use and administration of 251
- Resident board of directors 252, 257, 258
- Property, assessment, sales, redemption of 252, 253, 254, 255, 256, 259, 260
- Secretary board of directors of 252, 256, 259
- Treasurer irrigation district of 251, 252, 256, 257
- Water rights, public control of 252, 253, 258, [illegible]
- Water rights, ownership of, by district 250, 253, 258

Laws on irrigation, Nevada, statutes of:
- Acts passed, titles of 514, 520, 221, 524
- Annual water rent, conditions of 523
- Appeals, when allowed 518
- Appropriations 516
- Arable lands, when irrigated 525
- Artesian wells, bounty for 524
- Assembly, memorial of 520
- Beneficial use of water 515
- Board of county commissioners, their powers 514, 515
- Board of reclamation, its powers 521, 522, 523
- Bonds, appropriation for 522
  - issue and redemption 522, 523
- Certificates of priority, how issued 517, 518
- Clerk of supreme court [illegible], 518
- Civil engineer, provided for, duty of 522
- Construction of works, how provided for 516, 518, 519, 522, 523
- Corporations, how regulated 517, 518
- County, its relation to irrigation districts 515
- Courts, powers of 515, 516, 517, 518, 519
- Damages, willfully done 518
- District courts, their jurisdiction 515
- Ditches, owners of, their priorities 516, 517, 518
- Ditches, their regulation 519
- Division of water, when unlawful 521
- Diversion of water, when 519
- Elections, when held 522
- Head gates, use and protection of 515, 516

---

* Wright district act, and acts amendatory.

Page.

Laws on irrigation, Nevada, statutes of—Continued.
  Hydrographic surveys, memorial for 520
  Interest on bonds 523, 524
  Irrigation districts, how formed 521
  Newspapers, notices in 517, 518
  Priorities, water right 517, 518, 519
  Public property in water reservoirs, provisions relating to 516, 517, 518, 519
  State, comptroller of, his duties 523
    Governor of, his duties 514, 520, 523
    Officers, unlawful interest in 523
    Treasurer of, his duties 523
    Surveyor-general, his duties 522
  Water commissioners, their duties 514, 515, 516, 519
Laws on irrigation, Utah, statute of:
  Act incorporating irrigating companies 8, 11
  Advertising, provided 8, 9
  Agreement, to pay tax 8
  Appraisals of land 10
  Appraisement of land 9, 10
  Assessments, for irrigation 9, 10
  Average flow of water supply 6
  Ballots to be counted by 8, 9
  Board of references 6
  Books of record, water rights in 6
  Bonds to be filed 9
  Canals in district 8, 11
  Canals for irrigation 5, 11
  Certificate, district election 8, 9
  Certificates, water right 6
  Claims for water or damages 6, 7
  Clerk of district 8, 9
  Commissioners, water 6, 11
  Certificates, liability of 11
  Constructions, use of water 6
  Construct, works to 11
  Construction of irrigation works, by whom 11
  Corporations, how formed 6, 7, 8, 11
  County recorder 6
  Dams, when to be constructed 10
  Damages, payment for 8, 10
  Definitions, in law 7
  Distribution of water, who by 6, 9
  District work 8, 9
  Ditch, right of way for 5, 8, 9, 10, 11
  Ditches, construction of 5, 8, 9, 10, 11
  Diversion of water, when unlawful 11
  Domestic purposes for 7
  Duty of county comptroller 8, 10
  Duty of district officers 8, 10
  Duty of recorder 6
  Duties of selectmen 6
  Duties of trustees 8, 11
  Elections for officers 8, 9
  Estimates for works 8, 9
  Exemptions from 10
  Homestead, lien on 5
  Injury to settler 5
  Irrigation districts 8, 11
  Judges of election 8, 9
  Lakes, when used 10
  Landholders to form water districts 8, 11
  Location of districts 8
  Maps of districts 9
  Measurement of water 7
  Misdemeanor, when guilty of 10
  Notices, water districts 8–11
  Officers of water districts 8–11
  Patents, for lands, lien on 5
  Powers of trustees 8–11

Page.

Laws on irrigation, Utah, statutes of—Continued.
  Pre-emption, allowed lien on 5
  Primary rights 5–7
  Prior appropriation 5, 6, 7
  Priority of possession 5–7
  Public domain, references to 5
  Public highways, navigable rivers are 5
  Rate of taxation, how determined 9
  Real estate, owned by water districts 8–11
  Reclamation, water for desert land 5
  Right of way 7, 8
  Roads, when used 10
  Roll-list required 8, 9
  Secondary rights 6, 7
  Selectmen, ex officio water commissioners 6
  Settlers on public domain 5
  Streams in different countries 9
  Streams, not navigable 5
  Suits in equity 6
  Surplus water, use of 7
  Tax, for irrigation 8, 11
  Tax-payers, obligation of 8, 11
  Terms of district trustees 9
  Treasurer of district 8
  Trustees, for water districts 8, 11
  Unusual flow, secondary rights to 7
  Uses of water 6
  Utah, laws of, sessions of 1878–1880 5–11
  Value of lands 8
  Water, when insufficient 7
  Water rights, how secured 5–8

M.

Measuring weir, a 338
Mexican water laws 245
Military reservation 461
Mine mills at Empire 500
    Mineral Creek 452
    Virginia City 499
Mineral deposits 165
Mineral springs, etc 81, 135, 136, 137, 167
Mines, references to:
  Clifton Copper 408
  Comstock 335
  Harqua Hala, gold 427
  Gold 408
  Iron 408
  Lead 408
  Mining, wood for 165
  Silver 408
  Yuma copper 427
Mountains, names of:
  Ajos 478
  Amole 461
  Apache 409
  Aqui 69, 79
  Baboquivari 484
  Basins of 66
  Battle 146, 269
  Beaver 69, 80
  Beaver, notes on 80
  Belknap 80
  Big Cottonwood 36
  Black 451, 452
  Blue 50, 104
  Bradshaw 448
  Calinro 409
  Cananea 478
  Canelas 480
  Cacsade 488

Page.

- Mountains, names of—Continued.
  - Catalina 478
  - Cedar 104
  - Charleston 140
  - Chiricuhuar 428, 478, 479
  - Coal 66, 68, 69
  - Cucupah 376, 377
  - Cuyamaca 360
  - Davidson 503
  - Diablo 281, 292, 307
  - Diamond 503
  - Dragoon 409, 477, 478, 479
  - East 107
  - Eastern 63
  - Elk 50
  - Elsinore 381
  - Francisco 485
  - Fremont Peak 409
  - Gallura 478
  - Gila County, of 412
  - Green's 409
  - Huachuca 409, 465, 469, 478, 479, 485
  - Kerr 215
  - La Sal 72, 104
  - Limestone 478
  - Little Cottonwood 36
  - Long's Peak 409
  - Mazattelle 485
  - Mule 409, 478
  - Mustang 478, 480
  - Nebo 70
  - Oquinh 67, 69
  - Patagonias 480
  - Pedrogosa 478
  - Peloncillo 478
  - Pinaleno 478
  - Pinos Altos 451, 452
  - Rincons 461, 469, 478, 480
  - Rocky 295, 297, 388
  - Ruby 503
  - San Bernardino Peak 321
  - San Francisco 409
  - Santa Catalina 409, 461, 469
  - Santa Rita 428, 461, 480, 484
  - Schell Creek, at 503
  - Shasta 270
  - Sierrita 461
  - Sierra Aucha 409, 431, 434
  - Sierra Nevadas 131, 145, 147, 148, 234, 244, 269, 286, 295, 297, 299, 304, 331, 332, 333, 334, 340, 488, 498, 503, 505, 506, 508
  - Sierra Madra 325
  - Superstition 485
  - Tehachapi 265, 266, 269
  - Tonto Basin, at 409
  - Toy-ah-be 503
  - Turnbull 488
  - Twin Peak 36, 37
  - Uintah 66, 68
  - Virginia 503, 506
  - Wasatch 41, 42, 66, 67, 68, 69, 70
  - Whetstone 407, 478, 479, 480
  - White 409, 443, 485
  - Whitney 281, 283, 286, 287, 290, 299, 313
  - Zuni 444

N.

- Newspapers, Kern County Weekly News 316
  - Salt Lake Tribune 44, 45
  - San Francisco Chronicle on Lake Tahoe 138

Page.
Nevada, irrigation ditches in:
  Highland ... 514
  Lehman's Valley, in ... 149
  Orr ... 514
  Right of way for ... 163
  Steam-boat ... 514

O.

Orchards, mention of ... 69, 77, 88, 97, 99, 100, 102, 108, 109, 110, 111, 116, 287, 309, 316, 383
Orchards of almond ... 450
  apple ... 316
  cling-peach ... 315
  date ... 450
  fig ... 316, 450
  grape ... 347, 348
  olives ... 450
  orange ... 342, 347, 348
  peach ... 347, 348, 450
  pears ... 316, 347, 348
  pomegranate ... 450
Orchards in Cochise County ... 465, 466
  Kern County ... 315
  planted in southern Arizona ... 464
  watered by artesian wells ... 57

P.

Pass, Explorers ... 412
  Mono, of ... 333, 334
  Walkers, of ... 333, 334
Patrons of Husbandry ... 273
Pilot Knob, Colorado Desert ... 377
Pipes for irrigation ... 327, 330, 339, 346, 349, 370, 375
  cement ... 322
  iron ... 322
  Pasadena, at ... 330
  total cost of ... 322
Potash in water for irrigation ... 239
Population, agricultural ... 44
  ancient, their colony life ... 158
  estimated, for Arizona ... 427
  in California ... 198
  Kanab Creek, on ... 33
  San Juan County, Utah, in ... 51
  watershed, on Colorado ... 32
Powell, John W., Director U. S. Geological Survey ... 5, 36, 75, 76, 129, 138, 189, 273, 288, 296, 309, 314, 317, 330, 336, 339, 341, 350, 354, 400, 406, 422, 423, 449, 459, 471, 513
Productions:
  Agricultural ... 81, 238
  Arizona, of ... 458
  California, of ... 190, 416, 417, 418, 453, 454
  California, horticulture, of ... 238
  Nevada, of, for years 1887 and 1888 ... 141, 142, 179
  San Diego, county of ... 388
  Staple, Utah of ... 19
  Time for maturing stated ... 416
  Transportation of ... 418
  Utah, raised in ... 67
  Value of agricultural ... 428
Promonotory Point, Colorado River ... 377
Provinces of India, certain ... 379

R.

Railroads:
  Atchison, Topeka and Santa Fé ... 370
  Atlantic and Pacific ... 332, 427, 443
  Canadian Pacific ... 509

Page.

- Railroads—Continued. 333, 334, 335
  - Carson and Colorado 236, 498, 507, 508
  - Central Pacific 268
  - Santa Fé 332, 418, 427, 477, 480, 481, 482
  - Southern Pacific 43, 89, 93
  - Union Pacific 334
  - Utah Southern
- Rain-fall, references to 35, 42, 57, 61, 62, 66 67, 70, 71, 72, 74, 75, 96, 158, 168, 205, 236, 237, 244, 247, 268, 295, 322, 451, 457, 458, 462, 470, 473, 477, 480, 486, 489, 491, 502, 503, 504
  - 478
  - Albuquerque, at 247
  - Ample, an 502, 503
  - Annual, the 487
  - Annual distribution of 486, 487, 488, 489, 490, 491, 492, 493, 494
  - Arizona, precipitation of 325
    - Mountains, on 325
    - Plains, on 73
    - Salt Lake City, in 386
  - Belt 192
  - California, at 478
  - Camp Bowie, at 478
  - Camp Grant, at 237, 242
  - Deficiency of 72, 478
  - Denver, at 125, 127
  - Diagrams of 478
  - Drum Barracks, at 218, 486
  - Effect of, irrigation, on 486
  - Effect of, water storage, on 385
  - Elevation increases 385
  - Fallbrook, at 489
  - Fort Apache, at 478
  - Fort Bayard, at 478
  - Fort Benton, at 489
  - Fort Bowie, at 478
  - Fort Craig, at 478
  - Fort D. A. Russell, at 478
  - Fort Filmore, at 478
  - Fort F. Steele, at 478
  - Fort Garland, at 489
  - Fort Grant, at 478
  - Fort Huachuca, at 478
  - Fort Laramie, at 478
  - Fort Lyon, at 489
  - Fort McDowell, at 478
  - Fort Sanders, at 478
  - Fort Selden, at 478
  - Fort Snow, at 489
  - Fort Thomas, at 489
  - Fort Verde, at 478
  - Fort Yuma, at 276
  - Goshen, at 494
  - Greatest, Arizona, in 66
  - Hot countries, in 230
  - Increase at Fresno of 42
    - of foliage and plants by 74, 406
    - going westward 230
    - of, on account of irrigation 390, 478
  - Inches of 386
  - Julian, at 237
  - Kern County, in 276
  - Lemoore, at 276
  - Lewis Valley, at 299, 418
  - Light 210
  - Map of 489
  - Maricopa, at 488
  - Maximum 488
  - Minimum 478
  - Monterey, at

Page.

- Rain-fall, references to—Continued.
  - Mountains, on ... 72, 355, 487
  - Pantana, at ... 469
  - Phœnix, at ... 489
  - Prescott, at ... 489
  - Salt Lake City, at ... 72, 73
  - San Diego, at ... 385, 476
  - Santa Fé, at ... 478
  - Statistics of ... 209
  - Squaw Valley, in ... 184
  - Summer ... 31, 488
  - Territories, in ... 205
  - Timber, relation to ... 233
  - Tucson, at ... 469
  - Tulare, at ... 237, 276
  - Uncertain ... 295
  - United States, of ... 73
  - Utah, in ... 68
  - Visalia, at ... 276
  - Winter, in ... 401
  - Yuma, at ... 401, 406, 489
- Ranches, references, and names:
  - Algadones ... 379
  - Barker's, John ... 315
  - Bear Lake, at ... 23
  - Bellevue ... 303, 315
  - Belle View ... 397
  - Bennett's ... 137
  - Buena Vista ... 293, 301, 314
  - Burners ... 178, 504
  - Cranes ... 178
  - Kanarra ... 111
  - La Laguna ... 381
  - McClung ... 301, 314
  - Miller ... 86
  - Pinal ... 452
  - Ranchers ... 58, 92
  - Rancho de la Hacion ... 370
  - Rock Creek ... 186
  - San Juan ... 353
  - San Pascual ... 326
  - San Rafael ... 463, 464
  - Stockdale ... 303
  - Tejon ... 315
  - Van Burens ... 42
  - Walker ... 44
  - Walker River, at ... 173
- Reclamation fund of Nevada ... 143
- Reports, States, and Territories, from:
  - Arizona, by Commissioner of Immigration ... 427, 428
  - California, by State Board of Trade ... 188–207
  - Nevada, by State Board of Reclamation ... 129, 145
  - Utah, by governor ... 5–11, 66–73
- Reservoir sites:
  - Locations of ... 48, 49, 57, 59, 62, 66, 68, 69, 78, 81, 85, 86, 89, 93, 96, 98, 109, 116, 119, 132, 138, 145, 155, 197, 233, 266, 278, 279, 286, 325, 329, 331, 358, 374, 401, 424, 425, 426, 430, 431, 449, 461, 470, 471, 473, 479, 498, 500, 501, 511
  - Apache County ... 443
  - Bear Valley ... 336
  - Bear River Valley ... 95
  - Bear Lake ... 23
  - Butte ... 451, 452
  - Capacity of ... 77
  - Damming, by ... 148, 149, 456
  - Devil's Gate Valley ... 65
  - Donner Lake, at ... 474
  - Facilities for ... 31, 81
  - Fish Lake Plateau at ... 42
  - Government action on ... 367, 48, 49, 50

Page.

Reservoir sites—Continued. 42
Grass Valley, in 42
Hope Valley, in 48, 57, 72, 78, 92, 114, 145
In Mountains 78
Lakes 49
Land not wanted for other use 51
Mesas, on the 73
Mountain base, at 268
National City, in 84
Newton, at 418, 420
Otman Cañon 33
Pile drivers constructed by 447
Probable cost of 321
Proposed system of 460
Ruins of 42
Salina Creek, at 42
Sevier Plateau, on 359, 360, 390, 370, 376
Sweetwater, at 148
Tanks, small 65
Three Mile Creek, on 507
Truckee River, on 54
Weber River, on 186, 187
Willow Creek, on ....
Rivers, names of: 409, 731, 445, 448, 457
Agua Fria 117
American Fork 459
Arivaca 43, 114
Ashley Fork 19, 23, 41, 42, 43, 44, 45, 46, 57, 64, 65, 67, 81, 92, 93, 94, 375
Bear 70, 78
Beaver 36, 39, 48, 101
Big Cottonwood 409
Big Williams Fork 424
Big Williams Fork 485
Black 84
Blacksmith Fork 131
Bruneau 241
Carnel 131, 132, 138, 147, 187, 499, 500, 502, 503, 504, 505
Carson 111
Cave 409
Chiquito 220
Chowchilla 32, 33, 41, 43, 50, 51, 71, 72, 104, 105, 129, 130, 214, 319, 376, 377, 378, 379,
Colorado 382, 404, 408, 409, 412, 413, 414, 415, 420, 421, 431, 443, 451, 457, 485, 489, 505
.... 131
Columbia 95
Cottonwood, head of 444
Coyote 84
Cubb 98, 99
Dry Creek 114
Dry Fork or West Fork 500, 501
East Fork 84
East and South Fork, Little Bear 88
East Fork, Pahreah 105, 106
East Fork, Rio Virgin 134
East Walker 43
Escalante 43
Fremont 220
Fresno 270, 401, 404, 406, 408, 409, 410, 412, 413, 414, 418,
Gila 419, 420, 422, 424, 425, 429, 431, 436, 442, 451, 468, 472, 477, 485, 487, 489, 490
.... 43, 71, 72
Grand 68
Great 67
Great Bear 43, 71, 72, 86, 87, 114, 409
Green 409, 432, 456
Hassayampa 43
Henry's Fork 131, 132, 133, 147, 149, 151, 152, 153, 155, 184, 269, 504
Humboldt 14, 30, 39, 61, 67, 96, 97, 98
Jordan 105
Johnson 219, 274, 275, 277, 279, 280, 286, 287
Kaweah ....

Page.

Rivers, names of—Continued.
- Kern, 209, 211, 214, 218, 228, 241, 286, 287, 288, 290, 291, 292, 294, 295, 296, 298, 300, 301, 302, 303, 305, 309, 311, 314, 315, 394
- Kings, 133, 216, 219, 227, 228, 241, 273, 274, 275, 279, 281, 286, 299, 394
- Klamath, 270
- La Seata, 51
- Little Bear, 84
- Little Colorado, 443, 444, 445
- Little Cottonwood, 36, 99, 100
- Little Humboldt, 150, 151
- Little Truckee, 147, 498, 508
- Logan, 84
- Lone Pine, 330
- Los Animas, 51
- Malade, 81
- Mammoth, 88
- Merced, 220
- Middle Fork of Carson, 501
- Minnie Ward, 43
- Mississippi, 448
- Mojave, 319, 321
- Mokelumne, 209, 211, 220, 228, 241
- Muddy, 131, 134, 140
- Narrow Bear, 95
- Nevada, list of rivers, 131
- New, 300, 377, 378, 379
- Nile, 380, 381, 412
- Ogden, and North Fork of, 67, 118, 120
- Old, the, 220, 300, 302, 303
- Owens, 212, 241, 330, 331, 332, 333, 334, 335, 336
- Owyhee, 131, 151
- Paria, 53
- Pedro, 54
- Pitt, 212
- Price, 43, 86
- Prosser, 149
- Provo, 25, 39, 41, 68, 117, 118
- Queen, 188
- Quinn, 133, 150
- Rhone, 486
- Rillito, 467, 468, 469, 472
- Rio in Medio, Colorado Desert, 377
- Rio San Juan, 409
- Rio Puerco, 444
- Rio Verde, 424
- Rio Virgin, 32, 33
- Sacramento, 209
- Salt, 409, 422, 423, 425, 429, 430, 431, 432, 434, 442, 445, 446, 457, 475, 485, 491
- San Carlos, 474
- San Bernardimo, 383
- San Diego, 383, 390
- San Emigdio, 300
- San Gabriel, 242, 326, 327, 328, 320
- San Jaciento, 221
- San Jacinto, 381
- San Joaquin, 219, 227, 228, 299
- San Juan, 50, 51, 72, 104
- San Luis Rey, 383
- San Pedro, 409, 410, 425, 452, 453, 455, 457, 472, 477, 479, 480, 484
- San Pitch, 68, 69
- San Rafael, 43
- San Simon, 425
- Santa Ana, 221, 238, 241, 242, 344, 349, 351, 352, 354, 381
- Santa Cruz, 425, 435, 460, 461, 467, 468, 469, 470, 472, 480, 483, 484, 485
- Santa Clara, 32
- Santa Isabel, 390
- San Juan, 53
- Santa Margarita, 221, 383, 385
- Seviers, 31, 32, 42, 53, 57, 58, 69, 70, 87, 88, 104, 107, 109, 110, 111, 112

Page.

Rivers, names of—Continued.
  Snake ... 131
  Sonora ... 477
  Sonoita ... 459, 472
  South Dry Creek ... 100
  South Fork ... 118
  South Spring ...
  South Willow ... 98
  Spanish Fork ... 40, 68, 117
  Spring ... 90
  Stanislaus ... 220
  Sweetwater ... 370, 375, 383, 390
  Tehachapi ... 300
  Tejon ... 300
  Tia Juana ... 383
  Truckee .. 130, 131, 132, 138, 145, 147, 148, 149, 269, 498, 499, 501, 502, 503, 505, 507, 508, 509, 510, 511, 152, 513
  Tule ... 218, 219, 274, 275, 281, 283, 286
  Tuolumne ... 220
  Uintah ... 43
  Verde ... 409, 424, 445, 457, 476, 485
  Virgin ... 71, 131, 134, 140, 409
  Walker ... 131, 138, 503, 505
  Weir ... 315
  West Walker ... 134
  Weber ... 25, 41, 44, 53, 54, 67, 89, 90, 118, 119, 120, 121
  Whetstone ... 425
  White ... 43, 274, 275, 281, 286, 485
  Yuba ... 375
  Yuma County, rivers of ... 408
  Zuni River ... 444, 445
Rocks, mention of ... 42, 75

S.

Searle's Borax Works ... 332, 333
Seasons and aridity ... 28, 34, 38, 48, 51, 53, 56, 71, 72, 80, 91, 109, 112, 424
  Extraordinary droughts ... 45, 46, 62
  Floods ... 155
  Ordinary ... 93, 94
  Planting ... 469
  Plowing ... 91
  Rainy ... 371
  Spring ... 91
  Warm ... 51
Senators, United States, special mention of:
  Jones, J. K. (Arkansas) ... 150, 151, 153, 154, 155, 156. 189, 215, 218, 228, 232, 235, 236, 239, 267, 268
  Plumb ... 5, 16, 18, 19, 20, 21, 22, 23, 47, 49, 62
  Reagan, John H. (Texas) ... 129, 154, 189, 273, 286, 317, 336, 339, 341, 353, 354, 356, 400, 401, 403, 422, 423, 424, 434, 435, 442, 449, 459, 460, 468, 469
  Stanford, Leland (California) ... 213, 229, 514
  Stewart, W. M., chairman (Nevada) ... 5, 129, 184, 189, 273, 317, 341, 350, 354, 389, 400, 422, 449, 499, 509, 510
Slough of Buena Vista ... 303
    Goose Lake ... 301
    Panama ... 302
Snow-fall, reference to ... 25, 31, 34, 37, 113, 140, 158, 165, 368, 502, 503
  Cañons in winter ... 51
  Depth of, on mountains .. 51, 68, 69, 70, 71, 72, 77, 80, 84, 86, 89, 91, 107, 114, 116, 119, 122, 135, 159, 445, 515
  Region of ... 37, 140, 148
  Wasatch Range, melting on ... 42
  Utah, in ... 269
Soils, reference to:
  Adobe ... 51
  Alkaline ... 14, 77, 237, 278, 284, 328, 377, 379, 423, 424
  Alluvial ... 92, 113, 132, 379, 454
  Clay ... 51, 67, 71, 73, 75, 76, 91, 107, 114, 116, 378. 387

Page.

- Soils, reference to—Continued.
  - Clay, layers of, 75
  - Cultivation of, 24, 81, 383, 385
  - Formation of, 377
  - Granite, 37
  - Gravel, 70, 467
  - Mineral, composition of, 139
  - Nevada, fruitfulness of, 505
  - Productiveness of, 457
  - Porosity of, 157
  - Quicksand, 51, 171
  - Red clay, 374
  - Red sandy loam, 483
  - Sand, 31, 67, 69, 75, 77, 86, 344, 467, 478
  - Sandstone, 75
  - Subsoil, 157
  - White clay, 75
- Small streams, mention of, 11, 12, 17, 18, 25, 28, 31, 33, 38, 42, 45, 50, 51, 58, 64, 67, 77, 78, 79, 84, 87, 90, 91, 94, 96, 105, 114, 117, 119, 331, 434
  - Inches of water in, 93, 94, 140
  - That may be utilized, 191
  - Underground, 167, 466, 467, 478
  - Wasatch, on, 45
  - Weber, in, 41
- Spring used for irrigation:
  - Ash springs, 137, 140
  - Bear Cañon Spring, 98
  - Blind Spring, 81
  - Big Pine Fish Spring, 331
  - Braffit's Spring, 94
  - Claton Springs, 64
  - Dry Cañon Springs, 119
  - Dry Creek Spring, 117
  - Eight Per Cent Spring, 84
  - Fairfield Springs, 117
  - Falula Spring, 94
  - Flowing Springs, 137, 140
  - Fork Springs, 117
  - Fort Meadow Springs, 119
  - Gardner Spring, 84
  - Hiko Spring, 137, 140
  - Large Springs, supply in, 63, 165
  - Logan Springs, 137, 140
  - Morgan City Springs, 90
  - North and South Spring, 90
  - Ogden Springs, supply at, 269
  - Salado, 444
  - Sisson Spring, 509
  - Small, 63, 80, 106
  - Spanish Springs, 514
  - Spring Hollow Spring, 90
- Sonora frontier, the, 420
- Sorghum, growth of, 418, 459
- States, mention of:
  - California, 14, 46, 49, 129, 131, 139, 140, 146, 147, 185, 186, 189, 190, 191, 192, 193, 194, 213, 215, 226, 230, 232, 233, 235, 236, 241, 242, 243, 245, 246, 250, 259, 260, 262, 264, 273, 274, 278, 279, 289, 292, 293, 294, 296, 297, 299, 308, 317, 321, 333, 334, 352, 355, 370, 375, 381, 382, 383, 385, 387, 388, 389, 415, 416, 430, 433, 436, 439, 465, 488, 491, 498, 501, 502, 503, 504, 505, 508, 511
  - Colorado, 19, 31, 46, 51, 55, 72, 76, 108, 145, 209, 212, 358, 378, 402, 427, 436, 514
  - Connecticut, 408, 486
  - Delaware, 408
  - Florida, 139, 391, 254, 505
  - Idaho, 46, 81, 92, 129, 436
  - Illinois, 24, 473
  - Kentucky, 246, 278, 514
  - Massachusetts, 362, 486
  - Minnesota, 504, 505
  - Montana, 436

Page.

States, mention of—Continued.
Nebraska 151
Nevada 66, 70, 72, 129, 130, 131, 134, 135, 138, 139, 142, 143, 144, 145, 146, 147, 148, 150, 151, 177, 178, 184, 185, 186, 436, 498, 499, 501, 502, 503, 506, 507, 508, 509, 510, 513
New Jersey 383
New Mexico 408, 427, 436, 477, 487
New York 209, 415
Ohio 74
Oregon 129, 436
Pennsylvania 362
Rhode Island 408, 486
South Carolina 418
Sonora 408, 413, 478
Tennessee 279
Texas 504
Washington 436
Wyoming 92, 409
Storage reservoirs, reference to 25, 31, 34, 77, 167, 174, 199, 228, 236, 237, 267, 275, 322, 353, 354, 408, 419, 449, 453, 455, 457, 458, 475, 476, 477, 486, 510
Nevada Land and Cattle Company, system of 184
Resources for 70
Salt River 471
Sevier Lake Desert, in 59
Squaw Valley, in 154
Streams, by 64
Streams crossing the Sierra Nevadas 269
Storm-floods 435, 457
Storm-floods, by 435, 457
Wet season, in 29
Winter storage of 18
Supreme court of California, on water 247
Utah, decisions of 50
Surveys for irrigation 48, 51, 54, 281, 354
Government, for reservoir storage 161
Hydrographic 164
People can utilize 54
Reservations of reservoir sites 57
Topography 209
Topography of country 25
Topography of Nevada 130
Topographical advantages 190
United States geological 77, 135, 188, 189, 293, 296
United States by effect of 158
Utah Lake of 55
Report on engineers 43
Swamp-land act of California 290

T.

Tobacco 379, 401
Trees, mention of:
Ash 432
Banana 388
Brush 506
Camphor 388
Catalpa 432
Cottonwood 378, 506
English walnut 388
Ironwood 408
Lombardy 432
Locust 432
Magnolia 432
Mesquite 378, 408, 432
Mulberry 432
Palm 432
Pepper 432
Poplar 432
Rubber 388

Page.

Trees, mention of—Continued
- Timber growth 451
- Umbrella 432
- Vines and in Nevada 143
- Willow 378, 432

Towns, in and region, references to:
- Adamsville 79
- Adonde 418
- Alpine 117
- Alta 269
- American Fork 117
- Amsterdam 44
- Analheim 353
- Annabella 111
- Ashland 270
- Athens 381
- Aubrey 409
- Austin 504
- Bajai 378
- Bakersfield 217, 288, 290, 291, 292, 299, 300, 302, 303, 305, 314, 397
- Beam 79
- Beardsley 306
- Beaver 79
- Benson 479
- Berendo 227
- Big Pine 331, 334
- Bisbee 466
- Bluff 52
- Boca 498, 513
- Boston 74, 235
- Box Elder 66
- Brigham 62, 63, 64, 65, 80
- Cajon 387
- Caliente 299
- Calabasas 462, 484
- Camp Reno 444
- Candelaria 504
- Carizo 376
- Colton 266
- Colusa 226
- Coneto 444
- Corinne 19, 44, 45
- Crittenden 463
- Croyden 67
- Darwin 332
- Daytona 391
- Delano 314
- Deming 418, 476
- Denver 72
- Des Moines 72
- Dudlyville 477
- El Cajon 389
- Elko 504
- Elsinore 111, 381, 382
- Embryo 44
- Empire 499
- Estrecho de Rientes 361
- Etiwanda 327
- Eusenada 352
- Eustis 391
- Fairfield 117
- Fairview 107
- Fall Brook 355, 385, 386
- Florence 408, 419, 423, 425, 428, 432, 450, 451, 452, 453, 454, 489, 490
- Frisco 334
- Fowler 272
- Garden City 91, 96
- Genoa 500
- Gila Bend 270, 432. 433

Page.

Towns, in and region, references to—Continued. 105, 327
Glendale 473, 475, 476
Globe 488
Goodwin 117, 276, 299
Goshen 79
Greenville 129
Greenwich 118
Grove 399
Gungapoor 227, 277, 279, 280
Hanford 44
Hampton Bridge 466
Harshaw 508
Hawthorne 357
Highlands 140
Hiko Village 80
Honeyville 276
Hornbrook 500, 501
Horse Shoe Bend 87
Huntington 67, 119
Huntsville 269
Indio 376
Jacume 42, 69, 111
Joseph City 42, 57
Juab 386
Julian 331
Keeler 91, 96
Lake Town 436
La Tempe 117
Lehi 276
Lemoore 314
Lerdo 391
Livermore 463
Lochiel 140
Logan Village 132, 146, 152, 153, 269, 504
Lovelocks 46
Malad 117
Mapleton Ward 74
Mariette 501
Markleville 112
Marysville 91, 96
Meadowville 451
Mesa 79
Milford 79
Minersville 235
Mobile 232, 335
Mojave 111
Monroe 115
Mount Carmel 79
Mountain Dell 107
Mount Pleasant 89
Morgan 279
Mussel Slough 57
Nephi 391
Newburg 334
Olancha 357
Oneonta 339, 341, 344
Ontario 151
Oreana 361
Paisley 332
Panamint 425
Pantano 420
Parker 67
Parley's Park 436
Pima 118
Pleasant 504
Pioche 81
Portage 89
Porterville 359
Portland

Page.

Towns, in and region, references to—Continued.
- Poso, 314
- Promontory, 81
- Provo, 38, 39
- Randolph, 96
- Red Bluff, 247
- Redding, 270
- Redington, 463
- Redlands, 231, 336
- Richfield, 108, 109, 111
- Rocklin, 269
- Salton, 377
- San Emigdio, 398
- San Felipe, 376
- San Ignacio, 378
- San Jacinto, 355, 387
- San Joaquin, 208, 213, 227
- San Luis Rey, 355
- San Marcus, 357
- Santa Maria, 386
- San Pitch, 42
- San Pete Valley, 57
- Scipio, 104
- Sentinel, 270
- Sheffield, 361
- Sheridan, 500
- St. Johns, 442, 443, 444
- Solomonville, 477
- South Field, 79
- Spring, 107
- Springville, 117
- Springerville, 443
- Summit Station, 269
- Tahoe, 499
- Tehachapi, 333
- Temecula, 390
- Tempe, 423
- Tia Juana, 357
- Tombstone, 466
- Tulare, 268, 276
- Tuscarora, 504
- Tustin, 353
- Vallecitos, 376
- Verdi, 148, 498, 508
- Victor, 321
- Viejas, 386
- Vineland, 391
- Virginia City, 335, 503
- Visalia, 268, 276, 280, 281, 317
- Wadsworth, 269, 498, 501, 506, 508, 514
- Walters, 269, 270
- Wellington, 504
- West Portage, 65
- White Plains, 146
- Willard, 63, 64
- Williamsburgh, 362
- Winnemucca, 504
- Woodruff, 96, 489
- Yuma, 270, 400, 401, 402, 403, 404, 405, 406, 413, 415, 418, 423, 424, 426, 428, 431, 434, 436, 489
- Tulare Grange, the, 273

U.

Utah, irrigation ditches in:
- Alva Keller, 102
- Atkins & Sons, 124
- Annabella Irrigation, 111
- Avery Powell, 87
- Bear River, 22, 39, 64, 94

Page.

Utah, irrigation ditches in—Continued.
- Beckwith 94
- Beckstead 97
- Bellevue 124
- Bensen & Logan 84
- Big Cottonwood 100
- Big Cotton-wood Tanner 101
- Birch Creek 84, 119
- Blacksmith Fork 84
- Blue Cut 86
- Bluff 52
- Booth, Crocker, Crawford 94
- Boutwell, The 18
- Braffitts Spring, north and south 94
- Brigham Young 102
- Brockbank 86
- Brooklyn 110, 111
- Brown & Sanford 100
- Bryon 102
- Burch Creek 118
- Burns Bench 115
- Benton 115, 116
- Butterfield 98
- Cahoon & Maxfield 99
- Casper Chrislensen 86
- Castle Dale 86
- Central 114, 115, 116
- Chadwick 115, 116
- Chatelain 120
- Chapman & Strong 94
- Chrisman 102
- Chivers 115, 116
- City Creek 84
- Claton 84
- Clipper 84, 86
- Cubb River Irrigating 84
- Colton 115, 116
- Cottonwood 90, 94
- Coveville, lower and upper 84
- Crandal 87
- Crawford and Dykins 94
- Croydon, upper 90
- Dalton 90
- Day, upper 87
- Deep Cañon 84
- Dillman 115, 116
- Dodds 115, 116
- Doronenor and Brooks 115, 16
- Draper 98
- Dry Creek 98
- Dry Fork, north and south 98
- East Jordan 97, 99
- East Porterville 90
- East Richville, upper and lower 90
- Eden 118
- Edward White 103
- Eight Private 90
- Eleven Private 90
- Elsmore Irrigation 108, 109
- Fairchild 115, 116
- Ferrins 118
- Foreman 111
- Frank Laws 118
- Franklin and John Neff 102
- Gardner 84
- Glendale, east and west 106
- Green River 87, 101
- Gordon Creek 90
- Halls 118

Page.

Utah, irrigation ditches in—Continued.
- Harrisville 118
- Hill 86
- Humble 87
- Huntington 87
- Huntsville ....
- Huskinson 104
- Hutchinson R. R 86
- Hoagland 102
- Hoopers 118
- Ira Nebeker 94
- Isaacson 109
- Jeffs 86
- Jenkins 118
- Jensen 87
- Joseph Irrigating 110
- Jordan and Salt Lake 97
- Kanabfield 106
- Kanal City 106
- Kannedy 103
- King Ditch 86
- Langsdorf's 118
- Lake Town No 1, or north 94
- Lake Town No 2, or south 94
- Lake Town and Round Valley 94
- La Berkin 124
- Leeds 124
- Lee, W. H 94
- Lehigh 117
- Lewiston 84
- Lindsay 120
- Lindsay & Shaw 121
- Line Creek Irrigation Company 90
- Littleton Cañon Creek Irrigating Company 90
- Lynne 118
- Logan & Benson 84
- Logan and Hyde Park 84
- Logan & Richman 84
- Logan River 84
- Long Valley 106
- Loss Creek Irrigation Company 90
- Lower South 86
- Lower Dam 84
- Main Creek 113
- McHadden & Cleveland 87
- McKee 115, 116
- Meadowville 94
- Meadowville, West and Lower 94
- Middle Creek 113
- Middle Fork 118
- Middleton 124
- Millville, Nos. 1, 2, 3, 4 84
- Molen 86
- Monroe 111
- Montgomery & Roylance 118
- Mount Carmel, East 106
- Mount Carmel City 106
- Morsen Torensen 111
- Mountain Dell 124
- Mountain 118
- Muddy 86
- Munroe Irrigation Company 110
- Murry 115
- Neff, A. H 101
- Newton 84
- Nichol 100
- North Jordan 97
- North 87, 94
- Ogden Bench 118

Page.

Utah, irrigation ditches in—Continued.
  Ogden City ... 11
  Ogden, North ... 118
  Orderdale, West ... 106
  Otter, North and South ... 94
  Otter Creek Company ... 94
  Pack and Mill Creek ... 87
  Paradise, East and South ... 84
  Parker ... 98
  Parley's Irrigating ... 104
  Peterson ... 86, 90
  Pioneer, No. 1, No. 2 ... 86
  Pinto ... 124
  Plain City ... 118
  Pleasant Grove ... 117
  Portage ... 81
  Price ... 124
  Price Water ... 86
  Providence, Nos. 1, 2, 6, 7 ... 84
  Provo Bench ... 118
  Powell & Katell ... 115, 116
  Randolph Irrigating Company, Upper and Lower ... 94
  Randolph & Woodruff ... 94
  Richfield Irrigation ... 108
  Richards ... 100
  Richville Mill-race ... 90
  Richmand ... 84
  Riries ... 118
  River Dale ... 118
  Robert Snider ... 86
  Rock Point ... 115, 116
  Rocky Ford ... 111
  Round Valley Spring and Weber River ... 90
  Russell ... 102
  Salt Lake ... 97, 118
  Santa Clara Irrigating ... 124
  Sevier Valley ... 108
  Skidmore ... 102
  Smith ... 86
  Sink Valley ... 106
  Snyder ... 115
  South Willow Creek ... 99
  South Laketown, No. 2 ... 94
  South Jordan ... 97
  Stunaker ... 115, 116
  Stillman ... 102
  Stimpson & Dyke ... 118
  Strong's Cañon Creek ... 119
  Swan Creek ... 94
  Table of Ditches ... 88
  Tanner ... 99
  Taylor ... 115, 116
  Tooele Co. of ... 113
  Trenton ... 84
  Tucker ... 115, 116
  Turnbow ... 103
  Uintah County Irrigation ... 115, 118
  Union, Jordan ... 99, 100
  Union ... 115
  Union ... 116
  Utah and Salt Lake ... 97
  Upper Dam ... 84
  Upper Water ... 115
  Upper Kanab ... 106
  Upper ... 101, 116
  Upper South ... 115
  Veltman & Co ... 115
  Vermillion Irrigating ... 109
  Virgin City ... 124

Page.

Utah, irrigation ditches in—Continued.
- Virgin Field, 124
- Wakefield, 87
- Walker, 100
- Walton, W. K, 94
- Wasatch County, 68
- Washington County, 124
- Washington Town Field, 124
- Watsons, R. H, 86
- Weber and Davis, 118
- Weber County, 118
- Weir, 12
- Wells, 111
- Wells Irrigation, 108
- Wellville, South, 84
- Wellington, 86
- West Porterville, 90
- Westover, 124
- Wilcox, 86
- Wilson, 118
- Woodruff & South, 94

V.

Valleys, description of, 150, 370
- Elevation of, 51
- Pahrangat, 140
- Squaw, 160

Valleys, names of:
- Altar, 484
- Antelope, 133, 318, 319, 320, 325, 330, 331, 332, 333, 334, 335, 336
- Arid valleys, 70
- Ashley, 68, 114
- Babequivari, 472
- Bear, 24, 233, 329, 330, 346, 386, 498
- Bear Lake, 91, 92, 94
- Bear River, 91, 92, 94
- Beam, 78
- Beaver, 80
- Big Cheyenne, 424
- Big Grand, 86
- Big Meadow, 150, 151, 152, 153
- Black's Fork, 133
- Blen Spring, 87
- Blue Spring, 81
- Bruneau, 133
- Cache, 19, 20, 21, 46, 64
- Carson, 132, 187, 498, 499–500
- Castle, 71, 86
- Cave, 134
- Cedar, 42
- Charity, 501
- Clover, 133, 150, 155
- Colorado, 140, 407, 410, 412, 415, 458
- Cottonwood, 86
- Devil's Gate, 65, 80
- Diamond, 133, 500
- Dog, 498
- Duck, 134
- Dutch, 500
- Eagle Lake, 132, 134
- Edgar, 95
- Ferron, 86
- Fresno, 228
- Garden, 133
- Gila, 407 408, 410, 411, 412, 415, 418, 420, 422, 425, 427, 428, 429, 457, 458, 475, 489, 490
- Goshen, 42
- Grass, 69

Page.

Valleys, names of—Continued. 133
- Grubb's 479
- Happy 78
- Ha Wah Wah 233
- Hemet 132, 150, 151, 154, 502
- Humboldt 500, 501
- Hope 86
- Huntington 133
- Independence 86
- Joe's 57, 70
- Juab 133
- Kelly 227, 293, 298, 299, 300, 303, 314
- Kern 133
- King's River 134
- Lake 133
- Lamoille 134
- Las Vegas 149
- Lehman's 132
- Lemmon 276
- Lewis 86
- Little 424
- Little Cheyenne 133, 150
- Little Humboldt 105, 106, 500, 501
- Long 133
- Maggie Creek
- Mantua 133
- Mary's River 134
- Mason 134
- Meadow 78, 80
- Minersville 134, 433
- Mississippi 133
- Monitor 86, 134
- Muddy 133
- Newark 457
- Nile 67, 118, 119
- Ogden 195, 331, 332, 334, 335, 336
- Owens 133, 502
- Owyhee 134, 137, 139, 140
- Pahranagat 134, 137, 139, 140
- Pahrimp 69
- Panquitch 133, 150, 151, 504
- Paradise 133, 386
- Pine 96, 133, 501
- Pleasant 514
- Prosser 39, 68
- Provo 408
- Puebla Vieja 188
- Queen River 133, 150
- Quinn River 69
- Rabbit 133
- Rebel Creek 139
- Rio Virgin 186
- Rock Creek 155
- Ruby 70, 112
- Rush 148, 209, 210, 213, 234, 235, 269, 270
- Sacramento 78
- Sage Brush 21, 31, 64, 67, 68, 73, 118, 119
- Salt Lake 409, 422, 427, 428, 429, 431, 433, 434, 458
- Salt River 338, 241, 242
- San Bernardino 475
- San Carlos 266, 508
- San Gabriel 233
- San Jacinto
- San Joaquin 209, 210, 211, 212, 213, 214, 215, 216, 227, 228, 234, 237, 239, 241, 244, 269, 273, 294, 297, 299, 311, 333, 387, 396, 455, 479, 480
- San Pedro 68, 69
- San Pete 478, 479, 480
- San Simon 349, 351
- Santa Ana

Valleys, names of—Continued. Page.
  Secret 178
  Sevier 68, 69, 70, 75, 107, 111
  Shasta 270
  Silver King 501
  Sink 106
  Skull 70, 112
  Smith 134
  Snake 134
  South Fork 290
  Spanish Spring 132, 514
  Spring 134
  Springerville 443
  Squaw 154, 155, 160, 184, 186, 498
  Stanislaus 227
  Star 133
  Strawberry 117
  Steptoe 133
  St. Johns 444
  Sulphur Springs 425, 477, 478, 479, 480
  Susie Creek 133
  Sweetwater 371
  Thistle 68
  Tooele 70, 73, 75, 112
  Tonto 475
  Truckee 498
  Tulare 213, 274
  Utah 41, 68
  Vegas 139
  Virgin River 134
  Volcano 331, 334, 335
  Warm Spring 132
  Washoe 132
  Wasatch 70, 76
Vegas, Wash 505
Vegetables, growth in arid region 69, 93, 94, 97, 98, 99, 100, 103, 104, 108, 109, 110,
356, 385, 388, 411, 418, 443
  Beets 86, 379, 385, 388, 401, 411
  Cabbage 388
  Carrots 86, 388
  Cauliflower 388
  Corn 100, 459
  Onions 388
  Peas 388
  Potatoes 18, 80, 163, 350, 378, 388, 418, 449, 459
  Pumpkins 410, 421
  Roots 67, 69, 77
  Small garden 114
  Tomatoes 388
  Turnips 388
Vines, growth of 143, 287, 309, 327, 343, 383
  Grape 316, 352, 355, 389, 404, 430, 432, 464, 465
  Hop 316

W.

Water, cost, customs, extent, etc:
  Actual tax for right of 57
  Amount could be stored 161
  Amount to irrigate one acre 116
  Amount required of 45, 64, 116
  Ancient ways 458
  Annual cost of 57
  Apportionment of 65
  Appropriation of 13, 19, 25, 45, 318, 323
  Arbitration 66
    by Mormon Church 58
  Assessments for supply of 14
    annual, of 98
  Average depth of 450
  Boxes for 114
  Cubic feet of 38, 41, 45, 47, 56, 67

Page.

Water, cost, customs, extent, etc.—Continued.
  Cubic inches of 35
  Culinary purposes, for 29
  Débris and sediment of 481, 482, 483
  Depth of, at Lower Rock Island 419
  Developed by submerged dams 381
  Diminished supply of 238
  Distribution of 28, 59, 338, 345, 349, 375, 442
  Distribution in Los Angeles 322
  Capacity of 26
  Claims to 85, 211
  Company, stock in 13, 25, 27, 40
  Costs of rented 27
  Diversions of 12, 44, 46
    of, Salt Lake County, in 14
  Drainage of 14, 29, 46, 216, 217, 218. 480
  Duty of 56, 66, 67, 69, 70, 71
    72, 86, 115, 116, 124, 215, 216, 228, 230, 266, 345, 347, 338, 355, 414, 422, 429, 450
    of water-master 11, 12, 13, 28, 29, 56, 60
  Economy of 324, 325, 328
  Effect on wells by increase 232
    of sediment in 239
  Embankments for retaining 311
  Examination of supply during the year 241
  Excessive use of 339
  Flow, cubic feet of 45, 46
  Fresh 64
  Free use of 247
  Gallons consumed daily 35
  Gauging stations 59
  How to get 58
  Irrigate, to, inches of 35
  Judges, Nevada, distributing 13
  Lagunas in which could be stored 471
  Lack of 69
  Lakes as reservoirs 24, 36, 130, 148, 269
  Land-owners 59
  Law of, imperative 59
  Lawful appropriation of, for irrigation 48
  Limit appropriated 13, 60
  Locating reservoirs in Utah 25
  Loss of 216, 217. 347
  Measurement of 56, 59
  Methods of using 25
  Miles of mains 35
  Module for measurement of 305
  Organizing companies 5, 11, 13, 15
  Owners of ditches 11
    land of 59
    of sites 57
  Plan of distributing at Phœnix 442, 457
  Potable 378
  Power by 499
  Price of 12
  Primary owners of 5, 11, 13, 86, 104, 109, 111
  Priority, system of 59
  Prior appropriators 13, 18, 59, 246, 247
  Private ownership 13, 40, 98
  Probate court registration 28
  Property of State 13
  Public opinion on wasting 13
  Public ownership and control 393–399
  Pumping at Pasadena 231
  Quality of, for irrigation 236
  Quantity of, Nevada mountains 505
    for first or second years of irrigation 157
  Renters of 12, 13, 27
  Rights of users 11, 12, 14, 16, 17, 18,
    59, 77, 89, 90, 91, 95, 99, 118, 119, 120, 122, 228, 292, 349, 376, 339, 451, 448, 495

Page.

Water, cost, customs, extent, etc.—Continued.
Rights from running streams 119, 120
of way reserved 36
nature of 95
Judge Smith on 56
Riparian 245, 246, 288, 324, 439, 495, 511
Running waste 17, 63, 64, 70, 340
Scarcity of 13, 16, 116
Secondary rights 59
Separate reservoirs for 37
Service of 442
Shares of 12, 56
Stealing 46
Speculation in eliminated 247
Stock 25, 57
Temporary reservoirs 25
Territorial ordinance 28
Third right 59
Times of scarcity of 59
Titles of, in California 244
Torrents of 31
Ton of, to irrigate one acre 35
Use at Brigham City 62
Use of, Judge Goodwin, by 13
Use of, California, in 394
Use in Utah of eastern Sierra Nevada supply 512, 513, 514
Usages, Spanish, at Los Angeles 323, 324
Utilizing lakes at Provo River 41
Value of 287
Volume of 46
Waste 13, 14, 23, 37, 71, 135, 230, 282, 284, 290, 295, 456, 481
Works 96

Water, natural facts relating to:
Alkali, what used for 14
Evaporation area 17, 23, 28, 32, 42, 61, 65, 161, 186, 483
experiments 209
effect on 467
on mesa land 186
in mountains 72
at Reno 505, 506
at Pima 419
Evaporating pans, use of 72
Melted snow, precipitation of, in high latitudes 25, 139
Percolation of 42, 239, 423
Precipitation, average 62
on mountains 139
in valleys ....
Seepage of 28, 53, 65, 89, 103, 109, 111, 309, 314, 326, 329, 332, 334, 342, 344, 347, 349, 350, 398, 409, 421, 445, 482, 513, 514
Sheds 30, 37, 38, 148, 452, 472, 474, 477, 480, 486, 499, 501, 502, 508
Gila, of the 489
Santa Cruz, of 466
San Vedro River, of 478
Rillito, of 466
Truckee River, of 506
Utah, of 66
Verde and Salt Rivers, of 491
Sinking of, into sand-beds 283
Small streams from 270
Source of supply 17, 57, 62, 63, 88, 89, 163, 274, 275, 344
Spouts 185
Subterranean 73, 167, 273, 274
Supply of, sufficient 25, 30, 31, 33, 38, 39, 53, 57, 63, 65, 66, 67, 69, 71, 72, 76, 77, 80, 81, 84, 87, 89, 94, 95, 107, 117, 209, 213, 214, 236, 278, 295, 304, 329, 353, 354, 377, 378, 423, 400, 406, 415, 429, 457, 458, 476, 477, 480, 486, 490, 498, 499, 504, 505, 506, 507
of, Antelope Valley, in 319, 325
by canals, by 358

Page.
Water, natural facts relating to—Continued.
Supply from cañon 63
Increase of 34
Los Angeles, at 325, 326
Mountain water-shed, of 466
Rain-fall, by 385, 386, 387, 389
Salt Lake City, at 34
San Diego, at 390
San Bernardino Valley, in 241, 242
Yuma, of 415
Surface 70
Surplus of 11, 16, 37, 89, 92, 96
Surplus storage, of 37, 453
Surveyor-general's report, Nevada, on 138
Surveys for storage of 54, 489, 490
Supply systems, of 13
clay pipe, by 327
depends on location of 230
distributing 275, 343, 360
Etwanda, at 231
gauge, the 230
Hesperia, at 322
iron pipe, by 326
Ontario, at 231
pipe service, economizes 329, 330
Pomona, at 230
reservoirs, by 32, 57
storage to help out low 158, 229
to bring on land 157
Tulare County, catchment in 468
Tunnel construction for 280, 322, 468, 499
Volume of, in Humboldt River 153
Volume of streams 63
Water storage 6, 14, 17, 18, 22, 23, 25, 29, 34, 36, 38, 39, 40, 41, 42, 43, 45, 46, 51, 52, 53, 54, 58, 64, 65, 66, 67, 70, 71, 72, 77, 80, 91, 92, 96, 104, 105, 135, 139, 150, 154, 238, 248, 268, 276, 283, 296, 445, 446, 449, 456, 457, 462, 472, 484, 485, 500, 507, 511, 512
At Bear Lake 23, 42, 54
Capacity for 506
For irrigating 1,000 square miles 49
Weirs 305, 310, 311, 322, 337, 359
Calloway, on 309, 314, 315
Canal, of 310
Pioneer Bridge, at 314
Winds:
Desiccating, effect of 238
Polar, the ill effect in California 235
Witnesses' names:
Adams, P. T 352
Agiurre, Mr 484
Allan, Peter 104
Alexander, Colonel 396
Anderson, S. A 105
Ash, Joseph W 117
Baker, D. M 351, 352
Banks, T. C 117
Barker, John 397
Barnes, W. H 473
Barney, Walter 86
Beatie, A 114
Beattie, G. W 338, 339
Bent, Mr 320
Benson, William H 452
Black, John A 463
Black, Joseph H 114
Blackhouse, James 117
Blaisdell, H. W 400, 401, 402
Blakeslee, L. A 145
Blodgett, J. A 290, 291

Witnesses' names—Continued. Page.
Blowers, B. R 233
Bowman, H. E 106
Brady, Peter R 452
Bradley, J. R 145
Breckenbridge, William M 430, 431, 434, 446
Brewster, Cameron 463
Bristol, Judge 327
Bridges, Lyman 214, 498
Brinley, Charles H 403
Brit, William 114
Brodie, A. O 456
Broiler, E. A 286
Brown, O 289
Brown, B. T 338
Brown, George W 450, 452
Brown, W. E 508
Bonnelli, Daniel 139
Bothwell, John D 92
Bunderson, P. V 86
Butler, W. C 336, 337, 338
Cameron, Alice 465
Brewster 470, 471
Canfield, W 291, 292
Carr, William B 292
Carter, William 267
Castle, Fred'k 477
Casto, C. A 96
Clark, William H 107, 112, 114
Clark, George H 391
Chapman, W. S 227, 273
Chipman, N. P 216, 234, 247
Christensen, Casper 86
Crocker, Charles 507
Coffman, B. S. 477
Collier, William 233
Cook, E. H 476
Coronel, Don. Antonio F 317
Covell, A. T 227
Cunningham, F. H 267, 268
Cushing, Frank H 433, 458
Cushing, Hamilton 435
Davidson, A. J 396, 466
Denton, William 376, 380
Dewitt, M. E 283, 284
Dixon, W. L 292
Dods, Pardon 114
Dunbavard, Joseph 391
Durant, J 90
Eaton, B. S 323, 324, 325, 328
Edwards, E. E 352, 353
Edwards, T. D 129, 145
Enneking, William 356
Ephraim, James 89
Erwin, A. O 285
Estee, M. M 189, 213, 235, 239, 240, 247, 249, 266
Evans, C. S 341, 342, 343, 344
Evans, Elvaro 512
Farrer, J. F 87
Farish, T. E 422–428
Fairchild, John 114
Fish, A. C 265
Fowler, Thomas 509, 511
Fowler, Lincoln 434–441
Fowler, Samuel 287
Fox, Jesse W 24
Frampton, William N 117
Francis, S 89
Frankish, Charles 339, 340, 341

Page.
Witnesses' names—Continued.
Fraoulson, George ... 86
Friend, C. W ... 177
Fulton, W. L ... 145, 148, 149
Fulton, R. L ... 507, 509, 512
Gage, Matthew ... 232, 349, 350
Glassford, W. A ... 415, 456, 457, 486
Gleno, John ... 114
Graeff, William ... 465
Graham, William ... 114
Grauns, F. E ... 86
Green, W. S ... 226
Greenwood, B. H ... 108
Greely, A. W ... 487, 488
Guild, William E ... 449, 452
Gunn, Douglas ... 358, 359, 382
Goivanetti, M ... 395
Goodwin, F. H ... 459, 463
Hacking, James ... 114
Haggin, J. B ... 292, 297, 311
Haines, J. W ... 187
Hall, William H ... 208, 209, 210, 212, 213, 215, 230, 235, 266, 275, 394
Hammond, F. A ... 50, 104
Hamill, J. H ... 476
Hancock, William A ... 445, 446, 447, 448
Harrison, Henry A ... 391
Hatch, Jeremiah ... 114
Hatch, Alva ... 114
Heald, F. H ... 381, 382
Hemingway, George ... 458
Hensley, George V ... 357, 358
Henry, George ... 420, 421, 422
Heney, Francis J ... 463
Herman, Charles A ... 112
Heslep, B. F ... 465
Hesson, A. W ... 154, 155, 156
Hicks, Louis A ... 406, 407, 420
Hilgard, E. W ... 236, 240
Hoffman, C. H ... 227
Holt, L. M ... 230, 231, 232
Holley, E. Dwight ... 188
Hollister, O. J ... 41
Howe, H. G ... 477
Hughes, Thomas ... 272
Hunter, E. W ... 90
Huntington, O. B ... 117
Huntington, C. P ... 507, 508
Hurley, James M ... 451, 452, 469
Hutchinson, R. R ... 86
Ingalls, O. T. S ... 402, 403
Irish, Charles W ... 156, 502
Jansen, E ... 227
Jarvis, Joseph ... 347, 348
Jenkins, Washington ... 119
Jensen, James S ... 96, 108
Johnson, Chas. J ... 87
Johnson, A. G ... 117
Johnston, A ... 114, 117
Johnston, David ... 114
Jolley, R. G ... 105
Jones, Marcus E ... 66, 73
Jones, E. W ... 322
Jones, Joseph D ... 38
Julien T. V ... 148
Kelly, John ... 114
Kemp, H. E ... 431
Kibbey, Joseph H ... 452, 454
Kin, John W ... 44

Page.

Witnesses' names—Continued.
- King, Cameron H, 412, 416
- King, M. C, 273
- Kirk, William, 117
- Kirney, L. B, 108
- Knapp, M. A, 330
- Langrelhr, Henry C, 357, 358
- Le Duc, W. G, 378
- Lindsay, Tipton, 281, 282
- Little, James L, 30
- Luckett, John, 117
- Lyons, Charles, 114
- Manuel, George, 227
- Marks, Bernhard, 234, 247, 273
- Martin, Charles T, 476, 509
- Mayberry, James, 148, 509
- McEwen, George W, 317
- McFadden, James, 350, 351
- McQuiddy, T. J, 279, 280, 281
- Mendell, Major, 396
- Mercley, George, 114
- Mercley, Nelse, 114
- Mills, M. M, 208, 228, 234, 239, 243
- Mills, W. H, 512
- M'Millan, J, 442
- Miller, N. P, 86
- Miller and Lux's, 315
- Montgomery, Victor, 353, 354
- Moore, J. M, 284
- Moore, Justin S, 379, 380, 381
- Moseley, Edward B, 457
- Munroe, George, 104
- Murray, C. H, 476, 477
- Murphy, W. J, 428, 429, 430
- Naftzger, A. H, 348, 349
- Nebeker, W. P, 93, 96
- Nelson, Jens, 86
- Newell, T. H, 55, 107
- Newland, Francis G, 507, 509, 510
- Newman, G. O, 344, 345, 346, 347
- Norton, Geo. W, 412
- North, John, 341
- O'Kane, John, 151, 153
- Ottinger, G. M, 34
- Oury, F. W, 480
- Palmer, P. M, 151
- Parkinson, T. D, 184
- Patten, H. W, 318, 321, 329
- Peck, George H, 325, 326, 327
- Perrin, B. E, 235
- Peters, John D, 62
- Peterson, Jas. H, 107, 112
- Platt, W. E, 442–445
- Porter, Joseph R, 89
- Porter, J. P, 90
- Porter, E, 105
- Powers, F. T, 476
- Powell, W. S, 114
- Reed, James, 114
- Riddle, Isaac, 111, 162
- Riley, B. F, 150
- Roth, John, 268
- Safford, A. K. P, 472
- Sargent, A. A, 395
- Schuyler, James D, 369, 370, 371, 372, 376, 390
- Scott, Joseph, 96
- Sedgwick, Thomas S, 359–370
- Shanley Patrick, 476
- Shorb, De Barth J, 327, 328, 329

Page.
Witnesses' names—Continued.
Simmens, William 565
Sloan, Richard E 452
Smith, M. A 477
Smith, Baird 399
Smith, Elias A 11
Snider, Robert 86
Snyder, R 114
Springmeyer, Herman 145, 499, 500
Stanford, Leland 507, 508, 512
Steiger, J. B 407, 418, 419
Stewart, T. K 148, 459
Stoddard, C. H 148
Stone, Charles P 378
Stout, J. H 451
Taggart, J. H 404, 406
Taylor, T 414
Taylor, A 114
Taylor, William 86
Thies, J. H 153, 154
Thimber, Albert D 108
Thomas, Robert 117
Thomas, Arthur L 477
Thomas, Albert L 5, 65
Thorn, George 114
Touhy, John 273
Towne, C. A 227
Trippel, Alexander 473–476
Trippel, E. G 406, 407
Tuohy, John 268
Urton, John 277, 279, 280
Van Buren, A. C 86
Van Dyke, Theodore 354, 355, 356, 383
Veltman, R 114
Wade, George H 87
Waite, John A 352
Wallace, J. H 269
Walker, Joseph R 36
Walker, A. B 117
Watson, R. M 86
Wetmore, E. R 462
Wetmore, E. L 469
Wheeler, —— 509
Wheeler, O. L 411
Wheeler, R. G 151
White, T. J 477
Wilson, H. M 138
Williams, Evan 145, 511
Wilcken, Charles H 28
Wood, Leonard 484
Wooley & Seymiller 105
Wright, C. C 248, 249
Wrinkle, L. T. J 335

O

REPORT

OF THE

SPECIAL COMMITTEE

OF THE

UNITED STATES SENATE

ON THE

IRRIGATION AND RECLAMATION OF ARID LANDS.

PART II.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1890.

HD 1724
1890
Pt. II

REPORT

OF THE

SPECIAL COMMITTEE

OF THE

UNITED STATES SENATE

ON THE

IRRIGATION AND RECLAMATION OF ARID LANDS.

VOL. III.—ROCKY MOUNTAIN REGION AND GREAT PLAINS.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1890.

VOL. III.

ROCKY MOUNTAIN REGION AND GREAT PLAINS.

EL PASO AND LOWER RIO GRANDE (TEXAS).
NEW MEXICO.
THE STAKED PLAINS (TEXAS).
WESTERN KANSAS.
COLORADO.
WYOMING.
WESTERN NEBRASKA.

EL PASO AND LOWER RIO GRANDE (TEXAS) DIVISION.

EL PASO, TEX., *September* 6, 1889.

The committee met pursuant to call of the chairman.

Present: Messrs. Stewart (chairman) and Reagan; also Director Powell.

STATEMENT OF EDGAR B. BRONSON, OF EL PASO.

The CHAIRMAN. Are you familiar with western Texas and New Mexico?

Mr. BRONSON. To a considerable extent.

The CHAIRMAN. What opportunities have you had to become acquainted with those sections of the country?

Mr. BRONSON. The opportunities that a man will have who has been handling cattle over a considerable portion of the country to which you refer.

The CHAIRMAN. Commencing with New Mexico, state what you know of the irrigation that is practiced there, the water supply, and the practicability of increasing the acreage of land that may be cultivated by irrigation.

Mr. BRONSON. The bulk of the irrigation carried on at this time in the Territory of New Mexico is practiced under the old Mexican system. It is only within the last three or four years that anything has been done in reference to the coming in of organized capital with a view to developing the water supply. The water supply as a rule is meager. There is an abundance of water in the mountains, rising to great bold streams at the foot-hills, where it sinks in large sections. It only needs to carry that water out in canals to indefinitely increase the area of tillable lands in the Territory.

The CHAIRMAN. I believe the Rio Grande is nearly dry; no water running in it. Does that often occur in summer?

Mr. BRONSON. Very rarely occurs. It has occurred in seasons of extraordinary drouth. But new conditions are coming up—conditions similar to those that exist in the South Platte River in Colorado. That river flowed a great bold stream to its mouth, but the taking out of the cañons has run such a drain on the river that after the snow waters and spring waters are taken away it is dry almost its entire length. The same conditions are succeeding here in the Rio Grande Valley. Formerly, when it was necessary to irrigate the land, there was an abundance of water in this river; but at the present time the conditions are rapidly changing to the conditions that exist on the Platte. The changes made upon the river in the San Luis Valley are rapidly affecting the supply.

The CHAIRMAN. How is that affecting the inhabitants below?

Mr. BRONSON. To their absolute ruin. It means absolute ruin to the plantations of the Rio Grande from Albuquerque south. The crops are dying, and it is impossible to make any crop except one of corn. I mean that it is impossible to make a crop of small grain—wheat or barley. There will be water enough to make a crop that is planted in the late winter and harvested in June; but the crop that is planted on the same land early in July and harvested in the autumn may not be longer made, nor may the fruit crop be ripened.

The **CHAIRMAN**. Does it affect people on the Mexican side of the line as well as those in the United States?

Mr. **BRONSON**. Equally. And it affects them to a greater extent, because the settlement there is older and the acreage of tillable land is larger.

The **CHAIRMAN**. And perhaps the inhabitants there are dependent upon agriculture?

Mr. **BRONSON**. The inhabitants on the Mexican side of the river you may say are entirely dependent on agriculture, for this reason: They have no manufactures. The mass of the people are agriculturists, and those who are not, are merchants who depend on the farmers for trade.

The **CHAIRMAN**. About what is the population of the valley on the Mexican side?

Mr. **BRONSON**. On the Mexican side, from the line above Quitman Cañon, there is a population—I think it would be a moderate statement to say of 25,000.

The **CHAIRMAN**. About what is the population on the United States side that are affected in the same way?

Mr. **BRONSON**. Within a radius of 25 miles of El Paso there is, roughly estimated, about 40,000 to 45,000 population. That is the population of the valley proper that is affected by these conditions. Within the valley above Las Cruces, Mesilla, San Marcial, and Albuquerque there is an arid country with a population surely of not less than 30,000 who are directly affected by the stopping of the water supply of the river in the ditches of the San Luis Valley and below. There a ditch was taken out and nearly finished, having a length of 60 miles, which takes out about the last available supply from that stream.

The **CHAIRMAN**. What amount of water runs to waste in this river in flood-time?

Mr. **BRONSON**. That is a question of a technical nature that I can not answer.

The **CHAIRMAN**. It has not been gauged?

Mr. **BRONSON**. It has been gauged, and Major Mills can afford you information upon that subject. I can say that for three or four months of the year it runs at flood and the channel is full, and then there is an abundance of water for all the land that the ditches could be brought to.

The **CHAIRMAN**. If the water is stored, you think there is an abundance of water in the Rio Grande to furnish water to all the land?

Mr. **BRONSON**. To every acre that could be put under cultivation. It flows a great bold river every year through the periods of the flood, through all the winter months, and up to the middle of June or July.

The **CHAIRMAN**. What amount of land is there in the United States that can be irrigated from the Rio Grande, if the water were preserved?

Mr. **BRONSON**. That again is a very difficult question to answer.

The **CHAIRMAN**. It only calls for a rough estimate. It is a large quantity, is it not?

Mr. **BRONSON**. We have in the valley of the Rio Grande, from here to Quitman, 75,000 acres. In the Las Cruces Valley and in other valleys there are probably 250,000 acres. That is pretty close. As to what there is in the San Marcial Valley and from there up, I can not say. I should think a million acres a very low estimate.

The **CHAIRMAN**. Are you familiar with the topography of the country at the source of the Rio Grande?

Mr. **BRONSON**. To some extent. I have been in that country. It rises in the high mountain ranges of southern central Colorado, and flows thence through the San Luis Valley, and then through the cañons of northern New Mexico, coming out on the valley and plains below.

The **CHAIRMAN**. What other irrigating enterprises have been inaugurated or contemplated in New Mexico besides those waters directly from the Rio Grande?

Mr. **BRONSON**. Only two on anything like a large scale. One concerns the development of the Maxwell grant, in northern Mexico, of which you doubtless know a great deal. The streams are small, and they are confined to a system of small canals which they are proceeding to take out. They have availed themselves of the entire water supply, and that land is put upon the market at from $10 to $15 an acre.

The **CHAIRMAN**. Have they made an effort at the storage of water?

Mr. **BRONSON**. To no considerable degree. They have some small dams. The other enterprise which has been attempted is that of the Pecos Valley Irrigation and Investment Company.

The **CHAIRMAN**. You are interested in that?

Mr. **BRONSON**. Yes, personally.

The **CHAIRMAN**. Will you describe that?

Mr. **BRONSON**. The conditions are these: The Pecos River, like the Rio Grande, rises in Colorado. It flows to a point about Fort Sumner, where it sinks every year a distance of 80 miles. Then there comes in from the mountains on the west, striking out from the margins of the river, a series of springs, which create the Lower Pecos. There a ditch is taken out 37 miles long and 35 feet on the bottom. It is taken to a point 35 miles from there, where a series of new springs break out from the mountains affording another supply to the river, from which there is another canal 58 miles long and 45 feet on the bottom. The two canals will irrigate about 300,000 acres of land as now planned. It is then the contemplation of the company later to take those ditches along the line into Texas, and it is the expectation of the company that the amount of land will not be doubled, but very near it.

The **CHAIRMAN**. Do you contemplate storage reservoirs to save the storm waters?

Mr. **BRONSON**. There is no necessity for that under our present plans. That will become a practical question when the water supply of the river is run short. But we have an abundant supply for at least half a million acres. That is a definite calculation by one of your own engineers, Mr. Nettleton, of Colorado—that is to say, he is one of Director Powell's engineers.

The **CHAIRMAN**. By storage and the saving of water to its utmost extent you might increase the number of acres.

Mr. **BRONSON**. It may be indefinitely increased, because there are points where you could conserve the water through the winter. But there are no uses for it; it would simply run to waste.

The **CHAIRMAN**. Then your additional land will be in Texas?

Mr. **BRONSON**. The additional land will be in the State of Texas.

The **CHAIRMAN**. Making a rough estimate, about how much land in Texas could be reclaimed should you exhaust that water supply?

Mr. **BRONSON**. I believe over a million and a half in Texas; because the lower you go to the point where we take out these canals it is very narrow, but passing the Texas line the canal widens, and it could be carried out at least 30 miles from the river to a point down about Live Oak Springs, below Fort Stockton, a great broad valley being on the west.

The **Chairman**. What is the character of the land?

Mr. **Bronson**. It is a loose red, sandy loam, and very deep soil underlaid with limestone. With the storage of water the possibilities of that enterprise are so large it is very difficult to state them accurately.

The **Chairman**. How much of a river is the Pecos in flood-time?

Mr. **Bronson**. It is a river probably 150 to 175 feet wide, and from 20 to 25 feet deep. It is a very peculiar stream. It is narrow and deep. I have never seen anything like it in the West.

The **Chairman**. Has it a rapid current?

Mr. **Bronson**. Very rapid current—a sharp fall all the way. That is an important feature in the quantity of the supply of the water. It is a very rapid stream. The extent of the water that could be stored in the four months of idle season, in winter, is almost indefinite.

The **Chairman**. Have any streams been taken out?

Mr. **Bronson**. Small streams have been taken out at Pecos City, on the Pecos River, about 50 miles below Mexico.

The **Chairman**. How far is it from where you start, following down the river to the Texas Pacific Railroad?

Mr. **Bronson**. From the head of the northern canal it is 185 miles.

The **Chairman**. And you occupy with your canal what portion of that district?

Mr. **Bronson**. When the canals shall have been completed we will occupy the country to a point within 50 miles of the railway. We will occupy 130 miles of the Pecos. There is a break between of undesirable country that need not be covered. It is indefinite, but the canal system could be carried down farther south 100 miles at least if there were water sufficient.

The **Chairman**. What products do you raise there?

Mr. **Bronson**. Everything that is raised in this section of the country—all varieties of fruits. The country produces two good crops a year. The small grain crop—barley and wheat and all that sort of thing—is harvested in spring, and corn can be put on the same ground and harvested in the autumn, but that is not deemed the most desirable crop. Then we are nearer the markets than California.

The **Chairman**. What kind of fruits can you raise?

Mr. **Bronson**. We raise everything except the purely tropical fruits. The orange, olive, and such things have been tried in the Pecos, and they are doing very well. The grape, apricots, figs, and all kinds of apples can be raised.

The **Chairman**. Are there any other opportunities for irrigating in Texas further east except on the Pecos?

Mr. **Bronson**. Yes, on the Nueces.

The **Chairman**. Where does that river rise?

Mr. **Bronson**. That rises in the Blue Range, north of San Antonio, and flows generally south through southern Texas into the Gulf.

The **Chairman**. How much of a river is that?

Mr. **Bronson**. It is a dry stream below, after coming out of the mountains. But coming down it is a stream that will run 100 feet wide at the cañons, and be 78 feet deep. It is a large stream. There is a project to take the water from the cañon of the Nueces and carry it east out of the valley. A charter is granted for that purpose, and the company has been organized.

The **Chairman**. What crops can be raised on the plains of western Texas without irrigation?

Mr. **Bronson**. Nothing. In seasons of heavy rains occasionally a light crop of corn is made. But it is so entirely untrustworthy that it is not mentioned.

The **Chairman**. You have been over the Nueces and understand the topography of the country at its source. State whether there are any opportunities there for storage reservoirs.

Mr. **Bronson**. The opportunities are excellent, because the character of the country is especially adapted to that purpose. The streams lie deep, and they are crossed at different points by dikes of rocks, at which points storage reservoirs or dams could be made without great expense. When you get down to that lower country, as a rule the streams are broad, and they flow great bodies of water. At those points cheap dams could be put in that would accumulate the water and make possible the tillage of a great deal of land.

The **Chairman**. Is there any person you know who is familiar with that region of country and who can give us a report on it?

Mr. **Bronson**. I do not know of any one here at the present time.

The **Chairman**. How can we get that information without traveling over the country? In the absence of railroads it would be difficult for us to travel over these sections.

Mr. **Bronson**. You mean southwestern Texas?

The **Chairman**. Yes; and in northern Texas where irrigation is required.

Mr. **Bronson**. I should think that Mr. Streeruwitz, the State geologist, could give you that information.

The **Chairman**. Are there any other facts in regard to Texas and Mexico that you would like to state?

Mr. **Bronson**. I would like to state what are the local conditions here at El Paso: We have a proposition here, the suggestion originally of Major Mills, for the building by the Government at this point of a great International dam. He has studied the matter, and has brought it down to a pretty definite set of figures, which he will present to you. But in that connection I would like to say that we beg of you that you give that question very careful consideration, because it affects not only the question of irrigation of arid lands, but also the settlement and regulation of certain international difficulties that we have here—difficulties that must exist until this question shall have been settled. And the question involves the channel of the river. It is changing, and difficult and noisy litigation under international law comes up over these changes of the river channel. Now, there has been at this point, perhaps from the beginning of the settlement, a dam maintained exclusively at the cost of the people of Mexico on the other side, and without any contributions on our part, though it is being used by us with equal benefits. But they are now, in common with us, deprived of the water by the drain upon it in the ditches of the Colorado; and it seems to us a moral responsibility, if not a legal one, rests upon us to have the waters of the Colorado by some means stored. One way is to choke off these fellows in Colorado and New Mexico who have taken out the water in the face of an undeniable right. There should be a storage system here, by which the waters of the river could be retained in such quantity as to enable the people to cultivate their land under their original rights. We want you to study that question, as it is one of vital importance to the people of this section.

The **Chairman**. The scope of our power does not include a recommendation for Government work. The Government has commenced engineers' surveys, and will designate reservoir sites, lines of ditches, etc., and will make estimates of the cost of construction, for the purpose of informing the people where they can make homes. The Government will reserve all the sites that may hereafter be designated as suitable for reservoirs, with the land that may be irrigated thereby. But the law making these reservations also provide that the President, by proclamation, may open these lands to homestead settlers. Now, we want to ascertain if any further legislation will be necessary in that direction, and if so, what? It is our duty to ascertain, first, whether the subject is of sufficient importance to justify the expenditure of so large an amount of money as will be necessary for this engineering work.

Mr. BRONSON. There is one other feature that I wish to suggest in this connection, and that is as to the desirability on the part of the Government of going into expenditures in the West to develop the arid land. Millions are appropriated yearly for the improvement of the rivers and harbors, the promotion of local commerce. We have no harbors to improve, no channels to deepen; but the commerce of this country can be fostered and promoted, developed and enlarged, by storage reservoirs comprehended in your present study.

Senator REAGAN. You were asked the question about what streams there were from which water might be applied to land, and you mentioned the Nueces. How is it with regard to the San Antonio?

Mr. BRONSON. I mentioned one way in which the project was planned; but it is possible also on the San Antonio, the Guadalupe, the San Cruces, the Marquis, and even going farther east, on the Colorado. There is some farming land west of Colorado in that section.

STATEMENT OF W. H. STREERUWITZ, STATE GEOLOGIST OF TEXAS.

The CHAIRMAN. What is your occupation?

Mr. STREERUWITZ. I am a civil and mining engineer, and State geologist for western Texas.

The CHAIRMAN. Are you familiar with the topography of western Texas?

Mr. STREERUWITZ. I am as familiar with it as I could make myself within the last ten months and by short trips in former times. I am as familiar with it as any one here.

The CHAIRMAN. Have you during your investigations had your attention called to the possibilities of that country with regard to irrigation?

Mr. STREERUWITZ. Yes; I have for a number of years proposed the building of reservoirs in the mountains, because it struck me that it would be a very easy matter to do it, and probably it would be a great deal cheaper than experimenting with artesian wells. The mountains in some places come together very closely, and, so far as I could ascertain, the bed-rock being very close to the surface, it would form a number of reservoirs to cover say from 10 to 50 square miles.

The CHAIRMAN. What is the rain-fall in that region? Is it sufficient to fill a reservoir in the storm season?

Mr. STREERUWITZ. There are very few rains here; but when they come they come with a will.

Senator REAGAN. Of what portion of Texas are you now speaking?

Mr. STREERUWITZ. Western Texas; west of the Pecos River. So far as I could ascertain in ten years, the annual rain-fall within a circuit of 100 miles around Fort Davis has averaged 19.9 inches in February. Farther east, where I have my tent at the present time, I have had within the last three months 3¼ inches of rain-fall. That is the result, so far as I could make my observations by crude means.

The **CHAIRMAN**. Are you acquainted with Texas farther east?

Mr. **STREERUWITZ**. I know Texas very well. I am a citizen of Texas, and have been for twelve years, traveling around every year.

The **CHAIRMAN**. What are the particular streams that would furnish water for irrigation if the waters were stored in the mountains above?

Mr. **STREERUWITZ**. The Colorado River of Texas might; the Llano River partly; the San Saba River; part of the Brazos River; the Pecos River; the Nueces River; the San Antonio River; in fact, you might say any of the rivers of Texas—the larger ones that deserve the name of river. In eastern Texas it is not necessary, because we have more rain there than we need. Of course in western Texas the Rio Grande and Pecos Rivers are of great importance. But between those two rivers we would have to rely on the rain-fall.

The **CHAIRMAN**. There are no ravines between?

Mr. **STREERUWITZ**. Yes; but they are in the valleys, and they would not do for reservoirs. We have here between the mountains old lake-beds running down in sand and gravel many hundred feet in some places, so that the reservoirs, according to my idea, would have to be put back in the small valleys between the mountains themselves. There the mountains are close together, and the bed-rock is not more than 10 or 15 feet from the surface. If that were not so it would be expensive, and it would not pay to build them.

The **CHAIRMAN**. Has the subject of irrigation been discussed in Texas?

Mr. **STREERUWITZ**. It has been discussed here and on the Pecos more than anywhere else. So far as I know, and from what I see in the newspapers, it is becoming a vital question. There is no doubt that it is one of the live issues for the Rio Grande Valley.

The **CHAIRMAN**. There is a large amount of land that could be brought under cultivation from the various streams of which you have spoken and the reservoirs that might be built?

Mr. **STREERUWITZ**. There is a large valley extending, we may say, from Sierra Blanca down to Fort Davis, 10 miles wide, that is nearly as flat at this table, and of good soil. From about a half mile from the mountains it is excellent soil. I made an analysis of about twenty different soils along this valley.

The **CHAIRMAN**. Then there is a large amount of land containing good soil in western Texas?

Mr. **STREERUWITZ**. Excellent soil. All it needs is water. It is very good agricultural soil.

Senator **REAGAN**. Have you examined the country up in the Pan Handle?

Mr. **STREERUWITZ**. I was up in the Pan Handle, but I made no particular examinations?

Senator **REAGAN**. Have you made an examination to ascertain whether there are any streams in that section with which you could irrigate?

Mr. **STREERUWITZ**. The Upper Brazos. Its largest forks, the Salt Fork and the Double Mountain Fork, are hardly fit to irrigate with. One is charged with brine and the other one is too strongly alkali. Then there is Clear Water Fork; but the valleys there are not to be taken into consideration for irrigation, because the expense of the dams would be too high for the value of the land.

The **CHAIRMAN**. Have you been through the country to the Indian Territory, to Oklahoma?

Mr. **STREERUWITZ**. No. I was in Oklahoma for a year, spent the summer in the Chickasaw Nation, making examinations along the Santa Fé Railroad.

The **CHAIRMAN**. Would they require irrigation there?

Mr. **STREERUWITZ**. In Paul's Valley they had excellent crops on the Washita River. There is plenty of water there; the Washita River was full of water all summer.

Senator **REAGAN**. Have you any information about the wells along the plains?

Mr. **STREERUWITZ**. I have no information about the wells there.

STATEMENT OF SENOR J. ESCOBAR, CONSUL FROM MEXICO AT EL PASO.

The **CHAIRMAN**. Will you proceed and make any statement you may desire with regard to the effect of using for irrigating purposes the water above here on the Colorado and Rio Grande Rivers? Explain how it affects the people of your country.

Mr. **ESCOBAR**. I would prefer to answer questions. On that point, however, I will state that we consider our rights come from the first occupancy of the river. Having disposed of those waters for two centuries, we can not now be deprived of their use without injustice being done. I do not think it would be just to conserve all the water as they have done in Colorado and deprive the people of Mexico of it. I do not think it right to give life to a new people and in doing so kill an old people.

The **CHAIRMAN** About how many persons reside in the valley of the Rio Grande on your side of the line?

Mr. **ESCOBAR**. In this valley, for some miles, we have no less than 25,000 population.

The **CHAIRMAN**. And this population is dependent upon this water?

Mr. **ESCOBAR**. Yes.

The **CHAIRMAN**. Does it affect them below?

Mr. **ESCOBAR**. Not so much below. The necessity for the waters ceases at the confluence of those rivers.

The **CHAIRMAN**. But above that?

Mr. **ESCOBAR**. To allow the water to be taken out as it is now will be to destroy the people on both sides; because the life of the people is agriculture. They would have to emigrate; they could not live. If you will pass over our side you will immediately see the effect. Our vineyards have decreased one-half, thousands of fruit-trees are barren, and the corn-fields are entirely lost.

The **CHAIRMAN**. This is an unusually dry season.

Mr. **ESCOBAR**. It is unusually dry; but it is not only on account of the lack of rain, but it is on account of the deprivation of the water of the river. Such a thing we have never seen before. And it is now exceedingly difficult to make wells, while before this condition of things it was easy to reach water.

The **CHAIRMAN**. Did you feel its effect before this season?

Mr. **ESCOBAR**. No, not before this season.

The **CHAIRMAN**. When you have a more favorable season would not this difficulty be removed?

Mr. ESCOBAR. Oh, yes. In the winter we expect to have water. But our crops are already lost.

The CHAIRMAN. What have you to suggest as a means of restoring the water to you?

Mr. ESCOBAR. It seems to me that proper legislation in Colorado and New Mexico could avoid that. Of course, I acknowledge it would be a very difficult thing. But the project that has been presented by Mr. Mills is a satisfactory solution of the local necessities. His project begins by an acknowledgment of our water rights, and distributes the water in such a way that we can not claim more—one-third to the American side, one-third to the Mexican side, and one-third to form the current of the river; which will produce the effect of avoiding that constant change every year which has been the cause of perpetual strife on both sides. We are never at peace, and we can never be at peace so long as this shall be. No matter what may be done on both sides of the river, the question will be continued so long as the river is the boundary line between the two countries. But this proposition solves the difficulty. The changing of the river is the feature that makes this question very interesting. Its adoption will awaken the sympathy of the Mexican Government so soon as an official acknowledgment of it shall be made. It is an excellent project.

Senator REAGAN. For how many years has the Mexican side of the boundary been populated—as far as you know?

Mr. ESCOBAR. Not less than two hundred and seventy years.

Senator REAGAN. What portion of that time have the people been using the water out of the Rio Grande?

Mr. ESCOBAR. There was in the past a population that could not use all the water, because there was an abundance of it.

Senator REAGAN. How long have the people been using the water for irrigation?

Mr. ESCOBAR. From the earliest settlement. The Spaniards crossed first into Mexico, and established a settlement, and the other Indian towns that were established became Mexican. They were the first towns on the border of the river. Ever since that settlement there has been a little dam above the town. It has been renewed yearly. That is the one to which Mr. Bronson alluded. That has been giving water to the Mexican people since that time, plenty of water for irrigation. They opened a big canal sufficient to irrigate all the valley. That canal we have been using for centuries. But now there is not a drop of water in it.

STATEMENT OF MAJOR ANSON MILLS, U. S. ARMY, OF FORT BLISS, NEAR EL PASO.

The CHAIRMAN. We would like to hear any statement you may have to make on the subject of irrigation as applicable to this country.

Major MILLS. I suppose you wish first the general features of the project to build a dam in what is known as the North Pass, about 3 miles above the city, and form a large lake in the valley above. So I will give them.

The valley above extends for 60 miles. It widens gradually, after leaving the Pass going north, and has at some places a width of 4 and at others 12 miles. But what we have to do within our reservoir will only extend 25 miles from the city.

The plan is to build the dam, say 60 feet high, and at the most favorable point in this pass. We have made soundings at various places, and have discovered two suitable locations; one about 1½ miles from the city, and the other about 2½ miles. At the lower place we have one end of the dam in Texas and the other in Mexico. We have another advantage from the fact that we could use the Mexican dam during the construction of the new dam, and lower the water from 8 to 10 feet, and thereby have less trouble in sinking our caissons to build the dam.

Another advantage is that the bed-rock is nearer the surface there, the deepest sounding in the cross-section being 7 feet. The great difficulty in this location comes from the changing of the railroads—the Southern Pacific and the Atchison, Topeka and Santa Fé. The Southern Pacific would have to be changed for about 5 miles in order to keep the track out of the submerged district, and that would be somewhat difficult to do. The grade of the Southern Pacific is 1 per cent., or 52 feet to the mile. That is their maximum. The grade of the Santa Fé is the half of 1 per cent., or 26 feet to the mile, so that in order to rise over this 60 feet of dam from the city, it would be difficult to get the Santa Fé to increase their grade, because they would have to double their engines to get over the dam.

The upper location is preferable on account of the feasibility of climbing the dam by the railroad; also from the fact that it is not so broad. The dam would not be so long, and in that respect would not be so expensive, and yet in regard to bed-rock it would be more expensive.

Now, this elevation of 60 feet would throw the water back in the lake 15 miles from the upper dam and over 16 miles from the lower, the fall of the river being about 4 feet to the mile.

Mr. Follett, a civil engineer with experience in railroads, was employed by Colonel Nettleton to do the platting, and the map before you is his work. The blue line [indicating] describes the lake as it would exist when flooded. The average is 3 miles in width and 15 miles long. It would cover an area of 26,000 acres of land. Of that 26,000 acres, 16,800 acres are in Texas, and all of that but 1,000 acres are patented to individuals. These 1,000 acres are supposed to belong to the city as school lands. That part in Mexico will cover 9,400 acres of unconfirmed Spanish grants, the Refugio colony grant, and the Francisco Garcia grant. There are about 1,000 acres of public land, not covered by either of these grants or claims, in Texas.

To illustrate the difficulty of arriving at the location of the land and of ascertaining to whom it belongs, it should be explained that this river is constantly changing. It is inconstant in its flow and inconstant in its position. The present river is described by this other large blue line [indicating]. There is now a river opening here [indicating], and the next high season will carry the river over the Atchison, Topeka and Santa Fé track. This red line describes that; it represents the preliminary survey.

The CHAIRMAN. This line [indicating the railroad] will have to be removed?

Major MILLS. That is the preliminary survey, made by Mr. Follett up in the bluffs.

The CHAIRMAN. The railroad would have to be changed for 15 miles?

Major MILLS. Yes, in my judgment, it would have to be. So soon as that river opens it would change it anyway. There is no abutment within the range of any railroad company that could protect it.

The CHAIRMAN. Probably that could be changed without any difficulty.

Major MILLS. It would be an expensive change. We shall have trouble to induce the Atchison, Topeka and Santa Fé Railroad to adopt the new line without compensation from the Government. That road is not now paying the stockholders, and it could not be made to adopt that change without compensation. The Southern Pacific could make the change, and they would get a better grade. This [indicating] is the present Southern Pacific, and this [indicating] to this point is the proposed change for them.

The **CHAIRMAN**. Have they laws in Texas and Mexico providing for the condemnation of land for reservoirs for the storage of water?

[Mr. **HINTON**. There are such laws in Texas.].

Major **MILLS**. I have no knowledge in that respect. The river, at the time some of these surveys were made, ran here [indicating]. I might state that I was appointed to the army from this town, and was previously the surveyor for this district and surveyed all the land from the New Mexican boundary down to El Paso and 75 miles below. At that time this [indicating] was the position of the river. See how it has changed since. I made those surveys in 1858 and 1859.

This land could be easily condemned, and it probably ranges in value from $1 to $7 per acre. The whole expense, therefore, would probably be not over $100,000.

The **CHAIRMAN**. Outside the railroad changes?

Major **MILLS**. Outside the railroad. The dam at the upper location indicated would probably cost $200,000. Mr. Follett made an estimate of that last year. He estimates it at $221,000.

This project, I should have explained in the first instance, is for the control of the boundary and the preservation of the lands adjacent to it on each side. And to illustrate how necessary that is, I would like to show you a map that was made by the county surveyor, Mr. Heldt. That shows how changeable the river is, and the various complications that are constantly rising on account of those changes.

As shown by this map, El Paso is situated on the Ponce de Leon tract. Here [indicating] is the pass where the river has a straight line for 3 miles. There [indicating] is the lower Mexican line. The lower dam would be there [indicating], and the upper dam here [indicating]. You will observe that the river leaves the pass. It has always a tortutuous course, winding about. This line [indicating] shows where the river was in 1849; this one [indicating] shows where it was in 1858, when I made the surveys down below.

Now, if this dam could be built, it is believed that it would control forever the changes of the river bed, and that it would maintain a constant and invariable flow. So that, if the river is constant and invariable, the sediment will stay in the lake and the water will back clear through, and this boundary will have no changes. To do that a boundary commission would be necessary to cut off this bend, straighten the river, and throw that which would fall on the Texas side of the channel into the jurisdiction of Texas, and that which would fall on the Mexican side into the jurisdiction of Mexico. As it is at the present time, in seasons of high water most of these lands are overflowed. The river makes a sudden turn, and houses are carried into the water. Then comes these dry seasons in cycles of about seven years to dry up and kill new trees and vines, and make it almost impossible to raise anything.

Before the annexation of Texas all this land [indicating] was on the right bank, or Mexican side; but since then it has changed to a deposit on one side, by erosion on the other. Down below here [indicating] it is constantly changing. Here [indicating] we have a tract of land of several thousand acres. The river five years ago was running here [indicating] on the east side of it. In that high season it made a sudden change and destroyed the Galveston Railroad, just as will be the case with the Santa Fé some day out on the bluffs.

In order to irrigate their lands the Mexicans had to come on Texas soil. They built a dam on both sides of the river through Texas territory to irrigate their own land. I mention that to show the complications that are rising and will arise every year. Then there are other difficulties that may arise with the collector of customs. With his inspectors he may observe a train packed with goods and may attempt to seize them on account of their being in Mexico, and it will be difficult for any court to determine whether they are in Mexico or not. It is always difficult to convict in criminal cases—cases of arson, murder, or theft. The sheriff on one side may claim that he is without jurisdiction, having no boundary.

Now, if this project had simply the object of irrigation, I could speak with a little more minuteness as to that.

The CHAIRMAN, We wish to know what this dam would accomplish.

Major MILLS. The dam would contain 531,000 acre feet, that is, the whole of the dam. One-third of that, the upper 10 feet, would be available for irrigating purposes, and it would irrigate about 500,000 acres of land.

The CHAIRMAN. On which side of the river?

Major MILLS. On both sides.

The CHAIRMAN. It might be equally divided between the two.

Major MILLS. Yes. Of the new land which would come under the ditches, the Mexicans would have a little the preponderance. The Mexicans would have 125,000 acres that could be brought under the ditches. I dare say it is better to have a ditch only 50 miles long in this arid country where evaporation is so great and the soil loose.

The CHAIRMAN. Are you familiar with points farther up?

Major MILLS. Yes. There is a good site for a dam at Fort Selden, but it is not so good as this of which I have been speaking.

The CHAIRMAN. How far is Fort Selden?

Major MILLS. Sixty miles, I believe. There the site for the lake is contracted, the river bluffs coming together, and you could not impound so much water as in this dam, probably by one-tenth.

The CHAIRMAN. Does the river carry down much silt?

Major MILLS. Probably it does. When I first projected this plan I was told that it would be impracticable, because the silt would fill up the lake.

The CHAIRMAN. Have you made any investigations on that head?

Major MILLS. We have made investigations during the whole of this season, and we found that the average carried was less than one-third of 1 per cent.

The CHAIRMAN. Would you provide for sluicing the dam to clear it of silt?

Major MILLS. I think probably it would be three or four hundred years before this dam would fill up. So that we may leave it to the people. They will have better facilities for sluicing it then.

The CHAIRMAN. If this civilization is not destroyed.

Major MILLS. Yes. That is the view that I take of it. That is an element that need hardly be taken into the present problem.

Now, in regard to the construction of this dam—by whom should it be made—I would like to say this: I do not see how it will be possible to construct it by private enterprise; and for these reasons: It is international, in the first place, and it would be hard to get a charter from the two Governments that would sufficiently secure the investors in their rights to dividends. In our country it is very feasible, because here they can take a lien on the land for the money invested. In Mexico, however, it is different. The proprietors of this enterprise would necessarily be Americans, and there would be that doubt on the part of Mexico and on the part of the investors that they were fairly dealt with. Then, to control the boundary, I do not see how private individuals could do that.

The **CHAIRMAN**. Could not the Government sell the 100,000 acres of land that would be brought under cultivation by the dam?

Major **MILLS**. Yes, that would be true in Mexico; but in the State of Texas, where we own all the land, it would be different. There is in Texas very little vacant land belonging to the Government.

The **CHAIRMAN**. Could we not sell the water right? Suppose there were 100,000 acres brought under cultivation on the Texas side. That is valueless now; but with water on it it would be valuable, worth from $25 to $100 an acre. Could not the persons who occupy that land well afford to pay something for the water right?

Major **MILLS**. They would be willing to do it, I dare say.

The **CHAIRMAN**. On the Mexican side, where they have had water, it would not be fair to charge them; but where they reclaim new land, they might. And on the United States side it would be the same.

Major **MILLS**. That land would be the best land, according to my experience. Lately I have been in southern California, and I think you will bear me out that around Los Angeles the upper lands are better than the bottom lands because they can be irrigated without overflowing. Then they are not so heavy. So that these new lands would be more valuable than the old lands.

The **CHAIRMAN**. Would it be practicable for you, after having made the surveys and ascertained who owned the land, to get a proposition from the land owners stating how much they would pay for permanent water rights if the water were brought in by the Government?

Major **MILLS**. That would be practicable, to some extent. I surveyed 50 acres of land here for Mr. Hamburg, of San Antonio. Now it is owned by Mr. Dodge, of New York City. Mr. Heldt showed me his tax receipts. They were for large tracts of land in Mexico, but he does not know it. General Dodge is probably paying taxes on 75 acres of land over on the other side of the Rio Grande belonging to the Mexicans. This map was finished but a few days ago.

The **CHAIRMAN**. If the Government should run the water over the dam, you would not let it go out until it was paid for?

Major **MILLS**. My idea would be for the Government to build the dam, build the reservoir, change the railroad, and provide how that water should be disposed of, and turn it over to a private corporation thereafter. That could be arranged.

The **CHAIRMAN**. If there are 100,000 acres to be redeemed, the land reclaimed would pay the cost two or three times over at $25 or $30 an acre.

Major **MILLS**. Mr. Follett tells me that it is impossible for him to get up an estimate to rely on for changing the road. It will cost from $800,000 to $1,000,000 to complete the work, but that is merely a guess; it may not cost $600,000.

The **CHAIRMAN**. That would be $10 an acre for 100,000 acres?

Major **MILLS**. Then the water power would be there, and the climate, by the presence of this vast amount of water, would be changed. But that is problematical; we can not tell about that.

The **CHAIRMAN**. It is not problematical—covering the soil with vegetation would make the climate more healthful, and make the atmosphere more damp.

Major **MILLS**. I feel a great enthusiasm in the project. I believe it practicable, and I believe the country sufficiently progressive to build a dam, and have no doubt it will be built in the next few years.

Senator **REAGAN**. What is the fall of the river above this dam, and for some distance up?

Major **MILLS**. The river generally averages 4 feet to the mile for 50 miles above and below here. Strange to say, there is a greater fall in the valley than there was in the pass. That was a surprise to me. In the rapids the fall is less than where the river takes this turn here.

Senator **REAGAN**. There are table-lands lying east?

Major **MILLS**. Yes.

Senator **REAGAN**. Is there any water above where it could be taken out on that table-land?

Major **MILLS**. I am not sufficiently posted to state that. I suppose there is, by making a high dam.

Senator **REAGAN**. How far down below this do you estimate that the channel of the river can be controlled by the construction of this dam?

Major **MILLS**. I am quite sure if the dam should be constructed with the vast quantity of water that it would hold, the river could, in a degree, be controlled to the Gulf, and absolutely controlled to 100 miles to the cañon regions, because there is no confluence between this and 100 miles down. We would allow so much water to pass through the dam each day.

Senator **REAGAN**. What is the character of the valley?

Major **MILLS**. About 75 miles below, a little more—90 miles—below old Fort Quitman, the bluffs come in. These bluffs close in, and there is no valley land there.

Senator **REAGAN**. How far down does that cañon go?

Major **MILLS**. That runs down 100 miles.

Senator **REAGAN**. If you could control the bed of the river down to this cañon, no difficulty would arise. How much of the land that would be covered by the proposed reservoir is cultivated land?

Major **MILLS**. I do not think there is more than 500 or 600 acres. There is no cultivated land in the whole 26,000 acres that would be submerged, except a little colony called the Liunia. There is a town right there—a settlement—and they have taken out a ditch. The ditch would cover probably 1,000 or 2,000 acres. There are probably only 500 or 1,000 acres under cultivation. That could be condemned, because it is not deemed valuable.

Senator **REAGAN**. Are there any buildings or valuable structures on it?

Major **MILLS**. No.

Senator **REAGAN**. The marks here [pointing] indicate that the land has been taken up.

Major **MILLS**. It has been all taken up. Here [indicating] is a tract marked "State." That is school land. I think 1,000 acres belong to the State and to a great many individuals living here in the city. I own some myself.

Senator **REAGAN**. Is there any value fixed to that land?

Major **MILLS**. No. Some of it is sand-bars that you can not sell at any price. The other would be, if this project were carried out, the best land in the country; but at the present time nobody would settle on it. Something must be done to settle that land below. If you will ride from the city down on this or the other side you will see the trees perishing, and so with the vines; and this will continue to be the case until they have some water.

Senator **REAGAN**. Is there any current price on this land?

Major **MILLS**. I do not think there have been any sales in there; I have never heard of any. I have tried to sell mine, 100 acres in this tract [indicating]. I have owned it for thirty years. I tried to sell it, but could not do it. I offer to the committee a memorandum on the general character of the project:

INTERNATIONAL FEATURES—BOUNDARY—THE RIVER JOINT PROPERTY—VESTED RIGHTS IN THE WATER, BY APPROPRIATION TO PRIOR USES.

The lake covers an area of 26,270 acres, 16,830 being in Texas, all but about 1,000 acres (which is supposed to be State school lands) being patented to private parties; all that in New Mexico, 9,440 acres, except about 1,000 acres (which is supposed to be Government land), lies within two unconfirmed Spanish grants, "The Refugio Colony" and "The Francisco Garcia." The lake will be about 15 miles long by about 3 miles wide, and an average of 20 feet deep with a total capacity of 23,160,777,000 cubic feet of water; the capacity of the proposed reservoir of 10 feet on top will be 8,610,565,000 cubic feet.

Of the two proposed sites for the dam, one lies about 2¼ miles from the city and the other about 3¾ or about 1½ miles apart. Relative merits, bed-rock, six outlet gate-valves of 4 feet carry 2,400 feet with 50-foot pressure, and a crest overflow 200 feet long by 4 feet deep will carry 7,400 feet, equal to 10,000 feet, sufficient with the storage to relieve any probable or possible flood from overflowing the dam.

The first measurements of flow were taken on May 20, showing 4,300 feet, and were continued until July 28, when it had been gradually reduced to 29 feet, and river ceased to flow August 5.

Measurements for evaporation have continued since May 10 with an average of about 10 inches per month.

Measurements of sediment continued during the flow since June 10, showing an average of .345 of 1 per cent of the water carried.

Approximate cost of the work.

Condemnation of the lands to be submerged ($160,000); reconstruction of 15 miles of the Santa Fé Railroad; reconstruction of 5 miles of the Southern Pacific Railroad; building of the dam, gate-valves, and waste-weir; approximate total cost of work, $321,000.

The committee here took a recess until 2 o'clock.

The committee re-assembled at 2 o'clock p. m.

FURTHER STATEMENT OF EDGAR B. BRONSON.

Senator Stewart made a statement to me this morning after the meeting of which he desired an explanation. It was with regard to the condition of the arid lands of western Texas. He wishes me to demonstrate the necessity or no for appropriations looking to the investigation of the resources of the country for reservoirs, dams, and that sort of thing.

The **CHAIRMAN**. We want the facts to show whether it is necessary or not.

Mr. **BRONSON**. In the region of western Texas, which might, perhaps, be defined by a line drawn north and south, through Colorado City, there are some few mountain chains. But the mountain chain is not a prevailing feature of the country; plains are the prevailing feature. The character of the country is such that the rain-fall is very light. On the mountains, though, it is very great. There are very few of these mountain ranges which have permanent streams, yet, in the rainy sea son, they pour down torrents of water, and there are dams that would afford streams for irrigation. I speak of the great mesas lying to the west of Fort Davis. Along the Southern Pacific there is a mesa 150 to 200 miles long, averaging 30 to 80 miles wide. From the mountain ranges on the west side, in what Major Powell calls the torrential season, there are poured down great bodies of water, and there might be accumulated in reservoirs a sufficient quantity of those waters to irrigate an immense area of land.

The **Chairman**. Is that country occupied at all?

Mr. **Bronson**. It is sparsely occupied along the railway. There are small settlements and nothing else, because no tillage is possible there. It would require a community of labor and organized capital to make the large reservoirs necessary to irrigate that great country. Apropos of that subject, you go on the plateau of southern Mexico where there is a dense population, where the country is under tillage in cotton and all varieties of crops, and there the conditions are the same as in western Texas. They have no streams, and the rain-fall is inadequate to make irrigation possible; and the result is what—what we are beginning to do here. The whole country is covered. Each has a dam which conserves the water which falls during the rainy season and is held and stored over to the period when cultivation is desired, when it is used in irrigation. I think, perhaps, there are some hundreds of square miles actually under tillage south of the city of Santiago, Mexico, under the system which is now proposed in western Texas. I have seen it, and it is practically here as it is there. The rain-fall of that country is about as it is here. For instance, they take a region of country with a great drainage area behind it, a series of important hills or large range of mountains, and they bring several of the waterways together. The water is then brought down until it reaches a point where it is convenient to make a reservoir, and there they store the same. Those are the conditions of that country. When you get to the Texas Pan-Handle the conditions change from those you see here. There you have no range of mountains; the important ranges are sand hills, which are perfect sieves. But in almost the whole belt, or two-thirds of the Pan-Handle, the water is found 5 to 56 feet deep in an inexhaustible supply, and the system there is pre-eminently a well system. The water lies near the surface, and it is inexpensive to raise it. But the country does not lay in such shape that reservoir irrigation may be practiced to any great extent. There are a few places, such as the head of the Yellow Horse Cañon and Yellow Fork. They begin with long dry ravines, and in those places it might be practicable to make your systems of dam storage. But it has always seemed to me, since I became familiar with Santiago, that the same thing could be practiced here in western Texas, and the country become as rich as any in the United States. I think I am safe in saying that one-third of the cotton raised in the Republic of Mexico is raised under that particular system of irrigation—fully a third of the cotton.

Senator **Reagan**. Have you been acquainted with any place that is under cultivation by irrigation in Tom Green County or anywhere else?

Mr. **Bronson**. The Comanche Creek section, by Fort Stockton. It is at Fort Davis. That is the only place in western Texas outside of the valley.

Senator **Reagan**. Do you know of any one here acquainted with the waters of the Colorado or Tom Green County?

Mr. **Bronson**. It is there where irrigation is practiced to any extent. I understand there is a gentleman here who is familiar with some parts of that country, whether the particular parts to which you refer, I do not know. I am not familiar with it.

STATEMENT OF E. E. ROESLER OF DALLAS.

The CHAIRMAN. What is your occupation?

Mr. ROESLER. I am emigration agent for the Texas Pacific Railway, and I am also secretary of the Marienfeld Co-operative Fruit and Garden Irrigation Company.

The CHAIRMAN. Are you familiar with the topography of the country, the character of the land, and the other possibilities for irrigating portions of Texas?

Mr. ROESLER. Yes; I have made a special study of that since 1886.

The CHAIRMAN. In what portions of Texas?

Mr. ROESLER. From the Brazos River almost to El Paso. What is known as the Staked Plains.

The CHAIRMAN. Go on and describe the character of the country, and state what the facilities are for irrigation.

Mr. ROESLER. Beginning at the Brazos River, which is at an altitude of about 900 feet, the country rises in steps toward the west. It is generally in the form of one plateau above another. So you proceed westward from Brazos River 20 or 30 miles, and you come to a bluff 200 or 300 feet in height, and above that is a plateau which extends 20 or 30 miles. The difference in altitude is from 150 to 300 feet in these plateaus. From west of the Colorado River the rain-fall is from 20 to 46 inches, with an average of 26, and in that country it has not been found necessary to irrigate, although it is found advisable with the garden crops, vegetables, and things of that description. They have been benefited by irrigation. On the Concho near San Angela there are about 5,000 acres under cultivation by irrigation, and all the waters are obtained from the North and Middle Concho Rivers. About 50 miles north of San Angela that river springs out of the ground. Above that there is no river, but simply an old river-bed that extends all of 300 miles across the country into New Mexico. In the north branch of the Concho River, which is known where it crosses the Texas Pacific Railroad as the Mustang, irrigation is considered necessary. We have an extraordinary farming section there, and we found since 1882 about the following:

In 1882 there was abundant rain-fall, and wheat made from 18 to 25 bushels; corn ran about 30 bushels, and the small grains between 18 and 20 bushels. Vegetables of all sorts did well. In 1883 the crop was equally good. In 1884 they made about a half crop. This was all without irrigation. In 1885 there was an extra good crop. In 1886 there was a total failure. They planted all the seed wheat they had, put it in the ground five times, and lost every bit. In 1887 the failure was as great as in 1886. The result was that everybody became discouraged, and those who had money enough to leave the country left it; those who had not, staid. They then began to bore wells. In Martin, Howard, and Andrews Counties the farm land was increased in capacity to five or six times what it had formerly been. People bought wind-mills and erected small dirt tanks and went into fruit-raising. The result in the matter of fruit-raising has been very satisfactory. They find that every variety of grape that is grown in California will succeed there. They produce a raisin grape at least six weeks earlier than it can be produced in California, and every ranch in that section of the country is going into fruit-raising.

I had a number of notes ready for the committee, but I did not expect it for ten days to come. I got a telegram 30 miles off from my home.

The **CHAIRMAN.** You may describe from memory, and you can report more fully to the committee subsequently.

Mr. **ROESLER.** On the Colorado River, west as far as the Pecos, there are a few places where we can make dams, but in the balance of it you will have to rely on wells. Then on the Pecos River there is the Pioneer Company's ditch, which is now about 10 miles long, some 40 feet across the bottom, and they have gotten in operation this year. They are still building on the lower end. They have places under cultivation—three or four sections of land. They claim that that river is always running full; that it stays at a certain point and never becomes less. South of the Pecos is Toyeh Creek. That is an old settled portion of Rains County. That has been in cultivation for the last ten or fifteen years, and is irrigated from the waters of that creek. They say there are about 15,000 acres in cultivation there.

Senator **REAGAN.** What do you know about the wells up there?

Mr. **ROESLER.** The wells I have examined, a considerable number of them, and I find in Martin County the water consists of two strata. That which is found above the limestone is usually found at a depth of from 10 to 25 feet; it is not lasting, however, for it comes from the local rains. Then from below the limestone, which is usually from 40 to 60 feet, they get an abundant supply, which is not affected by drought or local rains. During the drought of 1886 and 1887 neither of them were dry. The local theory is that all these wells are fed from underground rivers; that the strata from which this water is derived falls from New Mexico, underneath the Staked Plains, and eventually emerge on the Guadalupe and Concho, and one hundred other streams that burst suddenly out of the ground and become rivers without headwaters. The San Pedro, San Antonia, Concho, and many streams in Southern Texas will all appear where the limestone ridge is broken. We hold that between the Pecos and Colorado Rivers the strata are entirely unbroken; that there is a ledge extending for hundreds of miles which is without fraction, and that the water enters it east of the Pecos, and there it is broken by the mountains of El Paso and Reeves Counties and the eastern part of New Mexico. Underneath that flows an immense body of water which again appears after it gets underneath this limestone ledge, where it is broken. It is lying about 200 miles north of the Gulf coast, and makes a semi-circle.

Senator **REAGAN.** Is there a flowing well at Washburn?

Mr. **ROESLER.** I understand there are four or five on a ranch there.

Senator **REAGAN.** Would that be in harmony with the theory just presented?

Mr. **ROESLER.** I think they are dependent on local causes alone. I spoke with a gentleman the other day who told me that he thought that the supply was gotten a few miles distant; that it was not a part of the general system, but simply some elevated valley that gathered the water and let it out a few miles below.

Senator **REAGAN.** Do you know the depth of those flowing wells?

Mr. **ROESLER.** One 60 feet, another 75 feet, and another 110 feet.

Senator **REAGAN.** Is not the one at Washburn 300 or 400 feet in depth?

Mr. **ROESLER.** I do not know. That is a recent discovery if it is there, and I have not learned of it. I am more acquainted a 100 miles south of the Texas Pacific road than I am north.

The CHAIRMAN. Whether you testify again or not you will write out your report and submit it to the committee.

Mr. ROESLER. Yes, I prepared one, and I did not expect you so soon. The news caught me 300 miles from home.

If a suggestion is in order I would like to make one to this effect, that on the part of the Government stations be established, say every 100 or 150 miles, in which there shall be a crew well supplied with a dynamite drill and strong pumping machinery, and that there examinations be made of the soil by boring ten or fifteen wells in a straight line, varying in distance from say 25 to 100 yards. Wherever a piece of land is found 10 or 20 miles in width and 30 or 40 miles in length, with the characteristics uniform, then make a test. After ten wells shall have been bored, put in a steam pump that is capable of pumping 20,000,000 to 40,000,000 gallons of water. Then measure and ascertain the most distant point from the center well which is not attracted by the well, that is, in this way. If you pump the center well dry the next well nearer to it will show a diminution of water, the one a little more distant will also show a little less diminution, and the most distant will show no diminution at all. Then in a radius of 250 or 300 feet, say, you can calculate the amount of water you can get out of a certain radius, and thus know how much water you have in every acre of land in a given distance.

The CHAIRMAN. Would it be expensive?

Mr. ROESLER. I think it will cost money.

The CHAIRMAN. Would it pay to do it?

Mr. ROESLER. It certainly would.

The CHAIRMAN. Have you fuel convenient?

Mr. ROESLER. We have mesquite wood, which will burn out a boiler as quickly as coal.

The object to be gained by such experiments is this: If a man wishes to irrigate on the Staked Plain now, he will have first to get a well, then a windmill, and then a tank, and the whole thing will cost him $400. The entire capacity of this well, at a cost of $400, will be 5 acres, and you will find that he would be paying from $50 to $60 an acre to get water. If the Government will make this test, and say that under a certain area of land so much water can be had, the man who wants to make this improvement can interest others, and instead of getting a little Jim Crow well and windmill, he will get a strong company who will build large tanks to furnish that water for $15 an acre, whereas a single individual could not do it for $75. One section of land in the vicinity of Midlands, as nearly as I can figure out, taking the wells that I know to be there, cost $16,800 to raise enough water and store it to give to each and every acre of that section 24 inches of water during the year. That means 2 inches each month on a dead level.

The CHAIRMAN. That would be more than you would need, would it not?

Mr. ROESLER. Well, perhaps so.

The CHAIRMAN. A foot is about the limit.

Mr. ROESLER. It will depend on the rain-fall. Take it on our irrigated tract, this year we have not used a drop of water. Had we planted in 1886 we would have lost every stalk we had on it. The rainfall we had then did not exceed 18 inches, according to the rain-gauge. It looks as if that country were well supplied with water, but at the time the crop needs it it does not get it. After the crop has failed, there will come a 10 or 15 inch rain and drown out the country. Then a farmer has a new crop in. I am satisfied that all that country between the Colorado and Pecos Rivers, with 15 inches of water on it, will make a crop every year. There is a critical moment, and when that moment comes, if you give the crop water, it will be good.

STATEMENT OF C. I. GARFIAS, OF THE CITY OF MEXICO.

The CHAIRMAN. What is your occupation?

Mr. GARFIAS. I am a civil engineer. I have been sent here by the Mexican department of public works to attend to the public work in the frontier.

The CHAIRMAN. Have you given attention to the proposed dam and reservoir on the Rio Grande?

Mr. GARFIAS. Yes. As soon as the Mexican Government was made acquainted with the fact that Major Mills was here, and that he was going to begin his preliminary work for the completion of his project, I received an order to assist him in every respect. And afterward, so soon as it was needed, to make a survey of the land that would be irrigated, I received an appointment to make the surveys of those lands and to make the location of the canal. So that the Mexican Government is perfectly acquainted with Major Mills's project, and is interested in its completion, and thinks it would be a perfect success.

The CHAIRMAN. What extent of country has been irrigated on the Mexican side?

Mr. GARFIAS. I am not acquainted with those facts. I am only beginning those works, waiting for another engineer who comes from the State of Mexico with instructions.

The CHAIRMAN. Have you run any lines to determine the new works?

Mr. GARFIAS. Not yet. I was appointed only a few days ago.

The CHAIRMAN. The Mexican Government is very much interested, you say?

Mr. GARFIAS. Yes.

The CHAIRMAN. And so are the people?

Mr. GARFIAS. Yes. I want to state that so soon as the American people on this side appointed a committee for this question the Mexicans also appointed a committee. All the members were here this morning; now there are three here; I am the secretary. The president does not talk English.

The CHAIRMAN. As an engineer do you think the plan which has been adopted and presented here this morning the right plan?

Mr. GARFIAS. I think so. The thing is that that location would be much better. The location has one end in Mexican territory and one in Texas. The irrigation canals for Mexico would all be in Mexican territory, and so it would not be required to run that water across New Mexico.

STATEMENT OF THOMAS H. LOGAN, U. S. ARMY, COMMANDING AT FORT HANCOCK, ON THE RIO GRANDE.

The CHAIRMAN. Have you looked over this region, having in mind the possibility of irrigating it?

Mr. LOGAN. Yes, very closely.

The CHAIRMAN. State your observations and your views of the question.

Mr. LOGAN. In the first place, the country needs water very badly. If we had plenty of water we could raise anything that will grow in any other place. That is the result of my observation. And as to the means for getting the water, I think that Major Mills's plan is a very good one.

The Chairman. For this locality?

Mr. Logan. Yes. I do not know anything about the country except from here down to Fort Quitman, 80 miles. There will be about 300 square miles on both sides of the river that will be under the ditch; that is, 150 on this side, perhaps, and 150 on the other side. The dam is simply a matter of dollars and cents to build it. The dam is practicable; it is a small dam in comparison with some I am familiar with. I mean to say the contemplated dams. There are dams that I know of three hundred years old that have been in operation right straight along for three hundred years. One of them is in Spain that was built in 1686, and I think it is in operation to-day. That dam is 110 feet high and, I think, about 750 feet long. It is a masonry dam, built for the purpose of supplying several Spanish towns with water and for irrigation.

The Chairman. It occurred to me while Major Mills was testifying, though I did not call his attention to it, that it is desirable, if possible, to build this dam higher than 60 feet.

Mr. Logan. It is simply a matter of dollars and cents.

The Chairman. It involves the difficulty of getting right of way from the railroad.

Mr. Logan. The Croton Works in New York are 210 feet high. So far as building the dam is concerned, it is simply a matter of dollars and cents and good engineering. I do not know what the local features are on this side and at the foundation, but no matter what they are it can be surrounded with proper precautions.

The Chairman. You can get a rock bottom.

Mr. Logan. There was a French dam built in Algiers right on a rock. There are no engineering difficulties at all. There has been some doubt expressed by a good many people in this locality about the dam filling up. That is all fol de rol. It will fill up, but it can be cleaned out. That dam in Spain, which was built three hundred years ago, is cleaned out every three or four years. It had not been cleaned out before 1884 for fourteen years, and the sediment had increased 75 feet. At that time it was cleaned out in four days at an expense of $150, because they had the appliances to do it.

The Chairman. Have you seen that dam?

Mr. Logan. I have not seen the dam, but I have books on the matter. ~~They have scouring~~ galleries.

The Chairman. Describe them off-hand. We can get the books afterward.

Mr. Logan. Of course the number of galleries depends on the width of the reservoir, and the amount of filth that will be deposited in a given time. That will have to be regulated by observation and experiment. They build near the bottom of the dam, leaving a hole—that is a good plan—something in shape like a wedge, on the upper stream side. They have that closed with gates, and when they want to clean out the dam they raise these gates. At times the silt has deposited so far above the gates that the water would not run. Then by means of a bit with augers they perforated a hole in the dam, and this up-stream side threw the silt right out. They cleaned out that dam of a deposit of fourteen years in four days, and at an expense of $150. The bulkhead was made out of timber. They send men in the lower side of the dam who take augers and bore holes in the timber so as to weaken it, and when they got enough holes in there they run away. On the occasion to which I refer it did not start until two days after they thought they had enough. They ran away because it was a dangerous place to be. After a while it burst out and, as I said, it was cleaned out in four days.

The **CHAIRMAN**. They left a hole there?

Mr. **LOGAN**. Yes, sir; they left it in the face of the dam. They are left at proper intervals. Of course they are built strongly and then closed by gates. There is a French dam that has gates that go down with proper appliances for raising them, and a child ten years old can raise them without difficulty, because they have the proper machinery. They do not appear to be necessary in this dam with the pressure of water. Forty or 50 or 60 feet of water has an enormous pressure. It generates such an immense current away above the dam, and gets swifter as it gets lower toward the bottom. There have been no difficulties in the dams that I have read about; that is to say, difficulties in cleaning them out. This dam was in a gorge of the mountains, with a fall of 15 feet to the mile, and the deposit was much more than would be in this river. I have kept a little record at Hancock of the volume of water that flows down this river, and it is enormous. This river runs fifty-eight days in July and August at an average depth of 7 feet and 250 feet wide. Now it is dusty, you know, and there is not a drop of water in the running river except in the hills. I had some difficulty in supplying the post with water. I have a little well dug on the river bank some 18 feet deep, and in it is an abundant supply of good water. The stuff that can be raised down there with a little bit of water is perfectly prodigious. I had some experience in Montana. Fort Keogh, Miles City, was my stamping ground. The same rule applies there as down here. If you can get plenty of water you can raise plenty of stuff. This country on both sides of the river presents less difficulty for a canal or ditch than any country that I have ever been in where they have ditches. There is no work at all except with a spade and shovel. There are places between here and Fort Hancock, 55 miles away, that would not require more than a mile of fluming, and in some places there would not be that much. There are some places where, in crossing ravines, it would be necessary to flume to protect the canal. I have had some talk with the Mexicans on the other side of the river. There, at Paso del Norte and Guadalupe and Fort Hancock, they are very much interested in the scheme. They wanted to know if I thought it would go.

STATEMENT OF J. F. CROSBY, OF EL PASO.

The **CHAIRMAN**. You know the subject under consideration, and you may go on and make your statement.

Mr. **CROSBY**. I have been very familiar with this question since the year 1852, when I first came to this country. I think I am somewhat advised of its importance, I may say its vitality, to the interests of this country.

The **CHAIRMAN**. Go on and make any statement you wish touching what you have observed, the water supply, the land to be irrigated, and the general conditions of western Texas.

Mr. **CROSBY**. I will endeavor to condense my statement as far as practicable under the circumstances. This country, going back to its historical record for upwards of three hundred years, is well known here. This country, on the other side of the river especially, has had the use of the waters of the Rio Grande for three centuries past. I came here first in 1852, and at that period there was an abundance of water on both sides of the river. In lieu of the dam that has been built since, almost entirely by the expenditure of money by our friends on the other side of the river, either local or by municipal governments, we have had nothing but brush dams. The waters of the Rio Grade afforded most abundant irrigation for all the valley on the other side of the river than was then or has since been in cultivation.

I would like to make one statement here which may perhaps strike you as a little astonishing, because you are familiar with these things. But Judge Reagan comes from a country where they have a surplus of rain and water. You come from a country where the conditions exist about as, I understand, they do here. I wish to state that I have seen the waters of Rio Grande like this. You have been at the Grand Central Hotel. Right opposite there stands an ash tree, in front of Mr. Prudenthal's store, and there was a volume of water that ran along there in 1852 to 1860, sufficient to start the grist-mill that did the grinding for almost the entire country around here. I understand that is 20 feet above the level of the river where it is to-day. And that irrigation and water power was accomplished at least 20 feet. I say in altitude above where the river stands now. Since the changes in the river, the withdrawal of the waters above, the withdrawal of those currents, the people have been forced to go down to the river bed with their irrigating canals until they have gotten down on a level with the river, and have a dry irrigating canal to-day, as our friends on the other side of the river have. There was no trouble then to get water for purposes of irrigation and water enough for all manufacturing purposes in this country. When you take the elevation of a canal of that kind necessary to run a mill to grind 200 or 300 bushels of corn a day, you can imagine what the force of the river was at that time.

But these things have changed from time to time until to-day we are left with a dry river. We have not even water-power here to run the mills, and we have not even power to nourish, invigorate, and foster the plants that we put into the country, and on this and the other side of the river the crop of corn, beans, and all those material products which afford a sustenance to the people are all lost. The question is as to what way this scarcity of water is to be ascribed. I believe it is to be ascribed to the fact that the waters of the Rio Grande, which in prior times ran down this valley, have been diverted. Human nature is human nature the world over, and the people who have settled on the Rio Grande, in Colorado want the water, and they take it and use it to the fullest extent to supply their necessities in the way of making their annual crops.

Then, I am told that there are laws on the statute books, both in Colorado and New Mexico, probably passed over a quarter of a century since. Those laws are very good laws. I have no doubt they are very well framed. They are couched in the language which a lawyer would use. But the question is as to the observance of those laws. I have been living in this country since 1852. I am satisfied that I can state here, as they state under oath, that the waste of water in this river for the last eighteen or twenty years has been sufficient to irrigate from four to ten times as much land as is now proposed to be irrigated, or as is now planted in this valley. We can not control those things; the question is how to do it. The only question with me is how to allow the people of Colorado to get the water they need. They are bound to use this water, just as a hungry man would eat bread or meat. A man in Colorado is not going to allow it to pass his field if his crops require it. He is going to take it. He will not care for the laws on the statute books. And when he has used the water he is happy.

In the valley of the Rio Grande, between here and Socorro, just 200 miles distant, I have seen lakes from 1 to 4 miles in width and 3 to 5 miles in length which I have forded on horseback up to my saddle's girth. All that water came out of the Rio Grande.

The **Chairman**. Do the irrigators take it out?

Mr. **Crosby**. Yes.

The **Chairman**. And it is wasted?

Mr. **Crosby**. Yes; that is about it.

The **Chairman**. That is criminal.

Mr. **Crosby**. The laws are against it. The question with me is how is that to be avoided. I believe if we had a dam here, that is, either at this or some other point on the Rio Grande (I have no interest in either), the whole of that difficulty would be avoided. I am satisfied there is a volume of water that courses down the channel of the Rio Grande from the 15th of May until the 15th of August, taking year in and year out, to irrigate ten times the amount of land that we expect to irrigate to-day. Mr. Bronson stated to-day in his testimony that he conceived there was about 75,000 acres of land in the county of El Paso that could be irrigated successfully by the building of such a dam as is proposed by Major Mills and others interested in this project. He made a hasty calculation. I think he very greatly underestimated the extent of territory that could be irrigated.

Mr. **Bronson**. That had no reference to the county, but to the valley proper.

Mr. **Crosby**. I am speaking of the valley proper. I now propose to refer to the valley proper. The valley from here to Fort Quitman, without following the meanderings of the river, but where you could run the shortest road, to the end of this valley is 92 miles. That valley has a width of fully an average of 3 miles. Then, I assume that with a dam such as is proposed here you could add to that valley, conservatively speaking, 3 miles more; that is doubling the extent. You put 4,500 acres in rough to the lake, 3 miles to the lake, and it gives about thirty-one lakes to Fort Quitman. Then you double that by the mesa and lower ground which could be irrigated outside of this valley, and you double that proportion, and my figuring is that that there would be over 320,000 acres of land that is susceptible of cultivation in El Paso County alone. A 20-foot dam would flow water over that much land; but with a 60-foot dam you would get it to the opposite side of the river, and you would double that amount; and what is to their benefit on the other side of the river, experience shows us, in a commercial way, is to our benefit. We buy their grapes, pears, apples, peaches, corn; we trade with them in every respect; and you may say that the valley of the Rio Grande opposite us is practically of as much commercial benefit to the town of El Paso as though it were on this side of the river.

And there is one other point to which I wish to refer. If you will measure from Fort Selden to this point, the distance is 90 miles. According to actual measurement, the fall of the Rio Grande River in that 90 miles is 240 feet. Major Mills stated to-day that the fall was an average of 4 feet to the mile. We have here the actual measurement, because the discussion here has led to a consideration of a dam at Fort Selden, 90 miles above this, in New Mexico, or here in the city of El Paso; and hence we have obtained, or endeavored to obtain, all the data, scientific and otherwise, in reference to the current of the Rio

Grande River. The fall of the river in that 90 miles, from Fort Selden to El Paso, I understand from Major Mills and other engineers who have made the observations, is 240 feet. . Now, with 240 feet of fall in 90 miles, in the flood time, when we have this immense flood—because it is not infrequent that we see this river a mile wide from the 15th of May to the last of August—the volume of water that comes down is ordinarily something surprising. It is an immense volume of water. If you could confine that water with a 240-foot fall you would not only benefit the agricultural interests of the country, but it strikes me you would obtain here and below and above in New Mexico a water-power that would be sufficient for almost any manufacturing purpose which water can subserve. You obtain an immense water-power, just as I stated about this little mill that ran day and night. These gentlemen, some of them, perhaps, in their boyhood have seen that mill run every day and night 20 feet above the river, and when we have any water it runs to-day. How much that can be improved by these scientific gentlemen, Major Powell and Major Mills, I do not know. The good of this country, the interest of the General Government, the amount of wealth that such a dam would contribute, not to the State of Texas alone, but to the General Government, in the way of taxes, would be enormous. It is almost beyond calculation.

Now, I wish to go back, if you will pardon me, to defend in a way our friends on the other side of the river. I make this broad statement: In 1848 the Government of the United States, under the treaty signed at Guadalupe Hidalgo, agreed upon the Rio Grande as a boundary line between the two Governments. What did that mean? Did it not mean that the two Governments should maintain that boundary line, that the two Governments, the United States and Mexico, were permitted to cultivate those lands; that they were permitted under the guaranties of this Government to cultivate that land up to the boundary-line? Both of the Governments have acknowledged it up to two years ago. At that time the Mexican Government made a large expenditure, as you will see, for the works on the other side of the river. To avoid the difficulties that were to ensue from this treacherous stream, this changeful current, they appropriated a great amount of money, and the people on the other side of the river have been taxed for works that have been established there by engineers of the Mexican Government. I do not know the amount of money appropriated, but it has been a large amount. They had been admonished that it was necessary to protect their banks. The United States has not expended anything to protect this side of the river. Land here in front of us on the other side of the river and in this town, by reason of the increased population of the two cities, has largely increased in value. Hence, the Mexican Government has sought to protect their banks of the river because of the change of the river. You will find that the homes over there of poor, indigent people have been swept away, first on one side and then on the other, by the currents of this river. That question is not pertinent to this committee, but I believe that morally and justly and equitably the Government of the United States, a great and grand and rich Government, should say to Mexico that "we gave you an international boundary, we are bound to maintain that; we have neglected to maintain it; you have begun to maintain it, and we should adopt all means in our power to bring that boundary where it belongs." I believe this dam would settle it, and I believe you could let it into your dam 30 feet or 50 feet wide, of clear water; no erosion to increase or decrease on one bank or the other, but you could follow it down with an expense far less than can be conceived of by those who speak lightly of the subject. I believe the thing could be done. I believe we can establish a boundary to-day that would be lasting.

Let us say that an offense was committed over there—murder, robbery, smuggling, or anything of the kind. You do not know where to fix the jurisdiction. We can not do it. Our courts are bothered to know where to fix the jurisdiction. But with this dam, and with a very slight work because there will be no rush of water; there will be only so much water run into that river—you could keep its channel according to the treaty of Guadalupe Hidalgo; and then the work on each side of the river to confine that water to its proper course would be a matter of very small import.

Of course, there are a great many other views of this matter. My judgment is that both the Governments are responsible to their people for all the changes that have occurred in the course of this river, just as if you had an artificial line across the plains from here to Fort Yuma and that were removed. I think these people should be indemnified for the loss of their land by the boundaries of that river. We should come up to the treaty.

I do not know that I should say anything more.

STATEMENT OF E. PROVENCIO, MAYOR OF PASO DEL NORTE.

(Interpreted by Juan S. Hart.)

Senator **REAGAN**. Will you inform the committee about the decadence of irrigation or loss of irrigation on the other side of the river within your remembrance?

Mr. **PROVENCIO**. Some twenty years past, during which time my observation has extended, and up to date, there has been a loss of no less than one-third of the territory which was originally irrigated by the waters of the river; to which I attribute, as the principal cause, the lack of water each succeeding year; and I attribute this lack of water to the fact of increased irrigating facilities that have been established in the upper portions of the valley of the river. On this account a large portion of the population of what was formerly known as Paso del Norte, and is now called the City of Juarez, has been of necessity forced to emigrate to distant parts to find support. These emigrants have formed in a great measure the new and thriving towns of La Union, La Mesa, Chamberino, Las Amoles, Nombre, and De Dios, in New Mexico, and along the borders of the Rio Grande, and also the additions in population that have been made to La Massila and Las Cruces. They have increased in population by reason of this emigration.

The parts on the Mexican side of the river that have suffered the greatest loss of population are Seni Cu, El Real, De San Lorenzo, and Tres Jacales; and in the very best inhabited portions of others of our border towns on the Mexican side it is noticed that a considerable portion of the population has left the larger towns.

The principal source of water, the irrigation canal that we had during the past twelve years, our main canal, which was formerly of a breadth of 12 feet and contained 6 feet of water in depth, now has less than 3, preserving its same width. There has been lost during that length of time the greater part of our crops on account of the lack of water. Four mills which have existed along that canal with a water-power are to-day without any means of turning their machinery. The mills are by name, first, Montoya's, Vicente Provencio's, Jose Caribal's, and Juan Gila's. Their doors are now closed entirely, without doing any work for the past three years.

Senator **REAGAN**. What amount of water comes down in flood time?

Mr. **PROVENCIO**. It is an immense quantity that comes.

Senator **REAGAN**. You have been mayor of Paso del Norte for how long?

Mr. **PROVENCIO**. I have been two years mayor of Paso del Norte, and for over six years a member of the local council.

Senator **REAGAN**. What steps have been taken by the Mexican authorities to protect the banks of the river on that side?

Mr. **PROVENCIO**. The work that was done in former years was almost useless. Very recently our Federal Government has ordered the banks of the river protected by such works as are now subject to your inspection at any moment on the river banks on the other side. I want to make known the fact, which no one can deny, that during the past six or eight years the water which they have had on our side has been hardly sufficient for the land which has been open for irrigation purposes. Prior to that time they had an abundance of water, which has been failing in quantity each succeeding year. I wish to have that impressed on the committee.

The **CHAIRMAN**. How much land was formerly under cultivation on the other side of the river from this point down to Quitman?

Mr. **PROVENCIO**. I would place the estimate at 125,000 acres.

The **CHAIRMAN**. How much is now under cultivation?

Mr. **PROVENCIO**. Hardly 70,000 now.

The **CHAIRMAN**. And is the amount gradually decreasing?

Mr. **PROVENCIO**. It is gradually decreasing. It is about three years ago that, at the expense of the municipality on the Mexican side, there was built just above the city a dam across the river of masonry work which cost about $40,000, thinking that even the shortage of the water, possibly, with such a dam, which was never necessary before, might have been stopped, and they would have a sufficiency of water; but that project has not given good results.

The **CHAIRMAN**. Is there apprehension that irrigation on the upper portion of the river will destroy it on the lower portion?

Mr. **PROVENCIO**. Undoubtedly. I cannot attribute the present scarcity of the water to any other reason.

The **CHAIRMAN**. And the more irrigation they have above, the less water they will have below?

Mr. **PROVENCIO**. Surely. Every new canal taken from the river above deprives us here of a certain amount of water. Besides I want to make it known to this committee that we have always lived in perfect harmony with the American side of the river. It is true we have established and maintained a dam across the river above the city, but we have always distributed the water in perfect proportions between the two sides of the river, and for that reason, for the fair treatment of the American people, we desire to be treated fairly on the opposite side of the river, and we desire to be given our share of the waters of the Rio Grande.

STATEMENT OF JOSEPH MAGOFFIN, OF EL PASO.

Senator **REAGAN**. How long have you resided in El Paso?

Mr. **MAGOFFIN**. I came here in 1844 and I have resided here since 1856.

Senator **REAGAN**. You have heard the course of examination. Will you state any facts in relation to the sources of water, the means of obtaining water, and the necessity for irrigation here, which you think would be of interest to the committee?

Mr. **MAGOFFIN**. Prior to 1861—I will go back—the population of Paso del Norte (city of Jaurez) was about 30,000. It was a thriving little city, and also the surrounding country was cultivated. They had no trouble from water, except in exceptional years. Probably once in ten or fifteen years the river would be cut off. During our interstate troubles here and the war of Maximilian, the dam above here was carried away by the flood, and a great many people on the other side of the river left, they being more interested in keeping their country intact than in looking after the dam. In 1868, when I returned here to El Paso, the dam that had been swept away had not been rebuilt. A year or so afterward the dam was again built, and the people who had left El Paso proper and all the farmers commenced to return to their homes and to cultivate the lands. They now have, on account of the scarcity of water and the difficulties that they have been having for the last two or three years in the scarcity of water, commenced to leave their part of the country and go above into New Mexico, Las Cruces, and elsewhere, where they have friends and relatives, seeking new homes. This state of things, it is regarded by not only the Mexican people but ourselves here in El Paso, is caused by our friends in Colorado and New Mexico taking out these vast ditches from the river. The water has lessened from year to year until this year we have none at all.

Senator **REAGAN**. Does that apply to both sides of the river?

Mr. **MAGOFFIN**. Yes.

Senator **REAGAN**. And are the people suffering in Paso del Norte as they are here?

Mr. **MAGOFFIN**. Equally so. There is no water on the other side of the river. The river was dry this year about the 1st of July, something that never occurred in the history of the country.

Senator **REAGAN**. What is the usual season of flood?

Mr. **MAGOFFIN**. The river never fails to rise here the 1st of May, and it keeps up continuously, so that no one can cross it until about the 25th day of July—I mean on horseback.

Senator **REAGAN**. Did you have any rise the 1st of May this year?

Mr. **MAGOFFIN**. Yes, we had plenty of water all of April, May, June, and you may say until the 1st of July. The river went dry about the 15th of that month. We had a full river before all the time. I think we had more water in the river than flows in any stream in Texas, Colorado, or anywhere else.

Senator **REAGAN**. Make any additional statement that you may desire.

Mr. **MAGOFFIN**. I do not know that I can say anything more than this, that our Mexican friends look upon our Government as a great Government, and are willing to restore these water rights to them. They are now moving in that matter with their government. They look upon it as a matter of justice to them that our Government should in some way restore their ancient rights to this water. It is a question of vital interest to them, as well as it is to the people on this side of the river. And there is nothing that I can see now that will give us this water except the establishment of that reservoir that Mr. Mills contemplates building. In building that reservoir it will cease all complications with regard to the boundary line which has destroyed thousands and thousands of dollars worth of property on both sides of the river. The water will be stored in such a way as not to come down in flood times and wash away the banks of the river. It washed away at Fort Bliss and destroyed my father's property there, worth $100,000, and has destroyed other property equally valuable on the other side. Sixty-five miles from here is Fort Selden.

Senator **Reagan**. Up the river.

Mr. **Magoffin**. Yes; they contemplate building a dam there for the purpose of irrigating all the land west of us here, in New Mexico. That will again take the water away from this section of the country; and if something is not done by our Government I do not see what the people below here are going to do. We can not do this work as a people, because the international questions come in that will interfere with private capital engaging in the enterprise. They are questions to be settled with Mexico amicably, and adjusted so that they may get their water rights. No one has a right to question or look into that question but our General Government, and we have our hands tied here expecting that you gentlemen will try to help us out of the fix.

STATEMENT OF W. W. FOLLETT, OF THE GEOLOGICAL SURVEY.

The **Chairman**. What is your occupation?

Mr. **Follett**. Engineer.

The **Chairman**. In the employment of what?

Mr. **Follett**. Temporarily in the Geological Survey.

The **Chairman**. You have been making surveys in this country?

Mr. **Follett**. I made the survey for the lake and these maps that have been presented. I made that above the town; the one below was made by the county surveyor, Mr. Heldt; but the survey above the reservoir I made.

The **Chairman**. Have you given any attention to the subject of irrigation?

Mr. **Follett**. I am from Denver down here for the purpose of making these surveys; was never in this country before.

The **Chairman**. Would it be practicable to build that dam higher?

Mr. **Follett**. Yes, 10 feet higher.

The **Chairman**. In building it 10 feet higher to what extent would it flood back on the land?

Mr. **Follett**. The principle amount it would cover would be directly in the river bottom, which, at the upper end, is 3½ miles wide, practically 2½ miles, covering 8 square miles more than now covered.

The **Chairman**. Would it injure much more property?

Mr. **Follett**. It would only a short distance above the head of the lake as now surveyed. I do not know how far, but I think only 4 or 5 miles. There is a town they call Montagu where there are vineyards, and it would flood those, and that is very valuable property.

The **Chairman**. Valuable, compared with what it would now cover?

Mr. **Follett**. Yes.

The **Chairman**. About how valuable would it be, too much to allow you to build the dam 10 feet higher?

Mr. **Follett**. Ten feet more would add about 40 per cent. to its present contents.

The **Chairman**. If they have the amount of land that they say they have, and there is a chance to fill it, it seems to me there is no difficulty about it.

Mr. **Follett**. The estimates that Mr. Heldt made on this side of the river from Faben's to Fort Hancock is 36,000 acres that it will cover, and there are probably 10,000 or 15,000 above that, making 50,000 acres on the American side.

The **Chairman**. Have you investigated to any extent the probabilities of filling such a reservoir?

Mr. **Follett**. I have investigated the probabilities of filling this particular one.

The **Chairman**. Do you think it could be filled?

Mr. **Follett**. Yes; it could be. The general flow of the river, allowing a reasonable amount to pass the dam, would probably fill it, the first filling, in the course of two years. Of course, a great deal would soak up It is hard to say how much would be taken up; but it is safe to say that it would be filled in two years, or two and a half after it is built. In July it was carrying 600 or 800 cubic feet per second.

STATEMENT OF J. W. EUBANK, OF EL PASO.

The **Chairman**. You have been county surveyor. What do you say as to the amount of land that could be covered by a dam 60 feet high for purposes of irrigation?

Mr. **Eubank**. I have made a calculation of the land in the low part of the valley, from here to Quitman, and I calculated that it was about 110,000 acres. But I think from what I see in that map that it will be something like 50,000 acres more, and adding the higher lands, up to 175,000 acres from here to the cañons below.

The **Chairman**. If you could get the water?

Mr. **Eubank**. Yes; raising the water 60 feet high. The valley falls 2½ feet to the mile. After that it falls 2 feet and over; after that a little faster, down to Camp Rice. I do not know what it is. I take it from the railroad, which falls 2 feet to the mile, or 1.9 feet.

The **Chairman**. How is it on the other side of the river?

Mr. **Eubank**. I have been all along there, and it would be just about equal; one side the same as the other. I have never made a calculation, but that is my observation.

The **Chairman**. Are you familiar with western Texas?

Mr. **Eubank**. Yes; I spent a year and a half coming out into this country on the Texas Pacific Railroad as an engineer. I know the country there pretty well; walked all over it.

The **Chairman**. What do you say as to the feasibility of irrigation in western Texas.

Mr. **Eubank**. I think it is feasible up to the point 30 or 40 miles west of the Pecos River, where you strike the mountains. From there east it is feasible to get water from the ground so far as I have observed.

The **Chairman**. To what extent can it be practiced from there east?

Mr. **Eubank**. Only from wells. There is no water there, except the well water, and we found water from 20 to 30 feet for railroad purposes, stations, and engines, wherever we dug.

The **Chairman**. Could the water be stored on the Pecos below?

Mr. **Eubank**. The plains are 2,989 feet, the highest point, where the railroad crosses, and the Pecos is 2,300 where the Texas Pacific crosses.

You see the difference is about 600 feet below the plains. You would have to go up the Pecos River and get it out on the plains. I do not believe it would be feasible.

The CHAIRMAN. But the valley?

Mr. EUBANK. It could be all brought under cultivation by the Pecos River.

The CHAIRMAN. How much valley is there?

Mr. EUBANKS. On the eastern side, before it comes to the hills, it is 2½ miles where the railroad crosses; but going west it comes 2 miles out and rises four-tenths of a foot to the 100 feet.

The CHAIRMAN. You do not know to what extent the Pecos could be brought on that ground?

Mr. EUBANKS. I went up on the Pecos River 6 or 8 miles from the railroad, and I have been farther than that from the railroad.

The CHAIRMAN. Is that good land?

Mr. EUBANKS. Yes; it appears to be good land. Down near the river it is alkali; but when you get away from the river it is splendid land.

Senator REAGAN. Have you made any examination that would enable you to say whether a dam built here, as has been spoken of, 60 or 75 feet high, would throw water out on the mesa on the east side of the river?

Mr. EUBANKS. The mesa is 170 feet above this town, and the highest point of the mesa is 374 feet above this town. In order to bring a ditch around this mountain San Marcial onto that land, by obtaining a grade of 1 foot to the mile to bring it out on this vast plain, you would have 30 or 40 feet cutting for a half mile.

Senator REAGAN. How much land would it open to irrigation?

Mr. EUBANKS. About 1,000,000 acres any way.

Senator REAGAN. What is the distance that you speak of where it would be necessary to bring that ditch out?

Mr. EUBANKS. One hundred and fifty or 160 miles; 120 miles.

Senator REAGAN. What would be the length of the ditch before you reached the San Marcial?

Mr. EUBANKS. You might add 20 per cent to the railroad for the windings of the ditch. The ditch would not be as straight as the railroad.

The committee took a recess, and on re-assembling heard the

STATEMENT OF LUDWIG HELDT, SURVEYOR OF EL PASO COUNTY.

The CHAIRMAN. Are you familiar with the topography and sources of water-supply for irrigation in western Texas?

Mr. HELDT. Yes; I am well acquainted with some of the latter.

The CHAIRMAN. State what you know of them?

Mr. HELDT. I was division engineer of the Southern Pacific Railroad for some years, and I am well acquainted with the Devil's River and part of the Pecos and nearly all the waters between here and San Antonio.

The CHAIRMAN. Go on and explain that.

Mr. HELDT. In Devil's River I have taken an extra interest, because a friend of mine asked me if it was possible to irrigate by damming the river, and I went out there and made a special examination of it. At another time I was at the head of the river.

Devil's River is an overflow from a small lake near Beaver Lake in Crockett County, Tex. It is a free flowing stream of clear water, and is everlasting. There is a rock bottom all the way, and it is very easily dammed up, and can be spread over 50,000 acres of land near Del Rio.

The CHAIRMAN. Do you think that there is a sufficient water-supply, if it were stored, to irrigate 50,000 acres of land?

Mr. HELDT. Yes, I do. They are irrigating 12,000 acres of land at Del Rio and at San Felipe Spring, and that spring must come from the Devil's River somewhere, because every time that river is up the spring rises, and when Devil's River is low it falls. But this San Felipe Spring is also everlasting. One curious thing about it is that they tried to dam it up a couple feet higher a few years ago; they found that it would not flow more, and that is my reason for thinking that there is water from the Devil's River, and by damming up the Devil's River I think this San Felipe spring will rise so much higher that they could irrigate nearly twice the land. That is my impression, and I think that I am right about it.

The CHAIRMAN. Then what is the next stream?

Mr. HELDT. That is the only stream that I have made any special study about.

The CHAIRMAN. Have you traveled over the others?

Mr. HELDT. Yes.

The CHAIRMAN. What is the next stream?

Mr. HELDT. There are no streams any farther down until you get to San Antonio River.

The CHAIRMAN. How far is Devil's River from here?

Mr. HELDT. Four hundred and fifty miles.

The CHAIRMAN. Is there any stream between that and here?

Mr. HELDT. There is the Pecos River. There is no irrigable land between Fort Quitman, 80 miles below here, and Del Rio, 90 miles below that point.

The CHAIRMAN. What is the next stream?

Mr. HELDT. The Pecos River.

The CHAIRMAN. No streams between?

Mr. HELDT. There is a small stream at Langtry, but it is in a cañon about 120 feet deep.

The CHAIRMAN. Are there no cañons or arroyos that have storage facilities?

Mr. HELDT. No; not between the Pecos and Devil's River.

The CHAIRMAN. What is the distance between Devil's River and Pecos River.

Mr. HELDT. Fifty miles; and that is the roughest country in the world.

The CHAIRMAN. Have you been up the Pecos?

Mr. HELDT. No, not for any distance. Well, I have been on horseback when I was trading cattle.

The CHAIRMAN. How much of a stream is the Pecos in flood time?

Mr. HELDT. In flood times I have known it to be 30 feet deep—up to the bottom of the bridge of the Southern Pacific Railroad.

The CHAIRMAN. How wide?

Mr. HELDT. One hundred and fifty feet wide.

The CHAIRMAN. Can you give an estimate of the quantity of water that runs in it?

Mr. HELDT. No.

The CHAIRMAN. Have you ever gauged it?

Mr. HELDT. No. Well, I think it would be possible to dam up those draws and irrigate some of that country there.

The CHAIRMAN. Where?

Mr. **HELDT**. About Murphyville and Marfee. That is a level country.

The **CHAIRMAN**. What surveys did you make?

Mr. **HELDT**. I made a survey of the river from here to a point about 10 miles below Fort Hancock.

The **CHAIRMAN**. And made a map? was that your map that was shown to the committee?

Mr. **HELDT**. Yes, sir; also a survey of an irrigation ditch to be used in connection with this proposed dam from Fabens to Fort Hancock.

The **CHAIRMAN**. What amount of land is there on the American side that can be reached from the ditches of this dam?

Mr. **HELDT**. I think there will be 125,000 to 150,000 acres between Fabens and Fort Hancock. By actual measurement I have found it 136,000 acres.

The **CHAIRMAN**. How much on the Mexican side?

Mr. **HELDT**. An equal amount.

The **CHAIRMAN**. In running your ditches, how far from the top of the dam would you take the water?

Mr. **HELDT**. Forty-five feet from the bottom of the dam. I used the Southern Pacific grade all the way down.

The **CHAIRMAN**. That will leave about 15 feet of water.

Mr. **HELDT**. Yes.

The **CHAIRMAN**. Do you think that will be sufficient to irrigate 135,000 acres of land?

Mr. **HELDT**. I really have not made that a study.

The **CHAIRMAN**. How many acres would 15 feet of water in that dam cover a foot deep?

Mr. **HELDT**. I would have to have some time to figure that out.

The **CHAIRMAN**. How much land could you irrigate if you came up six feet from the bottom?

Mr. **HELDT**. Fifty thousand acres.

The **CHAIRMAN**. If you came up 20 feet, how much?

Mr. **HELDT**. The increase would be rather gradual.

The **CHAIRMAN**. Is it proposed to make different places to draw the water out at different heights of the dam?

Mr. **HELDT**. I think not.

The **CHAIRMAN**. I think they ought to do that.

Mr. **HELDT**. I think the dam will be solid for 40 feet.

The **CHAIRMAN**. It ought to be solid at the bottom, too. In surveying the ditch from the proposed dam down to the cañon on the Colorado, you found that the river had been changing its bed very much?

Mr **HELDT**. Yes, very much.

The **CHAIRMAN**. And that the boundary is very uncertain?

Mr. **HELDT**. Yes, very uncertain.

The **CHAIRMAN**. In what respect has it been changed?

Mr. **HELDT**. In some places changed for 3 miles and over.

The **CHAIRMAN**. And it is continually changing?

Mr. **HELDT**. Continually changing, yes, sir.

The **CHAIRMAN**. Do these changes take place in flood times or are they constantly occurring?

Mr. **HELDT**. They always occur in flood times.

The **CHAIRMAN**. No change when water is low?

Mr. **HELDT**. No.

The **CHAIRMAN**. Then, if the flood waters were retained you do not think there would be any changes?

Mr. **HELDT**. I do not think there would be any changes.

The accompanying papers, reports, and statements were received and ordered filed by the committee.

Adjourned.

STATEMENT OF ANSON MILLS, MAJOR TENTH CAVALRY, U. S. ARMY, CONSULTING ENGINEER OF THE U. S. GEOLOGICAL SURVEY AT EL PASO.

While on leave of absence here last fall, I submitted to the city council of El Paso the project for a dam and reservoir in the Rio Grande, above this place; later on, while in Washington, I presented the same to the Director of the Geological Survey, Major Powell, who gave me such kindly encouragement that on the 10th of December, at the request of the then Secretary of State, Mr. Bayard, I wrote and he had printed a detailed explanation of my project, which is inclosed herewith, marked A.

In April, 1889, at the instance of Major Powell, I received the following order from the War Department:

Special Orders, }
No. 85. }

HEADQUARTERS OF THE ARMY,
ADJUTANT-GENERAL'S OFFICE,
Washington, April 12, 1889.

[Extract.]

* * * * * * *

6. With the approval of the Secretary of War, Maj. Anson Mills, Tenth Cavalry, will report for temporary duty to the commanding officer, Fort Bliss, Tex. In addition to his military duties at that post, he is authorized to extend his services in every proper way, when they may be requested, to the officers of the Interior Department in charge of the Geological Survey on that part of the Rio Grande 60 miles north and 60 miles south of the El Paso, Texas, this survey having for its object the redemption of areas of irrigable lands in the Rio Grande Valley. The travel enjoined is necessary for the public service.

* * * * * * *

By command of Major-General Schofield.

R. C. DRUM,
Adjutant-General.

Official.

J. C. KELTON,
Assistant Adjutant-General.

Major MILLS,
Worcester, Mass.

On reporting to the Director of the Geological Survey I received verbal instructions from him to make all reasonable investigations that would tend to develop the feasibility of my project, and the following written instructions:

DEPARTMENT OF THE INTERIOR, U. S. GEOLOGICAL SURVEY,
Washington, D. C., April 20, 1889.

SIR: I have the honor to acknowledge the receipt of your letter of 15th instant transmitting a copy of Special Orders, No. 85, current series, from the commanding general of the Army, authorizing you to extend your services, in every proper way, when they may be requested by the officers of the Interior Department in charge of the Geological Survey and its action with reference to improvements of the Rio Grande River, near El Paso.

In reply thereto I hereby request that you will act as the advisory agent of this Bureau in respect to matters connected with improvements of the Rio Grande River near El Paso, and relation to the use of its waters for purposes of irrigation. You are requested to keep this Bureau informed of all projects looking to such purposes and to communicate to it your opinions and advice thereon. In view of the fact that any works affecting the flow of the Rio Grande River must be matters of equal solicitude to the people of the United States and of Mexico, and to their respective governments, you are especially requested to acquaint yourself, so far as may be, with the views of the Mexican officials and people in relation to such matters, maintaining in your intercourse with them a most friendly attitude and representing to them a sincere and earnest desire of this office to treat all matters relating to the use of the waters of the Rio Grande for purposes of irrigation with a due regard for their rights.

It is the purpose of this Bureau to establish at El Paso a station for gauging the annual flow of the river, for measuring the evaporation, and for other purposes, and I should be pleased if you will exercise a supervision over this work of the employés, who will be instructed to report to you, and I further request that you will assist them in securing facilities for their work.

Very respectfully, sir,

J. W. POWELL, *Director.*

Maj. ANSON MILLS,
Tenth Cavalry, U. S. Army, Worcester, Mass.

EXHIBIT A.

EBBITT HOUSE, *Washington, December* 10, 1888.

SIR: Agreeable to promise at our interview this morning, I have the honor to submit the following general outline of my projected scheme for an international dam and water storage in the Rio Grande, near El Paso, Tex., for the control of the annual floods and the preservation of the national boundary to the Gulf, and for other purposes.

The Rio Grande, 1,800 miles long, rises from an unusual number of tributaries in the very high altitudes of southern Colorado and northern New Mexico, where the rain and snow fall is extraordinary, and the ice formed therefrom in the long winter enormous. As it flows southward the precipitation gradually decreases for 600 miles, when the Mexican boundary is reached, at El Paso, Tex., where there is neither snow nor ice, and but 8 inches annual rain-fall; from thence, 1,200 miles south, to the Gulf of Mexico, the rain-fall is only sufficient to compensate for the loss by evaporation (which latter is very great); and, for these reasons, the river has but few tributaries, and no increase of flow below El Paso.

The annual floods, caused by the melting of the snow and ice in the mountains, take place in May and last for about seventy-five days, during which period the average flow may be estimated at 200 yards in width by 2 yards in depth, with a velocity of 5 miles per hour, although in recurring periods of about seven years it is much greater. During the remaining two hundred and ninety days of the year the average flow is, perhaps, not over 30 yards wide by 1 yard deep, with the same velocity; and in the same recurring periods in the intervals between the high tides the river goes dry for months, as it is at this time, or at least has no current, with not enough water in the pools to float the fish.

There is a present popular opinion that this want of water comes from its diversion by the numerous irrigating canals lately taken out in Colorado and New Mexico, and while it is problematical what effect this may have, if any, I am of the opinion that most of this water returns to the stream again, either through the atmosphere, by evaporation and precipitation, or by the earth, through overflow and drainage, as, from personal observation, I know that these seasons of flood and drought were of about the same character thirty years ago.

After leaving the mountains the river passes through low valleys of bottom lands from 1 to 12 miles wide, and from 4 to 8 feet above low water level, of a light, sandy alluvium formed during annual overflows by sedimentary deposits from silt, which the water always carries in a greater or less degree.

In meandering along the Texan bank of the river, as a land surveyor, from the New Mexican line to a point below Fort Quitman, in 1858, 1859, 1860, I observed that the deposit was from one-half to 3 inches annually; that during the floods the bed of the river was constantly changing by erosion and deposit; and that in regular cycles it shifted from one of its firm rocky or clay banks to the other as the deposits had raised the side of the valley through which it then flowed above the level of the opposite side. Generally this change took place slowly by erosion and deposit of matter entirely in suspension; but frequently hundreds of acres would be passed in a single day by a cut-off in a bend of one channel and sometimes the bed would suddenly change from one firm bank to the other, a distance of perhaps 20 miles in length by 6 in width, for instance.

When surveying "El Canutilo," a valley a short distance above El Paso, the river was moving westward, and about the middle of the valley, which was some 6 miles wide, old Mexicans who had lived in the vicinity informed me that in 1821 the river ran close along the eastern bluff, where its bed was plainly to be seen, as was also a less plainly outlined bed along the bluffs on the opposite side where the river flows at this date, and gives evidence of returning abruptly to the eastern bluffs again at the next greatest high tide, to its old channel, along the bed of the track of the Sante Fé Railroad.

In another case, more recent and extensive, in the great valley below El Paso, some 12 miles in width and 20 miles long, the river, as was plainly evident at the time I was surveying the land, had made a sudden change from the bluffs on the eastern or Texan side to the western or Mexican side of the valley.

Mexicans, who had been residents continuously in that vicinity, informed me that this change took place in 1842.

Again, in 1884, in this vicinity, the river swept suddenly from the Mexican side, crossed the Southern Pacific Railroad, and destroyed both track and bed for a distance of 15 miles, stopping traffic for a period of three months and causing the removal of the road to hills above the valley.

Though these are the most extensive changes that came within my personal observation, similar ones are being made annually, from El Paso to the Gulf, which not only prevents the settlement and development of such of the lands as are sufficiently above the overflow (were the banks and boundaries secure), but, by reason of the river being the national boundary between the United States and Mexico for over 1,200 miles, cause fatal embarrassements to the citizens and officials of both republics, in fixing boundaries and titles to lands, in preventing smuggling, collecting customs, and in the legal punishment of all crimes and misdemeanors committed near the supposed boundary line, it being easy at almost any point in its great length to produce evidence sufficient to raise a reasonable doubt in the minds of the jurors as to which side of the line the arrest was made or the act committed.

At the last session of Congress the House passed a joint resolution (No. 112) requesting the President to appoint a commission, in conjunction with a similar one from the Republic of Mexico, to consider the matter above referred to. While surveying these lands in 1858, and prospecting for a crossing of the Rio Grande for the Memphis, El Paso and Pacific Railroad, which was then projected and, in fact, in course of construction, I examined the pass about 3 miles above the present city of El Paso, and discovered that it had solid rock bed and walls, the latter but about 400 feet apart, and that the valley above which came close down to the spur of the Rocky Mountains, which crossed the river and formed the pass, was from 4 to 8 miles wide, with a fall of about 4 feet to the mile, so that it would be an easy matter to build a dam in this pass and create an immense lake.

The water coming through this pass for ages has deposited at its lower end a great mass of rocks, over which is formed rapids with about 12 feet fall, and the aborigines of prehistoric ages made use of this to carry the water on to the lands below—no one knows how long ago; but it is known that the Mexicans have used it for two hundred years, under most disadvantageous and unsatisfactory circumstances.

I have witnessed, each succeeding year, hundreds of Mexicans piling loose stones on the top of this drift of rocks to raise the level to that carried away by the floods of the preceding year; and it has been estimated by a Federal engineer sent from the City of Mexico, that, had the labor thus expended been reduced to silver, the dam could have been built of the solid metal.

The difficulty has been, and always will be, that there is neither bed-rock nor solid earth in the bottom or banks, each being composed of quicksand.

In other places in the valley, temporary willow dams, 1 or 2 feet high, are made at convenient places, and the water carried several miles below on to the lands that are above the usual overflow; but these dams are carried away annually, and have to be rebuilt, and frequently the river bed moves miles away from the mouth of the ditch or acequia, rendering it useless, but even if these difficulties in carrying the water from the bed of the river to the lands are overcome in the usual manner, it is evident that by reason of a great overflow—say every seventh year—and a dry river in a like period, no system of irrigation for the Rio Grande can prove satisfactory that does not embrace a grand storage system sufficient both to restrain, to a great extent at least, the tidal flow and maintain a costant annual flow, especially since the great emigration and settlement in its valley is constantly doubling the demand for water.

Being on leave of absence in the city of El Paso recently, where I was a citizen before the war, having surveyed the first plat of the town, and being well known to most of its citizens, I was invited by the city council to submit to it a plan for water supply and irrigation that would overcome the difficulties above referred to.

It at once occurred to me that, as the Rio Grande was the joint property of the two nations, and especially as the Mexicans had used its waters since time when "the memory of man runneth not to the contrary," that any plan to be acceptable and satisfactory must be international in character, and the works, both before and after completion, under the joint Federal control of the two nations—the more so as riparian rights in this country, so far as regards irrigation, are not well defined by law and could be best brought about in this instance by treaty stipulations between the two countries.

The matter of restraining the tidal flow by storing the water, and thus protect the constantly-changing national boundary, occurred to me, if it could be introduced into the project, as likely to secure encouragement and substantial aid by liberal appropriations in money from both Governments.

And further, that at El Paso (now a city of over 11,000 population, with every prospect of being a large manufacturing city at no distant day, there being no place within 500 miles likely to compete with it), the subject of water-power ought also to enter into the problem, which of necessity is of such vast proportions as to require all incidental aid possible to attach to it to insure its success.

It will be apparent, from what has been written, that the Rio Grande is one of the first magnitude, not only in length and breadth, but for short, annual periods in devastating flow of waters, and that its general characteristics, as compared with other rivers with reference to irrigation, are so abnormal as to require different and more heroic treatment.

I therefore projected a scheme which may be briefly outlined as follows: To build a strong dam of stones and cement—say 60 feet high—in the pass before referred to, and by submerging about 60,000 acres of land now subject to overflow, and of little comparative value, create a vast lake 15 miles long by 7 miles wide, with a probable storage capacity of 4,000,000,000 cubic yards of water; place gates on each side of the river in the dam at the 50-foot level for waste wiers and irrigating canals to supply each side of the river and keep up a flow in its bed, which would bring the water in the canals 70 feet above the streets in the cities of El Paso and Juarez, respectively.

The gates at the 50-foot level would give an available reserve of water of 10 feet over the entire surface of the lake, over 2,000,000,000 cubic yards, which would be exhausted during the long season of little flow for the purposes of irrigation and other needs, as well as maintaining a constant stream in the river beds so arranged as to exhaust the reserve about the period of annual flood, which would be checked and held in reserve for the next season of little flow, and in this manner produce a comparatively constant and unvarying flow of the water for each entire year below the dam, redeeming many times the number of acres submerged above in the lake from overflow below, and fixing permanently the national boundary, the banks of the river, as well as the boundaries and titles to private lands, and making it an easy matter to collect duties and prevent smuggling, detect crimes and misdemeanors generally, arrest and punish criminals, as it is along other national boundaries.

The assumed flow given for the seventy-five days of high water will give about 7,500,000 cubic yards, and that for the remaining two hundred and ninety days 1,500,000,000 cubic yards, making an aggregate annual flow of 9,000,000,000 cubic yards. If we allow 3,000,000,000 of this for loss by evaporation and other wastes, which former, in this dry atmosphere, is very great, perhaps 20 inches, we have 6,000,000,000 cubic yards, and dividing this into three equal parts, one for each side of the river for irrigation and other needs, and the third for overflow through water motors to furnish power to the future manufacturing cities on each side and to maintain a constant flow in the river below to the Gulf, as would no doubt be demanded by the people there as their right ere they would permit the scheme to be carried out.

The 2,000,000,000 cubic yards falling a distance 50 feet over the dam, estimating the weight of a cubic yard of water at 1,500 pounds and one horse-power, the energy required to lift 33,000 pounds 1 foot in a minute would expend energy equal to over 30,000 horse-power for eight hours every day in the year, and produce a constant stream in the bed of the river 26 yards wide by 1 foot deep, running with a velocity of 5 miles per hour, to say nothing of the probability that the greater part of the other two-thirds would find its way again to the river-bed through the earth and air, the whole flowing in a steady, continuous stream to the mouth of the river, to be used as required at any season of the year, instead of, as is now the case, six-eighths of the entire mass of the annual flow going rapidly to the Gulf in the short period of seventy-five days untaxed.

Estimating the amount of water required for annual irrigation at 20 inches, the water reserved for that purpose would be sufficient for 1,000,000 acres on each side of the river, all that could be reclaimed from the desert for 100 miles below.

To carry out this project, I recommended to the people on each side of the Rio Grande that they petition to the executive authority of their respective nations for the creation of a joint commission, to draw up the necessary treaty stipulations to protect the work and the rights of all interested in them, the fundamental feature of which should certainly be that each nation should have the right to divert no more than one-third of the flow at any period, and that one-third the flow should be maintained in the bed of the river, and that this international commission have charge and control of the work after completion as well as during construction.

That the legislative authorities of the two nations be asked to appropriate, after complete investigations and estimates have been made, money sufficient to complete the work, probably $100,000 for the dam proper, $100,000 for the condemnation of the 50,000 acres of land to be submerged, and $100,000 for the removal of some 15 miles of the road-bed of the Atchison, Topeka and Santa Fé Railroad to bluffs above the old bed of the river, where the track now lies, subject to annual damage, and sooner or later, total destruction, unless removed.

It will also be apparent that the waters of this great lake will be clear and fresh, the silt held in suspension in the current of the river being precipitated as soon as it enters the still water of the lake, doing away with the great trouble and expense now necessary in keeping the canals and ditches cleansed of sedimentary deposits, and a further great benefit derived from using water reduced in temperature by exposure for months in a warm climate far below that used in the early spring, which comes in three days from snow and ice and is immediately applied to the young and tender sprouting plants, chilling and checking their growth.

I know of no point on the Rio Grande—between Albuquerque and the Gulf of Mexico—where nature has provided both the natural basin and rim for a lake of such great dimensions—for indeed it can be made 100 feet deep, if desired, and it may be questioned whether a depth of 60 feet with 10 feet reserve to draw from will afford sufficient storage to control perfectly the tide at its highest flow.

This project was well received by the people, and has been earnestly discussed in the public press of the locality ever since, with general approbation and a disposition to endeavor to carry it out as quickly as possible; the only question exciting any general distrust being that of the sedimentary deposit in the lake, which, it is held by some will shorten the life of the reservoir by filling the lake at such an early period as to render the scheme of doubtful expediency, and opinions differ very widely upon this subject, which is indeed a problematical one, and can only be determined even approximately by actual measurements of a great majority of the annual flow, for the quantity of sediment changes with flow and season.

That the bed of the river will eventually be filled, of course is only a matter of time; but whether in fifteen or one hundred and fifty years can only be ascertained by prolonged actual measurements; but, even if filled in the near future, it seems to me that the difficulty may be overcome by raising the dam, unless, indeed, that should be required too often.

The matter has already been referred to Major Powell, Chief of the Geological Survey, who has sent Capt. Clarence Dutten, of his department, to El Paso to investigate and report upon the feasibility of the scheme; but as the initial steps, should it be pronounced feasible, must come from your Department in the nature of international treaty stipulations, I have thought it proper to thus early acquaint you with the grand project.

I beg to refer you to the Hon. Mr. Lanham, member of Congress from Texas, who is acquainted with me personally and my projected scheme.

ANSON MILLS,
Major, Tenth Cavalry, Brevet Lieutenant-Colonel, U. S. Army

The SECRETARY OF STATE,
Washington, D. C.

EXTRACTS FROM MAJOR MILLS'S ANSWER TO CIRCULAR OF INQUIRY.

The country is certainly to be congratulated that Congress has so willingly and generously taken the initiative in making appropriations for experimental examinations, indicating a purpose of putting the matter on a footing with other internal improvements. While I lay no claim to any special attainments in the particular sciences applicable to the development of the great and grand schemes that are certain to be brought forward and accomplished in the near future, I feel that a youth spent in tilling the soil, and a manhood mostly spent on the arid plains of the Great Southwest, whereby I have obtained that general knowledge of its characteristic features that observation alone gives, but, more than all, a familiar acquaintance for the past thirty years with the abnormal characteristics of one, of the greatest rivers in the great North American continent, and destined, in my judgment, to cut a greater figure in the matter of providing water for irrigation than any other in the United States—the Rio Grande—has qualified me to say something of interest on the subject.

I beg to submit herewith as a part of my report (see Exhibit A), a copy of a letter addressed by me to the honorable Secretary of the State on the 10th of December, submitting a project for controlling the annual floods in the Rio Grande and the preservation of the national boundary between the United States and Mexico, incidental to which there would be derived great facilities to both nations for irrigation and water-power. What is said of the Rio Grande is true of all the larger rivers in the arid regions; they are all essentially torrential in character, at times carrying great floods and again dry, the latter condition generally happening in the season of irrigation, hence the generally unsuccessful efforts, almost universally practiced until recently, of attempts to take water immediately from the river beds without dams or reservoirs to the lands to be irrigated, allowing vast volumes to pass when not needed and being at the season most needed, in some years powerless to carry anything, and manifesting clearly the absolute necessity of abandoning present methods, and resorting to the more expensive, yet more certain and economical methods, of large dams and reservoirs. In soil, heat, and light, all so essential to vegetable growth, these arid regions are generally favored by nature above other parts of the country, and water is generally available in abundance if properly preserved until the time of need, and I predict that if the time shall ever come when even the greater portion of it is held in lakes and reservoirs, instead of being permitted, as now, to go quickly to the sea, that the high winds and extreme aridity of the atmosphere, now so prevalent and detrimental to vegetable growth, will be decreased by the exposure of large surfaces of water, creating greater humidity and more precipitation in rain and dew and a temperament of the extreme heat of the midday, thus modifying the parching dry winds.

My letter above referred to was perhaps the prime cause of my being stationed at this post under Special Order No. 85, current series, from the War Department to assist the officers of the Geological Survey in the preliminary international accommodations and adjustments between two peoples here and the preparation of the necessary surveys, plans, estimates, etc., to present the project in an intelligent form to Congress at its next session with a view to the procurement of an appropriation at as early a date as possible for the accomplishment of the work, in conjunction with similar agencies from the Mexican Government, the scheme in its entire scope being essentially an international one, the waters of the river being the joint property of the two nations. I have purposely delayed this report until this late day that I might be able to show some progress in the project which I have so much at heart and which I trust may not prove entirely uninteresting to those in authority over me.

I arrived here May 4, and at once presented my letter of instructions from Major Powell to Mr. Garfias, the Federal engineer; Colonel Candano, the Jefe Politico of the Canton del Bravo, and other local officials of the other side to whom I explained in detail the projected enterprise, which they one and all received in the most kind and encouraging manner, giving me permission to establish one end of my cable for the gauging station on Mexican soil, and promising to assist me generally in any reasonable manner. I then invited Mr. Garfias, the Mexican engineer, to co-operate with me to any extent he might see proper by accompanying me in my investigations, surveys, and measurements, that his Government might have a knowledge of all preliminary work in the matter from the beginning. He replied that he would take the responsibility of doing so at once, pending action on official application which he would at once make to his superior, the minister of public works in the City of Mexico, and later on he furnished me with a copy of the minister's authorization, and he has continued to inform himself with the nature of all our work.

On May 6, Messrs. Williams and Dyar reported to me, and we proceeded at once to procure the material for the establishment of the station for the measurement of the flow and evaporation of the water and the silt carried in suspension, selecting a point in the limits of this post and about 300 yards above the old dam in the river for the suspension of the steel cable, and on the 20th we had everything complete, and have continued our measurements to this date with the following general results:

I found the river abnormally low on my arrival May 4, carrying probably but 5,000 feet, and it has continued falling quite regularly, old residents saying that it has carried less water during the same period than they have known for many years. Every indication points to an entirely dry river within a few weeks, to last perhaps for many months, as sometimes happens, though heavy rains on the upper river may prevent. While this will be exceedingly unfortunate for the country, it will assist our investigations very materially in search of the bed rock and the prospects of the project generally.

Our first measurement of flow was taken May 20, showing 4,300 feet, and the last, taken to-day, shows but 100 feet.

The measurements for evaporation began May 10 and have run very regularly, averaging about .35 of an inch per day or 10 inches per month for May and June, but now seem to be decreasing to about .25 daily.

Mr. Dyar has taken almost daily measurements of the silt in suspension since June 10, with results varying from one quarter to one half of 1 per cent. of the water carried, save in one case of local rains, which lasted some twelve hours, wherein the per cent. rose to 1¼. The general average of the per cent. of the water carried, according to the assumption that a cubic foot of dry sediment weighs 85 pounds, is .345 of 1 per cent. Assuming this to be correct, and that it will take one year's time for the river to fill the lake with water, it will take about three hundred years for the lake to fill with sediment.

On the 27th of May, at the solicitation of the United States Senate Committee on Irrigation, the mayor of El Paso appointed Messrs. Bronson, Davis, Magoffin, McCutcheon, and Mills, a committee to collect data, etc., relating to the subject of irrigation, for the consideration of said Senate committee on its expected arrival here in September next; and a few days thereafter, at the solicitation of the mayor of El Paso, the mayor of Juarez appointed Messrs. Sanchez, Padilla, Provencio, Count Duprez, and Superintendent of Public Works Garfias, a committee to act in conjunction with the one on this side, and it is understood that this committee has requested of its Government that an engineer be sent to run a line of levels for a canal from the proposed dam, and to ascertain the quantity of land it would cover for 50 miles below, and that a committee similar to that of our Senate be organized to meet here in September to investigate and discuss with the American committee the international features of the project, to the end that a common and intelligent understanding may be reached at an early day between the two countries in the matter.

Meanwhile, Colonel Nettleton, the supervising engineer of the Geological Survey, visited this station and after a thorough examination of the project, the lands, the river, and the railroads, and an interview with the two committees, jointly decided to make the necessary surveys, plans, and estimates, and employed Mr. W. M. Follett, an engineer, with four assistants, who are now in a camp, the equipage of which was kindly furnished by the commanding officer of this post, doing the field work, and he informs me that he will be able to complete the whole, including the office work, by the time of the arrival of the Senate committee in September.

Colonel Nettleton having informed me that he had been instructed not to make any expenditures below El Paso this year, and seeing the necessity of some data to present to the committee showing the ever-changing bed of the river and the national boundary in the valley below for the past forty years, and also the extent of land that will be covered by a canal from the proposed lake or reservoir, I laid the matter before the El Paso committee, and it at once made application to the county commissioners, through the county judge, Mr. Townsend, resulting in an order from the commissioners to the county surveyor to report to me to prepare the necessary data at the expense of the county, in connection with Mr. Follett's surveys. I will try and arrange that the county surveyor and the Mexican surveyor, in preparing plats of the beds of the river at the different periods, when any considerable surveys of land were made on either side to work in conjunction, that the greatest detail and accuracy possible may be obtained.

I feel that our project is progressing as promisingly as could be expected, and that we shall be able to make such a clear showing to the legislative authorities of the two nations that it will fix and control their boundaries; that there will be little difficulty in arranging the necessary international treaty stipulations, and appropriations in money to complete the work at an early day, laying aside the great "object lesson" it would place before the people of both countries as to the possibilities in the line of irrigation.

I beg to suggest the examination later on of another international project of a similar nature, of a dam in the Rio Colorado at Yuma, a short distance above the Southern Pacific Railroad Bridge, say 30 feet high, that would create a large lake, mostly I think on unappropriated lands, control the floods and boundary below, and afford ample water for the irrigation of vast quantities of land both in Mexico and the United States, and the formation of a lake, say 50 feet deep, in that miserable "Yuma Desert," the center of which would be somewhere near Salton Station, tempering the climate so that the country would be habitable, and providing water for the irrigation of the thousands of acres not covered by the lake, but below the level of the sea. The Mexicans would be the greatest beneficiaries should this project be found practicable and carried out, but it would afford another grand "object lesson" in the possibilities of water storage.

EXTRACTS FROM MAJOR MILLS' REPORT TO E. S. NETTLETON, C. E., SUPERVISING ENGINEER, U. S. IRRIGATION SURVEY.

Mexican official action.—After receiving the necessary authority from the minister of public works in the City of Mexico, Mr. Garfias, their engineer, has kept himself advised concerning all our investigations to this date, and I propose furnishing him with a copy of all maps and reports relating thereto with a view to inducing the Mexican Congress (now in session) before their adjournment in January to pass a joint resolution authorizing their President to join the United States in the construction of the dam proper and appropriating $150,000 for that purpose should our Government make a like appropriation; this for the purpose of gaining a year's time in the commencement of the work.

Measurement of evaporation.—May 6 Messrs. Williams and Dyar reported to me. Measurements for evaporation began May 10 and were continued until the present date with the following results:

May (twenty-one days, 11th to 31st)	7.31
June	11.23
July	9.05
August	10.85
September	8.20
Total	46.64

A total of 46.64 inches for one hundred and forty-three days, or a mean of .32 of an inch per day. As these one hundred and forty-three days embraced the season of greatest aridity, it is probable that the annual evaporation will be about 6 feet.

Measurement of flow.—May 20 our gauging station was established, the first measurement taken that day showing 4,300 cubic feet per second; the last, taken July 30, showing 30 cubic feet. On August 5 the river ceased to flow, and has not carried any water to this date, though some small pools of water are still to be found in the pass, sufficient to float the evaporation pans. During the measurements of flow the fall of the river was very continuous and gradual, and other conditions favorable to the projection of curve for the measurement of highest flood as shown by drift marks, but, unfortunately, about the middle of our observations the crest of the Mexican dam, only 300 yards below the station, was raised about 12 inches, distorting the projection of the curve so that no reliance could be placed upon it. The river probably carries about 9,000 cubic feet at highest flood, and perhaps an annual average of about 1,200 cubic feet per second.

Measurement of silt.—Between June 10 and July 28, one hundred and eighteen samples of water were taken from different parts of the river's current, and the sediment of each carefully measured, with the following results: The average of the per cent. of the volume of water carried, according to the assumption that a cubic foot of dry sediment weighs 85 pounds, is .345 of 1 per cent. The results varied from one-quarter to one-half of 1 per cent. of the water carried save in one case of local rain, the flood of which lasted some twelve hours, wherein the per cent. rose to 1¼.

Assuming this to be correct and that it will take one year's time for the river to fill the lake with water, it will take about three hundred years for the lake to fill with sediment; this, however, is making no allowance for evaporation, which is very great (possibly on the surface of the lake one-fourth the annual flow), or for the moving quicksand in the river's bottom, or the detritus to be thrown into the lake by storms from the gulches and ravines from its mountainous sides.

It is, however, safe to assume that at least one hundred and fifty years must elapse before its basin can be filled with solid matter. If these premises be correct it should be remembered that each year one, one hundred and fiftieth part of the lake's basin will be filled with solid matter, thus decreasing year by year its storage capacity in that proportion; but the date when any or all of these causes may destroy its efficiency is so remote as to be unworthy of consideration. This silt problem seemed to be the most formidable one confronting the enterprise. After it had been favorably determined you visited the locality, inspected the proposed sites for dam, the basin for the lake, and the location of the two railroads, from an engineer's stand-point, and decided to have preliminary surveys, plans, and estimates for the entire work made as quickly as possible in order that the project might be presented to Congress at its coming session. * * *

Soundings for bed-rock.—The soundings for bed-rock were made under my supervision in the following manner: The rods were of octagonal cast-steel, printed as a square pyramid, one for shallow soundings of one-half inch steel 18 feet long, another three-fourth inch and 32 feet long for medium soundings, and still another double rod, jointed in two sections, of 1 inch, 26 feet long, each for the deeper soundings. A tripod 20 feet high with a ring in its apex was necessary to keep these flexible rods in a perpendicular position while being worked by four men with two iron clamp-bars, arranged to adjust to any part of the rod as it passed down. The entire 3 miles of the pass were prospected for the bed-rock at all points where the walls of the cañon rendered it practicable to build a dam; but only two available sites were found, the 52-foot rod failing to touch bottom at other points. * * * It is not absolutely certain that the true bed-rock exists as described in the soundings, or if it does exist that it is free from faults or rifts, or of such a quality as to support a dam of the kind designed; but every evidence possible with such soundings was obtained, being the more positive at the lower site by reason of the rock being so much nearer the surface, and the friction on the rods consequently much less. The rod rang out clearly when in contact with the rock at the lower site, while at the upper it was dull and indefinite. Before any permanent work is commenced, the fact of the existence of suitable bed-rock should be determined by boring out cores from it with a diamond drill.

Relative merits of the two dam-sites.—The upper site has but two advantanges over the lower one; the first being that it is of sufficient distance from the Santa Fé depot to allow that line to be rebuilt on its ruling grade and rise above the dam, which it is impossible to do from the lower site, it being 2 miles from the depot; the second, that the walls of the cañon will allow the dam to be built higher, should it ever be desired.

The lower site has many advantages over the upper one; first, the cost will probably be one-half that of the upper, the bed-rock being but 22 feet from the water-level at its deepest part and for the greater distance across the channel from 2 to 9 feet only, while the upper site is from 30 to 50 feet for the entire cross-section. The old Mexican dam, which has a fall of about 12 feet, is about 1,000 yards below this site, and by breaking this and opening a channel through the sand to this site, I think the water could be lowered 8 or 10 feet, so that the bed-rock for the greater part of the cross-section would be presented above the water; it would be necessary of course to do this in a season of low water and perhaps to flume the channel with lumber. In this manner I think this dam might be completed in one year, and if commenced at the right season the flood-waters of that year reserved. At the upper site it would take one year to build the coffer-dams and get the masonry above water. I have suggested a double curvilinear dam with three heavy buttresses, which I think well adapted to that site. These buttresses could be built in the manner indicated by moving the middle one a little nearer the left bank than shown by the pencil mark entirely out of water. Other advantages are that one end of the dam would be on Mexican soil, and that 1½ miles of expensive and difficult canals on either side would be avoided.

To have the benefit of these advantages, however, it is necessary to get the Santa Fé Railroad above the water in the lake.

It will be observed that the Southern Pacific in its north-bound course leaves the valley just before reaching the lower dam-site and climbs the bluff behind the smelter, crossing two arroyas marked A and B, on Mr. Follett's map No. 1, and on a down grade before reaching the bridge. It has occurred to me that the two roads might be adjusted to use a common double track from Fort Bliss, with a cut about 15 feet deep in the bluff behind the smelter, and by a strong retaining-wall built on the fills in the two arroyas mentioned, so that their tracks would be some 10 or 12 feet below the surface of the lake behind these walls and yet gain an altitude before reaching the third arroya near the present bridge sufficient to carry them above the waters of the lake. The problem then would be to cross the Southern Pacific over the broad river's channel by heavy and well ballasted crib-piers rising to near the surface of low water in the lake so that all the wood-work might be well preserved by submersion, and a superstructure of such a nature as to be restored independently. If this be practicable it will solve the difficult problem of putting one end of the dam in Mexico, and keeping both railroads exclusively in the United States.

The laws of Texas require joint or union depots in cities where railroads cross each other, and sooner or later the railroads in El Paso will be required to comply with them. Should the dam be built the radical changes wrought in the two roads mentioned above will no doubt hasten other adjustments in the city, and, as neither have any permanent depots, will probably result in a union depot, in which case the Southern Pacific would doubtless depart west on the south side of the Santa Fe, which would obviate the present crossing, which gives trouble in any adjustment for the dam.

I beg to recommend that on the first intimation of favorable consideration by Congress of this project, that an engineer be sent here to investigate the practicability of this double track and retaining-wall for the easement of the grade of the Santa Fe to enable it to rise over the water of the lake formed by a dam at the lower site.

Agricultural features.—The land that would be brought under a high-line ditch from this lake, with a fall of 12 inches to the mile for 60 miles below, would be over 100,000 acres, consisting of about 20,000 above the flood-waters of the river and below the waters of the highest ditches now in operation, which would hardly be considered as being redeemed by the project. About 40,000 acres are below the highest flood-waters of the river and about 40,000 more are above the waters of the highest ditches in operation, yet would be below the high-line ditch from the lake, so that 80,000 acres would be redeemed, and could justly be taxed for water rights should the Government see proper to re-imburse itself for the investment. On the Mexican side there would be perhaps 125,000 acres to be brought under their high-line ditch; this estimate is approximate only, no surveys having been made as on our side, though an engineer is about to commence the work.

Water-power.—The water-power made available by the construction of this dam would be of great magnitude. If, as before assumed, the mean annual flow of the river is 1,200 cubic feet per second, and one-half that quantity can be utililized in a fall of 50 feet over the dam, or from the high-line canals below to the lowlands, for irrigation, we should have 600 cubic feet per second, or 36,000 cubic feet per minute; assuming the weight of a cubic foot of water to be 62 pounds, we have 2,332,000 pounds falling a distance of 50 feet each minute, or 111,600,000 falling 1 foot each minute, which, divided by 33,000, gives us 3,381 constant horse-power, or 10,143 horse-power, less, of course, loss by friction, for eight hours every day in the year. There are few cities on the continent possessing such vast water-power, and, by reason of high price of coal here, it would be of greatest value to the citizens of the sister Republic in this locality. The leasing of this power, should it be thought proper, would produce another revenue for re-imbursement.

Vested water-rights.—The records of Jaurez, formerly Paso del Norte, clearly establish that when first settled by the Spaniards, over two hundred years ago, it was an Indian village subsisting partly upon vegetables raised by irrigation from a ditch and dam in the same location as the one now in existence; that this was a loose bowlder stone dam yearly repaired by piling bowlders on those not carried away and buried in the quicksand below by the floods of the preceding year. This process was continued until within the last six years, when efforts have been made to form a cement cresting on the dam, but it too has been annually destroyed. In 1827 Juan Maria Ponce de Leon made the first settlement on the left bank of the river, on a narrow strip of land then forming under the hills opposite Paso del Norte, and by common consent took a ditch from the waters above the dam which has been maintained for the benefits of the residents of this side of the river to this day without the expenditure of a single dollar in the original construction of the dam or the millions that have been spent in its repair. On the annexation of Texas to the United States, over forty years ago, the Mexicans raised no question of assessment or expense of maintenance, but generously continued to divide with our people the waters from their dam, the product of their own labor, there being sufficient for both except in seasons of extreme drought, about once in seven years. Now has come a great change; the river has been entirely dry for nearly three months,[*] was dry for about the same period last year; the people this side have suffered, but the Mexicans on the other side have suffered much more for the reason that their sustenance comes almost exclusively from agriculture. Should these seasons of drought be succeeded by two more, but a small portion of the population on the Mexican side could remain here for want of subsistence. There are now about 25,000 in the valley for 50 miles below, and an equal number on the American side.

Both the Americans and the Mexicans claim that this drought in the Rio Grande is caused by the taking of numerous ditches from that river and its tributaries by the citizens of Colorado and New Mexico, and it is apparent that it is true, though I am not as well prepared to substantiate the fact as you are. By reference, however, to the "Fourth Biennial Report of the State Engineer of Colorado for 1887–'88," it will be observed that there are over three hundred ditches taken from the Rio Grande and its tributaries in that State. (See pages 287 to 325.) Most of these ditches have had but a short existence and many others are being rapidly taken out, so that from that State alone the peril to the people here of a water famine in the future seems great indeed.

The Rio Grande has a much longer passage through the Territory of New Mexico, and it is well known that much water is being in like manner taken out from that river and its tributaries in an increased proportion each year, though I am unable to find any official statistics on the subject.

The Mexicans are in great distress, yet protest patiently that they are being deprived of vested rights inherited for many generations, and that according to riparian laws the United States is under a moral obligation to indemnify them for their loss or make some reparation, such as the construction of the projected dam and reservoir. I am not qualified to discuss the legal aspects of this case, but leave it to other hands.

Boundary line.—The "deepest channel" of the Rio Grande, except when "changed abruptly into a new bed by eruption or evulsion," is understood to be the boundary line between the United States and Mexico. The prime object of this project is to fix and control that boundary.

It is certain that it will do this for at least 200 miles below, if a comparatively constant flow of clear water unburdened by silt is allowed to pass through the dam into the channel constantly and the channel straightened and shortened by numerous cut-offs in the great bends so as to give greater fall and a better aligntment below 200 miles; the river has two considerable confluents, in the Pecos from Texas and the Concho from Mexico, the floods of which may possibly cause some changes, as they carry considerable silt.

---

[*] Superintendent Ennis of the Southern Pacific Railroad has since informed me that the wells of his road between this place and Hancock are failing.

I believe the reservoir in the lake will in the main control the boundary line from these tributaries to the Gulf of Mexico.

For the past forty years the river has been so continuously shifting its bed from one side of the valley lands to the other with each succeeding flood of water (in many cases unknown whether by evulsion or gradual erosion and deposit) that it is impossible to determine to which nation the land on either bank of the river belongs, for a great portion of the distance through the alluvial valleys, to say nothing of the fact that these lands are almost valueless by being submerged and rendered impracticable of permanent occupancy.

* * * * * * *

In order to illustrate graphically the changes made by the river, Mr. Townsend, the judge of El Paso County, with the approval of the commissioners, directed their surveyor, Mr. Heldt, at the expense of the county, to make the necessary surveys to determine the exact location of the river at this date, and from the sefield-notes and the surveys of other dates on file in his office to compile a map showing the changes that have taken place in the past forty years between the line of New Mexico and Fort Hancock; also to ascertain the quantity of land that would be brought under the ditch by running a line of levels for a high-line canal (to be taken from the proposed lake) from Fabens to Fort Hancock.

I was informed some time ago by Mr. Garfias, the Mexican federal engineer, that his Government had ordered an engineer to Juarez to make a similar survey of the river and lands on the Mexican side, together with a line of levels for a high-line ditch from the dam.

International features.—As the waters of the Rio Grande as well as the boundary line belongs jointly to the two nations, this project can never be carried out without their perfect concord in purpose and action, and in view of the evident prior rights of the Mexicans and the equally evident fact that they are being deprived of them by the citizens of the United States in Colorado and New Mexico, and the further consideration that they have furnished water from their dam untaxed for forty years to the citizens of the United States on this side, I recommend that the United States Congress take the initiative by making an appropriation to cover the entire expense of the work save the one-half the expense of the dam proper, conditioned only that the Mexican Government shall appropriate a sufficient sum to cover the expense of constructing the other half of the dam and accept this action on the part of the United States as full indemnification for their prior rights alleged to have been usurped, and that an international commission, similar to the one proposed in the House resolution before referred to, be organized for the double purpose of supervising the construction of the dam, changing and straightening the channel of the river, and establishing a permanent international boundary to forever coincide therewith, as far below El Paso as the dam may prove effectual in maintaining a constant channel.

Construction.—As under the most favorable circumstances, with the success of an appropriation from both Governments this winter, at least one season must pass, probably two and possibly three, before the waters from the dam can be available and that in all likelihood these seasons will be like the present and past, depriving the Mexican citizens of "El Canton del Bravo" of occupation and means of support, I further recommend that for the purpose of the entire construction of this project in rebuilding the railroads as well as the construction of the dam proper that the "Alien Labor Act" be suspended so far as it applies to that canton of the Republic of Mexico.

In conclusion, I beg to say that I think the construction of this work essential to the continued existence of these frontier settlements; I believe it an obligation justly due from the Government of the United States to the Americans and Mexicans composing them; that in accomplishing it the Government will be availing itself of the grandest opportunity to set before the whole people an "object lesson" of the very first magnitude in the line of that great national development of redemption of arid wastes now dawning upon the country, and giving promise to exceed all others with which it has been blessed, without compromising its future action in similar internal projects, because this, being international and more a question of the rectification of an international boundary, is unique.

MEXICAN ACTION IN RELATION TO PROPOSED WORKS.

[Extract from El Centinela, of Ciudad Juarez (Paso del Norte), November 24, 1889. Translation.]

The following petition has been addressed by the Mexican committee on the Rio Grande international dam and water supply, to their deputies in the Mexican Congress mentioned below. The editor of El Centinela says:

"The committee is deserving of great honor for the zeal it displays in favor of these towns.

"Water is the life of these settlements, drought their speedy ruin. If we do not take advantage of the opportune moment for regulating the vital subject of water, it will be a weary task at no distant day to repair the mistake and avert the threatened evil.

"People continue to emigrate, driven by hunger, and their departure entails poverty on those who remain.

"What are Guadalupe, Zaragoza, S. Ignacio doing with the protest of El Paso? Will these towns not stir? Is the water question of no importance to them?"

THE MEXICAN COMMITTEE ON THE MILLS PROJECT.

The committee in extraordinary session has resolved to intrust to you the object communicated, in a separate paper, in order that by making use of your influence and of the character lent you by your quality of representative and by your constituency, you may be pleased to entreat of those to whom it pertains the prompt dispatch of the subject to which we refer, which will inaugurate a real state of well-being in place of the melancholy situation in which this locality is placed by the absolute lack of water. We tender in advance our gratitude and protest our attentive consideration.

Ciudad Juarez, November 21, 1889.

DÁMASO SANCHEZ,
President.
IGNACIO GARFIAS,
Secretary.

To our Messrs Deputies in the Congress of the Union:

C. MANUEL RINCÓN, C. JOSÉ VALENZUELA, and MANUELO LEON.

THE MEXICAN COMMITTEE ON THE MILLS PROJECT.

This part of the frontier suffers at present from an absolute want of water, as the river has run dry since the end of July past. The consequences of this drought have been the total loss of the crops in the fields, and the diminution, on an enormous scale, of fruit in orchards, many of the more delicate trees in the latter having died of drought. Six mills, whose motor force was the water, have stopped running. Flocks find no watering places, and families lack the precious liquid, even for indispensable domestic uses. The authorities in order to alleviate to some extent this distress, have put up public pumps, and persons whose means permit have put up others, allowing the free use of them to neighbors who were debarred from resorting to the same expedient. Still, as the inhabited portion at a distance from the river is considerable, and the erection of pumps has been limited to the central part where the population is denser and the supply greater, the result has been that the families in the more distant portions from the center have had to emigrate, abandoning their homes, and suffering losses which in many cases have amounted to complete ruin.

All this injury is without natural cause. The river has enough water in its upper part, and that water would suffice if the one-half secured to us by treaty was allowed to run down to the frontier, but such is not the case. Irrigation companies have been formed in the United States, which take the water of the Bravo to irrigate the lands of Colorado and New Mexico, intercepting it altogether, leaving the river dry in the part which divides New Mexico from Texas, and afterwards separates the latter State from our Republic.

The inhabitants of Texas have already taken pertinent steps, asking the protection of their General Government, in order that they may in some way receive the water for the fertilization of their lands. They ask this as a favor, since the public lands of Texas belong not to the Federal Government, but to the State.

We must ask the same, not as a favor, but in virtue of the duty incumbent on the American Government according to existing treaties to turn over to us one-half of the water which the river naturally contains, which half has been unduly seized by citizens of that country, with the authorization and protection which the authorities have been obliged to give to those enterprises.

With this object, the inhabitants of this locality have raised a protest, which under the conduct of local and State authorities is already operative, in the hands of the secretary of relations, in order that the secretary shall make due reclamation to the Government at Washington.

In order to carry out practically the restitution which we claim, we have thought of means that may be employed. At first sight the most natural means seems to be to cause the waters now diverted to return to their natural channel; but since considerable interests have already been created by the irrigation companies to which we have referred, and since it would not be equitable to take from one an advantage which may be given to another by other means, we agree, both the citizens of El Paso, Tex., and those of this place, that the radical remedy lies in the realization of the Mills project at the expense of both nations and according to proper preliminary treaty. This project consists in the construction of a conduit 60 feet above the mean height of the water, which within the river channel is to close up the space between the bordering hills. Behind this conduit there is an extensive valley with very gentle slope, which is to be filled to an extent of 26,300 acres to a maximum depth of 3 feet 8 inches. Adopting a mean depth of 1 foot, the capacity of the lake is found to be 532,000 acres. The mean volume of the river is calculated at 1,200 cubic feet per second, of which we would be entitled to one-half, or 600 cubic feet per second, at a height of 50 feet on issuing from the conduit. This would yield a motive power of 3,381 horses constantly at work, or 10,143 horses working only eight hours a day, an enormous quantity, which will give rise to the establishment of new industries. This consideration alone should suffice to determine the execution of a work which is to produce so great an improvement.

At present there are irrigated and cultivated from 25,000 to 30,000 acres of ground, and inspection of the ancient works still existing assures us that by the new canal that is to issue from the projected conduit there might be irrigated 100,000 to 125,000 acres continuously, and without fear of the river's failure at any time.

Among other advantages of the project is this, that the outlays and labors will cease which the municipality and the population are constantly obliged to make in the repairs which the conduit requires.

But the great international importance of the work and the real advantage for the two nations lie in the fact that the dividing line marked by the river will never more undergo change up to the mouth of the river Conchos at Presidio del Norte, because its water being distributed in the American and Mexican irrigation canals, no more will be allowed to run in the river than the quantity necessary for the needs of the riverain towns farther down, the channel being rectified and a true canal being formed which will be invariable, and will smooth over the questions now existing concerning the proprietorship of the ground left by the river on one or the other side of its banks.

On the American side the preliminary steps have already been taken to insure the appropriation by Congress of the sum necessary to accomplish the work. The locality has been visited and all the pertinent data have been obtained by the Senators forming the Irrigation Commission, the deputy for the State of Texas, and the Chief of the Geological Survey. Engineers, topographers, hydrographers, geologists have come and surveyed the topography and made hydrographic and geologic studies, and have completed the project of the work, calculating its cost, including indemnity for the ground to be occupied by the two railways whose location will have to be changed.

All persons that have come to study the case are unanimous in their opinion that the primordial right of Mexico given by treaty is unquestionable. They further agree in holding that since Mexico made no objections after the annexation of Texas to the United States to the construction of conduits by Americans for the purpose of taking the water which they have used since that time for the irrigation of the new American territory, without having a share in the expenses of construction, reconstruction, and constant repair, she has thus acquired, in view of her generosity, and of the indemnity which she may claim for the damage she has suffered and will continue to suffer, by the occupation of waters which are her property, the moral right of not being called upon to bear one-half of the total cost of the work, but only one-half of the total cost of the wall or work of masonry. The total cost of the work will be $1,000,000, and the cost of the wall $300,000. Thus the Mexican Government would obtain for $150,000 all the advantages we have enumerated.

It is safe to say that our Government will not hesitate to make the reclamation, carry out the treaty, and vote the sum required; but the situation in which we are now placed is unbearable, and we need prompt remedy. Hence it is imperative that our petition, in the hands of our minister at Washington, shall be made efficient at the next meeting of the American Congress in the coming December, in order that that Congress, during its coming session, may appropriate the necessary sum for the work; and it is requisite that the indemnity be demanded by our Government, since the State of Texas may be denied what it asks as a favor, while our nation can not be denied what it asks as an indisputable right.

Hence it behooves to agitate without a day's rest, for the dispatch of the protest raised by the people of Ciudad Juarez, in order that our reclamation may arrive at Washington during the first days of the coming December in due form and through the proper channels.

This is the favor we ask and hope of you, trusting in your patriotism and in the interest which you bear this part of our territory.

We tender you in advance the most sincere demonstrations of our gratitude, and assure you of our particular and distinguished consideration.

Ciudad Juarez, November 21, 1889.

DÁMASO SANCHEZ,
President.

IGNACIO GARFIAS,
Secretary.

To the Messrs. Deputies in the Congress of the Union,
C. JESUS VALENZUELA, C. MANUEL RINCON, C. MARCELO LEON,
Mexico.

REPORTS OF MILITARY OFFICERS STATIONED ON THE RIO GRANDE FRONTIER, DEPARTMENT OF TEXAS.

CIRCULAR OF INQUIRY.

The following inquiries were made by circular issued from Army Department Headquarters at San Antonio, Tex., in response to the request of the chairman of the committee, made through its engineer expert, Mr. R. J. Hinton.

(1) What system of irrigation is used in your post or in the vicinity thereof?
(2) What is the source of water supply?
(3) What is the quantity of water-supplied?
(4) What is the area of land irrigated?
(5) What is the length of main ditch.
(6) What is the length of secondary ditches?
(7) What was the cost (approximate) of putting in the system?
(8) What was the value of the land irrigated per acre before irrigation was put in?
(9) Value after irrigation?
(10) Does the system belong to the land-owners or is it the property of a separate company?
(11) What is the cost per acre per year for irrigation?

STATEMENT OF W. C. BORDEN, CAPTAIN AND ASSISTANT SURGEON, AND D. J. RUMBOUGH, FIRST LIEUTENANT THIRD ARTILLERY, U. S. ARMY, OF SAN ANTONIO, TEX.

The only method used in this department is that known as bed-work irrigation. In this method the water is conducted from the source of supply by means of a main ditch and furnished to the land by means of secondary ditches. The inclosed map of the San Felipe ditch gives a good idea of this method, and the statement made by the owners shows the great advantages derived from irrigation.

This ditch was constructed by a company, each member of which had to own land on its line. In case of sale, the water privilege is transferred with the title. The total extent of land irrigated is about 7,000 acres, being ordinary river-bottom land, such as is found all along the Rio Grande. This land, before irrigation, is covered with mesquite brush and a sparse growth of grass or precarious and scant crop of corn. The ordinary price of this land varies from 75 cents to $2.50 per acre, according to slight differences of soil or proximity to water.

Profitable cultivation of the soil without irrigation is out of the question, as scant crops only are produced, and those only during a particularly favorable season, the seed sown often being entirely lost. In all respects the land irrigated at Del Rio by the San Felipe ditch is a type of the greater part of western Texas, in which there are vast tracts where water only is needed to change the land from barren or grazing land to soil capable of high cultivation.

The San Felipe ditch with its branches, under which 7,000 acres are irrigated, was put in at a total cost of about $30,000, or about $4.75 per acre. The land so irrigated, the highest price of which was $2.50 per acre, is now worth from $45, the lowest, to about $100, the highest, price per acre, a rise in value of from $42.50 to $97.50 per acre, at only an outlay of but $4.25 per acre. This rise in value is entirely due to irrigation, as the land immediately bordering on the irrigated lands is still held at the old price. From this we see that land which was originally worth $17,500 at the highest is by irrigation increased in value to fully $400,000, and that by an outlay of only $30,000, showing the immense gain on the money invested.

The cost of irrigation per year for such repairs and work as are necessary to keep the system in good repair is about 75 cents per acre yearly, varying with the year, being some years as low as 50 cents and others as high as $1.

The increased productiveness of the land can hardly be estimated, as before irrigation it was practically barren, while now grains, grass, and fruit are raised in the greatest abundance, changing what was before only a cattle range into a plain covered with cultivated farms.

It is true that the problem of irrigation at Del Rio was practically an easy one, as the water is derived from the San Felipe spring, so rendering the supply nearly constant and equal in quantity, and if the same conditions obtained in other parts of Texas the cost and trouble of irrigation would be reduced to a minimum. Such is not, however, the case. The rivers of Texas are subject to great and sudden rises, the Rio Grande particularly so, and in addition the bed of the river is constantly changing. The difficulties arising from the sudden rising and falling of the streams can of course be obviated by properly-constructed flood-gates, but the shifting of the river bed offers many and great difficulties, so great in fact that in some cases the engineers have been unable to overcome them.

The subject of irrigation by means of artesian wells is but a repetition of irrigation from streams, provided a sufficient supply of water can be obtained.

STATEMENT OF MAJOR MILL, TENTH CAVALRY, U. S. ARMY, AT FORT BLISS.

I have the honor to return, inclosed herewith, the letter with printed interrogatories, with the answers that suggest themselves to me as being most correct and appropriate to each of the eleven numbered questions, as follows:

To the first: None at the post; in the vicinity, in the valley of the Rio Grande, for 50 miles below, principally on the Mexican side, the old Mexican system of numerous small ditches is still in use.

To the second: The Rio Grande, exclusively.

To the third: Ample for about five years out of each seven, during which period there is one year of drought, when the river goes practically dry and another of great flood, each of which occurrences prevent the cultivation of the greater portion of the improved lands.

To the fourth: On the American side about 6,000 acres; on the Mexican side about 18,000 acres.

To the fifth: One principal about 10 miles, on the Mexican side; on the American side there are some four main ditches taken from the river, ranging from 4 to 8 miles long.

To the sixth: From 500 yards to 2 miles.

To the seventh: These systems are from one hundred to two hundred years old, and were built by a tax on labor, and on which it is impossible at this time to even approximate the money value.

To the eighth: The land was generally granted free, by the Spanish Government, to such as would undertake to put it or a portion of it under cultivation.

To the ninth: Mexicans have no approximate values on real estate; changes in ownership seldom take place as compared with us; if one wishes to sell he takes the first offer, and unless he does desire to sell he will accept no offer whatever; on the American side land under cultivtion is held at from $20 to $40 per acre, some of the same having in the past few years been purchased at from 50 cents to $2 per acre.

To the tenth: So far the systems in each country belongs exclusively to the owners of the land, in community, as public roads do in the States.

To the eleventh: This would be very difficult, even to approximate, the only expense being the keeping the mouths of the main ditches where the water is taken from the river in repair from destruction by floods and the changing of the river, which often takes place, sometimes moving miles in the same year; the annual cleaning of the ditches of a deposit of silt or sediment of from 6 to 10 inches in the bottom and sides of a thick heavy and sticky clay very hard to handle, and the other cares needful to such property, but as they are all carried on by a general pro rata tax on labor the money value can not be satisfactorily approximated even.

STATEMENT OF J. V. LAUDERDALE, MAJOR AND SURGEON, U. S. ARMY, AT FORT DAVIS.

My opportunity for observation is confined to an area of country 30 miles due north of this post, on the road to Victoria, Tex., and south as far as Marfa, Tex. The nucleus of the mountains and high lands in this vicinity, like those of the Rocky Mountains, consist of trap-rock; and their sides are flanked by more or less altered sandstones. The valleys between are filled in with rounded sand and gravel, and beds of clay and alluvium.

In every place that I have visited, where there are springs or perennial streams, large tracts of lands have been supplied with water through irrigation ditches led out from the main source. A few feet of dam thrown up about a spring forms a reservoir which may be made to irrigate miles of land. The main ditch at Victoria carries water over a tract of land 10 miles in extent.

In regard to reclaiming lands that depend upon rains alone for their supply of water, I would say that the only method which has proved to be at all successful to the average ranchman is to widen and deepen existing ravines and catchment areas, and allow them to fill during the rainy season. Water may be removed therefrom by pumping or led out through pipes to the lands below. They afford a supply of water for stock during a good part of the dry season.

All attempts at damming ravines and water-courses with earth and brush is labor thrown away, as the first freshet will wash them out. An instance in point is the efforts of the brothers Merrill, about 12 miles from this post, where, after weeks of labor, they made a dam of earth across an arroyo, about 75 feet in length, 50 feet wide at the base, and 25 feet high. It was made of alluvium and clay. The front of this dam was supported by brush, tree-tops, etc. It is needless to say that the first heavy rain carried everything before it.

Damming ravines or building reservoirs to successfully hold water is quite an expensive undertaking, and can be accomplished only by walls of cut stone laid in good masonry. Examples of this kind of reservoir may be seen at the water-works at Atlanta, Ga.; also at the crossing of the Encarnacion River, on the Mexican Central Railroad. At several points along Lympia Cañon ranchmen have constructed dikes or semicircular mounds to catch the storm-water that descends from the hills, only to see them washed away during a freshet. Tanks, to be capable of holding water, should be dug out of the natural soil or excavated in the rock formation at a suitable height above the lands to be irrigated. The water thus dammed may be tapped through a small gate set in masonry below ground, or removed by siphon or pump, above ground. A waste-gate for the overflow in time of freshet is indispensable in all such reservoirs. Rosebud Cañon and Fraser Cañon are localities that could be cultivated if they had reservoirs to supply them with water.

There is a large tract of land near the village of Marfa, on Southern Pacific Railroad, where water is now only obtained by pumping it from an artesian well and it sells at 20 cents a barrel, that could be provided with a reservoir for the storing of storm-water, and gardens and orchards could be irrigated from it. I am unable to give estimates of costs, etc., as my observations have been made without engineering instruments and I do not know the cost of such a structure. With a mean annual rain-fall of nearly 18 inches I believe that there are many square miles of land in this vicinity that may be reclaimed for agricultural purposes whenever our ranchmen and other citizens shall take steps to preserve the rain-water that now finds its way into subterranean caverns of the earth or by surface drainage into the sea. The elevation of this place above the level of the Gulf of Mexico is about 5,000 feet.

In response to Department questions the replies received are as follows:

E. M. Randall, captain, Fifth Infantry, U. S. Army, commanding at Fort Ringgold, states that there is no irrigation in vicinity of post; the garden at post is watered from works as water can be spared. The source is the Rio Grande River. The water-tanks of post have a capacity of 64,000 gallons. The garden is between 6 and 7 acres. The land on which post is built cost $20 per acre.

From Fort Brown the irrigation of from 2,000 to 3,000 acres is reported on a sugar plantation owned by a Mr. Brule. The main ditch is in length about 2 miles; the ary ones are about 300 yards in length. The value before irrigation was $1 and is now about $20 per acre.

George F. Towle, captain, Nineteenth Infantry, U. S. Army, commanding at Fort Concho, states that surface irrigation exists by water conducted in ditches from low dams in creeks and rivers. The sources are the North, South and Middle Concho Rivers, Dove and Spring Creeks. The average amount of water running in said streams is equal to about 150 to 200 cubic feet per second, nearly all which is at present utilized for irrigation. The amount irrigated is about 7,500 acres. The aggregate length of main ditches, which are in different hands, is about 50 miles; of secondary, 75 miles; approximate cost, about $5 per acre to get the land under water; of land, from $2 to $5 per acre; after irrigation, from $30 to $100, according to location. Most of the systems belong to land-owners; a few only belong to incorporated companies. The cost varies. For one farm of 1,500 acres it has cost $1.50 per acre.

George H. Morgan, first lieutenant, Third Cavalry, U. S. Army, commanding Camp Piña, Colorado, reports that irrigation is by acequia or ditch. Sources are Rainbow Creek and other very small streams. There is about 10 inches flowing, serving 10 acres. The length is one-half mile. The cost in work was eight mules and ten men one day. The value of land is nominal and due to water only. Post garden is made and controlled by troops. One man gardener can generally keep ditch in repair. Heavy rains generally wash all improvements out.

Charles Morton, captain, Third Cavalry, U. S. Army, commanding camp at Eagle Pass, reports post garden under irrigation with success, and watered from town wells and works. He adds that a large irrigating ditch 35 or 40 miles long is being made, to come from near Del Rio to this town. It will reclaim many thousand acres of land.

A. G. Brackett, colonel Third Cavalry U. S. Army, commanding at Fort Clark reports a system of irrigation by ditches, raising water above the bottom lands of stream, through differences in fall; the source is Las Moras Creek; supply is 1 barrel per second, but much more is available; on the reservation about 6 acres are irrigated, which belongs to the United States. Colonel Brackett also reports that at Mud Creek, about 16 miles west of Fort Clark, there is a gravity system by means of ditches, supplied from Mud Creek; it supplies about 1 barrel per second, irrigating 600 acres by a main ditch about 3¼ miles long; secondary ditches are short and in all about 3 miles in length; system cost $2,500; before irrigation land was worth $2 per acre; after it at least $50; the system belongs to the land owners; the cost of irrigation is about $2 per acre, including repairs to main ditch.

At the mouth of the Pinto, about 18 miles southwest from Fort Clark, there is a system of ditches supplied from Pinto Creek. At its mouth the Pinto flows about 4 barrels per second; there are about 200 acres under irrigation; main ditch is 2 miles in length; secondary ditches are short, about 2 miles in length; cost is $2,000; value of land before irrigation $2 per acre, after about $50 per acre; the system belongs to the land owners; the cost is about $2 per acre, including repairs to main ditch.

At Dolores, Kinney County, there is a system of irrigation by ditches. It is about 8 miles south from Fort Clark, and is supplied from Las Moras Creek; all the water is used, affording a flow of about 3 barrels per second, serving 1,000 acres; the main ditch is 2¼ miles in length, and secondary ditches are about 2 miles; system cost $1,400; land was valued at $2 per acre; now at $50; ditches belong to land owners; system cost about $2 per acre, including repairs to main ditch.

At Mariposa there is a system of irrigation by ditches; location is about 7 miles northwest from Fort Clark; served by Pinto Creek; the cross-section of water in the ditch is 1 foot by 3 and the current is 3 miles per hour, giving a flow of about 1 barrel per second; the main stream is much longer; it serves 600 acres; main ditch is 3 miles, and secondary ditches are short, their aggregate length being not greater than that of the main ditch; the cost was $6,000; land value before irrigation $2 per acre; after, $50 per acre; the system belongs to the land owners, and the cost was about $2 per acre, including repairs to main ditch.

STATEMENT OF B. K. BRANT, SECRETARY OF THE PIONEER CANAL COMPANY.

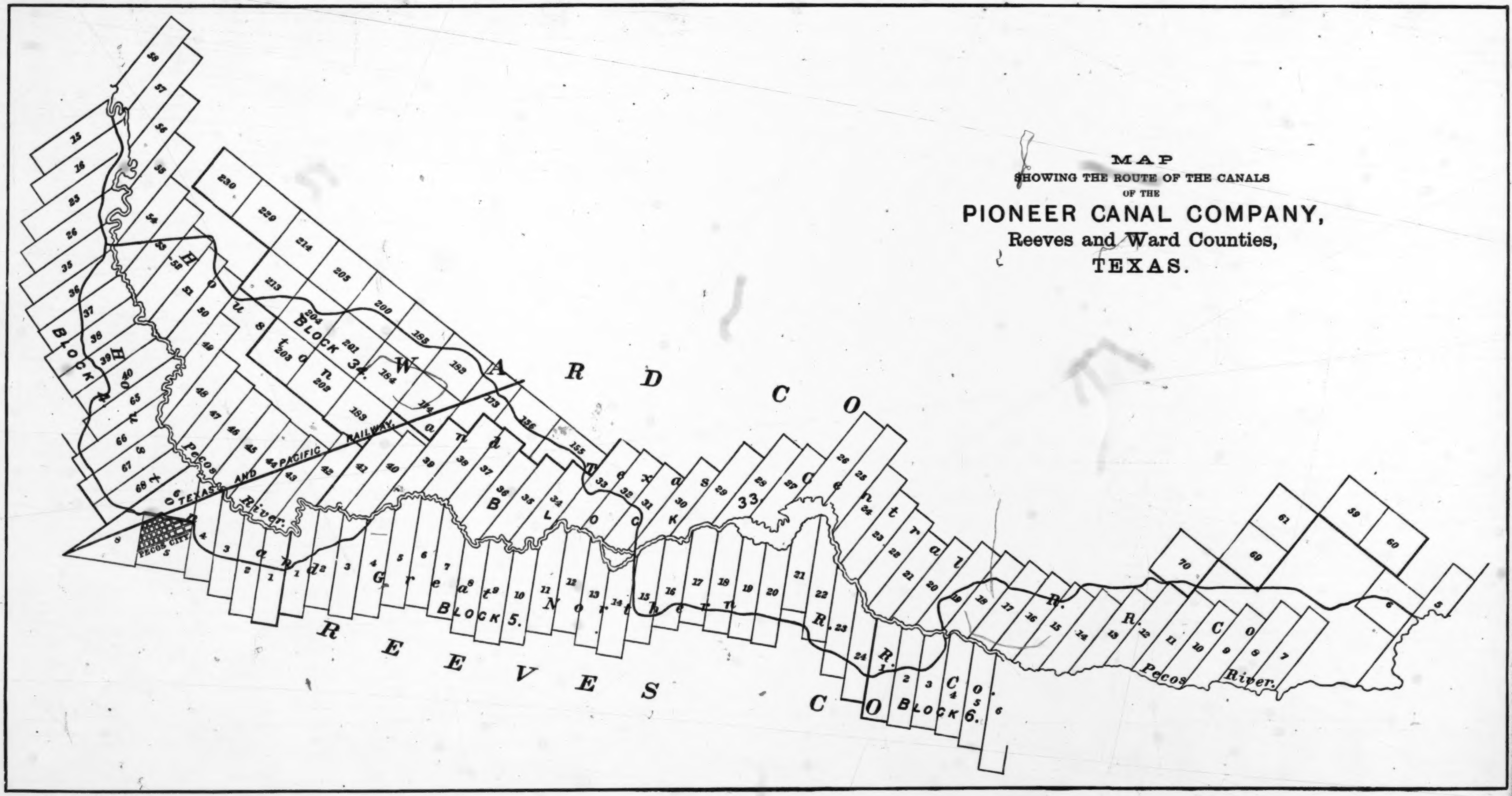
IRRIGATION IN THE PECOS VALLEY, TEXAS.*

Irrigation in Texas is of comparatively recent date. With the exception of a few canals in the valley of the Rio Grande, the irrigation in Texas dates subsequent to the year 1875. In that year the legislature of the State passed an "act to encourage the construction of canals for navigation and irrigation," and for that purpose made donations of land to any company incorporated under the laws of the State, constructing canals of the several classes named in the act.

Encouraged by this law a few ditches were taken out of the smaller streams tributary to the Pecos River, where it could be done at a small expense. Being so far removed from market at the time, from lack of railroad facilities, and the country being sparsely settled, the cost of building and fencing material so great, that the lands offered by the State as an "encouragement" proved but a slight inducement to the practical irrigator.

---

* Referred to in Mr. Brant's testimony in the Staked Plains Division.


WARD CO
REEVES CO
BLOCK 34.
BLOCK 4
BLOCK 5.
BLOCK 6.
BLOCK 33
Houston and Texas Central R. R. Co.
Houston and Great Northern R. R. Co.
TEXAS AND PACIFIC RAILWAY
Pecos River.
PECOS CITY

MAP
SHOWING THE ROUTE OF THE CANALS
OF THE
PIONEER CANAL COMPANY,
Reeves and Ward Counties,
TEXAS.

Report on Irrigation.

Under the law of 1875, however, there were constructed several canals in Reeves (then Pecos) County. Among them may be mentioned the Rooney Ditch, taken out of the Pecos River about 25 miles south of the present site of Pecos City. This was the only ditch taken out from the Pecos River under that law. From Toyah Creek, a tributary of the Pecos River, in said Reeves County, there were taken out several ditches of the third class, to wit: The Saragosa Manufacturing and Irrigation Company's ditch, capacity 6 feet on bottom, 2½ feet deep, and 3 miles in length; the Murphy, Syles, and Miller ditches, of similar construction and capacity. On each of the ditches, since their construction, have been grown a variety of grains and grasses, of large yield. The law, however, proved inadequate, and offered but little encouragement to investments in irrigation canals.

At a State convention, held in the city of Dallas in August, 1888, a resolution was adopted calling upon the legislature to pass some law for the encouragement of irrigation in the State. Responsive thereto the legislature formulated the present law, which will probably prove the one thing needful. The principal thing sought for in legislation is the needed protection to the appropriator of water. Priority of appropriation gives priority of right. That once secured, the rest of the legislation follows as a natural sequence. The same legislature passed the following resolution, calling the attention of the Texas Senators and members in Congress to the needed legislation on the subject of the right to the use of water in interterritorial and State streams. Such legislation by the General Government is very much needed, and should be based on the principle that priority in time of appropriation gives priority of right.

"Whereas several rivers having their sources in New Mexico and other Territories flow into and through the State of Texas; and

"Whereas the waters of said streams are necessary for irrigation in the arid districts of Texas; and

"Whereas it is expedient to obviate future litigation by providing for an adjustment and regulation of the rights of the respective citizens of said Territories and said State of Texas, entitled to the use of said waters for purposes of irrigation: Therefore, be it

"*Resolved by the legislature of the State of Texas*, That our Senators and Representatives in Congress be requested to secure the passage of such laws as may be necessary to effect the objects above set forth."

Encouraged by the legislation on the subject of irrigation, the Pioneer Canal Company, in the year 1888, commenced the construction of a canal on the Pecos River.

This canal is taken out on the west bank of the Pecos River, in Reeves County, Tex., about 9 miles north of the town of Pecos City.

The water is brought to the surface at the distance of about 3½ miles, where the main stem is divided into two canals, the east and the west valley lines. The former is then flumed over the river and serves the large valleys on the east bank of the river. The latter continues its course on the west side, crossing the track of the Texas and Pacific Railroad at the town of Pecos City.

The main canal, 7 feet deep, and 44 feet at the water surface, is 23 feet wide on the bottom, and carries 1,020 cubic feet of water per second of time, a quantity of water sufficient to irrigate 64,000 acres of land.

The two lines of the canal when completed will be 52 miles in length, of which 14 miles have already been completed. (Date of writing September 16, 1889.) The west valley line will be completed back to the river, a distance of 20 miles from the head-gate, by the 15th of November, 1889.

Work was begun on this canal in the month of April, 1888, and is being rapidly pushed to completion. The canal covers very fine bodies of land on either side of the river. Quite a number of small farms under the canal have already been opened, and there have been raised Indian corn, 35 bushels per acre; millet, 2½ tons per acre; sorghum, 6 tons first cutting, with a heavier crop promised for the second cutting; sweet potatoes very prolific, not yet dug; heavy crops of all kinds of melons, squash, beets, turnips, and general garden vegetables. Nothing was planted earlier than the 15th of June, owing to the fact that the canal was not sufficiently completed to furnish water for irrigation before that date. All lands were sod, being first grubbed and broken in May of the present year. This year's experiments in planting alfalfa has demonstrated the fact that alfalfa should be planted not earlier than the 1st of September, and may be planted until the 1st of November. It may also be sown in the spring with success from the middle of February until the 1st of April. Between the seasons indicated the sun is too warm for so tender a plant to get a good start. Once established alfalfa thrives in warm weather.

A large acreage of orchards will be planted this fall.

All kinds of deciduous fruit trees, English walnuts, soft shell almonds, French prunes, and a large variety of European grape vines, of which there is not the least doubt of the success of their cultivation, as they have been successfully grown near this point by irrigation. Under the canals on Toyah Creek, and on the Pecos River, in this county, have been grown large yields of rye, barley, oats, Indian corn, and wheat, a fair average of which would be for rye, 30 bushels per acre, worth $1 per bushel; barley, 50 bushels per acre, worth for feed $1 per 100 pounds; oats, 70 bushels per acre, worth unthrashed, $15 per ton; corn, 40 bushels per acre, worth 65 cents per bushel; wheat, 35 bushels per acre, worth $1 per bushel; alfalfa, 10 tons per acre, worth $18 per ton; millet, 3 tons per acre, worth $15 per ton; sorghum, 12 tons per acre, worth $15 per ton.

The Aztec Irrigation Company, incorporated in July, 1889, will also begin operations on Toyah Creek and be prepared to deliver water to consumers for the spring crop of 1890.

Flowing artesian wells, ten in number, inside the corporate limits of Pecos City, flow nearly, if not quite, 50,000 gallons of water per hour, and is used exclusively for drinking, washing, and all domestic purposes, including irrigation. As the wells have a natural pressure that forces the water 30 feet above the ground, they can be used for fire purposes. The artesian water belt in the Pecos Valley country is practically without limit, and can be utilized to irrigate thousands of acres at a moderate cost. A well that will irrigate 20 acres of land can be had, including the best of iron casing, at $300 to $400, and at a depth of 200 to 250 feet.

Climate.—Our winter climate is simply delightful—clear, bright days, with the thermometer rarely below the freezing point; very seldom rain, snow, or sleet; no "northers" or "blizzards," such as are common in eastern Texas and other States. In summer, owing to our altitude, 2,700 feet above sea-level, we do not have as warm weather as other points east of us in the same latitude. While the weather gets hot in summer, and the sun is brighter, apparently, than at most other localities in the State, the thermometer (in the shade) rarely reaches 100 degrees, and the nights are always cool and refreshing—never too warm to sleep well.

Rain-fall.—Our annual rain-fall is from 12 to 18 inches.

Soils.—Soils of the Pecos Valley under the Pioneer Canal are considerably diversified, there being the black and chocolate colored stiff lands, and sandy loams, varying in color from black to red. There are also about 5,000 acres of a peculiar whitish loam, and from the amount of silica and lime it contains it will certainly prove valuable as grain, alfalfa, and fruit lands.

Price of lands in the Pecos Valley.—There are a large number of sections of State school lands on the Pecos River under the Pioneer Canal, which alternate with various railroad surveys. These lands are offered by the State at $3 per acre on forty years' time, with 5 per cent. on the deferred payments.

The railroad lands are offered at correspondingly low prices—one-fourth cash, and balance in one, two, and three years.

Water-rights.—A Pioneer Canal permanent water-right is an amount of water for 40 acres of land, equal to an annual rain-fall of 40 inches, distributed under a head of 100 miners' inches. A 40-acre water-right is sold for $300.

This company is most liberal in taxing the land for water service, charging $1 per acre for the land in cultivation.

Analysis of soil.—An analysis of the soil of the Pecos Valley shows the following percentages:

Organic and volatile matter	6.73
Insoluble residue	76.97
Soluble silica	.14
Iron	3.13
Aluminia	2.07
Phosphoric acid	.21
Lime	5.22
Magnesia	Trace.
Sulphuric acid	.87
Alkalies (as chlorides)	2.27
Carbonic acid	3.22
Chlorine	.07
Total	100.90

Analysis of Pecos River Water.—An analysis of the water in the Pecos River shows the following percentages:

Suspended matter	36.32
Total solids in clear solution	308.48
Organic and volatile matter	53.00
Total mineral matter	255.48
Total soluble matter	172.59
Total insoluble matter	135.89
Total hardness	27.42

Temporary hardness	4.05
Permanent hardness	23.37
Sulphuric acid	64.57
Alkalies (as chlorides)	58.70
Chlorine	39.05

MEMORANDUM OF IRRIGATION CANALS OF THE PIONEER CANAL COMPANY IN REEVES AND WARD COUNTIES, TEX.

Head gates on west side of Pecos River, 9 miles above Pecos City.

	Miles.	Feet.
Length of main line	3	160
Length of east valley line	34	....
Length of west valley line	14	1,473
Total miles	51	1,633

Main line:

Width at bottom	feet	23
Width at surface of water	do	43
Depth	do	7
Carrying capacity per second	cubic feet	1,020
Miles of water-ways now complete	miles	19
Land susceptible to irrigation	acres	64,000

Work commenced April, 1888.

Quality of land.—Alluvial, and chocolate-colored and black sandy loam; products are the serials, alfalfa, the deciduous fruits, raisin grapes, and all varieties of European grapes, French prunes, English walnuts, and soft-shelled almonds———

STATEMENT OF THE PECOS RIVER IRRIGATION COMPANY, PER O. W. WILLIAMS, PRESIDENT.

The officers of the company are O. W. Williams, president; T. J. Ray, secretary; A. P. Wooldridge, treasurer. The principal office is at Fort Stockton, Tex. This company possesses an old canal, built in 1878, 9 feet wide, 3 feet in depth, carrying 65 cubic feet of water per second of time, and supplying 5,000 acres of land. The head gate is at Ripples, 30 miles southeast of Pecos City. The canal is now being enlarged and extended. Where the enlargement is completed, the canal is 25 feet wide by 3½ feet in depth, carrying 250 cubic feet of water per second. The canal is now 10 miles in length, and covers 8,000 acres of good land. Work is progressing, and it is intended to make the canal finally 30 miles in length, 40 feet in width, 4 feet in depth, with a capacity of 500 cubic feet of water per second of time. Work progresses at the rate of 1¼ miles per month. Water rights are held (permanent), at $2.50 per acres, subject to annual assessment for the necessary repairs, etc., incident to keeping the canal in good condition.

There are some places along the canal where good storage can be had.

NEW MEXICO DIVISION.

SANTA FÉ, N. MEX., *September* 7, 1889.

The committee met pursuant to call of the chairman.

Present: Messrs. Stewart (chairman) and Reagan; also Director Powell.

Members of the State constitutional convention were examined.

STATEMENT OF W. H. H. LLEWELLYN, OF LAS CRUCES, N. MEX.

The CHAIRMAN. How long have you resided in Las Cruces?

Mr. LLEWELLYN. For the past five years.

The CHAIRMAN. Have you given attention to the subject of irrigation?

Mr. LLEWELLYN. Yes.

The CHAIRMAN. And of water-supply in this Territory?

Mr. LLEWELLYN. Yes.

The CHAIRMAN. Will you state the condition of your county, and any other portions of the Territory with which you are familiar? State what you have now, the supply of water you have, and what are the prospects of reclaiming land there.

Mr. LLEWELLYN. The lands in the Mesilla Valley, in Doña Aña County, are irrigated by canals which take the water from the Rio Grande. We have now under cultivation in the Mesilla Valley, in the vicinity of Las Cruces, about 20,000 to 25,000 acres of land. There is, however, a large tract of land there which, with proper arrangements for the storage of water, is equally good with the lands now under cultivation, and which could be brought under cultivation—probably about 200,000 acres.

The CHAIRMAN. From where would you obtain the water?

Mr. LLEWELLYN. We would obtain the water supply from the Rio Grande.

The CHAIRMAN. How would you be required to do it?

Mr. LLEWELLYN. We would do it by the construction of a canal at a point probably about Socorro, and probably as far up as Las Cruces, which would carry the water on to the tract of country known as the Jornado del Muerto, and this canal, if built, would cover in addition to the land I have mentioned before 200,000 acres of land, and other tracts of very rich land, which are now valueless on account of having no water.

The CHAIRMAN. Is there sufficient water in the river to supply the needs?

Mr. LLEWELLYN. There would be an abundance of water by the construction of proper reservoirs.

The CHAIRMAN. What is the condition of the water at flood-time? You have not gauged it?

Mr. LLEWELLYN. There is an enormous quantity of water that annually passes down the Rio Grande early in the spring.

The CHAIRMAN. That goes to waste?

Mr. LLEWELLYN. Flows absolutely to waste, to the Gulf?

The CHAIRMAN. Have you had any surveys or estimates of this plan of this stream?

Mr. LLEWELLYN. Yes, there has been an accurate level line run and survey made.

The CHAIRMAN. Have you a report of it?

Mr. LLEWELLYN. I have not with me. I have it in my valise.

The CHAIRMAN. Will you furnish a report of that?

Mr. LLEWELLYN. I will, I will be glad to hand it in.

The CHAIRMAN. Are you acquainted with other portions of the Territory?

Mr. LLEWELLYN. Yes; I am acquainted with every portion of New Mexico by personal observation.

The CHAIRMAN. Describe any other portion with which you are specially familiar.

Mr. LLEWELLYN. By describing one particular tract or section of country it will be applicable to all portions of the Territory. There are in New Mexico numerous water-courses which, during a high stage of water carry an immense volume of water, which passes away, and later in the season the streams are nearly dry. By the construction of reservoirs this water could be stored, and thousands of acres of valuable land could thereby be brought under cultivation.

The CHAIRMAN. If the Government would make the necessary surveys and investigations to show what could be done, with estimates of cost, would that be of any advantage to your people here?

Mr. LLEWELLYN. It would be a great advantage.

The CHAIRMAN. Are there many places where private capital or by association of capital they could construct the works?

Mr. LLEWELLYN. There are many places where private capital is now constructing irrigating-canals.

The CHAIRMAN. Describe some of them where private capital is now engaged and what the plans are, if you are familiar with them?

Mr. LLEWELLYN. In the Maxwell land grant, in the northern part of the Territory. This land grant company during the past year constructed a number of irrigating-ditches, and in connection with the irrigating-ditches have constructed reserviors to store water. In the lower valley of the Pecos, in Lincoln County, there are three large canals now in process of contruction by private capital. But these two localities are especially well situated for private capital to carry out this work, more so than any other places in the Territory.

The CHAIRMAN. Have you in Mesilla Valley, or anywhere else, given special attention to the quantity of land that an ordinary family, a man and wife and two or three children, can cultivate profitably by irrigation?

Mr. LLEWELLYN. Yes; I have myself personally.

The CHAIRMAN. Without hiring help?

Mr. LLEWELLYN. Without hiring help.

Mr. CHAIRMAN. How much land would they need?

Mr. LLEWELLYN. In my opinion a family is much better off in Mesilla Valley if they intend to cultivate the land themselves, with part in alfalfa and part in fruit, to have not to exceed 15 or 20 acres. That is as much as a family can take care of.

The **CHAIRMAN.** What occurs in this Territory when they undertake to irrigate too much land as a general thing?

Mr. **LLEWELLYN.** It generally occurs that they make a partial failure of it; their crops are not so good. In other words, 10 acres of land properly cultivated will produce more than 40 acres indifferently cultivated and irrigated.

The **CHAIRMAN.** The land in this Territory wants to be cut up into small farms?

Mr. **LLEWELLYN.** That is my opinion—to have irrigated lands cut up into small allotments.

The **CHAIRMAN.** What schemes have these companies that are bringing out water adopted for disposing of the water?

Mr. **LLEWELLYN.** There are several different plans. The plan of the Pecos Irrigating Company is to charge $15 per acre for the water-right that is attached permanently to the land. They then charge an annual rental thereafter of $1.50 an acre. They divide, however, this $15 into annual payments. There is another company down there that charges $10 an acre and divides that payment into ten annual payments, and then it charges in addition to that $1.50 an acre for the water.

The **CHAIRMAN.** Have any of them adopted the plan when they have paid for the water of turning the establishment over to the settlers and allowing them to take care of it?

Mr. **LLEWELLYN.** I do not understand that they have. There may be companies in the Territory organized under that plan, but I do not understand so.

The **CHAIRMAN.** That plan, I would suggest, has worked best in California. The colonies will come in more readily if they can have the entire property.

Mr. **LLEWELLYN.** Yes; and I understand that is carried out very successfully in Idaho and Utah.

The **CHAIRMAN.** In Utah the settlers more readily take hold of it if they are to have ultimately the property in hand. In fact, they could not do it individually, and are willing to pay a good price, but want the title absolutely in their hands.

Mr. **LLEWELLYN.** The ditches we have in the Mesilla Valley are community ditches.

The **CHAIRMAN.** How are they managed?

Mr. **LLEWELLYN.** Under Territorial statutes. In January next we elect three water commissioners for the ditch system, and we also elect a major domo, or overseer of the ditches. And we have what we call repartidors, who act under him.

The **CHAIRMAN.** Then persons are not allowed to measure out their own water?

Mr. **LLEWELLYN.** No; it is done sometimes, but only by common consent, and where there is an abundance of water. But the major-domo has general supervision of the ditch.

The **CHAIRMAN.** You elect him every year?

Mr. **LLEWELLYN.** Yes; it is done under provision of the Territorial Statutes.

The **CHAIRMAN.** That is practically an adoption of the Spanish custom and law.

Mr. **LLEWELLYN.** Yes; it is practically the old Spanish way.

The **CHAIRMAN.** How long have the lands in this Territory been cultivated by irrigation?

Mr. LLEWELLYN. From a period extending back, probably, three hundred years; that is, since the Spanish invaders occupied the Territory, and perhaps many hundreds of years before that.

The CHAIRMAN. They found irrigation practiced here?

Mr. LLEWELLYN. Yes.

The CHAIRMAN. Have you in this Territory many of the ruins of ancient irrigation works?

Mr. LLEWELLYN. Yes; a number.

The CHAIRMAN. How extensive are they, and what are their character?

Mr. LLEWELLYN. There are the ruins known as the Gran Quivera. They are situated in the eastern part of Valencia County. There are the remains of a system of very extensive ditches there; they have been cemented and plastered. You can trace them for miles.

The CHAIRMAN. The cement still remains therein?

Mr. LLEWELLYN. Yes.

The CHAIRMAN. Still in a pretty good state of preservation?

Mr. LLEWELLYN. Yes; but the water has disappeared entirely.

The CHAIRMAN. Do you know where they got the cement?

Mr. LLEWELLYN. No.

The CHAIRMAN. That was before the Spaniards came?

Mr. LLEWELLYN. That was before the Spanish occupation.

The CHAIRMAN. Have you any material for making hydraulic cement?

Mr. LLEWELLYN. Yes, it is made near Springer; it is of very good quality, and it can be manufactured at other places.

The CHAIRMAN. You do not know where they got theirs; that is to say, those ancient irrigators?

Mr. LLEWELLYN. No.

The CHAIRMAN. It is real hydraulic cement?

Mr. LLEWELLYN. Yes; and it stands there to-day in a very good state of preservation. Coronado, in his first occupation of this country, describes the ruins in Salt River Valley and elsewhere, both here and in Arizona. They have been found at Casa Grande, and at La Tempe, where the ancient canals were constructed.

The CHAIRMAN. Have you any further statement that you desire to make?

Mr. LLEWELLYN. Well, I differ somewhat from some of our friends with reference to the real cause of the low state of the water in the Rio Grande. I do not think it is attributable altogether to the diversion of the water in Colorado. We have had two years of very low stages of water, and I think it is largely due to the fact that we have not had a regular snow-fall on the head-waters of the Rio Grande. But that does not do away with the Government taking active measures to afford us relief, because new lands will be opened up in New Mexico that will get the water off further below.

The CHAIRMAN. When these schemes, of which you speak, are carried out, the water will be largely used above here?

Mr. LLEWELLYN. Yes.

The CHAIRMAN. Has there been a rain-guage kept in this Territory for any considerable length of time?

Mr. LLEWELLYN. There has been.

The CHAIRMAN. Have these dry seasons appeared before, coming in cycles?

Mr. LLEWELLYN. As I understand, the periods of drought in Arizona in recent years, that is, very low stages of water in the Rio Grande, were in 1872, 1879, last year, and this year.

The **Chairman**. I suppose old residents here will recollect other periods.

Mr. **Llewellyn**. Perhaps so.

Senator **Reagan**. What is the character of the crops that you raise about Las Cruces?

Mr. **Llewellyn**. We raise corn, oats, rye, barley, wheat, and various varieties of sweet potatoes. We raise nearly all the fine European varieties of grapes, and in fact all the fine fruits.

Senator **Reagan**. Will you state the amount per acre of these crops that can be raised on irrigated land.

Mr. **Llewellyn**. If we have the water we can cut four crops of alfalfa, with an average of a ton and a half to the cutting. Five crops have been cut, but four is a very safe estimate. Our vineyards will produce from 16,000 to 24,000 pounds of grapes to the acre.

Senator **Reagan**. How much wheat?

Mr. **Llewellyn**. I have known personally of one small crop which produced 42 bushels to the acre.

Senator **Reagan**. What would be the general average there?

Mr. **Llewellyn**. I think it is safe to say, with an abundance of water, good cultivation, and good farming, 40 bushels can be produced?

Senator **Reagan**. How much corn do you raise to the acre?

Mr. **Llewellyn**. The corn crop would generally average, under our present system of cultivation, not more than 25 bushels to the acre.

Senator **Reagan**. What has similar ground without irrigation produced in that portion of the country?

Mr. **Llewellyn**. Nothing—absolutely nothing.

Senator **Reagan**. What you say as to the crops there applies generally throughout the Territory?

Mr. **Llewellyn**. It will apply pretty generally throughout the Territory, except in elevated regions, where the frost might come too early in the fall or too late in the spring. There are a great many sections of New Mexico where it has been demonstrated that all the fine varieties of fruit can be raised.

Senator **Reagan**. What kinds of fruit do you raise around Las Cruces.

Mr. **Llewellyn**. We grow dates; pomegranates have been raised; also apricots, pears, peaches, quinces, nectarines, apples, prunes. We have no fruit pests there. Curculio is absolutely unknown.

Senator **Reagan**. Can you say anything as to their quality?

Mr. **Llewellyn**. Their quality is reported to be the finest in the world.

STATEMENT OF WARREN BRISTOL, OF DEMING.

The **Chairman**. You have resided in the Territory how many years?

Mr. **Bristol**. Ever since the spring of 1872, something over seventeen years.

The **Chairman**. You have been United States district judge?

Mr. **Bristol**. For a little over twelve years, not quite fifteen years, continuously.

The **Chairman**. Are you a judge yet?

Mr. **Bristol**. No.

The **Chairman**. Have you given attention to agriculture by irrigation?

Mr. **Bristol**. A good deal; and since my boyhood I have had an interest in that. I was brought up on a farm.

The **Chairman**. Have you pursued agriculture to some extent in this Territory?

Mr. **Bristol**. As far as vineyards, on a small scale, are concerned.

The **Chairman**. Where was that?

Mr. **Bristol**. At Mesilla; at present at Deming. I am now living at Deming.

The **Chairman**. Have you a water supply at Deming?

Mr. **Bristol**. Yes, but we have to pump it up 50 feet.

The **Chairman**. Explain anything you think will be of interest to the committee.

Mr. **Bristol**. So far as my experience in Deming is concerned, it is this: I have bought town lots 25 by 142 feet that, with the exception of my dairy and barn and the rest, are planted in fruit trees. I have a large pump and an 18-foot well in connection with another man. We are supplying water for fourteen or fifteen families, and several gardens are being irrigated from it. My garden is most prosperous, as I give special attention to it. Fruits of all kinds and grapes grow to perfection; the Bartlett pear, and even the peach, the early and late Crawford. This year we have as fine a flavored peach as any coming from the Chesapeake Bay. It was a surprise to me.

The **Chairman**. Will you describe that country at the time the railroad was brought there, and before any water was put upon the land?

Mr. **Bristol**. At that time there was no water on this table-land, except occasionally when the water came down by flood. No water was known to exist there, but there is a region of country from 25 to 50 miles wide, and 100 miles long, north and south, that we know of (and how much farther it exists we do not know) where, if you dig down anywhere you will strike water at about 50 feet in inexhaustible quantities. To illustrate, at my place I have a powerful windmill, an 18-inch wheel (Holladay's). Each revolution of that throws out 100 gallons of water. You can run it up to one hundred and sixty revolutions per minute. There are only 2½ feet of water in that well, and that quantity can not be lowered with that pump. It is so all over the plain.

The **Chairman**. How did that plain appear before you discovered that water?

Mr. **Bristol**. As a barren plain; a desert with nothing but grama grass growing anywhere on it.

The **Chairman**. I thought that was the most unpromising place I ever saw.

Mr. **Bristol**. It was very unpromising. Deming has a great many windmills now, and is a pretty place. The change really seems like a miracle. The Southern Pacific Railroad Company was the first to discover this water beneath the surface. Since then it has improved; the whole plain I have described is covered with cattle ranges, and the ground is all occupied with pumping machinery of this kind to water the cattle. A great deal of money is invested there. The whole plain is taken up.

In addition to that, in the water system to the north of Deming—Cook's Peak mountain, which you probably know—there is one place where the water comes down every year from the mountains, and passes through a range of foot-hills about 3 to 4 miles from the main chain of mountains. A perfect flood or river of water comes down there every year, several times during the rainy season, and it has dug out immense excavations in the ground. These are filled with water, extending away out on the plain. It is a beautiful plain of the richest soil, and cattle from all over the country frequently, for several weeks at a time, gather in there. That would be a good place at which to build a reservoir, for it would afford accommodation for several thousand acres.

The CHAIRMAN. Then from your observation of New Mexico, are the opportunities for reclaiming land and making homesteads plentiful?

Mr. BRISTOL. Yes, very; especially so along the range of lower mountains and foot-hills. This year has been an exception in some instances, but I have noticed in the extensive range of mountains here that there is rain-fall enough, if it was equally distributed over the plain, to make it one of the most fruitful countries in America. Even in these mountains (a tract that has only recently been discovered) millions of acres may be cultivated without any irrigation, by clearing off the pine forests. In addition to that the great waste of water that flows out from the foot-hills on to the plains could be collected in immense reservoirs and distributed over the plains for agricultural purposes. The opportunities for that are very great.

The CHAIRMAN. What do you say of the climate of New Mexico?

Mr. BRISTOL. I have lived in New York, and I have lived in Minnesota, in the latter State for twenty-five years. I have lived in New Mexico for something over seventeen years, and I regard New Mexico as one of the most healthful climates on the continent. My experience and observation convince me that the most salubrious climate is not high up in the mountains at an extreme altitude, nor down in the river bottoms where they have more or less malaria, but out on these plains where water can be had, and where the breezes blow and there are no malarial influences. I consider this as good a climate as there can be in the world.

The CHAIRMAN. What do you say of the production of crops?

Mr. BRISTOL. I simply say "water is king." Wherever water can be had or can be got on the soil it is wonderful in its productiveness. It is rich in all the elements of fruitfulness, even out on this barren plain that we have been calling a desert. Put water there and everything will grow in luxuriance. On the plains the greatest drawback at present, in my opinion, to successful cultivation is the strong spring winds which obtain in every country where there is no wind-break. As soon as forestry is cultivated here systematically, and trees are planted so as to break the prevailing winds, it will be a wonderful country for productiveness, providing you get water. The altitude of Deming is about 4,000 feet. It is on the first plain out of what we call the Mesa Valley of the Rio Grande. It commences on the Bluffs of the Rio Grande and is a lovely plain all the way on into Arizona.

STATEMENT OF T. B. CATRON.

The CHAIRMAN. Will you please state to the committee any facts of interest that you know regarding this Territory and its irrigation?

Mr. CATRON. I have resided in this Territory for twenty-three years, most of the time at Santa Fé, but part of the time in the southern part of the Territory, where Major Llewellyn resides. What he states about that section of the country is substantially correct. What I can state is, that this Territory is divided, as you observe upon the map, almost equally from north to south by the Rio Grande. On either side of the Rio Grande there is a range of mountains extending nearly the whole distance from the northern to the southern part of the Territory. It extends, with a few breaks only, on the west side entirely through, and on the east side through excepting that due west of here the continental divide is not very high, though a little bit higher than this place. The Rio Grande between the 1st of April and the 1st or middle of July in each year contains almost as much water as the Missouri River does during that period—enough water to irrigate, if properly husbanded and properly divided, at least half of this Territory, if it could be reached—that is, during the crop season. But the Rio Grande is fed by constant streams coming from the mountains on either side. There are also streams on the other side of the mountain running in the other direction. These streams come down very rapidly. There are large quantities of land that it would be difficult to reach from the Rio Grande because they are in cañons. By making reservoirs in those streams (which can be made cheaply) immense volumes of water could be collected in the spring time, as our mountains have from 3 to 10 feet of snow in the winter, and furnish, ordinarily, outside of the Rio Grande, all the water that is furnished for our lands. I do not suppose that more than one-twentieth or one-fortieth of all the land is attempted to be cultivated—probably not more even than one-fiftieth part is attempted to be cultivated—that can be cultivated, for the reason that the people are quite poor and unable to construct reservoirs and extensive ditches. But on all places like that in which you are now, the city of Santa Fé, there are immense bodies of land at the foot of the mountains which can be irrigated, and these streams being deep and being susceptible of damming, can hold a great deal of water. We have hardly enough at this time for our drinking purposes. But the stream above here can be dammed in forty places with dams, some of them not over 40 feet, some 100 feet long. Those would irrigate a great many acres.

The same state of facts exists all along the range of mountains clear up to Colorado on both sides of the river. On the other side of the mountains the same state of facts exists, where the land slopes to the east. There are many fine streams there, which run principally into the Canadian River. Others flow south and run into the Pecos. Much of the land in ordinary seasons can be cultivated without irrigation, but that would not produce over half a crop or one-third. With the assistance of a very slight amount of irrigation, all these lands can be made to produce what would be called a crop in this country.

The CHAIRMAN. Also a variety of crops?

Mr. CATRON. Any variety you can think of. All those uplands will produce wheat, rye, or barley. Corn does not grow so well. It is not so good a crop as the others. Irish potatoes grow in abundance on the uplands, while on the lowlands along the Rio Grande the sweet potato does well. Almost all grapes, except the Mission grape and the El Paso grape, do well. The fruit here, I think, is a better fruit than that on the Rio Grande, while perhaps not so large. Fruit grows excellently here in any place where you protect it.

The CHAIRMAN. How is it with the plains outside the bottom—the lower plains, or what you call the mesas?

Mr. CATRON. This is a mesa around here. These mesas can all be reached by water stored in dams in these mountain streams. The land is very rich and will produce as good a crop as that in the valley of the Rio Grande, if you can get water to it. But I may say nineteen-twentieths can be reached, because under our present system we have not water enough, and the people are not able financially to store that water.

The **CHAIRMAN**. The first thing in order, it seems to me, is a survey and exploration for irrigation purposes only.

Mr. **CATRON**. Yes; the first thing is such a survey. There is a Government surveying party up this river now. The first thing is to see how much water can be located and the cost of it.

The **CHAIRMAN**. Do you think, when that is done, that the people will utilize many of the places?

Mr. **CATRON**. I think a large number of places would be utilized. The fact is, that every day now they are increasing the supply of water by putting in more or less dams or going above and taking water.

The **CHAIRMAN**. Have they studied the economy of water much in this Territory?

Mr. **CATRON**. In this place there has been no economy studied at all.

The **CHAIRMAN**. So that you would not be able to state what would be the duty of water here?

Mr. **CATRON**. No; I can not state that. I think Mr. Llewellyn has given you the best figures on that. There should also be a big profit wherever a man would take water from any supply that could be furnished from this river. It would yield to the man cultivating the land a large profit over and above what he could realize from that same land without having water.

The **CHAIRMAN**. How much water would irrigate an acre here?

Mr. **CATRON**. I could not give you those facts. There are other gentlemen here that can give you the figures.

The **CHAIRMAN**. About what portion of New Mexico can ultimately be reclaimed by irrigation, according to your best observation?

Mr. **CATRON**. About one-half of it.

The **CHAIRMAN**. Do you think so much as that?

Mr. **CATRON**. Yes.

The **CHAIRMAN**. About how much of it could be brought under cultivation without resorting to any refined methods, but simply storing and using the ditches without piping?

Mr. **CATRON**. From one-fourth to one-half of New Mexico can be done in that way.

The **CHAIRMAN**. By the ordinary methods used in other Territories?

Mr. **CATRON**. Yes, by the ordinary methods used in other Territories; by taking out these ditches, and probably more after a time by the use of storage. Our railroad transportation here has been so high that we have not been much encouraged. We pay twice as much railroad fare to here from the East as you pay to San Francisco.

The **CHAIRMAN**. I should think that would impede the growth of the place.

Mr. **CATRON**. Well, it does not hurry it along any.

Senator **REAGAN**. Are you familiar with the distribution of the water by irrigation in the valley of the Rio Grande?

Mr. **CATRON**. Yes, I think I am; that is from observation only.

Senator **REAGAN**. What measures, if any, have been adopted to prevent the water from going to waste so loosely in the distribution of water in the valley?

Mr. **CATRON**. There have been no measures whatever adopted when there was a surplus of water to prevent it from going to waste. Each community has taken out a ditch from the Rio Grande, and run out sometimes around the foot-hills, and sometimes around their land just high enough to get it on their land, and they have used all the water sufficient to irrigate their land, and they let the balance go.

Senator **REAGAN**. Is that allowed to run to waste from the end of the ditch, or do they shut it off so as to allow the water to continue to run in the river?

Mr. **CATRON**. Sometimes they let it run off, and sometimes they turn it back into the river at the end of the ditch.

Senator **REAGAN**. Have you no legislation controlling that?

Mr. **CATRON**. No.

Senator **REAGAN**. It is one of the great problems here to save that water?

Mr. **CATRON**. I understand, of course, that that water goes back into the river at the end of the ditch.

Senator **REAGAN**. Is it your observation that the water is used with due reference to economy and to the interests of the people alone?

Mr. **CATRON**. No; in taking out their ditches they do not pay much attention to the people below. They take out their water and let the people below look out for themselves. The system of irrigation is very crude.

Senator **REAGAN**. It is a subject very well deserving the attention of the Territorial legislature.

The committee then took a recess until 3 o'clock, when it again convened.

STATEMENT OF ARTHUR BOYLE, OF SANTA FE.

The **CHAIRMAN**. How long have you resided in Santa Fé?

Mr. **BOYLE**. Nine years.

The **CHAIRMAN**. Have you given any attention to the subject of irrigation?

Mr. **BOYLE**. I have been raising fruits and crops by irrigation since I came here.

The **CHAIRMAN**. Tell us where you pursued that business and with what success?

Mr. **BOYLE**. I lived for three years in the extreme northern part of the Territory. I was farming and ranching there. I found that land which without irrigation barely raised a half a ton of natural grass to the acre produced with irrigation at the first crop 60 bushels of oats and 42 bushels of wheat. Corn does not do very well; still I did raise a very satisfactory crop of corn. The same land without irrigation would be comparatively useless. Since I came to Santa Fé I have given my attention principally to the cultivation of small fruits and the orchard business generally.

The **CHAIRMAN**. Give us your experience with that?

Mr. **BOYLE**. The land I took was a very poor cornfield, that scarcely returned seed from one season to another. Last year the trees planted in 1882 gave me a profit of over $1,800.

The **CHAIRMAN**. For how much?

Mr. **BOYLE**. For 2½ acres of land.

The **CHAIRMAN**. What kind of fruit were they?

Mr. **BOYLE**. Small fruit, such as apples, pears, plums, grapes—in fact, everything that I have tried here up to the present time, where water is sufficient, has succeeded. Under the very common, careless, and ignorant method of irrigation in use here now, land which was scarcely worth cultivating produces good crops. I have put in orchard trees that are thriving very well, and in five years' time from the present spring I think that they will bring me from $300 to $500 an acre.

The **CHAIRMAN**. Profit?

Mr. **Boyle.** Profit. I have seen a great deal of country that is very similar to New Mexico, both as to soil and climate—particularly some portions of Spain and the Nile—great portions of Australia, some portion of the steppes of the Danube, and they are very similar to the land here. In all these places where water is not systematically used the land may be called waste; whereas with a proper application of water there is no richer land in the world. I think it safe to say that New Mexico can easily anticipate an increase of five times her present population within ten years if the storm waters that fall naturally be saved and used for the purpose of turning the water to the best advantage.

We have an annual rain-fall of which the Government has full reports. On the brightest days in July, August, or September, a storm will burst in the mountains, and the water will come tearing down the streams and practically run to waste. It often comes when the crops need it, but it goes to waste. If that water can be saved, it can be made advantageous instead of mischievous, and be made to support a large population. In this particular locality and north of here much of the land which at present is used for pasturing sheep, either because it is too high above the river or because the water in the river is already taken out by riparian occupants, can be supplied with water, and there is water enough for it to depend upon an average crop. Of course virgin soil in the first year would give a heavy crop, but I think an annual crop could be had of from 30 to 35 bushels of wheat, judging by my own efforts, and 40 to 45 bushels of oats. Some portions of the upper part of the Territory would not do so well, but the greater part would give 20 to 25 bushels of corn to the acre. There are other crops that are raised here, such as onions, that are not equaled in any other part of the world except Spain. The onion crop in New Mexico, with water sufficient to apply at the right time, could be made sufficient to supply the whole of the United States. I am stating that, after having made considerable inquiry about it, and giving statements to the freight agent of the Atchison, Topeka and Santa Fé Railroad on this very subject. So I think it is correct. Other things naturally, as the land came in cultivation, would be found suitable for this particular climate and soil, which at the present time we do not raise but look upon as commercial products.

I alluded just now to Spain. Of course, these people are Spanish people, and derive many of their ideas of irrigation from the country from which they came. But they have either forgotten or never knew the improved methods of irrigation in use in the old country. Water here does not serve for 1 acre where there is an abundance for 5 acres. That is so for many reasons. In the first place, each man looks for water only for himself, and does not think of his neighbors. He has practically no control over the waters. Consequently much water goes to waste. The ditches are improperly and badly constructed, and are not kept in repair. I believe that at the present time the establishment of a proper and efficient system of storage reservoirs is of very much more importance to this section of country than any other question which we have before us at the present time. A new population is coming in at the headquarters of all our streams. Colorado is diverting a great deal of water from this country that the people of this country have depended on in years past. Not only the Rio Grande, but the other streams—the headquarters of the Pecos and other rivers in southern Colorado—are now being used at their sources, and therefore when a flood occurs it is turned off on the land, and the people living below along the course of the river are deprived of water entirely. Unless something is done in the way of storing the surplus water the people of the Lower Pecos, the Lower Rio Grande, and so on will have to abandon their farms for want of the water to which they have been accustomed.

In 1868 I was instrumental in introducing the silk industry into South Australia, in conjunction with Sir Samuel Davenport and Prof. George Francis and Mr. Atwater, who was then curator at the museum at Adelaide. I think this climate more nearly resembles that portion of Australia than any other climate I have met with. The success there was most pronounced. The industry has grown from that time until it is now of very great importance. The French, the Italians, and the people of other portions of Europe where silk is grown to a great extent, as well as India, send to Australia now for their seed, which is called "grain." That grain is sent from Australian ports to the proper places, the steamers being fitted for the transportation of it as in China and Japan, and the value of one cargo will frequently be as high as £150,000 to £300,000 sterling. These cargoes are made up simply of the eggs of the worm. From the fact that the mulberry tree flourishes here, and that the leaf contains precisely the constituents that are best adapted for the production of the largest amount of silk and the health of the worm, I think the industry will be established here to advantage. Further than that, the peculiarly dry atmosphere we have here, the electrical conditions of the atmosphere, and the season which can be made so long by a succession of hatches, would make the profits of the industry very much larger than I am informed they are in California.

I also wish to add that not only in the valley of this Santa Fé River, but in all portions of this Territory, the northern half of which I know very well, storage reservoirs can be made in natural depressions with very small expense. In the interior of Australia, 500 miles from the coast, I have known of sheep stations, intended to carry only five hundred sheep, which, by diverting the water, carried fifty thousand head of sheep within three years. Away from the rivers the waters should be carried in some way so as to prevent them from going along either through the deep cañons or the arroyos, which are simply ravines. The water should be diverted from them and retained in those natural reservoirs, and that could be done at a slight expense. I think there is no locality adjacent to the mountains where any very large expenditure need be contemplated to put an enormous area of land under cultivation.

STATEMENT OF FRANK SPRINGER.

The **Chairman.** You have heard the examination here. Please state your views with regard to irrigation, and your own experience also.

Mr. **Springer.** I have lived for about sixteen years in the northern part of this Territory. The condition of the part of the Territory that I am best acquainted with is very much such as Mr. Catron described as applying to land on either side of the mountain ranges bordering on the Rio Grande. There are a number of streams flowing to the eastward, none of which are very large, but which flow out at a very rapid rate, but the fall of these streams after leaving the foot-hills is on an average about 40 feet to the mile. In the mountain region it is considerably greater. I should say that the principal of the streams in the locality I speak of is about 12 to 15 feet wide, and during the winter season the flow, at an average, from 1½ to 2 feet of water.

The **Chairman.** In depth?

Mr. SPRINGER. In depth; the velocity which would be indicated by the fall I have stated. During the early spring, when the snows begin to melt, and from that on to about the 1st of June, the flowage of the water in those streams is very much increased, so that they oftentimes run five or six weeks at a time at a depth which makes it impossible to cross them except on bridges; 3, 4, or 5 feet deep. Sometimes they overflow their banks and fill the whole valley. I have several times seen one of these small streams in Colfax County, where I formerly resided, 200 or 300 feet wide, running for a week or two. That water, for nine months in the year, is lost.

I presume all of the irrigating is done during the months of June, July, and August; very little is done before that. Occasionally the farmers irrigate the land before plowing it, in order to make it plow the easier; but the great bulk of irrigation is done during these months. The first two of those months are those in which the streams are usually lost. Our rainy season, in the latter part of July and August, frequently produces a large flow of water at that time.

The subject of storage has been very much considered in our part of the Territory, and storage will be undertaken to some extent by private enterprise. I can give, if the committee desire it, some facts with regard to some private enterprises in Colfax County, of somewhat considerable dimensions.

The CHAIRMAN. You may proceed.

Mr. SPRINGER. Those I speak of are upon private property—upon the Maxwell grant, which is a large body of land held in private ownership. During the past year there have been two large irrigating systems put in operation. One of them is from a stream called the Vermejo. From that a ditch 20 feet wide at the bottom has been taken out, running about a distance of 20 miles. The smaller laterals, of course, make the mileage considerably more. This water is carried into a series of natural basins which happen to be so favorably situated as to render it practicable to store in them a great quantity of water without artificial means, except to lead the water into them. There are five or six of those lakes. That system of ditches, with the aid of reservoirs, brings under cultivation about 30,000 acres of land. Thirty thousand is now considered as directly belonging to the system, but with the addition of some similar lakes in that vicinity it is expected to very considerably increase it.

Another irrigation system is taken out from the Cimarron River in the same county by a ditch a little larger—24 feet at the bottom. In that they have made one very large reservoir by re-enforcing the bank at the lower end, adding to the natural bank an artificial one of dirt of about 25 feet height. That system will irrigate about 30,000 acres of land. Besides that there are some smaller enterprises. Those are the two principal ones, whose lands are to be put on market. Those lands are sold at about $15 an acre, including a perpetual water right.

The CHAIRMAN. Do they give any time?

Mr. SPRINGER. Yes; the time is usually ten annual payments at 7 per cent. interest. They get one payment down and have all the payments completed in ten years. The title does not pass until the payments are completed.

We estimate the duty of water, based principally on the experience of Colorado, at a very conservative rate, as we think, about 50 acres for each cubic foot per second.

The CHAIRMAN. That is, a miner's inch to the acre?

Mr. SPRINGER. Yes, I believe that amounts to the same thing.

The **Chairman**. One-fifth of a cubic foot per second is, I believe, the miner's inch.

Mr. **Springer**. I believe so. We think that when a particular district has been irrigated for a number of years water will go farther than before. That seems to have been the experience of those who have been irrigating for five or ten years. As to the crop raised there, all of the crops that grow in the northern part of the temperate zone do well there, and some of our farmers have even been raising pretty good corn crops during the last four or five years, getting a good, quick variety of corn. I know one gentleman who raised 71 bushels to the acre last year on 25 acres of corn. Barley has been grown considerably there this year, in addition to the other small grains that have been mentioned. They are also finding that many fruits grow there very well. Some very fine apple orchards can be seen there now. Of course, as in all new countries, fruit always comes last. There is one gentleman who for ten years has been engaged in creating a very large orchard. That, however, is down in the cañon of Red River, about 1,000 feet below the general level of the country. He raises, I think, everything that can be grown in the temperate zone.

The **Chairman**. Does the Red River run through this country?

Mr. **Springer**. Yes; it heads in the valley I have been speaking of, in Colfax County.

The **Chairman**. Are they irrigating much on the Red River?

Mr. **Springer**. No; there is not much, in this Territory, because the water very soon passes into a deep cañon. They irrigate little patches of ground in the cañon.

The **Chairman**. When it gets below the cañon it can be taken out?

Mr. **Springer**. Yes, but that is pretty well out of the Territory.

The **Chairman**. Where would that carry you?

Mr. **Springer**. That would carry us down by Fort Bascom, that is, on Red River. The Red River runs east of Las Vegas and into the Pan Handle of Texas.

The **Chairman**. Where does it go then?

Mr. **Springer**. It runs down through the northern part of Texas and adjoins the Arkansas.

The **Chairman**. Does the country down below require irrigation? Are you familiar with that part of the country?

Mr. **Springer**. I am not very familiar with that part. The country slopes off very rapidly. I suppose the same principles apply there as in the Rio Grande Valley. I might add on the subject immediately in hand that at the headwaters of almost all those streams originating in the mountains there are ancient lake beds which formed the original source of the streams undoubtedly. The streams break through the mountains in narrow cañons. There are many of those places where a dam 100 feet wide would perhaps create a lake of the average diameter of a mile, with a depth of 50 to 100 feet at the lower end and gradually becoming less. Such as that can, I think, be found at the head of all those streams, and very often in the tributaries of the streams. Those are pretty well up in the mountains, where the water is not so hot, and where it is supposed that the evaporation is considerably less, though we have no statistics on that point.

The **Chairman**. Would the suitable places for reservoirs in your locality be on public or on private land?

Mr. **Springer**. In the locality that I have been speaking of, in Colfax County, they would be mostly on private lands. In the counties on the eastern slope of the mountain range there are many such places on public land.

Mr. Catron. The majority would be on public land.

Mr. Springer. I think so; I think on that side of the mountain the majority would be.

Mr. Catron. On this side they would almost all be on public land.

Senator Reagan. What is the volume of water in the Pecos River? What is the size of the stream that enters Texas?

Mr. Springer. That I can not tell you.

Senator Reagan. I thought you described irrigated land on the Pecos.

Mr. Springer. No, not on the Pecos, but from streams farther north; though there are gentlemen here from that county who can give you a great deal of information.

Senator Reagan. What is the volume of the Canadian River where it enters Texas?

Mr. Springer. That I can not tell except from an estimate. That stream is formed from five streams that I think would average 12 to 15 feet in width, and in the winter season, in ordinary times, 1 to 5 feet in depth.

Senator Reagan. You are not familiar with the Canadian River down near the "Pan Handle?"

Mr. Springer. I am not.

STATEMENT OF CHARLES H. GILDERSLEEVE.

The **Chairman.** Have you given some attention to the subject of irrigation?

Mr. Gildersleeve. Yes. For the last two years I have given considerable attention to that subject in New Mexico and the promotion of irrigation enterprises among Eastern capitalists.

The **Chairman.** Please state what you know on that subject.

Mr. Gildersleeve. I have lived here about fifteen years. A little over two years ago the legislature of New Mexico passed some laws that were very favorable to the encouragement of investment by capitalists in irrigation, in storage reservoirs, and similar enterprises. With other gentlemen in New Mexico, I organized several irrigation companies and spent considerable of my time East in promoting them and endeavoring to encourage the investment of Eastern capital in those enterprises. I have encountered a good deal of trouble in that matter. I find in the first place that there is much ignorance among Eastern people on the subject of irrigation.

The **Chairman.** Is that ignorance confined to the people of the East?

Mr. Gildersleeve. Hardly; but I think there is more ignorance in the East about it than in the West. The only people before whom I have laid enterprises of that kind are Eastern people—those of New York, Boston, Philadelphia, and Hartford. I find they are very ignorant on the subject of irrigation and they have very little knowledge not only of our conditions but of the capability of production of our soil.

The **Chairman.** There is no doubt about that. What can you tell us about the soil of New Mexico?

Mr. Gildersleeve. The soil here, when it has a system of irrigation that will insure a good supply of water, each year, will produce from two to three, and sometimes five times, as much as the soil of the East, that depends entirely on rain fall. The distribution of plenty of literature among our Eastern friends might educate them on this subject. I want to make another statement here affecting legislation, which may be influenced by your report regarding New Mexico. Our conditions are somewhat different from those of any other Territory, and probably from those of all the States. Many of the sources of water supply in New Mexico, and particularly large bodies of land lying contiguous to the large rivers that are suitable for irrigation and colonization, are held by private owners in large Spanish and Mexican grants. From my long experience with those owners, I know that they are very favorably disposed to assist in any effort that will look towards the irrigation of their land or of lands contiguous to theirs that are held by the Government.

In one notable case with which I was connected, the owners of the lands which were adjoining the source of water supply and the river bottoms offered to donate one-half of all their land grants, aggregating 500,000 acres, to an irrigation company, as a subsidy to encourage them to build their irrigating canals and storage reservoirs, but owing to some unfortunate legislation of Congress in the anti-alien act, a corporation was precluded from owning over 5,000 acres of land, and as the area which those people intended to grant exceeded 5,000 acres, and amounted, in fact, to several hundred thousand acres, the company was unable to avail itself of that very generous offer. The company could not take a fee to the land, and could not mortgage it to a trust company or bank, because they were corporations. So we were placed in a very embarrassing attitude, and are yet. Unless Congress will make some legislation to enable these owners to put the land in the hands of companies, or to construct storage reservoirs or mortgage the land, we are in a very unfortunate plight.

I wish to say something with reference to some experience I have had in regard to the Santa Fé River. At the instance of some eastern capitalists, I caused a survey to be made of the river for the establishment of storage reservoirs about 1½ miles east, to ascertain the approximate amount of public or Government land that could be irrigated from the Santa Fé River, and by these storage reservoirs. The report of the engineer was that a reservoir could be established near the city at an expense of $250,000 which would store sufficient water to irrigate between 100,000 and 150,000 acres of land lying from 50 to 300 feet below the bottom of the reservoir. The matter was laid before the eastern investors and they were loath to invest their money and rely solely upon their investment for an income from sales of water rights. They seemed to think that in view of the fact that the Government lands which were now being sold at $1.25 would be worth from $5 to $10 an acre, the Government ought in some way to assist them by donations of land. But, as no encouragement to that end can be offered, they have declined to go on with the storage system or reservoir.

The CHAIRMAN. You appear to have been studying the land question. What would the difficulty be in constructing hydraulic works that would irrigate 100,000 acres of land? Nobody could take that land but homestead settlers. What difficulty would there be in your selling the water to them?

Mr. GILDERSLEEVE. There would be none; but the difficulty is to encourage eastern investors to do the work. They say it is a new thing and a little uncertain.

The CHAIRMAN. What does the company want of the land if the Government is willing to give it to those who go on and buy the water?

Mr. GILDERSLEEVE. As an additional incentive to encourage investment.

The CHAIRMAN. When they have the water, that is pretty much all there is of it?

Mr. GILDERSLEEVE. Yes; there is more land than water, and I am frank to say that I have endeavored to persuade those people that an investment in water lands would yield a handsome income.

The CHAIRMAN. I think they will be convinced after a little while. I feel certain that an investment in water is the safest investment, providing you sell it to the homestead settlers outright, giving them time in which to make their payments; not getting all the money on the first making of the contract, and not attempting to levy contributions perpetually on the settlers. In the first place it would be very difficult to get settlers to take hold of it, if there should be a perpetual tax on them to pay it. They would prefer to own the water-works as a community and take care of them themselves.

Tell us what you have observed with regard to the sources of water supply.

Mr. GILDERSLEEVE. The period of largest water supply in the Santa Fé River is during the months of March, April, and May. The larger part of the water falling during those months, I might say almost the entire quantity, goes to waste. This water, from my examination, by a system of storage reservoirs along the line of the stream immediately north or east of the city of Santa Fé, could all be preserved and then used during the irrigating season of May, June, July, and August, for the irrigation of from 100,000 to 150,000 acres of Government land lying immediately contiguous and to the south and west of the city. I have caused some examination to be made (in connection with organizations with which I am identified) of the Rio Grande River from Espanola to El Paso.

The CHAIRMAN. What distance is that?

Mr. GILDERSLEEVE. About 400 miles. My investigation was prosecuted among the oldest Mexican and American inhabitants living along the line of the river, who were familiar with the volume of water running in the river. They informed me that the months of March, April, and May formed the season of high water in the river. The volume of water at that season is so great that it often threatens to wash out towns and cities lying below Peña Blanca. To my personal knowledge, the cities of Albuquerque, Socorro, San Marcial, and other towns lying on both sides of the river have at various times been threatened with inundations, and have occasioned the inhabitants great apprehension and expense to preserve their towns. They all unite in saying that it would be a great blessing to them if, in that season of the year, the water could be diverted from the main channel of the river and held in storage reservoirs conveniently located on both sides of the river, which should then be utilized during the proper season for irrigation purposes. As far as I know, that is the universal sentiment of the people living along the Rio Grande Valley. I estimate that there are forty thousand people living along that valley that require water for agricultural purposes, stock raising, and other industrial pursuits, and that ten times as much land lying on both sides of the river could be irrigated by a competent modern system of irrigation from storage reservoirs which could be filled during the season of high water in the river.

The CHAIRMAN. How much would that amount to.

Mr. GILDERSLEEVE. It would amount to about 4,000,000 acres, approximately. Do you wish to know how much of this land would be Government land and how much private land?

The CHAIRMAN. If you have an idea give it to us.

Mr. **Gildersleeve.** I have made an approximation that one-third of the land would be Government land and that would be irrigated along the Rio Grande River.

Mr. **William L. Rynerson.** If one-third were public land, the balance would be private land. I would like to ask Mr. Gildersleeve to state that a great portion of this land that is called private land consists of community grants or a species of public land.

Mr. **Gildersleeve.** Yes; I will state that the greater portion of the other two-thirds is covered by either private or community lands or grants to the Atlantic and Pacific Railroad by the Government.

STATEMENT OF WILLIAM B. SLOAN.

The **Chairman.** Have you given any attention to the amount of land under cultivation in this Territory by irrigation?

Mr. **Sloan.** I have.

The **Chairman.** How did you obtain that information?

Mr. **Sloan.** As superintendent of the semi-decennial census of 1885, and by personal observation traveling through the Territory.

The **Chairman.** Please state how much it is.

Mr. **Sloan.** The amount of the lands under cultivation in 1880 was 5,053 farms, with an acreage of 237,392 acres which was improved. The valuation was $5,514,399. The farming implements at that time were valued at $255,162. The live stock at that time was worth $5,010,800. The value of all farming productions at that time was $1,897,771. In 1885 there were 10,511 farms, a gain of 5,458, with a value of farming implements amounting to $1,595,370. The value of the farm products was $2,914,984, an increase of $1,016,910. That was on the farm products alone. If you want the acreage of the Territory, I can give you that.

The **Chairman.** Give us the acreage that is under cultivation by irrigation.

Mr. **Sloan.** The total land acreage of the Territory is 78,374,400 and the area for pasturage is 63,374,400 acres. Unoccupied pasturage amounted to 12,874,000. Public lands, subject to irrigation, amounted to 13,965,000 acres.

The **Chairman.** That could be irrigated?

Mr. **Sloan.** That could be irrigated.

The **Chairman.** Of private land that can be irrigated, how much is that?

Mr. **Sloan.** I do not separate them.

The **Chairman.** Would there be as much public land as private land?

Mr. **Sloan.** No, there is more public land in the Territory than private lands.

The **Chairman.** That is, more of public land that can be irrigated than private land that can be irrigated?

Mr. **Sloan.** Yes. The Gila, the Palomas, the Rio Grande, the Pecos, the Red River, and their tributaries, all have their natural flow to the south, the southeast, and southwest. Their valleys, etc., all embrace a large area of public land. Immediately adjacent to the mountains there is quite a quantity of land, what we term bench land, that is subject to cultivation without irrigation. Passing from that—the foothills—down into the valleys below, that are susceptible of irrigation, there are large bodies of public land to be found throughout the territory. In Taos

County there are some very fine lands on streams that are tributary to the Rio Grande, that by the construction of proper reservoirs could be made to hold water to be let into the Rio Grande at the proper time. The flood of the Rio Grande is so great that if the water was held at the proper time it could be carried a long way off. The Pecos River, likewise, holds a good quantity of water. Altogether, we have thirty-one streams in the Territory that at proper seasons of the year contain more or less water. The main streams are those larger ones I have mentioned, while the others are tributaries; but in the spring season, after the snows begin to melt, there are large bodies of water, all of which could be husbanded and saved for the purpose of irrigation in the vicinity of those lands I have mentioned.

STATEMENT OF WILLIAM G. RITCH.

The CHAIRMAN. What is your occupation?

Mr. RITCH. I have been secretary of the Territory during the last twelve years, and during that time I acted as governor for about two years and a half.

The CHAIRMAN. You have heard the examination here. Please state to the committee anything additional which may be of interest to us regarding irrigation in this territory.

Mr. RITCH. I have heard something of the examination this afternoon, but I was not here this morning.

The CHAIRMAN. We shall be glad to have any statement you desire to make.

Mr. RITCH. My statement would be more general than specific perhaps. I will say that my means of information have been more especially in connection with the Bureau of Immigration, with which I was associated in various capacities for seven or eight years.

As to the sources of water supply, they are mainly in the central and northern portions of the Territory from the mountains, and depend very greatly upon the quantity of snow that falls in the winter. Of course, we have the rainy seasons, but the water usually runs off rapidly, and we have the benefit of only a small proportion, relatively, of the quantity that falls. It is very manifest to me that in order to have the full benefit of the precipitation, storage reservoirs are an absolute necessity. The present system of irrigation is manifestly a very wasteful one. With a proper saving of the water, I have no doubt but what anywhere from fifteen to twenty times (probably more) land could be brought into use than is now under cultivation. If the water was stored and taken out in pipes the increased quantity of land that could be brought under cultivation would be almost indefinite; I should say, possibly, an increase of forty or fifty times; that is, saving all the water and utilizing it to the best possible extent. The soakage of the water is very great at the best when it is taken out in open ditches. Our soil, I think, is unexceptionable.

The CHAIRMAN. Are the crops good?

Mr. RITCH. The crops are good wherever you can get water on the land.

The CHAIRMAN. You have been looking at this question with a view of bringing emigrants upon the land. Suppose the country were accurately surveyed, and the places for reservoirs located, showing that the land could be covered by certain water designated, and if the expense of the work were estimated by the Government engineers, would you then be able to get colonists to take up some of the land?

Mr. RITCH. Certainly; and I think there would be no trouble in that direction. Enterprises of that kind have gone on before in other places, and I think we shall have no trouble in having them taken up here in New Mexico.

I reside in the southern portion of the Jornado del Muerto, and I am quite familiar with that portion of the country. In Socorro County, and counties adjoining that, I think more than one-half the land is Government land, which is good soil, and can be reached through reservoirs where the water has been brought from the Rio Grande. Of course surface water could be utilized. There are cañons in the mountains where natural reservoirs could be made. There are also depressions in the Jornado, where large quantities of water could be stored at little expense.

In regard to the fruits that can be produced in this Territory, I think it is one of the finest fruit-growing countries in the United States. As to the fruits produced here at Santa Fé and in the Rio Grande Valley, you find no better. There has been sufficient experiment in that direction by amateurs.

The CHAIRMAN. Do you get a crop nearly every year?

RITCH. Nearly every year. I think we are a little peculiar in that respect. We seldom have a frost; and while the crop may be a failure in one locality, it is generally very good; certainly away above a half or three-quarters of the crop of what may be termed a good year. Our soil is susceptible of growing all the crops adapted to the temperate zone.

The CHAIRMAN. How do the crops here, in quantity and quality, compare with the crops raised where people rely on rainfall?

Mr. RITCH. I think where we have a certainty of irrigation we can produce crops in very much greater quantity. There is one advantage in connection with irrigation—that we need little or no fertilizers, because, coming down with the water, in solution, are natural fertilizers, and no artificial fertilizers are required.

The CHAIRMAN. Has there been an experiment here of cultivating the land for a long time?

Mr. RITCH. Yes; for two hundred years or more.

The CHAIRMAN. Does that land produce as good crops as it ever did?

Mr. RITCH. That is its general reputation. It is understood that it rather improves in the valleys.

The CHAIRMAN. Do the Mexicans manure their land—put fertilizers on it?

Mr. RITCH. I do not understand that they do. There may be exceptional cases, but I know of none. They depend on irrigation to fertilize the soil as well as to moisten it.

STATEMENT OF HENRY F. GRIERSON.

The CHAIRMAN. What is your occupation?

Mr. GRIERSON. I am foreign immigration agent of the Santa Fé Railroad.

The CHAIRMAN. Please give us such information as you may have in regard to irrigation in this Territory.

Mr. GRIERSON. The information I can give is largely the result of what I hear from people that we bring in here. The universal opinion of the farmers that have come from foreign countries where they have had to depend upon rainfull is, that they would not, under any consideration, go back to the old method of depending upon that source for watering their crops. They find that irrigation is much more satisfactory, as they can give the crops what water they require and at the right time, just so much and no more. The crops raised under irrigation are very much heavier than the crop raised under rainfall. For instance as to alfalfa; in Kansas they would consider themselves very lucky if they got 2 tons to the acre each year, where they depend upon rainfall; here 5 or 6 tons is a very conservative estimate of the crop. The trouble we have had so far is not in getting people to come here, but in getting suitable locations for them. Wherever we can find land with good water facilities, at reasonable prices, we have no difficulty at all in colonizing it.

Take the Maxwell grant, for instance, of which Mr. Springer spoke a few minutes ago. It was only quite lately—a few months ago—that they put that land on the market. They sell it on long time payments, with light interest. Forty thousand acres that they have under ditch will, I think, be sold by next year to small farmers and be brought under actual cultivation. On the 15th of last April I was there, and there was not a spear of any product then growing, except the natural grass. I went there two weeks ago again, and one farmer, on 1,200 acres, had as good a crop as any 1,200-acre farm in the world, comprising alfalfa, oats, barley, and vegetables, beside other crops, and hundreds of fruit-trees thriving. It may interest you to know that that land was previously worth probably $2 or $2.50 an acre for grazing cottle and would not now be worth that because of the present low rates for cattle. They have increased that land in value from $3 to $12 or $15 an acre.

When the Australian commission was here a few years ago, whose report I read in the Government book prepared by Mr. Richard J. Hinton, they said that land out West was plentiful but of little value; that the value here was in the water. That of course is very manifest. I have probably brought in more settlers for the past few years than anybody in the Territory, and they are all satisfied. Last spring several French wine growers came here by my invitation to look into wine possibilities in this field. They have been importing a half a million dollars worth of wine from Louisiana to cross with French wines. They do not like the mixture very well. The California wines they liked less, the amount of alcohol in it not being sufficient to make it a good carrying wine. They say it is their intention, if the Government or any other corporation would put any large body of land under cultivation, to bring a large number of men here for the growth of grapes and the making of wine for exportation to France.

People from France have also been looking at this Territory with a view of observing how it would suit for silk culture. The conditions of electricity and other features which they do not understand make this one of the best places for silk culture in the world. Some French gentlemen are to be here in a few days who will determine its possibility as to that.

They tell me that they have tested the grapes grown, and analyzed the wine made in the Rio Grande Valley, and find that the percentage of sugar is large. The soil here has a constituent such as it has near Naples—a mixture of volcanic ash, which seems to have the effect of enriching the grape very much.

As to the question of soil being impoverished by constant cultivation without fertilization, there is no doubt whatever that irrigation fertilizes land very considerably, on the Rio Grande Valley at least; I can not answer for other places. In the Rio Grande Valley you can take what seems to be dead white sand, irrigate it for a year or two, and it will grow beautiful crops. Every year it is observed that the growth of the plant is aided by the addition of alluvial deposits from the water, as is the case in Egypt, South Africa, and India.

The **Chairman**. Have you been through India?

Mr. **Grierson**. Part of India. I know South Africa quite well so far as irrigation there is concerned.

The **Chairman**. How does India compare with this country as to irrigation?

Mr. **Grierson**. This is a very rich country, very much like South Africa. They do there very much as we do—raise two crops a year. In the winter they irrigate their growing wheat.

The **Chairman**. If this is a richer country than India, how do you account for their supporting 250,000,000 of people on 800,000 acres of land?

Mr. **Grierson**. It is accounted for by intense cultivation and the fact that they can live on very little—a little rice makes a very good meal for the Hindoo. They do not want fine foods or woolen clothes.

The **Chairman**. We have over 1,300,000 square miles of arid lands.

Mr. **Grierson**. Irrigated land will without doubt support a very much larger population in any portion of the world than land which depends upon rain-fall.

There is another point which these French people feel confident of, that is, that in New Mexico there is a very superior capability for raisin growing—a capability such as no country in the world has. The percentage of moisture or humidity in the southern portion is about 29 per cent. by weight, which is very low. You can dry your grapes in your own vineyard. In California and other places they have to ship their grapes away from their vineyards in order to dry them, and then they have to bring them back.

The **Chairman**. Similar conditions of climate exist in Arizona, do they not?

Mr. **Grierson**. Perhaps so, though I can hardly state that to be a fact of my own knowledge. It may interest you also to know that a French commissioner was here in the spring for another purpose. He had been looking all over the world for a sanitarium for French consumptives. He was the agent of a society of rich people. They have been examining all parts of the world, and they report that New Mexico is about the best place in the world for the cure of consumption. The Mexican Government have offered them a donation of 10,000 acres of Government land. The gentlemen who have examined both countries say that New Mexico is their choice.

STATEMENT OF E. S. STOVER, OF ALBUQUERQUE.

The **Chairman**. How long have you resided in New Mexico?

Mr. **Stover**. Thirteen years.

The **Chairman**. You have heard what has been stated here. If you can add anything that will be of service to the committee, we will be glad to hear it.

Mr. **Stover**. I should like to re-enforce what has been said by Judge Bristol, that it is not a question of land but of water. As has been stated, in Bernalillo County, at Albuquerque and the town of Bernalillo, 20 miles this side, it is a very rare thing for us not to have water for the land we are cultivating. I suppose that not over 15 to 20 per cent. of the river bottom is cultivated. At the present time I think we have nearly all the water that is required for the land that is being cultivated. There apparently lies also under Albuquerque a large basin of water. For instance, while we have had no rains this year so far, except a very few little showers, at any point on my place within 2 miles of Albuquerque I can strike standing water at 2½ feet. In fact, I have a fish-pond on my place which was got by simply taking a plow and scraper and scraping it out. There is nothing, in fact, but water from below—subirrigation.

I desire to say also that in the Rio Grande Valley we raise good crops by subirrigation; that is, forage crops, not good crops for corn or wheat or even grapes, but forage crops. There lie on each side of the river what are called mesa lands. I should say that in the counties of Bernalillo, Valencia, and Socorro, nearly a million of acres on each side of the river is not irrigated at all, although it is most excellent land if they had the water with which to irrigate with. It can not be irrigated with the systems we have now. With other gentlemen I had a survey made on the east side of the river several years ago by a competent engineer, and his report was that he did not think it was practical to come up the river far enough this way for private capital to take out a ditch from the Rio Grande to irrigate this large mesa or tableland which lies east of Albuquerque, but recommended the reservoir systems. Of course, he said it could be done, but the expenditure would be so large that no private capitalist could be induced to take hold of it. I understand that is largely so on the west side of the river also. If the report of the engineer would be of any use to you I will furnish you a copy of it.

The CHAIRMAN. We should like to have the copy.

Mr. STOVER. I will furnish it. It will give many figures in regard to the matter.* My opinion is that if irrigating or diverting the water from the main stream diminishes the amount of water in the stream, by the time we irrigate what lands we have in Bernalillo County our friends down below in Socorro County will not have any water at all. Having taking some interest in that matter and inquired into it, my opinion would be that the way to solve this matter would be to keep this vast amount of water above us in the Rio Grande Valley.

The CHAIRMAN. You think a system of reservoirs would answer the purpose?

Mr. STOVER. From my experience and from the information I have had from competent engineers, I am convinced that this system of holding the waters back in the mountains is the proper system.

STATEMENT OF ALBERT J. FOUNTAIN, OF LAS CRUCES.

The CHAIRMAN. How long have you resided in Las Cruces?

Mr. FOUNTAIN, I have resided in the Mesilla Valley for twenty-seven years.

The CHAIRMAN. Tell us what you know of irrigation here?

Mr. FOUNTAIN. I have for some years made a study of this subject. I foresaw years ago that we would experience the difficulty we now encounter. I speak specially now of what is known as the Mesilla Valley and the great table or mesa land adjoining it. In the Mesilla Valley we have in the river bottom about 130,000 acres of land, of alluvial deposit, through which the Rio Grande meanders. About 30 per cent. of this land is under cultivation, producing the finest of all kinds of crops —wheat, corn, on the same land each year by irrigation only. The floods come down in the spring, spreading out to places in our valley for a mile and a half in width, running probably six weeks to two months, and during that time a sufficient body of water flows by us, going west, to the ocean, to irrigate millions of acres of land lying on the table lands or mesa on each side of us, all of it being Government land, very little of it at this time being appropriated. Above us on the valley of the Rio Grande are a number of deep cañons and streams, such as the Perches, the Animas, the Palamas, the Cuchillo Negra. They drain the Rocky Mountain range. When those streams come down they add to the flood which comes from the northern part of the Territory.

---

* Report was not received

These great cañons afford probably the best opportunity of a reservoir system, with little expense, that can be found anywhere—especially the Perches, through which a great quantity of water flows down during the year. There are the best of facilities in the Perches cañon for holding water, below Hillsboro, and so of all the other streams I have mentioned. If a storage system could be established by which this water might be saved it could be taken out on this mesa land, especially on the Jornada del Muerto on the east of the river, a tract of about 90 miles in length, averaging about 30 miles in width. I am very familiar with that section. A very large portion of that country could be reclaimed. There are great facilities for storage of water on the Jornada del Muerto. At times great streams rush across it. I remember on one occasion I was water-bound for several hours by a torrent of water probably 6 or 8 feet in depth, and several feet in width, rushing across the Jornada del Muerto. I was stationed there while in the military service in 1863 and 1864 at Fort McCrea, and I made a note at that time of the water fall and kept a note also of the amount of the water that passed from the Jornada del Muerto through the Fort McCrea cañon. On the west bank of the Rio Grande, that is, on the mesa lands, say from Deming south, and the country between Deming and the Rio Grande, is a vast tract of very level country, unappropriated, which could be brought under cultivation if water could be put upon it. I believe that could be done by storage of water in the north.

It is my opinion, derived from actual observation, and from a study of the question, as well as from inquiry of engineers and those who profess to be familiar with the subject, that from 8,000,000 to 10,000,000 acres of Government land now unappropriated, could be put under irrigation and reclaimed if we could save by storage this water which runs off to waste every year. The engineers tell me they will experience no very great engineering difficulties in doing that. There is no doubt that lands on the mesa, if put under irrigation, could be made quite as valuable as those on the river bottom. An acre of unimproved land in the Mesilla Valley is worth now from $25 to $30, with water facilities. If they could put in alfalfa it would produce from $50 to $60 per year. Alfalfa is an unfailing crop, with water. Or if put in vines the acre of land will produce $250 per year. The vines are an unfailing crop. If put in fruits it will bring something less than that, or about that. The apple crop seldom fails. The peach crop frequently fails, however.

I have experimented largely and for many years with small fruits and vegetables. I have laid out a small piece of land 40 feet square, and divided it up into pieces and experimented with it. I find that with full irrigation a double crop can be produced compared with the crop that can be produced with insufficient irrigation. Without irrigation nothing can be produced. In addition to what has been stated by other gentlemen from this section, we can grow rice and tobacco. Experimentation with cotton has shown that it can be produced not only on the river bottoms but on the mesa. Adjacent to the valley of the Mesilla, about 15 miles to the east, is a range of mountains known as the Organ Mountains, cut up into cañons. Torrents of water flow from the mountain to the river in the rainy season. Sometimes they flow down through our town, threatening instant destruction. We have been compelled to erect a dam in order to protect our town. There are the best of facilities for preserving that water. A storage system there would, in my opinion, furnish water enough to fill a large canal which would supply the necessities of the valley below it, and El Paso, for several months in the year—not sufficient for the whole year, but as a feeder it would aid considerably in keeping up the water supply of El Paso.

On the subject of fertilization, lands are enriched by irrigation. Lands entirely barren—sand-bars on which nothing would grow—will, if irrigated one year, produce good crops; if irrigated a second and third year the land becomes as good as any land that we have in the valley. At a certain period of the year, when what is known as the Puerco River comes down to our place, a large amount of sedimentary matter is contained in suspension in the water, probably 10 per cent. of it; but that is not for any great period, probably four or five weeks during the year. That enriches our land to such an extent that irrigation with that water from the Puerco River would in itself be more valuable than all the fertilization that would be put upon it excepting with irrigation. It is my opinion, derived from a study of the subject, that if the water be held in reservoirs placed upon those high lands there could be opened to settlement of the public lands in the county of Doña Aña at least 5,000,000 or 6,000,000 acres. On the eastern side of this Organ range there is a broad valley 50 miles in width and 150 miles in length, bounded on the east by the Sacramento Mountains and the White Mountains. At certain periods of the year there flow from those mountains into this valley great quantities of water which evaporate and waste. In that valley many hundreds of thousands of acres of land now unappropriated, valueless for any purpose, even for grazing purposes (for there is no water), could be reclaimed and opened for settlement. The same thing may be said of the adjoining county of Lincoln. The White and Sacramento mountains are in that county and partly in the county of Doña Aña.

To the east of the Sacramento Mountains flows the Pecos River. Artificial irrigation is now being carried on there. Canals are being taken out and large reservoirs are being constructed. But between the Pecos River and the White and Sacramento mountains—a strip of country nearly 60 miles in width—vast quantities of land now unappropriated could be reclaimed by artificial irrigation and by the storage of water.

The **CHAIRMAN**. Then you attach much importance to Government surveys for ascertaining the possibilities of storage, etc.?

Mr. **FOUNTAIN**. I attach the utmost importance to them. It is my opinion, based upon the experience of the last four or five years, that if the Government does not take some such steps the dry belt will keep extending to the north, and will in time dry up the Mesilla Valley, where we have millions of dollars invested in the finest fruit lands in the world. We have made magnificent orchards and vineyards. This year we might have lost them.

The Rio Grande is now absolutely dry, and we lose a fine crop of alfalfa. If it be true that the diversion of water north of us is the cause of the drought, then it will continue; if it be true that the drought is the cause of the light rain-fall of the last few years, then we may hope next year to have an increase of rain-fall and sufficient water for our necessities.

But we are brought face to face with the fact that vast quantities of water are being taken out north of us, as has been said by Governor Stover. Great canal systems are being inaugurated. If that water be diverted from us, as it probably will be, and if the Government affords no remedy by giving us a system of storage supply, we will be ruined.

But, independent of that, we desire, of course, to populate our county. We desire to colonize it. We desire that these vast tracts of land, at present comparatively valueless, should be opened to settlement. I believe that will be done if the Government will establish a system of water storage. Therefore I attribute to the movement on the part of the Government in the matter of surveys for irrigation of the utmost importance, and I think that expresses the view of every citizen of this Territory. Not only will it be of very great advantage to us, but it will tend to settle what may be an international complication. Our people are diverting water to which the people of our neighboring State of Chihuahua, in Mexico, claim to have a vested right.

The CHAIRMAN. We went into that fully yesterday in El Paso.

Mr. FOUNTAIN. A portion of the county of El Paso has been dried up. This storage system will entirely eradicate that evil and will afford relief. I might say much more, but so many gentlemen have gone into the subject fully that I have no need of saying anything further.

FURTHER STATEMENT OF T. B. CATRON.

Mr. CATRON. There was one statement made here which I think is a little inaccurate. Mr. Sloan made a statement that there were thirty-one rivers in this Territory, the water of which might be stored. I have traveled through this Territory for the last twenty-three years, and I am acquainted with nearly every river in the Territory. I can enumerate over one hundred and fifty rivers that have constant water in them, which can be stored. The sources of nearly every one of those rivers is on the public domain, and the places for the storage of water which I would conceive to be proper places for storage, are cheapest and best, most of them on the public land. Very few of them are on private property.

STATEMENT OF W. L. RYNERSON.

The CHAIRMAN. If you know anything in addition to what has been stated, please give the committee the benefit of it.

Mr. RYNERSON. There is one matter in addition to what has been testified to which might be an advantage to the committee.

I have been in this Territory for twenty-seven years. In addition to the testimony to which I have listened I wish to add something in regard to storage reservoirs in the Rio Grande. I do not believe it is practical. I think no matter how high you may build your dam, that in a very short time it will be filled up with sediment, and you will have no way to clean it out. When the Rio Grande is high it carries, much of the time a vast amount of sediment. At certain seasons of the year the water is quite clear.

If reservoirs were constructed out of the bed of the Rio Grande you might run the water into these reservoirs when it is not being used in the valley for irrigating purposes, because there is a certain portion of the year—two or three months—that it is required for irrigation.

For the section of country lying below what is called the Jornade del Muerto, if the water of the Rio Grande was conducted on to that of the Jornada del Muerto, which has been called a desert, and is an extent of country some 75 miles in length and about 25 in width. There are natural depressions all over this Jornada del Muerto that would hold all the water that the Rio Grande would run in a season. That is my opinion. The water then could be conducted from this point down to our Mesilla Valley and also supply Texas, as has been suggested. This is a mere idea of my own.

STATEMENT OF R. N. WHITE, OF SIERRA COUNTY.

The **Chairman**. How long have you lived in this Territory?

Mr. **White**. I have resided in Sierra County, this Territory, about nine years. The Rio Grande runs through it for about 50 miles. The county is almost entirely Government land. I think there is not more than one hundredth part of the county which is not so. There are five rivers running through this county from west to east, having their sources in the Black Range. There are many places which are specially good for damming and preserving the water. There is a range of mountains dividing them, at about one-half their length, and at every place where the rivers break through this range of mountains—the Cuchilla Negra range—dams of not more than from 250 to 500 feet in width would back up waters for a distance of from 1 to 10 miles. Another source of dams could be found south of the Alamosa, the Cuchilla Negra, the Rio Polomas, and the Rio Las Animas, with which to irrigate a strip of country 10 miles in width and 50 miles in length, beside serving as reservoirs for the Mesilla Valley, that valley being a continuation nearly of the valley of the Rio Grande, just running northerly and southerly.

The county of Doña Aña raises all the vegetables and almost all the fruits. The altitude is about from 3,800 feet to 6,000 feet. There has been a dam on one of those streams, built by private parties, which illustrated the feasibility of penning the waters. That dam was on the Rio Perches, and dammed up the water for about a mile in length for the entire length of the valley. It was neglected and washed away. The sediment is not a drawback at all. It has not been so found there.

I am acquainted with other parts of the Territory and can confirm the statements that have been made by the other gentlemen here.

Mr. **Catron**. What proportion of your county could be reclaimed or cultivated if there was water stored there in your various streams—of the total amount of acres in the valley, what percentage?

Mr. **White**. Fifty per cent. The Jornado del Muerto is part of the county. Of the Rio Grande Valley there are more than 600 square miles which can be irrigated.

The **Chairman**. More than 50 per cent. of the whole can be reclaimed?

Mr. **White**. Yes; I think so.

Mr. **Stover**. I think that is true all over the Territory.

STATEMENT OF M. S. OTERO, OF BERNALILLO COUNTY.

The CHAIRMAN. The committee will be glad to hear any statement you wish to make in regard to farming in this country.

Mr. OTERO. I am a very poor farmer, but have observed a little about the great lack of water in the country and the disadvantage at which the people are placed on account of it. I think that if the Government would help us a little we could in our county alone have enough farming land for double the number of people that are in the county, and it is one of the largest counties on either side of the river. I think that by building a dam probably up above Peña Blanca on the Rio Grande, the water could be taken up on the mesa east of Albuquerque, which is a stretch of land about 25 miles in length and 12 in width, very good land. There is enough water in the Rio Grande to store reservoirs on the mesa or prairie, if the water could be raised. The whole of it could then be reclaimed.

Then you come to the Jaemos range, or the Tejaemos, as it is called in the survey. That section of country has some streams. We have some beautiful streams there at the tops of the mountains. There are five or six places that, with very little cost, would enable us to have an immense storage of water by piping that water or fluming it on top of the mesa. Between the Puerco and the Rio Grande there is another mesa of about 15 to 20 miles wide, and probably 25 miles long, or 30, as far as Albuquerque. It runs clear on through to the Rio Puerco as far as 50 miles probably. I am satisfied that if that river could be brought up on top of the mesa we would have 300,000 or 400,000 acres of land that could be irrigated and made to produce. To-day it is going to waste, and the same thing can be said of the Rio Puerco range.

On the Rio Puerco there is an abundance of good, tillable land, but we have not the means to store the water. There are three or four months of the year that big volumes of water run down without any way of saving it. The crops this year on the Rio Puerco have been very good. The corn is as good as you can raise anywhere in the country, but the wheat was a failure on account of the lack of water. The people could not save the water or take it out of the Rio Puerco; it came in such volumes as to carry away the little dams, and they lost their wheat crop. The corn crop was very good. On the west side of these same mountains, and on the the range of the San Juan mountains, the same thing could be said. There is an immense territory there, of which, with proper reservoirs, all the land could be saved.

The CHAIRMAN. Then you think an engineer's survey and estimate of cost would be valuable?

Mr. OTERO. They would indeed. We do not suffer in our county for the want of water, but with more water we could make that county a big country—a very paradise.

Mr. RYNERSON. If these storage reservoirs were made and the water was conducted on the land you spoke of, would it not injure your sheep ranges?

Mr. OTERO. No; I do not think it would. We do not range our sheep there. We would like to have that land on the west of the river very much.

The CHAIRMAN. You can go farther back with your sheep when you get the water?

Mr. OTERO. Yes.

Mr. CATRON. There are some things more valuable than sheep ranges.

Mr. STOVER. Are you familiar with northwestern New Mexico?

Mr. OTERO. Not very much. There is a beautiful spot at El Rato. There is much level and beautiful country there if water could be got on it. I do not think that a reservoir would be very costly. I am more interested in the Tejaemos Mountains, and I think Major Powell will agree with me that it is a great country. That country would irrigate the western part of our county, which will make a Territory of itself.

STATEMENT OF L. S. TRIMBLE, OF ALBUQUERQUE.

The CHAIRMAN. How long have you resided in Bernalillo County?

Mr. TRIMBLE. I have lived there about ten years. We have plenty of water, but it comes at the wrong time and gets away from us so that it does not be of any use. If you can invent any means of keeping that water here until we want it, you will have acomplished a great thing. There is enough water to-day flowing out of the Sandia Mountain, 12 miles east of Albuquerque, and that has flowed out of it in the last three months, to irrigate the mesa land east of Albuquerque from Bernalillo to Indian village, a distance of about 38 miles. There was last week a stream of water running out of that cañon with a rush which has become as fine a stream as you would care to look at. When there are rains, there is a perfect torrent rushing out of these cañons.

The CHAIRMAN. Is it not a fact that that is the condition of most of the cañons in the Territory—that there is a rush at the time of high water, and that what you want to do is to keep that water back by dams or by storing it. You first want a survey to show what can be done?

Mr. TRIMBLE. Yes; this water can be kept back out of the mesa in the winter.

The CHAIRMAN. That can be determined by surveyage, if you have the water and the land; the survey is desirable to find out in detail what you can do?

Mr. TRIMBLE. The water is here if it can be utilized.

The CHAIRMAN. And the land is here?

Mr. TRIMBLE. The land is here. If the land that is on the level could be utilized, the crops of New Mexico would be increased sixfold.

Mr. CATRON. Six hundred fold.

Mr. TRIMBLE. The crops of Bernalillo County could be very greatly increased if that single mesa were utilized. There is no question in my mind that if the water could be preserved it would be a great benefit to the country, and it would induce people to take up the land.

STATEMENT OF JAS. K. LIVINGSTONE, OF LAS CRUCES.

The CHAIRMAN. What is your business?

Mr. LIVINGSTONE. I am general agent for the real estate—the lands of the Atchison, Topeka and Santa Fé Railroad in New Mexico.

The CHAIRMAN. Can you add anything in the way of information to what has been said here?

Mr. LIVINGSTONE. I have lived in the Territory for about eight years. I have frequently heard the criticism made that if all the land were brought under cultivation which it is claimed can be irrigated in New

Mexico there would be no market for its produce—that we are too isolated from the other States and Territories, and that being on the Mexican border we would be unable to find a market for our produce. The fact is we have a fine home market. I believe that is a point that has not been touched upon to-day.

Adjourned.

ON THE TRAIN AT LAS CRUCES, N. MEX., *September* 8, 1889.

The committee met pursuant to call of the chairman.

Present, Senators Stewart (chairman) and Reagan; also Director Powell.

STATEMENT OF JOHN B. BOWMAN, LL. D.

The CHAIRMAN. How long have you lived in New Mexico?

Mr. BOWMAN. About seven years; five years of that time at Aleman on the Jornado del Muerto, and here at Las Cruces.

The CHAIRMAN. Are you familiar with the Rio Grande Valley in New Mexico?

Mr. BOWMAN. I am familiar with the central and southern portions, extending from Albuquerque down to the State line of Texas. The entire extent of that valley through New Mexico is about 360 miles. From Albuquerque to the State line it is about 230 miles. A section of that portion in southern New Mexico is known as the Mesilla Valley, and is about 50 miles long, Las Cruces being the chief town. Another section lying north of that is known as the Jornado del Muerto, rising from the river at the town of San Marcial, and widening out into a broad, beautiful valley of a higher level, nearly 100 miles long, and an average width of nearly 40 miles. Another section extends from San Marcial to Albuquerque, the first level being from 3 to 5 miles in width, and extending indefinitely up on to the mesa.

The CHAIRMAN. What are the sources of the water supply of the Rio Grande Valley, and what the annual amount of water for irrigation purposes?

Mr. BOWMAN. The sources of water supply are the Rio Grande, rising in the Rocky Mountains of Colorado, and from tributaries which below Albuquerque flow almost exclusively into it from the west side, and also from the storm-waters which fall generally in the months of July, August, and September, the average annual rain-fall being from 10 to to 12 inches in the valley.

As to the amount of the annual supply of the Rio Grande and its tributaries for irrigation purposes, I have no means of estimating, but if properly saved by dams and by a system of storage reservoirs and canals, I am satisfied that, in connection with the storm-waters gathered from the mountains, the supply would be ample for all the irrigable lands in the valley. As it is, this river rises to flood height usually in the months of May and June, from the melting of the snows in the Rocky Mountains; flows rapidly to the Gulf, oftentimes with great damage and destruction; then subsides quickly, as in the last two years, drying up bodily for hundreds of miles and for several months below Albuquerque, leaving the crops to perish and the farmers to lose hundreds of thousands of dollars, and stopping all immigration into the valley. This natural flow of the water to southern New Mexico and western Texas and to Old Mexico is being rapidly curtailed by the large immigration into southern Colorado and the northern part of New Mexico. These thrifty people are constructing canals right and left, and by degrees are taking the Rio Grande out, during the farming season, almost bodily. The result is, that this season a water famine has existed in the valley for hundreds of miles above and below El Paso, and a panic exists among the people as to the future supply. This in my judgment can only be remedied by the saving of the flood-waters of the river in the early season, and of the storm-waters from the mountains later on, by a system of dams, reservoirs, canals, and laterals, to be constructed either by the Government itself or by its encouragement of private capital. Unless this is speedily done, one of the fairest and most productive portions of the southwest will be desolated and deserted. Immigration to it has already ceased, lands have greatly decreased in value, and many people are preparing to leave this valley.

The CHAIRMAN. What is the character, extent, and source of water supply of the large area of country known as the Jornado del Muerto, upon which you have resided for five years.

Mr. BOWMAN. It is one of the most interesting and peculiar conformations of lands in all the arid regions. It is a broad, fertile plateau, at an altitude of 4,500 feet above sea-level, on the thirty-third parallel of latitude, lying somewhat in the form of an ellipse rising gradually from the eastern side of the Rio Grande near San Marcial several hundred feet, and then sloping downward and southward for about 100 miles, with an average width of 40 miles, bounded on the west by the Cristobal and Caballo Mountains, curving around with the river behind them to Rincon, a station on the Atchison, Topeka and Sante Fé Railroad, which crosses this valley in a direct line, and on the east by the San Andreas Mountains then narrowing down to the base of the Doña Aña and Organ Mountains to a beautiful mesa, nearly to El Paso, crossing the State line of Texas about 20 miles above said city. This remarkable area of country, containing about 2,000,000 acres, has not a living stream of water upon it, except one or two small springs in the Caballo Mountains. On the eastern side of the railroad, for 100 miles by 25 miles in width, there has not been, in all the past nor at present, but two habitations outside of the railroad stations, one of these the "Aleman" or "Martin's well," and the other Ojo Denaio, a small spring which rises and runs a few hundred yards and sinks on the plains. The railroad supplies its stations with water hauled from the Rio Grande and from reservoirs and wells sunk at great depth. This area of country is capable of 50,000 homes for colonists, if water could be put upon it.

The climate is perfect both winter and summer. Its soil is rich and highly productive, having been formed by the deposits from the adjacent mountain ranges for ages past, and is admirably adapted to the growth of all kinds of fruits and cereals of a semi-tropical climate. The whole plain and mountain sides are covered with luxuriant growth of gramma and other grasses indigenous to these arid regions, and indications are most favorable for large mineral deposits in the surrounding mountains, which are also covered by an abundance of timber for fuel and other purposes.

The CHAIRMAN. You speak of the Mesilla Valley; what is its extent, and what its resources?

Mr. BOWMAN. The Mesilla Valley extends from a point near Fort Selden to the Texas line, a distance of about 40 miles. The lower level of land is from 3 to 5 miles in width, the mesa lands on the east about 15 miles in width, extending to the Organ Mountains, and on the west side extending indefinitely towards the town of Deming, on the Southern Pacific and Atchison, Topeka and Santa Fé railroads. The lower level of land has been partially under cultivation for several hundred years, and has a wonderfully rich soil, capable of the production by irrigation, from the muddy waters of the Rio Grande, of all crops of cereals, and especially of all semi-tropical fruits and vegetables, to a remarkable degree. Perhaps no country in America can excel it in the production of all varieties of grapes, both as to quantity and flavor. Apples, pears, peaches, plums, apricots, figs, and nectarines grow to great perfection, superior, we think, to California.

The CHAIRMAN. You speak of the Rio Grande failing in its supply and having been absolutely dry for several months during the past two years. How can these valleys be relieved from this water famine in the future, and how can this large area of mesa land be settled up?

Mr. BOWMAN. Only by saving the great floods of waters of the Rio Grande which waste away to the Gulf of Mexico every year, during its spring rise, and also gathering the storm waters which flow from the mountains in the summer and fall.

The CHAIRMAN. Have any steps been taken by the people themselves to protect them from this threatened annual water famine? You have organized a company, I believe. Please state its character.

Mr. BOWMAN. More than a year ago a number of the best citizens of southern New Mexico and El Paso, Tex., many of them small farmers, whose all depended on a regular water supply, fearing the increased failure of the river from its absorption by the people of Colorado, and with a view to settling up the large tracts of adjacent mesa lands, organized a company, known as the Jornada and El Paso Canal and Reservoir Company, subscribed a fund for preliminary surveys and expenses, and appealed to Congress for aid in the construction of a canal and laterals, with a series of storage-reservoirs, to be built under the direction and auspices of the Government, by private capital, and in exact line with the policy indicated by this investigation.

The organizer ask the right to operate under a national charter under the directon of the Secretary of the Interior, and for the right of way, and to take from the Rio Grande, under proper restrictions by the Government, the waste or flood waters of that river; also, to gather the storm waters from the mountains and plains, and to conduct and store the same by a system of canals and reservoirs, to be located by the U. S. Geological Survey, taking the waters from the river at any point on either side of said river, between Fort Selden and Albuquerque, and carrying them across the Jornada down at the base of the Organ Mountains, with a branch canal or lateral near Fort Selden running south through the Mesilla Valley to the State line of Texas, where the waters can be conducted into the large international reservoir, which is suggested to be built by the Governments of the United States and Mexico. In order to construct this large and expensive system of works, and to develop the large area of public lands on this peculiarly situated Jornada del Muerto, and to save the beautiful Mesilla Valley from a constantly recurring water famine, they ask for an appropriation of $25,000, to be expended under the direction of the Geological Survey, for the permanent surveys and locations of said system of works, and they ask also for the right to purchase at a reasonable rate the alternate sections of public lands along or near said canals and reservoirs, to an amount not exceeding 1,000,000 acres, which lands are now practically worthless and uninhabited. Only in this way can private capital be induced to take hold of this great work, which will cost several millions of dollars. This settlement of more than 2,000,000 acres of rich but arid lands will be postponed indefinitely, unless these works are constructed by this means or by the Government itself.

The policy of the people who have organized this company is not only to save their own valley, but to encourage the settlement of these unoccupied lands by colonies of small farmers, who will be enabled, under governmental protection, to secure water rights which will attach perpetually to the lands purchased by them.

I beg leave to file with this statement copies of the maps and profiles of surveys which have been made by this company, showing the practicability of the proposed routes and works, with some photographic views of the Mesilla Valley; also, a copy of the bill introduced in the last Congress, with a report made in its favor by the House Committee on Agriculture; also, arguments before the Senate Committee on Agriculture, which committee gave the measure most favorable consideration, without action, near the close of the last session.

The following papers were received by the committee and ordered filed for publication.

STATEMENT OF EDWARD F. HOBART, UNITED STATES SURVEYOR-GENERAL OF NEW MEXICO.

The Committee on Irrigation of the United States Senate:

GENTLEMEN: New Mexico is, by reason of its inland situation, naturally an arid region. This condition is however greatly modified by its mountains, which cover a large part of the northern portion of the Territory and are scattered over the rest of its surface in detached groups.

If these natural reservoirs of moisture were supplemented by works that can be readily constructed by man, a very large portion of what is now a barren waste could be turned into a very garden of the Lord, for at the touch of water these prairies become equal to the most fertile land in the world, and the crop is much surer than it can be where it depends upon rain.

From the mountains a great number of streams run out onto the plains of New Mexico.

The water that runs in these streams during the summer is used to some extent for irrigating the bottom lands; the water that runs during the rest of the year goes to waste.

For an example of these streams, take the little river Gallinas, which runs through Las Vegas, the flow of which I have measured at Las Vegas Hot Springs for the last six years.

The stream commences to rise from the melting of the mountain snows early in April, and soon attains a depth of 1 foot more than that of its ordinary stage; as the weather gets a little warmer this increases to 2 and then to 3 feet and two years ago last spring it reached the extreme height of 8 feet above low-water mark, which in a swift running mountain stream is quite remarkable.

The high stage of water in the spring continues about two months. Taking the average height during this time as 2 feet and the width as 30 and the velocity as 4 miles, there flows by every day a body of water 100 miles long, 2 feet deep, and 30 feet wide, or more than enough to irrigate a square mile of land for a year after all allowance is made for evaporation during the time it needs to be held. Therefore during the two months ending the middle of June ample water for irrigating 60 square miles of land could be saved up by the proper reservoirs.

For miles above Las Vegas Hot Springs the river enters a cañon 100 feet deep, 75 feet wide at the bottom, and 200 feet at the top. A dam constructed here at an expense of some $30,000 would hold the before-mentioned water, which could be let down as it was needed on the land.

The area of land to be irrigated could also be greatly increased by smaller reservoirs on the prairie, costing from $500 to $3,000 each. For example, 2 miles out on the prairie, from the point where the Gallinas leaves the mountains, a flat valley on elevated ground could be crossed by an embankment 24 feet high in the center, containing 13,000 cubic yards of earth, and costing $1,500. This would produce a storage lake half a mile in diameter and of an average depth of 10 feet.

Four miles north of the Gallinas is a smaller stream; 10 miles north of the Gallinas is a Sapello of equal volume; 8 miles farther north is the Mora, and so on. Everywhere streams come forth from the mountains at frequent intervals, and if the water was saved it would irrigate a belt of land all along the foot of the mountains from 10 to 20 miles in width. How many thousands of happy homes would cover these tracts now barren and useless.

The same method of treatment just suggested continued to the streams along the upper Rio Grande would solve the problem for that river.

In the side cañons of the river at the north the waters should be held that now come down in devastating floods, and when the water becomes scarce a steady flow could be secured by releasing the water from the artificial lakes. The experiment made by the Government on the upper Mississippi shows that such a plan is practicable. It is what our country needs, and is beyond the power of private enterprise. It is for the general good, and will render valuable a vast quantity of Government land. Therefore we ask the aid of the General Government.

FROM COMPILED LAWS OF NEW MEXICO.

ACEQUIAS OR IRRIGATING DITCHES.

[Filed by Governor I. Bradford Prince.]

Title 1, *Chapter* 1.

SECTION 1. No inhabitant of this Territory shall have the right to construct any building to the impediment of the irrigation of lands or fields, such as mills or any other property that may obstruct the course of the water; as the irrigation of the fields should be preferable to all others.

SEC. 4. In case a community of people desire to construct a ditch or acequia in any part of the Territory, and the constructors are the owners of all the land upon which said ditch or acequia is constructed, in such case no one shall be bound to pay for said land, as all the persons interested in the construction of said ditch or acequia are to be benefited by it.

SEC. 5. The course of ditches or acequias already established shall not be disturbed.

SEC. 6. All rivers and streams of water in this Territory, formerly known as public ditches or acequias, are hereby established and declared to be public ditches or acequias.

SEC. 7. From and after the publication of this act, it shall be the duty of the several justices of the peace of this Territory to call together, in their respective precincts, whenever it may be deemed convenient, all the owners of ditches or acequias, as well as the proprietors of lands irrigated by any public ditch or acequia, for the purpose of electing one or more overseers for said ditches or acequias for the same year.

SEC. 10. The regulation of ditches or acequias which have been worked shall remain as they were made and remain up to this day.

SEC. 15. All acequias, public or private, when completed, shall be the property of the persons who may have completed such acequias or ditches, and no person or persons who may desire to use the waters of such acequias or ditches shall be allowed so to do without the consent of a majority of the owners of such acequies or ditches, and upon payment of a share proportionate to the primary cost of such acequia or ditch to the amount of the land proposed to be irrigated, or the quantity of water proposed to be used: *Provided*, That the provisions of this section shall not apply to any acequias or ditches, public or private, that may pass from the limits of any one county to within the lines of any other county.

SEC. 16. Where any acequia or ditch, public or private, passes from within the limits of any one county to within the lines of any other county, such acequias or ditches, within the proper precincts of their respective counties, shall be under the exclusive control and management of the officers of such precincts and counties.

SEC. 17. All the inhabitants of the Territory of New Mexico shall have the right to construct either private or common acequias, and to take water for said acequias from wherever they can, with the distinct understanding to pay the owner through whose land said acequias have to pass, a just compensation taxed for the land used.

SEC. 18. If the owner or owners of land where a new ditch for an acequia is to be made should ask an exorbitant price as a compensation therefor, which shall not be satisfactory to the owner or owners of such acequia, it shall be the duty of the probate judge of the county in which it may occur to appoint three skillful men of well-known honesty to make an appraisement thereof and fix the compensation, which once done shall be executed and without appeal.

SEC. 24. In each precinct of this Territory, where public necessity requires it, an election shall be ordered and held on the third Monday of February, 1880. for the respective directors of acequias, for each one of such acequias as shall irrigate different places, as hereinafter provided.

SEC. 25. The manner of conducting the election, and the number of overseers, shall be regulated by the justice of the peace of the precinct, and the only persons entitled to vote at said election shall be the owners or renters of lands irrigated by said ditches or acequias.

SEC. 26. It shall be the duty of the overseers to superintend the repairs and excavations on said ditches or acequias; to apportion the persons or number of laborers furnished by the proprietors; to regulate them according to the quantity of land to be irrigated by each one from said ditch or acequia; to distribute or apportion the water in the proportion to which each one is entitled, according to the land cultivated by him, also taking into consideration the nature of the seed, crops, and plants cultivated, and to conduct and carry on said distribution with justice and impartiality.

SEC. 29. The pay and other perquisites of the overseers shall be determined by a majority of the owners of the land irrigated by said ditch or acequia.

SEC. 35. All persons interested in a common ditch or acequia, be they owners or lessees, shall labor thereon in proportion to their land.

SEC. 36. All owners of tillable land shall labor on public ditches or acequias, whether they cultivate the land or not.

SEC. 37. It shall be the duty of the proprietors to furnish each one the number of laborers required by the overseer, at the time and place he may designate, for the purposes mentioned in the foregoing section, and for the time he may deem necessary.

SEC. 48. The penalties on those who shall fail to supply the amount of work due by them, according to the provisions of this act, or the number of laborers on them apportioned, or for any violation of existing laws on this subject; and those penalties that are applicable under existing laws to major-domos shall be the same that shall be applied in these cases, and they shall be executed and fines shall be disbursed in the same manner.

SEC. 49. All currents and sources of water, such as springs, rivers, ditches, and currents of water flowing from natural sources in the Territory of New Mexico, shall be and they are by this act declared free, in order that all persons traveling in this Territory shall have the right to take water therefrom for their own use and that of the animals under your charge: *Provided*, That the word traveler shall not in any manner extend to persons who travel with a large number of animals, for in that case they shall not use the water of any spring belonging to any individual without having first obtained the express consent of the owner: * * * *Provided further*, That this shall in no manner apply to wells in this Territory: *Provided further*, That this act shall not be applicable to ponds or reservoirs of water that persons may construct for their own proper use and benefit, and no person under pretext of title to said sources, springs, rivers, or ditches shall have the right to embarrass and hinder or molest any transient person or traveler in or at the time of taking the water for his proper use and giving water to his animals.

SEC. 52. It shall be the duty of the major-domos of ditches and the commissioners of the same to prosecute all persons who shall violate the provisions of this act.

Title 18, *Chapter* 1.

SECTION 1305. The different communities or Pueblos of Indians residing within our settlements shall be subject to render their services in working the acequias and highways in which they have the common use of the water of said acequias with the immediate citizens to their Pueblos, and enjoy at the same time the benefit and commercial traffic: *Provided*, That in such service they shall be entirely subject to the laws now in force on both branches of roads and acequias.

In addition to the foregoing there prevails among the Pueblo Indians of New Mexico the custom of annually electing a mjaor-domo by all interested. He has control over the distribution of the water and calls out the help required for repairs, etc., much in the same manner as practiced among the Mexicans.

MINING AND WATER RIGHTS.

Section 5, article 14, adopted as part of the proposed State constitution by the constitutional convention which met at Santa Fé, N. Mex., September 3, 1889.

Whenever by priority of possession rights to the use of water for mining, agriculture, manufacturing, or other purposes have vested and accrued the possessors and owners of such vested rights shall be maintained and protected in the same, and the right of way for the construction of ditches and canals for the purposes herein specified is acknowledged and confirmed subject to the restrictions of this constitution as to taking property for public or private use.

LIST OF WATER AND IRRIGATION INCORPORATIONS.

[Filed by the Secretary of Territory.]

Albuquerque Consolidated Water-Works Company.
The Albuquerque Land and Water Company.
The Albuquerque Mountain Water Company.
The Aqua Pura Company of Las Vegas.
Albuquerque Water-Works Company (consolidated).
Albuquerque Water-Works Company (The A Mountain).
The Albuquerque Water Company.
The Albuquerque Water-Supply Company.
The Albuquerque Water-Works Company.
The Cerrillos Gas and Water Company.
The Cerrillos Gas and Water Company.
The Cerrillos Gas and Water Company.
Citizens' Water-Works Company.
La Campania de Agua Cristalina de Manantial.
The Deming Artesian Water Company.
The Dark Cañon Water Company.
The Deming Water-Works Company.
The Gavilan Ditch and Water Company.
Gallinas Canal and Water-Storage and Irrigation Company.
Gila River Ditch and Water Company.
Hot Springs Water-Works and Railway Company.
Kingston Irrigating, Mining, Milling, and General Water-Supply Company.
Kingston Water Company.
Las Cruces Water-Works Company.
The Lordsburg Water-Works.
Moreno Water and Mining Company.
The New Mexico Water Company.
Pecos and Placer Water-Pipe Company.
The Raton Water Company.
The Roswell Water Company.
The Santa Fé City Water-Works.
The San Juan Water Company.
Sandia Water Company.
Santa Fé Water-Works Company.
The Santa Fé Water and Improvement Company.
Silver City Water Company.
Sierra Madre Water, Mining, and Reduction Company.
Silver Madre Water, Mining, and Reduction Company.
Socorro Water Company.
The Springer Water Company.
The Springer Water-Works and Railway Company.
Tuerto Water Company.
The Water and Improvement Company.
New Mexico Water and Immigration Company.
New Mexico Water and Irrigation Company.
The Silver City Water-Works.
Socorro Water-Works Company.
Albuquerque Ditching and Irrigation Company.
Albuquerque Irrigating and Ditch-Improvement Company.
Albuquerque Irrigating, Canal, and Land Company.
Albuquerque Irrigating, Canal, and Land Company.
Animas, La Plata and San Juan Irrigating Canal Company.
Bernalillo Ditch and Irrigating Company.
Black River Ditch Company.
The Bowman Irrigation Company.
Black River Ditch Company.
B. R. Cañon Ditch Company.
The "B. R." Cañon Ditch Company.
The Cabresto Ditch and Irrigation Company.
The Chama Valley Mill and Irrigating Ditch Company.
The Detroit and Rio Grande Reservoir and Pipe Line Company.
Echo Irrigating Ditch Company.
Eureka Irrigating Ditch Company.
The Guadalupe Valley Irrigating and Milling Company.
McDermott Irrigating Ditch Company.
McDermott Irrigating Ditch Company.
Mesilla Valley Irrigation Company.
The Mountain Irrigation Company.
The New Mexico Irrigating and Land Company.
The People's Ditch and Irrigation Company.
The Pecos Irrigation and Investment Company.
Penasco Tank, Irrigating and Ditch Company.
Reservoir Irrigating Company.
Rio Grande Irrigation and Colonization Company.
The Rio Grande Irrigating Canal, Land, and Live Stock Company of New Mexico.
The Rio Grande Irrigating and Improvement Company.
The Rio Grande Irrigation and Ditch Company.
Santa Fé Irrigation and Colonization Company.
The Santa Cruz Land and Irrigation Company.
Socorro County Irrigating and Agricultural Improvement Company.
The Socorro Ditch and Irrigating Company.
The South Spring River Land and Irrigation Company.
Una de Gato Canal and Irrigating Company.
Water Cañon Stock and Irrigating Company.
Western Union Cattle, Land and Irrigation Company.
New Mexico Irrigation Company.
New Mexico Irrigating Canal Company.

DITCH COMPANIES.

American Bend Ditch Company.
Bosque Grande Ditch Company.
The B. R. Cañon Ditch Company.
The Dark Cañon Ditch Company.
The Farmers' Ditch Company.
The Fort Sumner Land and Ditch Company.
Fresnal Ditch and Improvement Company.
George Danner Ditch Company.
Good Bend Ditch Company.
Greylands Ditch Company.
The Guadaloupe Valley Ditch Company.
Hondo Falls Ditch Company.
The Island Crossing Ditch Company.
The Largo Land and Ditch Company.
LaPlata Indian Ditch Company.
Lea & Cockrell Ditch Company.
The Lincoln County Ditch Company.
Lower Felix Ditch Company.
Mimbres Ditch and Pipe Line Company.
The Mimbres Canal Company.
Mimbres River Canal Company.

Messilla Valley Canal Land and Improvement Company.
New Mexican Artesian Well Company.
The North Spring River Ditch Company.
Old Fort West Ditch Company.
The Polvadera Ditch Company.
Perry Fountain Ditch Company.
The Pecos River Ditch Company.
Pecos & Placer Mining and Ditch Company. (change of name.)
Pecos Valley Ditch Company, of Lincoln County, N. Mex.
The Pecos Valley Land and Ditch Company.
Porter Ditch Company.
Rio Hondo Ditch Company.
Rio Pecos and Salt Lake Ditch Company.
The Riverside Ditch Company.
The Rio Arzul Ditch Company.
Rio Grande Ditch Company.
Rio Hondo Ditch Company.
The Rio Grande Placer Ditch Company.
Rio Grande Pecos and Ortiz Grant Canal Company.
Rio Pecos and Salt Lake Ditch Company.
Rock Corral Ditch Company.
San Jose Ditch Association.
San Juan South Side Canal Company.
The San Juan Canal Company.
The San Juan Land and Canal Company.
San Antonio and Placer Mining and Ditch Company.
The San Simon Cattle and Canal Company.
The Spring Valley Ditch Company.
The Union Ditch Company.
Rio Grande Valley Water Company.
The La Plata Ditch Company, of Colorado.
Jacarilla Mining and Water Company.

STATEMENT OF GEORGE M. KELLOGG, M. D., OF DEMING, N. MEX.

No word, even of an out-door naturalist, can be needed to emphasize the importance of the matter your committee has in hand. But as germane to the primary line of your investigation, I respectfully call your attention to another subject also deserving the consideration of your body. I refer to the natural productions of these upland plains and mountains, and would suggest an investigation as to the plant-life adapted to climatal conditions here present—the vegetation which with a modicum of irrigation would prove the most profitable and satisfactory. It would be in place—an inquiry as to the nature and value of products found in regions analogous to this, as the steppes of Asia, the plains of Tartary, Persia, and Arabia. Many of the choicest known medicines and condiments originated in those lands, and might with great advantage be introduced here. There are many native products the collection of which would be valuable, and the best methods of their cultivation, where cultivation should prove practicable, would constitute an inquiry of rare importance. I refer to such plants as the yucca or amoli, the mesquite, as tree or bush, and the cañaigre-plant, so rich in tannin.

Since the Irish potato, as is now generally believed, originated in New Mexico, it might reach here in this land of sunshine, with but a modicum of irrigation, its highest development. There might be initiated the successful cultivation of medicinal rhubarb and the best quality of gum-opium, which now are produced only in the high and dry plains of the Eastern Continent.

The vegetation of these upland plains should be sedulously studied. There are native trees and shrubs which would flourish with a slight help from irrigation. It is such which should be selected for the growing of timber and shade trees. I would emphasize this because of some usages noticeable in this country, such, for instance, as the cultivation of the cotton, wood, an enormous water consumer of little value as timber or fuel. A species of black walnut, here indigenous, is well worthy of cultivation for its fruit and timber. In the mountains where there is, in some places, an excess of moisture, such trees as the cotton, wood are permitted to usurp the ground where trees a hundred times more valuable for shade, timber, and fruit might be grown with marked success.

When it is considered that a majority of the medicinal plants and a large moiety of those used by man as food, had their origin in the high and dry parts of the earth, we may, in western phrase, find "a pointer" to moderate our zeal in endeavoring to emulate the highly-watered alluviums in agricultural products.

There is, in this country, an abundant plant, which seems, in flavor and from the presence of thein, a fair substitute for China tea. Doubtless the tea plant itself might flourish here as well as some of the hardier varieties of Arabic coffee.

I would respectfully memorialize Congress to establish botanic gardens and laboratories for the thorough investigation of the native products of our country, and for the careful selection of the exotics adapted to the various sections. The fair returns in-coming to the country from scientific fish-culture now fostered by the Government, is encouragement for analogous work as to plant-life. And such work should be inaugurated before the utter extermination, as now threatened, of many valuable species.

STATEMENT OF JOHN SYMINGTON, ACTING ASSISTANT SURGEON, OF FORT MARCY.

The Santa Fé River rises in the mountains north and east of Santa Fé, flows in a direction almost west, until it reaches the Rio Grande, distant some 30 miles. At present some 12,000 acres are under a high state of cultivation, the water supply being conducted by a system of ditches (many of which antedate the Spanish conquest) taken from the stream above the town. A thoroughly accurate test of the volume of water available has never been taken, as in addition to the numerous irrigating ditches derived from the river, a dam has been thrown across the river 3½ miles above the city, from which the town is supplied by mains, but a rough estimate of the volume of water flowing past a point below the last important ditch, will show that, could it be utilized a large portion of the 50,000 acres of land adjoining the valley could be brought under cultivation. Successful efforts to cultivate these lands have been made, and in all seasons of a fair rain-fall they have produced abundantly the usual cereals and some of the products of lower altitudes. The soil being of a reddish loam and capable of retaining moisture, has induced the establishment of rude storage-reservoirs at points where the rain-fall from the adjacent foot-hills could be collected, and are made by throwing the earth on a cribbing of stakes, brush and bowlders, built in a circular form, at the rim of which are planted willows, which in growing fill the interstices of the cribbing with a thick growth of roots, thus giving stability to the structure; the bottom is made impervious to water by driving cattle or, preferably, sheep around the inclosure until the earth becomes thoroughly packed to the depth of several inches, and many reservoirs so made have served the purpose of their construction for many years, without the necessity of repair or loss of water, save by evaporation. With each shower they are refilled, or their contents added to, and frequently insure the safety of a crop during a critical season.

These several enterprises show conclusively the feasibility of the scheme of water storage, as during the spring months the river is filled with water from melting snows, and in the latter part of July and August, at the time of the greatest precipitation, the stream often causes great damage to its banks from overflow. Of all this water not one-fourth is utilized, and it is the observance of this fact that induces me to believe the application of storage dams and ditches to keep them filled would be the means of reclaiming from 50,000 to 75,000 acres of valuable lands adjacent to Santa Fé, the greatest portion of which are subject to entry, and from their situation easily irrigated and capable of producing good crops, for which a ready market can be found in the adjacent growing mining towns of Cerrillos and San Pedro. Many natural sites for reservoirs exist, as in arroyos with rocky and precipitous sides, where no great cost would be incurred in their construction, and which would be filled from the rain-fall, and a succession of such reservoirs could be constructed, connected by ditches, which passing in close proximity to the foot-hills, would render auxiliary what water fell on them, as frequently showers do not extend to the plains.

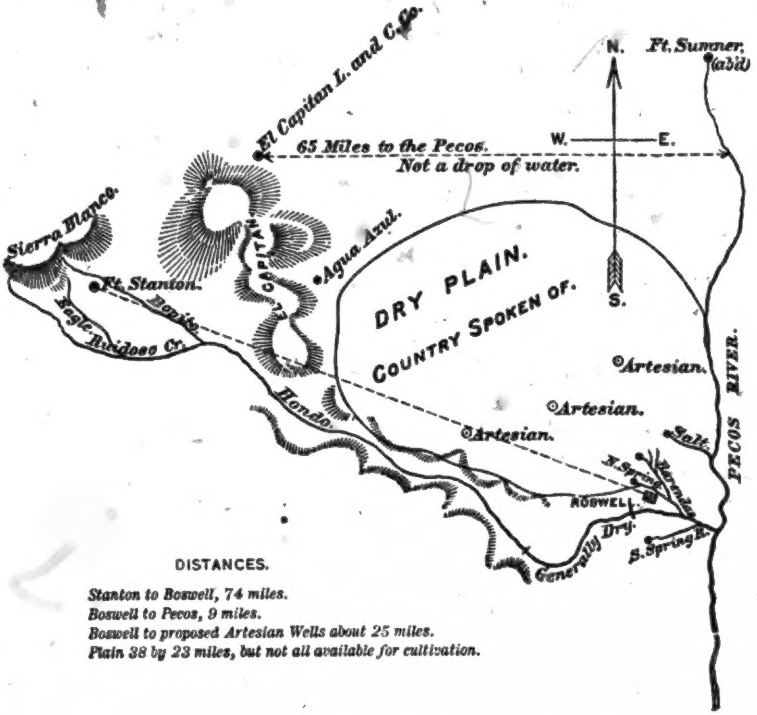
STATEMENT OF THOMAS CRUSE, FIRST LIEUTENANT, SIXTH CAVALRY, OF FORT STANTON.

There is, bordering on the Pecos, to the eastward of Fort Stanton, a plain about 30 miles wide, and wherever water has been put over the land the results are simply wonderful. The crops are varied, command excellent prices, and the fruits grow well, except semi-tropical varieties. Peaches and sweet-potatoes especially seem to be suited to that locality and thrive in the soil.

There is at present in the vicinity of Roswell, N. Mex., about 200,000 acres of the very finest land, that I think would be a good subject for discussion by the honorable commission, and some attempt on the part of the Government to reclaim. In my opinion, this can be most readily done by sinking, say, three artesian wells, 10 miles apart, in order to demonstrate whether or not water can be obtained in that way.

That the effort in that direction will be rewarded I am led to believe from the nature of the surrounding country and the very curious water system that exists in the vicinity of Roswell. This is seen in the rough sketch hereto appended. A word in explanation of the sketch. The El Capitan Mountain is very high and has snow on it; still there are no streams flowing from it. In the vicinity of Roswell no less than six good-sized streams gush from the surface of the almost level plain and flow into the Pecos, about 9 miles away. Enough water is obtained from these streams by irrigating ditches to cover about 60,000 acres. My idea is that one of the three artesian wells would tap the subterranean lake which feeds the large streams at Roswell, and I calculate that $10,000 would settle the matter one way or the other. North Spring River

is about 30 feet wide, 6 to 8 feet deep, and runs at the rate of 8 miles per hour. South Spring River is about the same size, and the three Barendas flow about one third as much water.


El Capitan L. and C. Co.
N.
Ft. Sumner. (abd)
W.
E.
65 Miles to the Pecos.
Not a drop of water.
Sierra Blanca.
CAPITAN
Agua Azul.
DRY PLAIN.
COUNTRY SPOKEN OF.
S.
Ft. Stanton.
Bonito
Eagle
Ruidoso Cr.
Hondo.
Artesian.
Artesian.
Artesian.
Salt.
PECOS RIVER.
N. Spring
Barendas
ROSWELL
Generally Dry.
S. Spring R.

DISTANCES.

Stanton to Roswell, 74 miles.
Roswell to Pecos, 9 miles.
Roswell to proposed Artesian Wells about 25 miles.
Plain 38 by 23 miles, but not all available for cultivation.

STATEMENT OF E. H. KELLOGG, ENGINEER OF THE MAXWELL LAND GRANT COMPANY OF RATON.

I am in receipt of your favor of the 15th of June, with inclosure of letter from Mr. Richard J. Hinton, expert of the Senate Committee on Irrigation, requesting information as to the irrigating enterprises in which your company has been engaged. I take pleasure in complying with the request, the more that the subject is one of deep interest to me, both as engineer and citizen, and I am confident that the results of this investigation, by the collection and dissemination of valuable information, will accomplish a very decided advance in the intelligent development of the Rocky Mountain region.

I desire to preface my report with the remark, that within the year during which I have been engaged on the irrigation systems of the Maxwell Grant the time has been almost wholly devoted to construction and so little of it in practical operation, that I shall be unable to answer many of the most important questions out of my own experience, except so far as experience under parallel conditions elsewhere enables me to speak with certainty.

The Maxwell Grant occupies the north central portion of New Mexico, and embraces an area of 1,714,000 acres of mountain and prairie land, with a border on the west of a range of mountain peaks, many of which reach an elevation of nearly 14,000 feet above the sea. Between this range and the plains lies a broad band of foot-hills, which but for their nearness to the main range would rank as mountains. This region is generally covered with heavy timber of pine, spruce, cedar, and piñon. Near the headwaters of the main streams which drain this area are numerous open parks of greater or less extent. The foot-hill belt ceases abruptly at the western edge of

the plains, sharply defining the limits of the two topographical extremes—prairie and mountain. Through their several cañons a number of water-courses discharge the accumulated rain-fall of the hill region and through the leading channels into the main artery—the Red or Canadian River.

The prairie lands have till now been utilized only as grazing lands, while their agricultural possibilities have been wholly ignored. The signal success which has attended the efforts to redeem the so-called arid lands of Colorado encouraged the owners of this grant to inaugurate a system of irrigation works with a view to increasing the productive, and necessarily the selling value, of lands till then of nominal value only. In pursuance of this plan surveys were made, and all available data concerning water supply, climate, soil, etc., were collected. These latter were meager enough, since no systematic record had been kept and the reports of the oldest inhabitant were tinged by the extent to which he had been prosperous or afflicted in the time covered by his residence here. Some were so impressed by the drought of a certain year as to be unable to recall an offsetting wet one. Others could only remember those years when abundance of rain made irrigation unnecessary. From the average of this curious medley of reports the opinion was reached that the mean annual precipitation here was not less—probably greater—than that of regions where successful agriculture is practiced in Colorado and Utah, and that if even a decent moiety of this water could be saved, a very large body of land could be reclaimed.

With no more definite facts than these it was decided to proceed. As a result we have the two completed systems definitely described below. First:

THE SPRINGER SYSTEM.

This system draws its supply from the Cimarron River, at a point 13 miles northwest of the town of Springer. It begins with a canal 20 feet wide on the bottom, with slopes of 1 to 1 and a fall of 5.28 feet per mile, capable of carrying a depth of 4 feet and discharging approximately 400 cubic feet of water per second. At the end of 6 miles a branch is diverted, and conducted in a flume down to the first of a series of natural lake beds 90 feet below the main ditch. These lake beds are arranged by nature so that water can be drawn through the whole chain to the lower (No. 6) by the simplest means. No. 7 (see plat) is artificial, being formed by an embankment across a low valley. From this in turn a ditch 10 feet in width carries water to the lands about Springer.

From the point of first departure the main line is reduced to 12 feet in width, but increased in fall to 7.6 feet per mile, following a ridge or divide, which necessitates several "drops" of simple but novel construction. This is called the "High Line," and is about 8 miles long. Continued under the name of the North High Line about 13 miles, and gradually reduced from 10 to 6 feet in width, the Red River Valley is reached.

The system as now completed consists of 47 miles of main and distributing ditches, four reservoirs of 40 acres each, averaging 6 feet in depth; one of 62 acres, 6 feet deep; and one of 475 acres, 9 feet deep. The entire plant is designed to serve 20,000 acres with competent irrigation. The total cost of this plant will be approximately $60,000, or $3 per acre, on the land redeemed.

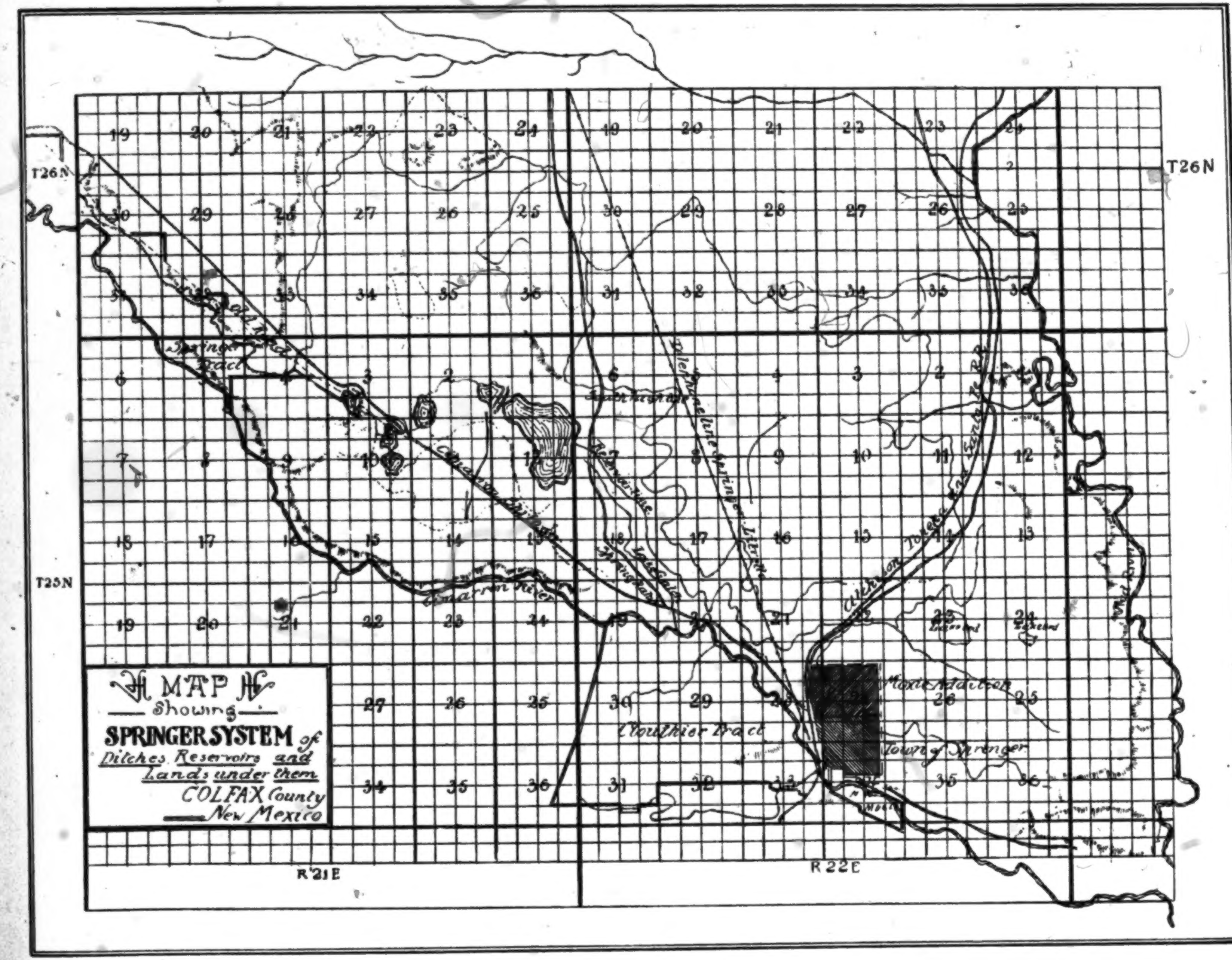
The details of construction are of the simplest order; lines are laid in tangents and regular curves; banks are built 2 feet above high-water mark, with bermes of 4 feet; wood-work is substantially framed and coal-tar is used liberally on all bearings. The outlet to the large reservoir is a masonry conduit with two iron valve-gates and flap-gates at head for emergencies; heavy masonry bulk-heads are erected at head and foot of conduits. The embankment is built with a width of 12 feet on top, inner slope 3 to 1, outer slopes 1½ to 1. It is 4,000 feet long and 28 feet high at highest point; overflow weirs at either end each 16 feet in width, 2 feet below high-water mark and 8 feet below top of bank, insures against any possibility of surcharge.

THE VERMEJO SYSTEM.

The Vermejo system is essentially one of storage. The main canal (20 feet wide on bottom, 4 feet deep, fall 5.28 feet per mile) taps the Vermejo River near John B. Dawson's house, above the mouth of the Vermejo Cañon, and at the end of 9 miles begins to feed lakes Nos. 4, 5, 6, 7, and 8; at 12 miles it flows through lake No. 1, and at 13 miles discharges into the Laguna Madre. At the ninth mile the width is reduced to 18 feet; at the eleventh mile to 16 feet, and the grade doubled.

In this line there are five drops, aggregating nearly 100 feet in all, but in two cases the water is allowed to run wild over the sod. The essential feature of the wooden drops is the tub sunk below the lower level in which all the turmoil of falling water is exhausted.

Water is drawn through the Laguna Madre into main laterals to the north and south; former supplies Laguna Rodondo, Moccasin Lake, and Nos. 15, 13, 14, and 18.


MAP
Showing
SPRINGER SYSTEM of
Ditches Reservoirs and
Lands under them
COLFAX County
New Mexico
T26N
T25N
R21E
R22E
Springer Tract
Cimarron River
Atchison Topeka and Santa Fe R.R.
Clouthier Tract
Town of Springer
Moxie Addition

THE

VERMEJO SYSTEM

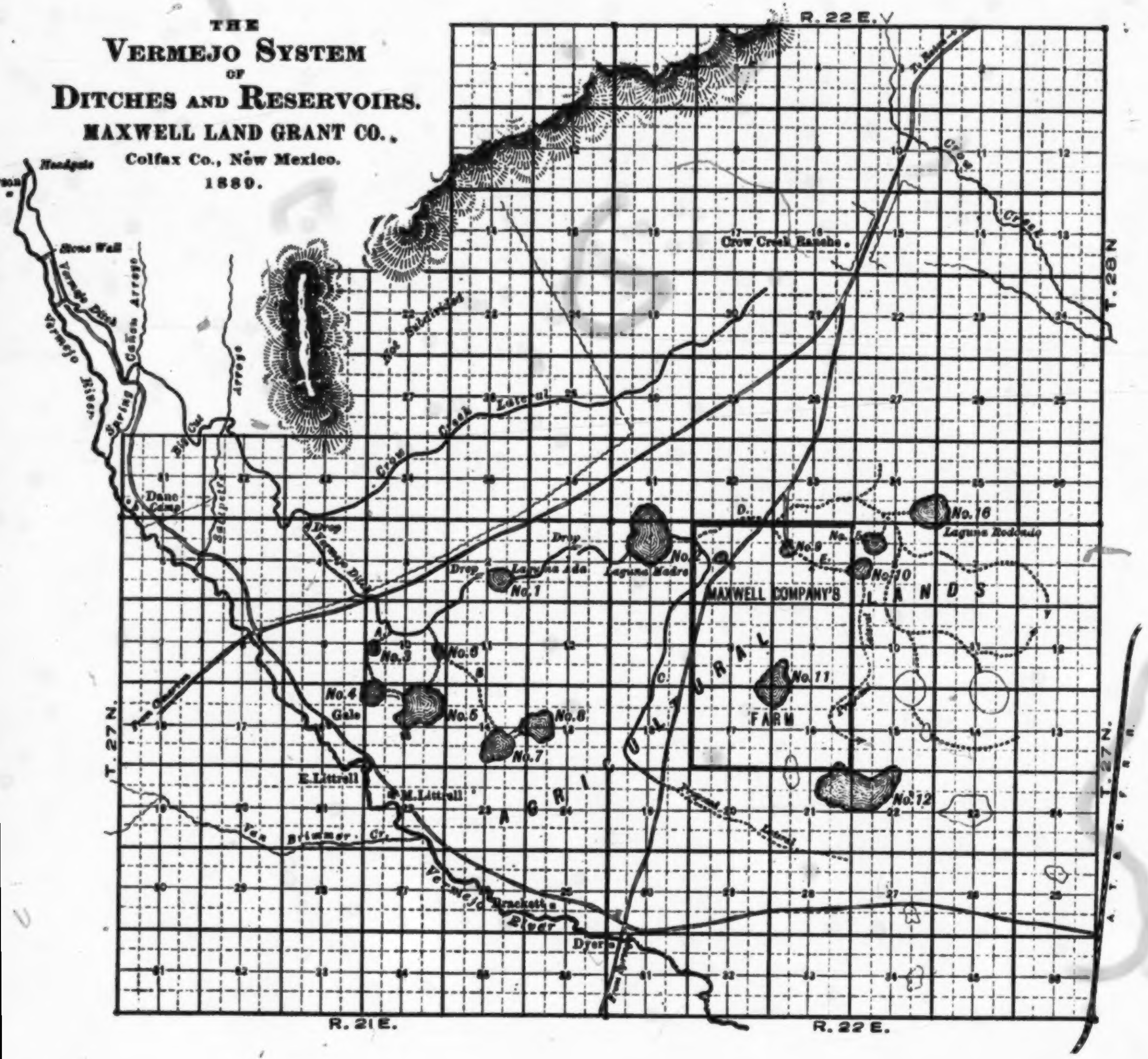
OF

DITCHES AND RESERVOIRS.

MAXWELL LAND GRANT CO.,

Colfax Co., New Mexico.

1889.


R. 22 E.
R. 21 E.
R. 22 E.
T. 28 N.
T. 27 N.
T. 27 N.
Headgate
Stone Wall
Vermejo Ditch
Vermejo River
Cañon Arroyo
Arroyo
Spring
Big Cut
Dane Camp
Drop
Crow Creek Lateral
Crow Creek
Crow Creek Ranche
Laguna Ada
No. 1
Laguna Madre
No. 2
No. 3
No. 4
Gale
No. 5
No. 6
No. 7
No. 8
No. 9
No. 10
No. 11
No. 12
No. 16
Laguna Redondo
MAXWELL COMPANY'S
AGRICULTURAL LANDS
FARM
E. Littrell
M. Littrell
Van Brimmer Cr.
Vermejo River
Brackett
Dyers

The south lateral runs south about 3 miles and then unites with a lateral from the chain of lakes first mentioned. This arrangement places the lands south and east under seven lakes. Enough of the lateral system and lake improvement has been done to supply all demands for this year. The only novelty in the way of construction on this system is in the employment of wood pipe running under vicious ravines instead of overhead flumes. These pipes are 6 feet in diameter, and are constructed at the place where they are used of staves of Texas pine, banded with steel rods, 10 to 18 inches apart. Sufficient fall is given between receiving and discharging ends to insure a powerful flow. Floods pass harmlessly over these pipes, and being thoroughly painted inside and out with coal-tar, are very durable. I estimate their life at twenty years. At the seventh mile of the main line, and at the head of the second drop, a high line lateral, 8 miles in length, carries water to Crow Creek.

This system is designed to serve 30,000 acres of land, although the river is somewhat smaller than the Cimarron; the remarkable number and sizes of the natural storage basins scattered over the tract making this increase of service possible. All the eighteen lakes will be re-enforced by embankments at an early day, and their capacity fully doubled. The total cost of construction to date is, approximately, $56,000, or $1.87 per acre. This cost is considered phenomenally low.

SUPPLY.

The Cimarron and Vermejo Rivers head against the main range, but many important branches run into them from the foot-hill country north and south. The total area of mountain country drained by these river is, approximately, 250,000 acres. A very considerable part of this area is subject to very heavy falls of rain and snow, which, except on occasional "off years," insure a very large and steady flow, besides many severe floods. The climatic habit of the region seems to be fairly defined. An early spring thaw, supplemented by rain and soft snow, mark the months of February, March, and April as a high-stage period; May and June are generally destitute of rain, but the extra heat attacks the snow reserves, and the high stage is fairly maintained. During July and August frequent rains may be expected, making the lessening river flow of small importance to the farmer. September and October are bright, open, and dry, and enough water to complete the last watering of meadows and fruit-trees can be pretty safely relied upon. Neither of the streams mentioned has been systematically gauged, and their variable flow makes estimation little better than guess-work. In 1888 the Vermejo held its high stage from May 1 to August 1, and low water was not reached till September. During the same year the Cimarron maintained a strong flow throughout the season. So far this year, owing to the absence of snow in the mountains, there has been no rise of any consequence in the Vermejo, though the Cimarron ran strongly from February 15 to May 1. It is now even lower than the Vermejo.

SOIL.

The soil is very uniformly a close-grained clay, of great depth; it is easily saturated, and retains moisture excellently. In point of fertility the new experiments on the Maxwell farm, on the Vermejo, promise nobly. Alfalfa and almost all kinds of grain, large and small fruits, and vegetables, are in excellent condition, and the showing is remarkable for entirely new land.

DUTY OF WATER.

On this subject much has been said and written, more or less directly to the point, but the very great diversity of opinion arising from the almost infinite variations of conditions of soil, climate, crops, and seasons, as well as the degrees of intelligence with which water is applied, make it impossible to formulate any standard gauge. Our experience on the Maxwell grant is too young yet to give us any definite or reliable data. It is, therefore, only an opinion of my own that 1 cubic foot per second, flowing constantly through the irrigating season, will serve 40 acres the first year, 50 acres the second and third, 60 the fourth, with a possible rise to 80 acres under the best conditions. It would be quite safe, I believe, to set the figure at 60 acres, for an average of a number of seasons.

STATEMENT OF THE RIO PECOS IRRIGATION AND CANAL ENTERPRISES.

The Rio Pecos rises in the northern part of New Mexico, northeast of Santa Fé.

It flows in a southeasterly direction to the neighborhood of Fort Sumner, and then a little east of south across the territorial line into Texas, finally forming a junction with the Rio Grande.

It is a mountain stream, subject to alternate flood and drought, until it reaches the neighborhood of Roswell, N. Mex.; thence for 100 miles, in a due south line, it runs a tortuous course of probably 250 miles, receiving at intervals large quantities of spring water.

These springs generally flow into it along its bed, following the general limestone strata of the country.

They represent the drainage from the eastern slopes of the Capitan, Sierra Blanca, Sacramento, and the Guadalupe Mountains, and the waters of the upper river which disappear below Fort Sumner.

Careful measurements show that the permanent supply is sufficient to fill both of the canals now in course of construction, and calculated to carry 1,600 cubic feet per second, or 80,000 miners' inches.

The drainage area, or catchment basin of the Rio Pecos, within the Territory of New Mexico, and available for irrigation purposes, is approximately 20,000 square miles, at varying altitudes from 3,000 to 11,000 feet, and extending across four degrees of latitude from the thirty-second to the thirty-sixth parallel.

The lands of the valley between Roswell and the territorial line, subject to irrigation, are of the choicest limestone soil, and the total area between the foot-hills on the west and the river, is nearly or quite 1,000,000 acres. Of this fully 400,000 acres is below the level at which it is practicable to deliver water from the Pecos.

The 40 miles of the Northern canal, now under contract, will cover about 75,000 acres of bottom and mesa land, and more than that area can be covered by extending the canal farther south.

The Southern canal is much the larger one, and will irrigate more than 100,000 acres on the west side of the river, north of the Texas line, while there is practically unlimited area that can be made available, by extending south of that line. Several bodies of choice land can also be covered on the east side of the river if desirable.

These lands are, for the most part, covered only with the scant growth of gramma grass.

Where the greasewood is found it is not in the way of the plow, and the roots of the mesquite more than compensate for the grubbing, where that occurs.

The surface needs no leveling for the distribution of water. The natural slopes to the west, toward the river and to the south, are just enough to afford every facility and to make the practical work of irrigation quite inexpensive.

The Northern canal is being constructed 30 feet wide on the bottom, with sides sloping 1½ to 1 foot, and to carry water 5 feet deep, taking its supply from the Hondo, the principal tributary of the Rio Pecos, below the junction of the North Spring and Barenda Rivers, deriving its chief supply from permanent springs of great volume. Three miles from its head it crosses and receives the waters of the South Spring River, and is deepened to 6 feet to accommodate the increased supply at that point. These streams are all fed by permanent springs.

The Southern canal was constructed a distance of 11 miles by the company from which it was purchased by this company, with the capacity to irrigate 30,000 acres. It is being enlarged to 45 feet wide at bottom, 63 feet at the top, and 6 feet deep, and by careful computation is intended to utilize all the available water of the river during the entire irrigating season. Its length within New Mexico will be 55 miles.

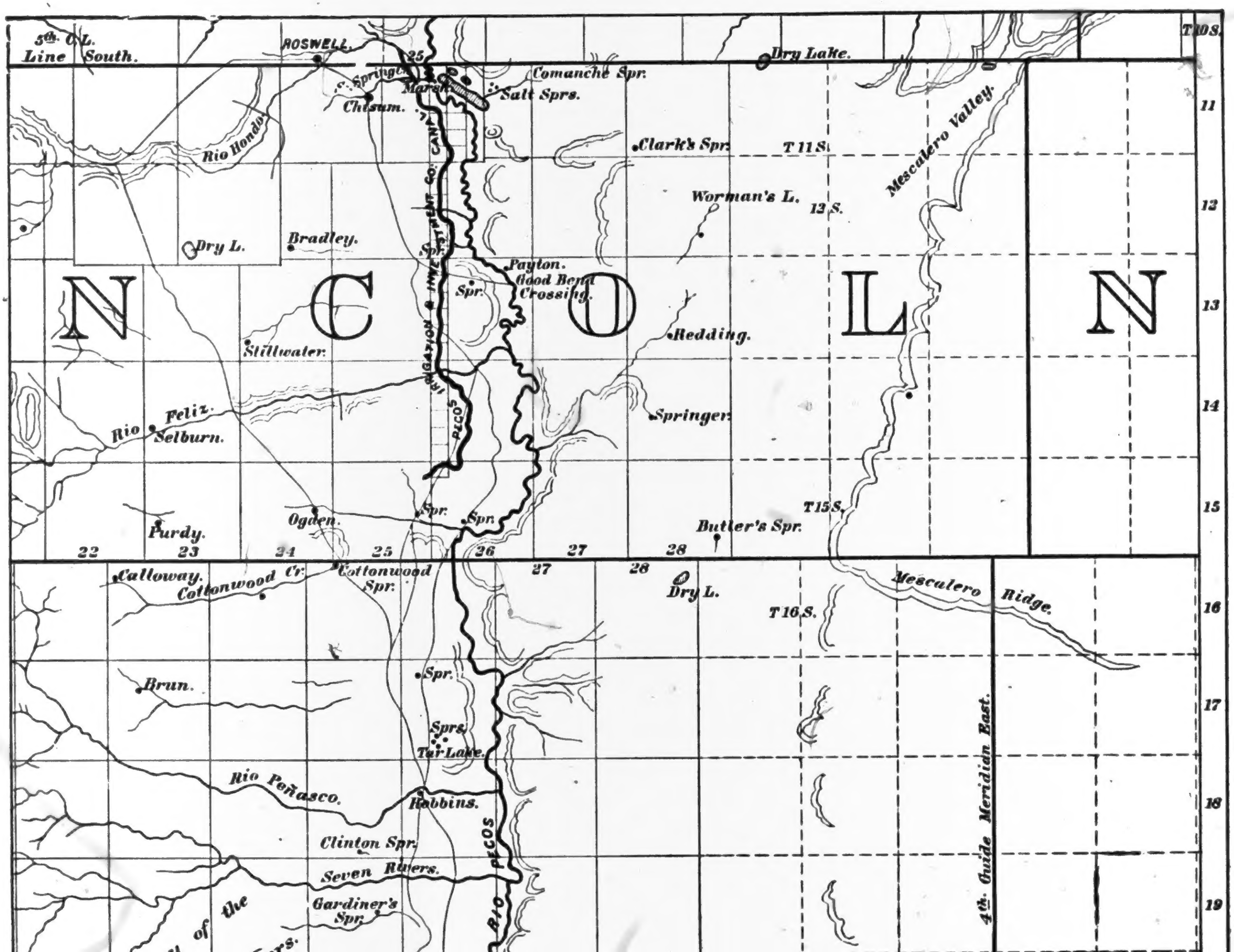
It is taken from the east side of the Rio Pecos a few miles below Seven Rivers. Although the waters of the Pecos are sometimes enlarged by floods, at the point where this canal is taken from the river, a dam 3 feet high, built at trifling expense, suffices to turn the water to fill the canal. It is controlled by head-gates, and the fall of the river is so great at that point that the rise does not exceed 6 feet—indeed, it never gets out of its banks. The river is a succession of rapids, and the fall within 6 miles amounts to as much as 50 feet. Very much of the water can be utilized at the crossings of arroyos for water-power, and then be discharged so as to cover large areas of agricultural land, without any loss of water. The canals are secure from floods. On the Hondo the reservoir at the dam backs fully half a mile up-stream, making dead water, and giving perfect control.

The price of water rights has been fixed for the first 20,000 acres at $10 per acre—one-tenth cash and the balance in annual payments of $1 per acre. The next 10,000 acres will be sold at $12.50 per acre, and after that none will be sold for less than $15 per acre. The annual water rent has been fixed at $1.25 per acre for cultivated land, and 50 cents per acre for uncultivated land, one-half payable June 1st, and the other half payable December 1st of each year.

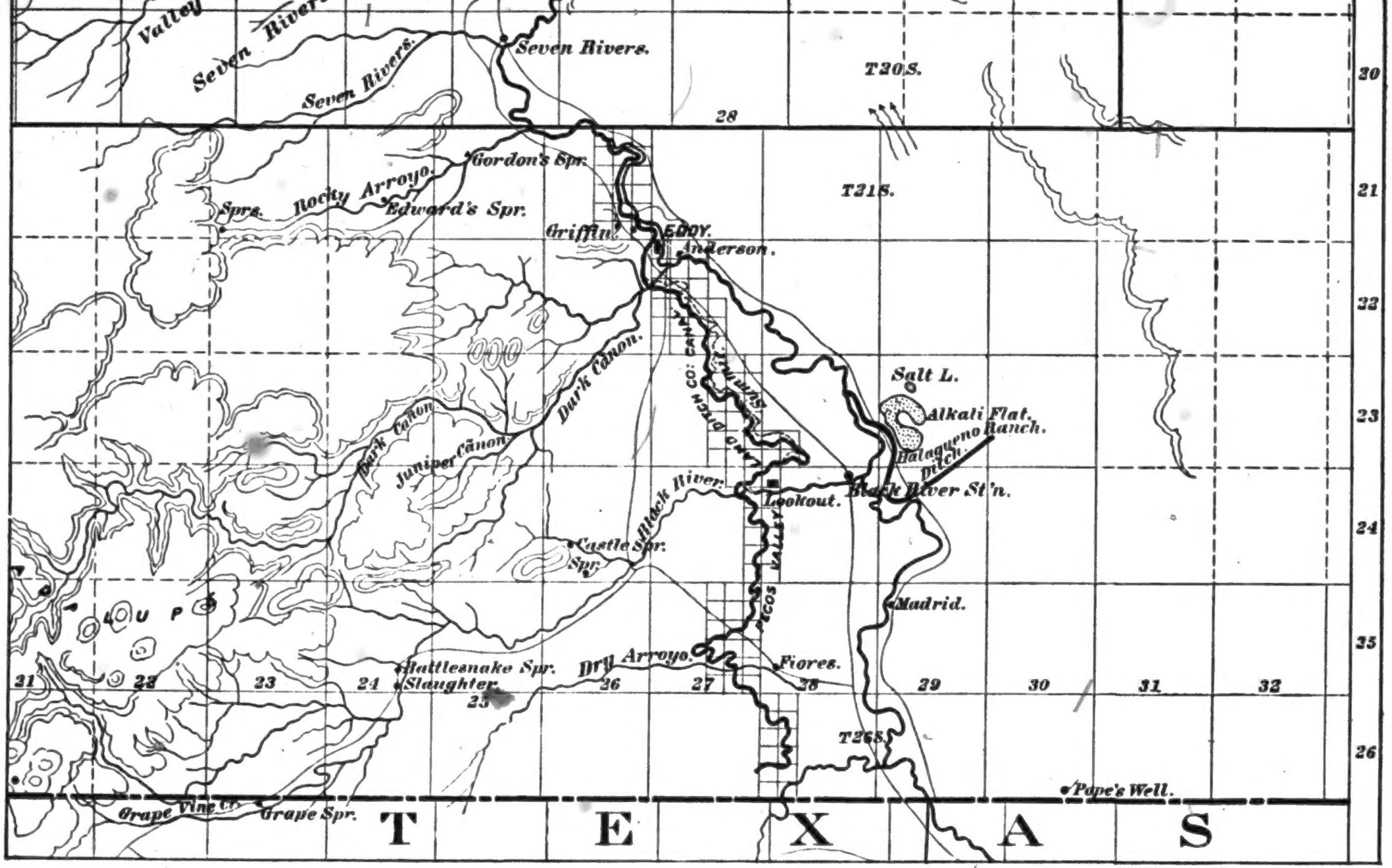
SKETCH MAP
SHOWING LOCATION OF THE CANALS
OF THE
PECOS IRRIGATING AND IMPROVEMENT COMPANY,
AND
PECOS VALLEY LAND AND DITCH COMPANY.
Lincoln County, New Mexico.

By H. HARTMANN, Santa Fe, New Mexico.

Scale, 120 chains to 1 inch.



5th. C.L.
Line South.
ROSWELL.
Springs
Marsh
Chisum.
25
Comanche Spr.
Salt Sprs.
Dry Lake.
T 10 S.
11
Rio Hondo.
Clark's Spr.
T 11 S.
Mescalero Valley.
Worman's L.
12 S.
12
Dry L.
Bradley.
Spr.
Payton.
Good Bend Crossing.
N
C
O
L
N
13
IRRIGATION & INVESTMENT CO. CANAL
Stillwater.
Redding.
PECOS
14
Rio Feliz.
Selburn.
Springer.
Spr.
Ogden.
Purdy.
Butler's Spr.
T 15 S.
15
22
23
24
25
26
27
28
Calloway.
Cottonwood Cr.
Cottonwood Spr.
27
28
Dry L.
T 16 S.
Mescalero Ridge.
16
Brun.
Spr.
17
Sprs.
Tar Lake.
4th. Guide Meridian East.
Rio Peñasco.
Robbins.
18
Clinton Spr.
Seven Rivers.
RIO PECOS
Gardiner's Spr.
of the
19


Valley
Seven Rivers
Seven Rivers
Seven Rivers.
Seven Rivers.
T20S.
20
28
Gordon's Spr.
Rocky Arroyo.
Sprs.
Edward's Spr.
T21S.
21
Griffin.
EDDY.
Anderson.
22
Dark Cañon.
Dark Cañon.
Juniper Cañon
PECOS IRRIGATION CO. CANAL
Salt L.
Alkali Flat.
Halagueno Ranch.
Ditch.
23
Black River.
Lookout.
Black River St'n.
24
Castle Spr.
Spr.
PECOS VALLEY
L U P
Madrid.
25
Rattlesnake Spr.
Slaughter.
Dry Arroyo.
Flores.
21
22
23
24
25
26
27
28
29
30
31
32
T26S.
26
Pope's Well.
Grape Vine Cr.
Grape Spr.
T E X A S

Report on Irrigation.

STAKED PLAINS AND PAN HANDLE (TEXAS) DIVISION.

ON TRAIN AT PECOS, TEX., *September* 9, 1889.

The committee met pursuant to call of the chairman.

Present, Messrs. Stewart (chairman) and Reagan; also Director Powell.

STATEMENT OF R. K. BRANT, OF PECOS.

The CHAIRMAN. Have you a paper which you desire to present to the committee?

Mr. BRANT. I have a resolution which, though it was not signed by the governor, was passed by the legislature.

It is as follows:

IRRIGATION RESOLUTION.

Concurrent resolution addressed to Senators and Representatives in Congress for passage of such laws as may be necessary to adjust and regulate the rights of citizens of several of the Territories and the State of Texas in the use of waters of interstate streams.

Whereas several rivers having their sources in New Mexico and other Territories flow into and through the State of Texas; and

Whereas the waters of said streams are necessary for irrigation in the arid districts of Texas; and

Whereas it is expedient to obviate future litigation by providing for an adjustment and regulation of the rights of the respective citizens of said State and Territories entitled to the use of said waters for purposes of irrigation: Therefore,

Be it resolved by the legislature of the State of Texas, That our Senators and Representatives in Congress be requested to secure the passage of such laws as may be necessary to effect the objects above set forth.

[Indorsed.]

Concurrent resolution to request our Senators and Representatives in Congress to secure the passage of laws to define and regulate the rights and privileges of citizens of several of the States and Territories and the State of Texas respecting the use of waters of interstate streams.

Adopted by the Senate February 13, 1889.

C. M. BOYNTON,
Secretary of Senate.

Received from the Senate February 14. Taken up, read first and second times, and adopted.

W. M. IMBODEN,
Chief Clerk House of Representatives

THE STATE OF TEXAS,
Department of State:

I, J. M. Moore, secretary of state of the State of Texas, do hereby certify that the within and foregoing is a true copy of the original concurrent resolution adopted by the twenty-first legislature of the State of Texas, at its last session, which adjourned on April 6, 1889, entitled "Concurrent resolution addressed to Senators and Representatives in Congress, for passage of such laws as may be necessary to adjust and regulate the rights of citizens of several of the Territories and the State of Texas in the use of waters of interstate streams;" the said original being now on file in the archives of this department.

Witness my official signature and the seal of State affixed, at the city of Austin, this 2d day of September, A. D. 1889.

[SEAL.]

J. M. MOON,
Secretary of State.

Mr. BRANT. I have also a paper showing the number of canals and their lengths owned by the Pioneer Canal Company in Reeves and Howard Counties.*

There is a small company taking out 50 feet of water by a canal 35 miles long. Then there is a company north of here.

The CHAIRMAN. Have you examined the mountains here to see what the chances are for increasing the supply of water by storing?

Mr. BRANT. I have been in those mountains, and I have no question that reservoirs can be made in the high peaks.

The CHAIRMAN. In the mountains you have flat places where there have been lakes, which discharges through a narrow cañon?

Mr. BRANT. No, I do not call to mind any particular situation of that kind, but I am satisfied they exist.

The CHAIRMAN. You estimate that with the natural flow of the streams you can bring under cultivation how many acres?

Mr. BRANT. Sixty-four thousand acres.

The CHAIRMAN. You think you have enough water for that?

Mr. BRANT. We are the first on the stream, and we can get that if we get our appropriation. Every gallon of water I know is valuable. Our statutes provide for an economical use—a very good way. The consumer does not want to waste the water. There is no disposition on the part of anybody to waste it.

Senator REAGAN. Will you furnish the committee a copy of the laws on irrigation?

Mr. BRANT. Yes.

The CHAIRMAN. How about artesian wells?

Mr. BRANT. We have a fine artesian belt here. Wherever we put down a well we get a flow from 212 to 350 feet. There are about eight or ten wells around this town.

The CHAIRMAN. Have you noticed any diminution in the flow on account of the number of wells that have been sunk?

Mr. BRANT. No; never.

Adjourned.

ON TRAIN AT COLORADO, TEX., *September* 9, 1889.

The committee met pursuant to call of the chairman.

Present, Messrs. Stewart (chairman) and Reagen; also Director Powell.

STATEMENT OF FRANK E. ROESLER, OF DALLAS.

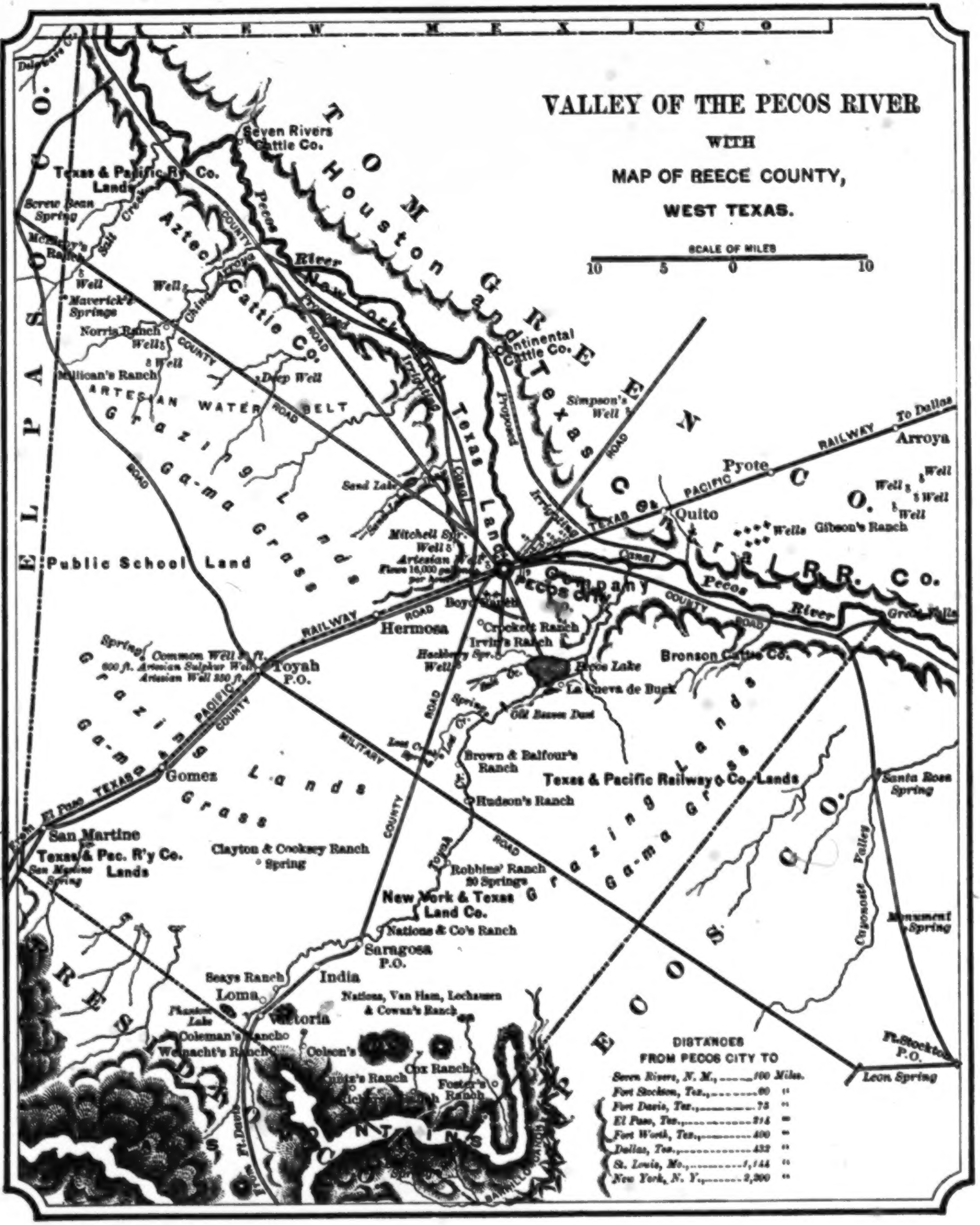
The CHAIRMAN. What is your occupation?

Mr. ROESLER. Secretary to the Marienfeld Fruit Growing, Gardening, and Irrigation Company; also emigration agent of the Texas Pacific Railway.

The CHAIRMAN. Have you given much attention to the subject of irrigation in Texas?

---

* The paper referred to will be found on pages 54 to 57 of this volume.


VALLEY OF THE PECOS RIVER
WITH
MAP OF REECE COUNTY,
WEST TEXAS.
SCALE OF MILES
10
5
0
10
NEW MEXICO
TOM GREEN CO.
EL PASO CO.
PECOS CO.
PRESIDIO CO.
Houston and Texas
Texas & Pacific Ry. Co. Lands
Texas & Pacific Railway Co. Lands
Texas & Pac. R'y Co. Lands
Texas & Pacific R. R. Co.
Seven Rivers Cattle Co.
Aztec Cattle Co.
Continental Cattle Co.
Bronson Cattle Co.
New York & Texas Land Co.
Pecos River
Pecos City
Pecos Lake
Toyah P.O.
Hermosa
Gomez
San Martine
Pyote
Quito
Arroya
To Dallas
Sargosa P.O.
India
Loma
Victoria
Ft. Stockton P.O.
Leon Spring
Santa Rosa Spring
Monument Spring
Public School Land
ARTESIAN WATER BELT
Grazing Lands Gama Grass
Screw Bean Spring
Maverick's Springs
Norris Ranch
Millican's Ranch
Deep Well
Sand Lake
Mitchell Spr.
Artesian Well
Boyd's Ranch
Crockett Ranch
Irvin's Ranch
Hackberry Spr.
La Cueva de Buck
Old Beaver Dam
Brown & Balfour's Ranch
Hudson's Ranch
Robbins' Ranch 20 Springs
Nations & Co's Ranch
Seays Ranch
Nations, Van Ham, Lochausen & Cowan's Ranch
Phantom Lake
Coleman's Rancho
Weinacht's Ranch
Colson's
Cox Ranch
Foster's Ranch
Clayton & Cooksey Ranch Spring
Simpson's Well
Gibson's Ranch
Wells
Common Well
Artesian Sulphur Well
Artesian Well
San Martine Spring
Grass Valls
Cayonosa Valley
MOUNTAINS
Proposed Irrigating Canal
TEXAS & PACIFIC RAILWAY
COUNTY ROAD
MILITARY ROAD
DISTANCES
FROM PECOS CITY TO
Seven Rivers, N. M., 100 Miles.
Fort Stockton, Tex., 60 "
Fort Davis, Tex., 75 "
El Paso, Tex., 214 "
Fort Worth, Tex., 400 "
Dallas, Tex., 432 "
St. Louis, Mo., 1,144 "
New York, N. Y., 2,200 "

Report on Irrigation.

Mr. ROESLER. Yes; I have given it considerable attention.

The CHAIRMAN. Have you reported upon the subject?

Mr. ROESLER. Yes; at various times.

The CHAIRMAN. Is the paper you present your report upon that subject?

Mr. ROESLER. Yes. There are also several other reports that were sent in at various times to Major Hinton, your engineer, which are now in his hands.

The CHAIRMAN. And those reports are all you wish to say about the subject?

Mr. ROESLER. Yes. I would like to add that the reports relating to irrigation published by the department heretofore, are of interest to this State.

The CHAIRMAN. What have you to say in reference to the benefits of engineers' surveys designating the points for reservoirs and making estimates of the cost of construction, etc.?

Mr. ROESLER. A survey of that sort would be of invaluable benefit.

The CHAIRMAN. Would it help to develop Texas?

Mr. ROESLER. Yes; very much. I would like to suggest that the nature of the surveys in this region should be to determine as far as possible: First, the amount and character of the visible water supply like that in the Colorado River, the Rio Grande and Pecos, the Delaware and Olympia Cañons, and a considerable number of small streams that are scattered through the arid regions of Texas. Second, after these, are a number of underground rivers which are known to exist, and could by a little effort be traced. Also in the western portion of Texas, including the Staked Plain, a number of ancient river beds are also worthy of survey, which are now filled with filth and sand, it being demonstrated in many places that water is found in them at a depth varying from 2 to 10 feet. A line of levels run at various places will show that this water now lying under this sand could be carried on to the neighboring uplands and be applied for purposes of irrigation.

The CHAIRMAN. What have you to say about a tank for storing storm waters?

Mr. ROESLER. Through all western Texas, particularly the mountain regions, there are numerous ravines which could be made suitable for storing storm water, which is now lost and useless. That this is practicable is proved by experiments. It is proved on the ranch of C. C. Slaughter, in Martin County, where at an expenditure of $1,700 he has created a tank or reservoir having a width of nearly a quarter of a mile, a length of nearly a mile, and a depth varying from 6 to 20 feet. Much of the water in this tank was lost at first by seepage and by evaporation. It has been observed that the shallower the tank the greater the evaporation; but as the quantity of water augmented and the whole of it remained cooler, the evaporation grew less, and more water was secured. There are various places along the line of railroad where the embankment has crossed the ravine, and it has filled up above and formed lakes. Now, many of these dams could be built so that they would water a considerable area.

The following paper was then read by Mr. Roesler:

THE SUBHUMID REGION OF TEXAS AND ITS FACILITIES FOR IRRIGATION.

It is somewhat difficult in Texas to determine with any accuracy the boundaries of what might properly be called the arid, the semiarid, the subhumid, and humid areas. An arbitrary division by meridians will hardly hold good, because the rainfall varies much at different points along a meridian, and further the altitude is not uniform along the same line. A record of the rain-fall, will hardly suffice, because the observations are of such recent date that they can not be said to be well established. The altitude of the various parts of the State in connection with the rain-fall record as far as observed, seems, therefore, the only available method of determining the boundaries of each area.

THE ARID PORTION OF TEXAS

can by this method be classed as that part of the State in which the altitude ranges between 3,000 and 6,000 feet and in which the rain-fall in a number of years varies between 10 and 17 inches; say all that part of Texas lying between the Pecos and Rio Grande Rivers, and in which farming is impossible, except by irrigation.

THE SEMI-ARID REGION

should by the same method be designated as that part of Texas having an altitude varying between 2,000 and 3,000 feet, and possessing a rain-fall of 17 to 30 inches per annum; enough in quantity to mature any crop, provided the rain-fall was timely and properly distributed, a section of country that will mature all kinds of forage plants to perfection, without resort to irrigation, and will produce good small-grain crops in favorable years, say four years out of six. An irregular line drawn from east boundary Hansford County, touching altitudes of 2,000 feet to the Colorado River in Mitchell County, and thence southerly to the Rio Grande, would about indicate the east boundary, and the Pecos River the west boundary of the semi-arid region. This territory is more particularly described in a previous paper on the Irrigation of the Texas Staked Plain.

THE SUB-HUMID REGION

according to the same rule might be safely indicated as lying immediately east of the semi-arid region, its western boundary being described as the eastern boundary of the semi arid part of the State. It might, perhaps, be better described by saying, that it is an irregular line lying near the one hundredth meridian, crossing the same at various points, but seldom being more than 50 miles on either side. The eastern limit of the subhumid region might be shown by the irregular line trending southerly from the southeast corner of Montague County to San Antonio, passing by way of various points along that line having an altitude of about 1,000 feet above sea-level.

The rain-fall of the subhumid region as noted by the various Government and private observations, made during a series of years, is about as follows:

Brackettville, Kinney County, 29.12 inches; Coleman, Coleman County, 27.71 inches; Fort Concho, Tom Green County, 25.07; Decatur, Wise County, 28.63 inches; Fort Griffin, Shackelford County, 24.75; Fort McKavett, Menard County, 22.71 inches; Graham, Young County, 25.11 inches; Henrietta, Clay County, 22.73 inches; Jacksborough, Jack County, 26.20 inches; Fort Elliott, Wheeler County 28.38 inches; Baird, Callahan County, 22.37 inches.

The average rain-fall is 24.96 inches, as shown by the information at hand. The smallest precipitation was rated at Baird, in 1886, when the total rain-fall only amounted to 16 inches, and the greatest was rated at Fort Concho, Tom Green County, in 1885, when it amounted to 42.67 inches. It will be readily observed that in the matter of quantity, the subhumid region is as well provided for as are the best agricultural portions of the United States.

It does not appear that such crop failures as have been encountered were due in any measure to a lack of precipitation, but rather to the want of discretion on part of the rainmaker in a proper distribution of the same. The conditions of the precipitation in Texas are peculiar and well defined.

The conditions of temperature, altitude, and direction of the winds determine the time as well as the quantity of the rain-fall in the various portions of the State, as may be readily observed from a study of its climatology. A mild winter in Texas almost invariably means a moist spring in the subhumid region, and an excess of rain-fall in eastern and southern Texas. A long, cold winter generally means a rather dry spring in the subhumid, and a moderately moist spring in the humid region. Nearly all of the moisture precipitated in Texas is derived from the Gulf of Mexico, over which the rain clouds are formed and then drifted northward and westward as far perhaps as northern Kansas or Nebraska and eastern Colorado. The Staked Plain, the Pan Handle, where the altitude is over 3,000 feet, and the mountain ranges of El Paso County and New Mexico may be properly called the weather breeders of the State. As spring opens in Texas generally in February the low-lying lands of the eastern and southern parts of the State warm up first under the genial influence of the sun. The prevailing winds are then from the south, spreading out fan-like as they proceed northward. They are warm, and carry much moisture, which is dissipated in Kansas, Nebraska, and northward; as the cooler temperature of these States is encountered, at intervals of about two weeks during each spring, a norther will sweep southward, pushing before it the moist clouds from the Gulf. The vapors are suddenly condensed, causing a snow-fall in Kansas, and a day or two later, heavy rains in eastern and western Texas. The blizzard will continue on to the Gulf, and a few days later return in a greatly demoralized condition. The warm south wind is pushing it northward, and the line of contact between the opposing winds is the source of another rain-fall; a wet norther generally brings with it about a week's rain. For about two weeks following the norther there will be mild, balmy spring weather, and then another norther may be expected, bringing with it another rain or cold, windy, and disagreeable weather. During February and half of March the humid region gets nearly all the rain that falls. In March and April the subhumid region begins to share in the rain-fall, and by the middle of April it has warmed up sufficiently to attract a goodly portion of the rain clouds. The winds have shifted more to the westward, and carry much more moisture there than they did the month before. Vegetation in eastern and southern Texas has generally obtained a fair start in March, and corn is well up. The subhumid region shows signs of awakening about a month later than the humid region. Between April and May the Staked Plain, or semi-arid region—altitude 2,000 to 3,000 feet—has warmed up, and partakes copiously of its semi-monthly potations of rain-water, and about the end of May wears its Sunday clothes, the whole plain being a carpet of flowers, consisting of hundreds of varieties, many of surpassing beauty. Between June and July the moist Gulf winds have reached the mountain ranges of El Paso County and New Mexico, and the heavy rains of the arid part of Texas may then be expected. In the interval between February and the end of June the greater portion of the precipitation is dependent upon the northers, which seem to come between the 5th and 9th and the 17th and 21st days of each month, bringing with them a sufficient lowering of the temperature to cause precipitation. Between June and September a change of temperature is also noticeable about the same time in each month, but the change is not sufficiently pronounced to cause rain-fall. To ascertain what relation there is between these constantly recurring northers and the changes of the moon would be an interesting study. Between June and September, much of the precipitation is subject to purely local causes, as in midsummer the thermometer ranges equally high in all parts of the State, though there is a material difference in the humidity of the air. As far as personal comfort goes, a temperature of 100° Fahrenheit at an altitude of 2,000 feet is far more agreeable than a temperature of 80° at an altitude of 500 feet.

During midsummer rainbearing clouds are nearly always in sight in the subhumid, semiarid, and arid regions, and anything that will cause a disturbance of the equilibrium of the temperature will bring about a rainfall. It has been frequently observed that the evaporation from a dry water-course, or a field in cultivation will chill a passing cloud sufficiently to cause a heavy local shower. A sandy tract of land absorbing more heat than the surrounding densely grassed lands will frequently cause local winds to rise, which coming in contact with a passing cloud will cool it by evaporation of part of the moisture of the cloud itself, and cause a general disturbance of the equilibrium of temperature and bring about a heavy rainfall, extending sometimes over several hundred miles. A prairie fire extending over several miles of country has been observed to have a similar effect. In the mountain region the average annual rainfall on the level mesa lands does not exceed 12 inches, but on the mountains it rains often and the showers are nearly always heavy. one single rain sometimes equaling 12 to 18 inches. It appears that owing to their great altitude the mountains are always cooler than the clouds, and whenever they come in contact the clouds are sure to be robbed of nearly all their moisture. It is a well known fact that all the mountain ranges of El Paso have their springs and their verdure on the eastern slope, and none worth mentioning on the western side. It seems also, that during the summer months the gulf winds are deflected northeastwardly by the mountain ranges of New Mexico, as it is claimed by residents of western Kansas and the northeastern Pan Handle of Texas, that their heaviest summer rains nearly always come from the southwest. From August to December the rainfall gradually decreases in western Texas. The highest elevations west of the Pecos River lose their heat first. Their ability to attract the moist winds from the gulf decreases and the rains become fewer and lighter, and after August very little rain is expected. In the semi-arid region heavy fall rains are usually expected up to the middle or end of November, subject to the semi-monthly northers. In the subhumid region heavy rains will generally come until December 25th. In January and February very little rain is expected. The routine work of the norther is occasionally disturbed by a general rain covering all the Gulf States, but these as a rule are too irregular to cut any figure in the general weather system of the State. About the 1st of January winter sets in in earnest. Two to 6 inches of snow in northern Texas, 2 to 4 inches occasionally on the Staked Plain, heavy snows on the mountain sides, and hardly any on the mesas in

6

El Paso County; heavy rains in eastern and southern Texas during the prevalence of a norther usually constitute a Texas winter. The temperature rarely falls below zero, though it sometimes reaches 4 to 6 degrees below. An ordinary norther in midwinter generally ranges a few degrees above or below freezing point, and seldom lasts longer than a week.

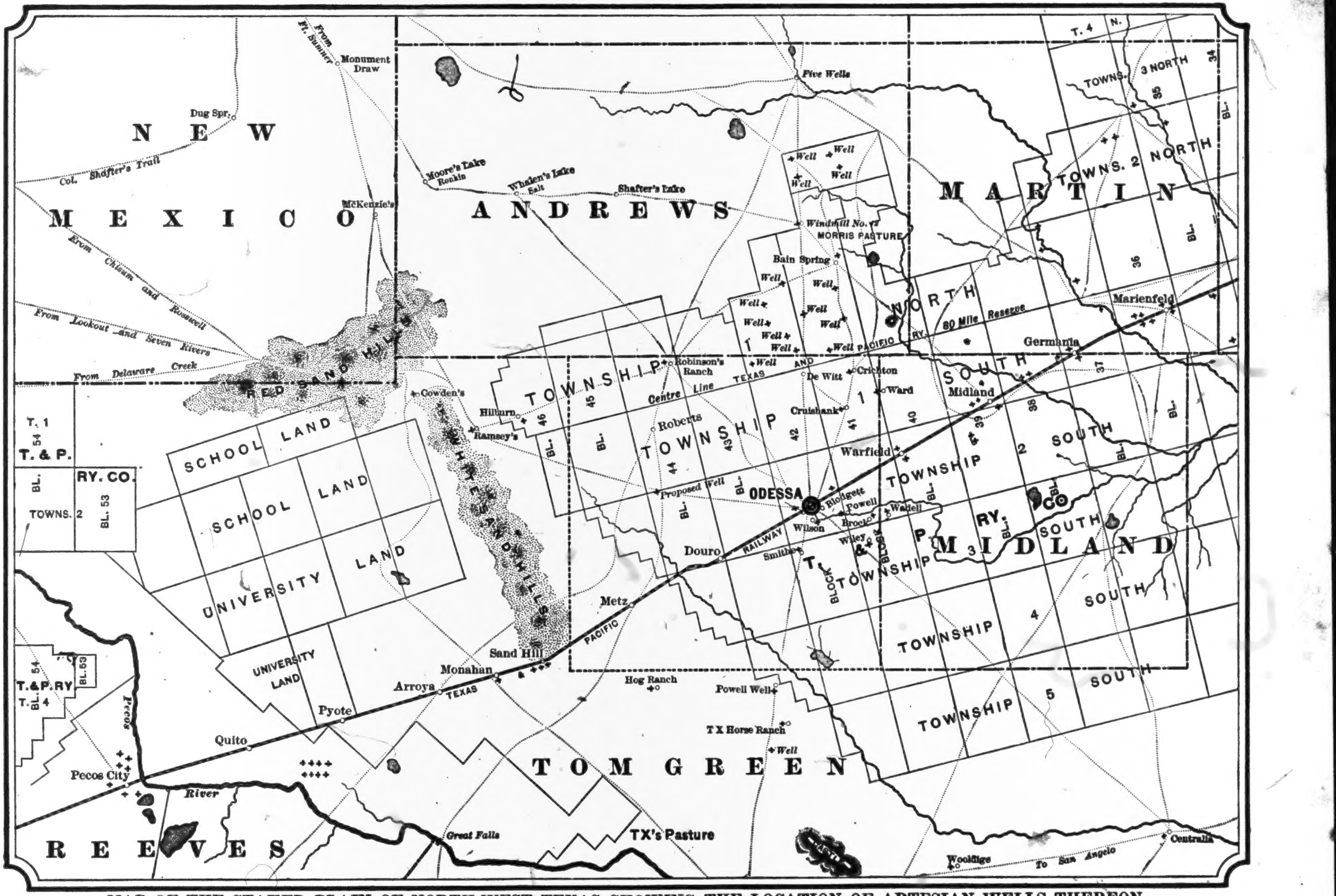
TOPOGRAPHY OF THE SUB-HUMID REGION.

A profile of the Texas and Pacific Railway will show the following changes in altitude, proceeding westward from Brazos River: Brazos crossing, 750 feet, but at Lamber, 30 miles east, nearly 1,200 feet; at Gordon, 875 feet; at Strawn, 900 feet; at Ranger, 1,425 feet; at Eastland, 1,500 feet; at Baird, 1,700 feet; at Clyde, 2,025 feet; at Abilene, 1,700 feet; at Merkel, 1,875 feet; at Trent, 1,920 feet; at Sweetwater, 2,175 feet; at Loraine, 2,297 feet, and at Colorado River crossing of the Texas and Pacific Railway, 2,075 feet. The surface of the northern part of the subhumid region in general presents large expanses of gently undulating prairies, broken in a few places by stretches of rolling and hilly land, and along the water-courses by small areas of rough and broken land; about four-fifths of all the land is suitable for cultivation. The soil on the uplands or table-lands is generally red or chocolate colored loam, of great fertility. The river and creek valleys have dark and black loams, generally heavier than the uplands. Along Red and Brazos rivers the soils are usually a bright red in color, but quite as fertile as the best black lands. On the uplands are numerous mesquite flats, or nearly level tracts, which generally have heavier and darker sandy loams than the adjacent tracts. On the ridges or local divides, between the smaller water-courses, are narrow strips of red or grayish sand, commonly known as shinneries.

The native vegetation of the black or dark valley lands, or of the nearly level mesquite flats, is generally the short, curly mesquite grass. The more mellow red and chocolate lands are usually covered with gramma and other varieties of grasses, while the sandy lands carry from fifty to seventy-five different varieties of native grasses, as well as an unlimited number of flowering weeds, mesquite, shrubs, chapparell, uno de gato, post oak, live oak, shin oak and sedge grass 6 to 7 feet high, grow on these lands in the greatest profusion. The soils, considered from an agricultural point of view, are very well adapted to general farming, and ordinarily produce, without resort to irrigation, the following crops per acre: wheat, from 20 to 30 bushels, frequently 40 bushels, weighing from 61 to 63 pounds to the measured bushel. In isolated cases 45 and 50 bushels have been made. Corn yields from 20 to 45 bushels, and if the rain comes "just right" 60 and 70 bushels. Oats run from 50 to 65 bushels per acre, but 100 to 110 bushels are frequently made by a few individuals. Cotton is grown as far west as the Colorado River, in Mitchell County, and quantity per acre and quality are considered equal to that of any other part of Texas; a crop of some kind has been made in every year since 1882, excepting the droughty years of 1886 and part of 1887. The unusual duration and exceptional severity of this drought is perhaps best illustrated in the fact that in parts of Eastland and Callahan counties thousands of forest trees, which had reached an age of thirty to forty years, withered and died, showing that there had been no such drought in their lifetime, or within thirty to forty years before. As to the drought-resisting qualities of the various soils, it can be said that the black river-bottom soils have the advantage of natural subirrigation, and will resist a short spell of dry weather easily. The black or dark mesquite flats produce equally as well as the river bottoms, but during a severe drought will suffer considerable, often reducing the yield to one-fourth or one-half crop. The mellow and porous red lands of the table lands, while probably not so rich as the black bottom lands, will in time of dry weather make a better and larger crop than any of the lands above mentioned. The ridge soils, are sandy "shinneries," retain moisture to a remarkable degree, and while apparently thin and poor in quality will withstand a drought almost indefinitely. No fruit trees or vines planted on these lands have succumbed to the drought of 1886–'87, and all that was harvested during this period was grown on shin oak land. The timber of the subhumid region is mainly found in the "upper cross timbers," a belt of oak forest extending from Red River southward for a distance of 100 miles or more, and varying in width from 5 to 50 miles. This forest consists in the main of live oak, black jack, post oak, red oak, shin oak, and a few other varieties. The Texas and Pacific Railway passes through the upper cross timbers between Weatherford and Baird. Small local areas of timber of other kinds are found in nearly all counties, and consist of pecan, elm, hackberry, cottonwood, cedar, chittim, wild china, etc. East of Clyde Station there is timber in abundance for all uses of the farm. West of this point there is enough timber for fuel, but the country is essentially open prairie, except in the river and creek bottoms.

WATER SUPPLY AND IRRIGATION.

To a direct question as to whether or not a farmer can hold his own in the subhumid region of Texas, without resorting to irrigation, I should certainly reply in the affirmative. Taking one year with another, I think it perfectly safe to make the


NEW MEXICO
ANDREWS
MARTIN
MIDLAND
TOM GREEN
REEVES
From Ft. Sumner
Monument Draw
Dug Spr.
Col. Shafter's Trail
McKenzie's
From Chisum and Roswell
From Lookout and Seven Rivers
From Delaware Creek
RED SAND HILLS
WHITE SAND HILLS
Moore's Lake Rokkin
Whalen's Lake Salt
Shafter's Lake
Five Wells
Well
Windmill No. 12
MORRIS PASTURE
Bain Spring
T. 4 N.
TOWNS. 3 NORTH
TOWNS. 2 NORTH
TOWNS. 1 NORTH
80 Mile Reserve
Marienfeld
Germania
Midland
PACIFIC RY.
TEXAS AND PACIFIC RAILWAY
Centre Line
Robinson's Ranch
De Witt
Crichton
Ward
Cruishank
Cowden's
Hilburn
Ramsey's
Roberts
TOWNSHIP 1 SOUTH
TOWNSHIP 2 SOUTH
TOWNSHIP 3 SOUTH
TOWNSHIP 4 SOUTH
TOWNSHIP 5 SOUTH
Warfield
Proposed Well
ODESSA
Blodgett
Powell
Wadell
Brock
Wilson
Wiley
Smithers
Douro
Metz
Sand Hill
Monahan
Arroya
Pyote
Quito
Pecos City
Pecos River
Great Falls
TX's Pasture
Hog Ranch
Powell Well
TX Horse Ranch
Woolidge
To San Angelo
Centralia
T. & P. RY. CO.
SCHOOL LAND
UNIVERSITY LAND
T. 1
BL. 54
T. & P.
RY. CO.
BL. 53
TOWNS. 2
T. & P. RY
T. 4
BL. 34
BL. 35
BL. 36
BL. 37
BL. 38
BL. 39
BL. 40
BL. 41
BL. 42
BL. 43
BL. 44
BL. 45
BL. 46
BLOCK

MAP OF THE STAKED PLAIN OF NORTH-WEST TEXAS, SHOWING THE LOCATION OF ARTESIAN WELLS THEREON.

Artesian wells are marked +.

Report on Irrigation.

assertion, that notwithstanding the fact that the sub-humid region has passed through a most severe period of drought, the aggregate losses by drought of each acre under cultivation, compared with another acre located in Eastern Texas, will amount in dollars and cents to less in the subhumid region, during a period of seven years, than do the losses in Eastern and Southern Texas by reason of excessive rainfall. In the subhumid region there have been two total failures and an occasional partial failure of crops. In Eastern and Southern Texas there have been partial failures nearly every year, and it is a rare occurrence that a full crop of all that has been planted is secured. A total failure of all crops in the humid region is not known, but a perfect crop of corn, cotton, wheat, oats, and fruits, from the same farm in the same year is a very rare occurrence though the subhumid region has produced such several years in succession. The question of farm drainage by ditching and tiling in Eastern and Southern Texas is becoming more and more pressing each year. If it rains too much and the crop is in danger of spoiling, it is too wet to cut a ditch, and when it is dry weather, the East Texas farmer doesn't need a drainage ditch. The farmer in the subhumid region is slowly availing himself of the natural facilities rendered for irrigation, and is gradually realizing the fact that a liberal water supply applied to a crop at the right time will bring a cash dividend much quicker than a dozen protracted prayer meetings. One or two irrigations of 2 or 3 inches each on the level, will make a full crop every year, and for some years in succession no irrigation will be needed. There is in all counties a critical moment, when the precipitation or absence of rain will decide the fate of the crop. No portion of the United States is better provided with the facilities for overcoming this critical moment by an occasional irrigation than is the subhumid region of Texas.

Small grain generally will pull through without irrigation, and cotton likewise. Corn could be doubled in yield if irrigated occasionally. Fruits and vegetables could be grown with absolute certainty, but in addition to these, hops and many other high-priced commodities could be grown to perfection. Instead of growing one garden crop, the subhumid farmer should grow three. The storage capacity of the subhumid region is enormous, and the rain-fall necessary to utilize this capacity is ample. Very few places exist in which there is not sufficient water for 5 up to 160 acres under irrigation. The Red River, Brazos, Colorado, and Conchos, and their numerous affluents afford water in abundance all year round. The headwaters of these affluents carry water part of the year, and could be easily dammed and made available for the whole year. In the more hilly portions are many hundred depressions that catch the drainage of a large area, and could be made to store immense quantities. Springs are found in nearly all counties, and are becoming more numerous since the land is placed in cultivation. Water in ordinary dug or bored wells is found in almost all places where sought for, and by the use of wind-mills could be raised to the surface and be used for irrigation. The drought of 1886–'87 brought to light a few points of interest bearing on the underground water supply. In 1886 the drought extended over the entire subhumid region. The Black Wax belt of Texas, extending from Weatherford to Mineola, and from Red River to the latitude of Austin, received sufficient rain-fall to mature crops. East of the Black Waxy region, both in Louisiana and in southern Texas, as far as the Gulf coast, the weather was exceptionally dry. Of all the wells dug or bored between the Pecos and Sabine rivers, none were affected by the drought except a considerable number of wells in Shackelford, Eastland, and Callahan Counties, which temporarily lost their water. The wells in the counties east and west did not show any diminution of their supply during the drought. In August and September heavy rains began to fall in southern and eastern Texas, while none fell in the subhumid region, which is from 500 to 1,000 feet higher. The dry wells in Shackelford, Eastland, and Callahan Counties, within a few days were again supplied with water, though no rain had fallen in the neighborhood or at any point of greater altitude within 600 miles.

The filling of the wells was at the time a subject of remark, and was not explained. The only explanation possible is, that the waters from the mountains of New Mexico and Colorado find their way to the Gulf of Mexico through underground channels, and that they maintained an unobstructed flow southeastward during the entire period of drought. Wherever the strata lay close enough to the surface to be dug or bored into, they furnished an unlimited supply of water. In places where the channels lay deeper the underground waters were not reached, as in the counties mentioned, but the wells were dependent on the local rain-fall. In a wet year in eastern and southern Texas, the underground channels become clogged through the pressure of the water above them, and as the water lies between impervious strata and can not find a ready outlet, it causes the backwater to rise a thousand feet or more. The wells in the counties mentioned were therefore filled by the water coming from New Mexico and Colorado, which could not find an unobstructed flow to the Gulf of Mexico. If there had been no drought in southern and eastern Texas, as well as in the subhumid region, the supply in the wells of Callahan, Shackelford, and Eastland Counties would have remained normal whether it rained or not in western Texas. As a further proof that there exists an underground system of rivers extending from the mountains of El Paso County, New Mexico, and Colorado to the Gulf, it can be said that a considerable number of these underground streams have been discovered in various portions of Texas; but perhaps the best evidence of an underground connection between the mountains and the Gulf, is shown in the famous "Breathing Well," at Eagle Flat in El Paso County, Tex. This well is distant about 550 miles from the nearest point on the Gulf coast. Its altitude above sea-level is 4,500 feet. A boring of 300 or 400 feet was made in the hope of finding water, but instead, an underground cavern was discovered, and the work of boring discontinued in consequence. With the removal of the boring apparatus it was discovered that for a number of hours a current of air would be forced out of the bore-hole, and that later in the day there was great suction of air into the cavern. This process repeats itself every day. The only way to account for the "breathing" of the well is that the lower end of this cavern is alternately filled with water, and again emptied by the tides of the Gulf, over 500 miles away. An examination into the mysteries of the underground rivers, channels, and deposits of water, is of importance, not only from a commercial and agricultural, but also from a scientific point of view, and merits much more attention than is now given the subject. The artesian waters lie deep in the subhumid region, and but few wells of limited capacity have been bored. It is thought, though, that artesian water can be had by borings of proper depth. The upland prairie farmer will have to depend in a great measure on his well and wind-mill, and will generally find enough water for his purposes. The writer understands perfectly well that a 160-acre farm can not be irrigated from a common barn-yard well, and knows also that not one in five hundred farmers is financially able to bore or dig enough wells and erect enough wind-mills to irrigate such an acreage. There is nothing in the way, however, to prevent the subhumid farmer from successfully irrigating 5, 10, or 20 acres, and to plant on this irrigated land such crops as will bring the highest possible market prices. If he will not grow for the market, he can to almost absolute certainty raise all the food products needed for home consumption. In a droughty year, like 1886–'87, he may not make any money, but will always have enough to maintain his household, and thus avoid becoming an object of charity. He can still raise wheat, corn, cotton, hay, and forage generally on his dry land, but his irrigated patch will secure him a money return of five times the value per acre, than will his dry land under cultivation. Having neither topographical maps of the respective subhumid counties, or detailed information as to the exact location of water supply, or storage sites at hand, this report is more general in its character than it should be, but it is hoped that some information may be found therein that may be of use.

Adjourned.

ON TRAIN FROM MIDLAND, TEX.,
September 9, 1889.

The committee met pursuant to call of the chairman.

Present, Messrs. Stewart (chairman) and Reagan; also Director Powell.

STATEMENT OF B. F. WILLIAMS, OF FORT WORTH.

The **CHAIRMAN**. How is agriculture prosecuted in this section of the country?

Mr. **WILLIAMS**. In various ways. There has been a good deal of experiment here with farming in different ways, but they are trying mostly to demonstrate it here by irrigation; but it has been very poorly prosecuted, take it as you may.

The **CHAIRMAN**. Can you raise crops here without irrigation?

Mr. **WILLIAMS**. You can when you have any season for it.

The **CHAIRMAN**. How often do the seasons prove favorable?

Mr. **WILLIAMS**. Once in four years.

The **CHAIRMAN**. As often as that?

Mr. **WILLIAMS**. Yes, I think so.

The **CHAIRMAN**. What do the people do in the meantime?

Mr. **WILLIAMS.** Some of them try it—keep making experiments, but do not do anything.

The **CHAIRMAN.** What success have you had by means of irrigation?

Mr. **WILLIAMS.** From my own observation there has been very little success. So far as experiments have been made they have been satisfactory.

The **CHAIRMAN.** How many wells are in this vicinity?

Mr. **WILLIAMS.** For irrigation purposes?

The **CHAIRMAN.** Yes; for irrigating gardens or anything of that kind.

Mr. **WILLIAMS.** There are three here that I know of.

The **CHAIRMAN.** We have seen more than that.

Mr. **WILLIAMS.** They are not for irrigation. I only speak of what I have seen—the results of my own observation.

The **CHAIRMAN.** You have seen three?

Mr. **WILLIAMS.** Yes.

The **CHAIRMAN.** What size wells were they?

Mr. **WILLIAMS.** Six inches in diameter.

The **CHAIRMAN.** Do you know how deep?

Mr. **WILLIAMS.** No, I can not tell you the exact depth at Midland.

Mr. **GEORGE E. BRIGGS.** The depth of the water is 70 feet.

The **CHAIRMAN.** With the three wells that you have observed here for irrigation purposes, what do you raise?

Mr. **WILLIAMS.** Well, fruits, vegetables, and different kinds of crops by means of irrigation.

The **CHAIRMAN.** How do the fruit trees get along?

Mr. **WILLIAMS.** They do exceedingly well. I have noticed more trees this year that had as much as 5 feet of growth on them than heretofore. They were peach trees.

The **CHAIRMAN.** Did they get that much growth in one year?

Mr. **WILLIAMS.** Yes; I can show you cottonwood irrigated a very little, with 10 feet of growth.

STATEMENT OF GEORGE E. BRIGGS, OF COLORADO.

The **CHAIRMAN.** You have lived at Midland?

Mr. **BRIGGS.** Yes.

The **CHAIRMAN.** Are you acquainted with the wells run by windmills in Midland?

Mr. **BRIGGS.** Yes.

The **CHAIRMAN.** Will you state about what amount of water is thrown out by the different wells, and the size of the windmills?

Mr. **BRIGGS.** As a rule they use 12-foot mills; that is, for stock purposes and for domestic use. They do not irrigate. I irrigated 2½ acres and subirrigated the trees that I planted out a year ago this April. This season they bore fruit. I had one tank that held about 46 gallons of water. I had it shut off half the time, and more too, I judge.

The **CHAIRMAN.** If you had saved all the water during the year with a suitable tank how much land could you have cultivated with a 12-foot mill?

Mr. **BRIGGS.** I think a man could irrigate by subirrigation 10 acres. That is of course quite different from surface irrigation, that is by saving all the water that a 12-foot mill would pump.

The **CHAIRMAN.** What do you say of this locality for fruit?

Mr. **BRIGGS.** The finest I ever saw for peaches, plums, and lemons

The **CHAIRMAN.** How are the pears?

Mr. **Briggs**. The trees that I have seen at Colorado have no fruit, but they grow finely. In Colorado they grow abundantly.

Senator **Reagan**. How with regard to grapes?

Mr. **Briggs**. They do remarkably well. The California and European grapes do as well as they do in California. So people tell me.

Senator **Reagan**. Have any of them been cultivated long enough to produce fruit?

Mr. **Briggs**. Yes, fine. I have some put out a year ago last March, and they bore a quantity of grapes.

Senator **Reagan**. What kind?

Mr. **Briggs**. The Muscat and Black Prince. I do not know the varieties. I bored a well on the Staked Plain.

Senator **Reagan**. What material did you go through?

Mr. **Briggs**. Lime rock, principally.

Senator **Reagan**. At what depth did you strike lime rock?

Mr. **Briggs**. It varies from 15 to 30 feet. I have one well 30 feet.

Senator **Reagan**. How thick is the lime strata?

Mr. **Briggs**. Well, it varies. I can not tell you that; I do not know how thick it is.

Senator **Reagan**. But you go through it?

Mr. **Briggs**. Yes, go through it.

Senator **Reagan**. Before you get your well?

Mr. **Briggs**. Yes, it is from 40 to 70 feet deep.

Senator **Reagan**. And the lime rock is 30 to 50 feet?

Mr. **Briggs**. Yes; and there is some red clay. I think the rock, as a rule, is not over 10 or 12 feet, and then they strike another layer.

The **Chairman**. In what do you find the water?

Mr. **Briggs**. The best water is found in this white gravel. If you go to that depth you will strike it at 68 feet.

The **Chairman**. After passing through lime rock you strike gravel?

Mr. **Briggs**. Yes.

The **Chairman**. White gravel beneath the lime rock furnishes the water.

Mr. **Briggs**. Yes; and you can not exhaust it. I have let my well run for ten days at a time and never exhausted the water.

The **Chairman**. Does the water rise in a pipe?

Mr. **Briggs**. About 30 feet—stands that way. The lime rock is very shaly and porous. It will absorb an immense amount of water. It would rise much higher if that were a solid mass.

Adjourned.

Toyah, Tex., *September* 9, 1889.

The committee met pursuant to call of the chairman.

Present: Messrs. Stewart (chairman) and Reagan; also Director Powell.

STATEMENT OF H. H. CLOUD, OF EDDY, N. MEX.

The **Chairman**. What is your occupation?

Mr. **Cloud**. Civil engineer.

The **Chairman**. On what works are you now engaged?

Mr. **Cloud**. The Pecos Irrigation and Investment Company's canal.

The **Chairman**. Where is that canal?

Mr. **Cloud**. One is located about 5 miles from Roswell, taken out in Lincoln County, N. Mex. It is taken from the Pecos and Hondo Rivers.

The length of it will be 37 miles to 40 miles, when completed, and will cover about 100,000 acres of land. The lower canal is in the same county, but it will also be in Eddy County, N. Mex. It is projected to be 50 miles in length.

The **CHAIRMAN**. Will that get into Texas?

Mr. **CLOUD**. No, it will cover about, as contemplated now, 100,000 acres of land.

The **CHAIRMAN**. Will that exhaust the capacity of the river?

Mr. **CLOUD**. It will not.

The **CHAIRMAN**. Is there a large amount of water running in the river?

Mr. **CLOUD**. There is an extraordinary amount of water.

The **CHAIRMAN**. In flood times how is it?

Mr. **CLOUD**. Very large.

The **CHAIRMAN**. Has it been gauged?

Mr. **CLOUD**. I think it has been in flood time. Mr. Nettleton has the figures on that. He is Mr. Powell's assistant, on the irrigation survey.

The **CHAIRMAN**. He has the gauging of the river?

Mr. **CLOUD**. Yes.

The **CHAIRMAN**. How much land is there on the Pecos that might be irrigated, if there were water enough?

Mr. **CLOUD**. I can not say; but it is practically inexhaustible.

The **CHAIRMAN**. Practically unlimited?

Mr. **CLOUD**. Yes.

The **CHAIRMAN**. What are the opportunities for storing the waters of the river and increasing the volume?

Mr. **CLOUD**. They are very excellent. I know where water reservoirs could be constructed, where 5,000,000 cubic feet of water could be stored.

The **CHAIRMAN**. What is the character of the country for reservoirs? Explain a little more particularly.

Mr. **CLOUD**. Immediately above our lower canal there are places where the bluffs come in toward the river, and by damming at those points we can make extensive reservoirs. We have not had the exact surveys except on one, and if we make our dam at that point it will have a capacity of 500,000,000 cubic feet.

The **CHAIRMAN**. What is the character of the land on the Pecos, in New Mexico and Texas?

Mr. **CLOUD**. Well, it is a lime soil. I have been here but four months at the canal itself.

The **CHAIRMAN**. Have you any knowledge of the fertility of the soil?

Mr. **CLOUD**. Mr. Shields, at Las Cruces, has made experiments, and so has Mr. Eddy, and I know they grow large crops at Rosswell. They have very fine orchards, and they yield immensely.

The **CHAIRMAN**. And generally it is good land?

Mr. **CLOUD**. Yes; and will produce all sorts of crops. They say it is very fine for fruit and grapes and things like that.

The **CHAIRMAN**. Do wheat and corn grow generally?

Mr. **CLOUD**. Yes; corn, potatoes, and crops of that kind.

The **CHAIRMAN**. Is there anything further that you could state?

Mr. **CLOUD**. It seems to me that the opportunities here are exceedingly great for investments of this kind.

The **CHAIRMAN**. There are opportunities for reclaiming the land?

Mr. **CLOUD**. Yes. At Pecos you will find another ditch under construction. The engineer of that is Mr. Wood. He is not here now.

Adjourned.

FORT WORTH, TEX.,
September 11, 1889.

The committee met pursuant to call of the chairman.

Present, Messrs. Stewart (chairman) and Reagan; also Director Powell.

STATEMENT OF W. S. MARSHALL, OF FORT WORTH.

The CHAIRMAN. Are you familiar with western Texas, the water supply, and the chances for irrigation in that region?

Mr. MARSHALL. Yes, I am somewhat.

The CHAIRMAN. Make your statement in your own way.

Mr. MARSHALL. I have worked in western Texas putting in wells, erecting windmills, in stock raising, and developing the water supply there for four years. I can give you a map of the country in which we have done most of our work. This country here and in Pecos County, Reeves County, El Paso County, Crockett County, Tom Green, and all of Old Tom Green, including the six or seven new counties, we have something like six hundred wells. I traveled over this country, 9,000 miles, in my buggy and investigated it personally.

The CHAIRMAN. Describe the country.

Mr. MARSHALL. Starting at the south here through Pecos County and Tom Green an abundant supply of water is to be had. We will take at Dryden, on the Southern Pacific road—the well is 1,800 feet, and the water after they struck it came within 600 feet of the surface. We built some wells north of Dryden on the Pecos, one of them 650 feet. That was connected with three more from 300 to 500 feet. We have got to go a great depth for water in that county.

The CHAIRMAN. Is it good water and plenty of it?

Mr. MARSHALL. Yes, at 1,800 feet. Then north of there, at Pecos City, we got flowing water. Every well we put down—the deepest was 275 and the shallowest was 235 feet.

The CHAIRMAN. What did you go through?

Mr. MARSHALL. At Pecos we struck no hard rock at all. There are gravel veins, thick sand, and hard clay. Then there is an alkali, we call it; but it is a sort of decomposed lime. I thought it was alkali, but the State geologist gives no record in his report. There is no rock at Pecos City, but there is rock in the southern part of Pecos County.

The CHAIRMAN. There was a radical change of formation then in these shallow wells.

Mr. MARSHALL. Where we got the flows?

The CHAIRMAN. Yes.

Mr. MARSHALL. I would not call it a radical change. We struck a very hard substance; it was not a rock; it was hard pan. It was what I call a clay hard pan. That was only 18 inches thick, and as soon as we broke through that the water commenced to flow.

The CHAIRMAN. That is what held the water down?

Mr. MARSHALL. It is a 3-inch hole, and it flows 350 gallons a minute. Those wells are very strong. Now, working north, take the center of the Staked Plain as a sample, and there is a vast change in the country; it is what gives the country the name of Staked Plain. But north of here the cactus and Spanish bayonet and all that sort of vegetation disappears, and you come on to a perfect type of prairie, such as you find in Nebraska and Iowa. The mesquite and gramma grasses grow there, and the lay of the country is exactly the same and the formation is the same, as I found putting in wells in Iowa. There we strike water in abundance. In Hockley County, for instance, we never made a failure in finding the water, and I know there are fifty wells we put wind-mills on.

The CHAIRMAN. At what depth?

Mr. MARSHALL. One hundred seventy-five feet; the shallowest is 35 feet. The average will be 100. None of them are as deep as 200 feet. The water very seldom rises there except in the northwest corner, where there is a valley and where there are surface veins at 100 feet, and a flow of 200 gallons a minute. Those were the only two flowing wells. In Hale County the wells run shallower, not over an average of 50 feet in the whole county. In Crosby County they run 100 feet, and in the west part of Lubbock, you go 300 feet to get good water. But all through this country there is an abundance of good water when you get down to it, and that is within 400 feet.

Senator REAGAN. Do you know of a flowing well north of this point?

Mr. MARSHALL. I do not know of any.

Senator REAGAN. Is there not a flowing well north of Washburn?

Mr. MARSHALL. No; I do not know.

Senator REAGAN. Where is it?

Mr. MARSHALL. I do not know of a flowing well on the railroad.

Senator REAGAN. The newspapers have it reported that there is one.

Mr. MARSHALL. At Washburn we have fitted up a pump for the railroad. I am not sure whether I am right about Washburn. I do not think there is a well on the Denver and Fort Worth road in Texas, except it may be in Fort Worth.

The CHAIRMAN. What have you to say as to water tanks, etc.

Mr. MARSHALL. The drainage of that country is in basins or surface lakes. There is no place where the water will flow across and run to important streams, but it runs in basins. It is like a saucer. The drainage water that falls in the different seasons of the year goes into those basins, and either evaporates or goes away with the underground drainage. The rain-fall there is a great deal more than in the center and lower ground.

Senator REAGAN. What is the topography of that country through there?

Mr. MARSHALL. A rolling prairie country.

Senator REAGAN. No mountains?

Mr. MARSHALL. No. [Indicating on the map.] There are very few passes. You can not drive upon the plains in some places. It is a wall right up and down, and at other places it is breaking away—the earth, rock, and so forth. When you get on one of these plains you have the horizon all around about. It is a high country. To the west you just see a hill 6 or 8 miles ahead of you; but when you get there there is another one. You are going up all the time.

Senator REAGAN. Is there any irrigation in that country?

Mr. MARSHALL. No. There is some at Toyah. I do not know what they have done there.

Senator REAGAN. Is there any here?

Mr. MARSHALL. By windmill at Midland. Also at Odessa, and also at Mansfield. That is in Hamilton County.

Senator REAGAN. Is there any in Tom Green County?

Mr. MARSHALL. There is some irrigation near San Angelo, Tom Green County. That is from the streams. There are no streams here from which there could be any irrigation, unless they were dammed and the water saved at the time the rains come.

The CHAIRMAN. What are the chances for that? Explain that.

Mr. MARSHALL. In the headwaters of all these streams there are plenty of draws to be dammed across and make large basins. I have come across the river perfectly dry, and then there would come a big storm and for four or five hours there would be plenty of water; but it would be dry again in twenty-four hours.

The CHAIRMAN. Could you find places where you could hold it?

Mr. MARSHALL. I think there could be, because the subsoil is clay on the top and rock underneath. Generally the river is all run down to the rock and the top soil is clay.

The CHAIRMAN. And you could find places where ponds of water could be had?

Mr. MARSHALL. We would have no trouble for ponds of water for our windmills—pumping into the cañon and having it full of water in a short time. There would be no trouble in making a dam and having it impound the water. I have seen a good deal along the Colorado in Mitchell County. There is a pond that I have never seen dry. Fish put in there six years ago are there yet.

The CHAIRMAN. The country north of that is similar?

Mr. MARSHALL. Yes. There is water enough falls in that country to be saved. There is a little mistake in the distribution of it, the time they send it out. There is a full description and plat of it. [Producing paper.] We got this out to distribute to the stockmen.

The CHAIRMAN. I wish to ask you about the expense of tar and pitch. It seems to me that, as in California, there would be a vast amount of bitumen here and a great quantity of bituminous rock.

Mr. MARSHALL. There is bitumen in this county. Take also Navarro County. All through that country we find that water must be conducted over sandy, loose ground, where the seepage is very destructive.

The CHAIRMAN. Have you given any attention to the cost of these things?

Mr. MARSHALL. Yes; that can be made and kept up at very much less expense than would be the case with plank or cement. In our tank works I have used all three—cement, plank, and coal-tar. I find coal-tar, while in some instances it costs a little more for a small tank than for wooden tank, yet when you get up to 250,000 gallons the cost is not one-tenth. In fluming I should think the plank would be as much to make it good. It would cost about $4 a hundred square feet. That woul be there equal to lumber at $40 a thousand. But when it is there it is for all time.

The CHAIRMAN. That depends somewhat upon the freight.

Mr. MARSHALL. It would not cost that here. It costs freight from here out to where we have used it west 33 and 38 cents a hundred.

The CHAIRMAN. What would it cost here?

Mr. MARSHALL. I could put it down here inside of $3 a square.

The CHAIRMAN. That would be less than 3 cents a square foot.

Mr. MARSHALL. Yes; if it runs out of water and stands in the sun it does not open the cracks; if it runs out of water and freezes it does not open the cracks. It remains perfectly tight without any repairs. We find it is the case with that where it is not the case with cement and not with plank. Once put on there it costs practically nothing to keep it up.

The CHAIRMAN. In what portion do you mix it?

Mr. MARSHALL. We just take coal-tar pitch. If we can not get that we take the coal-tar and boil it down and make pitch. When it gets stringy, and to ascertain that you do as you would in the case of making molases candy, put a stick in it to see if it strings out. We generally put it on hot, with two coats; the first coat being hot is just like water, and it will soak into the sand and make a quarter and a half inch coating, according to the condition your bank is in. It becomes a kind of amalgamation of sand and pitch. Then you put your sand on the top to keep it from running. We thought it better not to put on any sand at all, but just a thin coating of pitch, a double coat. When you have it on from a half to three-quarters of an inch thick, you can walk on it, walk all over it and being a little careful not to dig your heels into it. Even in the hottest days it will bend under your feet and not break. We tell everybody that the reservoir down there cost $1,800. That is half what it would have cost to build it of stone. The actual cost was $1,150 to $1,200.

STATEMENT OF E. T. DUMBLE, OF AUSTIN.

The CHAIRMAN. What is your occupation?

Mr. DUMBLE. I am the State geologist.

The CHAIRMAN. Are you familiar with the topography, the water supply, and the means of irrigation in western Texas?

Mr. DUMBLE. As well as it is possible to be in the short time that we have been at work.

The CHAIRMAN. Make any statement in regard to it that you think would be interesting to the committee.

Mr. DUMBLE. Do you wish to know what the chances are for irrigation in western Texas?

The CHAIRMAN. Yes; state what the chances are for irrigation in that section.

Mr. DUMBLE. Well, you have examined the Rio Grande, and so you know all about that. Have you information with regard to this country through here, that is, below the railroad on which you came in?

The CHAIRMAN. No. State anything that you know of this side of the Rio Grande—the waters that do not flow into the Rio Grande. We wish to know about them.

Mr. DUMBLE. There are no running waters of any consequence. But these flats are all susceptible of irrigation.

The CHAIRMAN. To what flats do you refer?

Mr. DUMBLE. The country is a series of flats or plains interrupted by mountain ranges, and in those ranges there are places in which dams could be made that would hold water sufficient for irrigating a large amount of land that lies in the flats. The rain-fall, as nearly as we have gotten at it, is from 15 to 20 inches yearly throughout that region. One section, in Quitman Mountain, the one we have examined most closely, a dam about 200 yards long will hold the drainage of some 45 square miles in those mountains. That opens out on this flat below here, a large plain. That is true of a great many other mountain ranges through there. At Fort Davis there is already considerable irrigation from the waters of the Olympia Cañon on Olympia Creek.

The CHAIRMAN. Do they store the water there, or do they take the natural flow?

Mr. DUMBLE. The natural flow. The city of El Paso and presidio—there are many places where the water could be stored and used for irrigation and stock-raising or for mining purposes.

The CHAIRMAN. It would not be very expensive, would it?

Mr. DUMBLE. No, not very expensive; because the mountains are tolerably steep, and material is always at hand to build the dam.

The **CHAIRMAN**. Do the streams discharge in narrow gorges?

Mr. **DUMBLE**. Yes.

The **CHAIRMAN**. Can there be some irrigation from wells?

Mr. **DUMBLE**. I do not think so. The water so far as yet found lies too deep, and it would be too expensive to pump it. The railroad companies have gone down 700, 800, and 1,000 feet all along the line without getting water. That is between the Pecos and the Rio Grande.

The **CHAIRMAN**. Does it extend up north?

Mr. **DUMBLE**. The plains come in here—about Drouro Station on Texas and Pacific [indicating on the map]. It takes in the mesas.

The **CHAIRMAN**. Have you been up the Pecos to its source?

Mr. **DUMBLE**. No; I have not.

The **CHAIRMAN**. Take it farther north, in the Pan Handle, have you been there?

Mr. **DUMBLE**. No.

The **CHAIRMAN**. Can they irrigate with wells?

Mr. **DUMBLE**. Yes.

The **CHAIRMAN**. They have equal facilities for storage reservoirs, have they not?

Mr. **DUMBLE**. They have on the east side of the Staked Plain, where those cañons make in and streams begin there. The whole body of that country is red clay, and they can build dams there for reservoirs very well. There in Tom Green County, on the Conchos, they are damming those creeks, and will have an abundance of supply of water for irrigation. They are increasing that all the time, and they are increasing their water supply.

The **CHAIRMAN**. From your observation what is your opinion as to the extent of irrigation that may be generally, not in detail, practiced in western Texas, where rain-fall is insufficient?

Mr. **DUMBLE**. They can irrigate nearly every part of it. There are some flats or plains in between the mountains where the land to a great extent could be reached by it.

The **CHAIRMAN**. What would be the productive capacity of that country when irrigated?

Mr. **DUMBLE**. It would be very great. The soil is very fine. It is old lake bottoms.

The **CHAIRMAN**. How is the climate for products?

Mr. **DUMBLE**. That I do not know; I could not say. The thermometer gets very high, but it is a dry climate.

The **CHAIRMAN**. I mean in reference to the production of crops.

Mr. **DUMBLE**. They grow anything that will grow around El Paso, and in that country, wheat and all kinds of fruits; corn, cotton, and anything of that kind which is suitable to this lower country.

Senator **REAGAN**. Is you bureau collecting statistics about irrigation?

Mr. **DUMBLE**. Yes; all we can. For instance, I am having the border of the Staked Plain mapped, with instructions so that they may know the places where dams can be built, and in Tom Green County I have a map of that irrigation district, and I am having a map of the suitable places in El Paso County where dams can be made.

Senator **REAGAN**. On the western tributaries of the Colorado there is some partial need of irrigation. What do you say about the streams down there?

Mr. **DUMBLE**. These streams, the ones in Tom Green County, are running all the time. They are very seldom dry. When you get along the edge of the Staked Plain they run during the wet season; but frequently the beds are entirely dry—a great many of them.

Senator **REAGAN**. What stream is this [indicating on map]?

Mr. **DUMBLE**. That is the Llano.

Senator **REAGAN**. Have there been any efforts made to take out that stream?

Mr. **DUMBLE**. Some small efforts. In Llano County, from some of these creeks, there are gardens that have been irrigated, and some fields that have been irrigated.

Senator **REAGAN**. And some on the San Saba?

Mr. **DUMBLE**. Yes; and from those streams there are places where they could irrigate large quantities of land.

Senator **REAGAN**. In the Concho and its tributaries. What do you say about that?

Mr. **DUMBLE**. That comes in there [indicating].

Senator **REAGAN**. At the Red Fork of the Colorado. What about that?

Mr. **DUMBLE**. I can not give you any definite information about that. You have had information about Midland, Odessa, and about there.

Senator **REAGAN**. Coleman is where they have had fine water?

Mr. **DUMBLE**. Yes; they have good water there.

Senator **REAGAN**. Is there any irrigation from the streams in there?

Mr. **DUMBLE**. I do not know of any irrigation at the present time.

Senator **REAGAN**. Is it needed?

Mr. **DUMBLE**. They needed it two years ago, if they could have gotten it in any way.

Senator **REAGAN**. Do you know whether there have been any efforts at irrigation on the Clear Fork of the Brazos?

Mr. **DUMBLE**. No.

Senator **REAGAN**. You have no information that you have collected on that subject?

Mr. **DUMBLE**. No.

Senator **REAGAN**. Could you at an early day send any information on that subject to the committee at Washington?

Mr. **DUMBLE**. Yes, I will do so.

STATEMENT OF CHARLES E. PRATT, OF ABILENE, TAYLOR COUNTY.

The **CHAIRMAN**. What is your occupation?

Mr. **PRATT**. Commission merchant.

The **CHAIRMAN**. Have you observed the effect of irrigation upon the production of crops?

Mr. **PRATT**. Some; up from the Pecos and in the Pan-Handle.

The **CHAIRMAN**. Anywhere in western Texas?

Mr. **PRATT**. Yes.

The **CHAIRMAN**. State what kind of crops.

Mr. **PRATT**. Alfalfa; that is about all I have seen.

The **CHAIRMAN**. What success did you have in raising alfalfa with irrigation?

Mr. **PRATT**. This season not much; because they could not get the water turned on at Pecos in time.

The **CHAIRMAN**. I do not mean your success this season, but how water affects it; whether you can raise crops with water.

Mr. **PRATT**. I do not know that I could state that.

Senator **REAGAN**. Do you not know whether it makes better crops with water?

Mr. **PRATT**. Yes, it makes better crops. In Taylor County, had we rain when we needed it, I know we would have made fine crops in 1886;

but as it was we made nothing, everything perished for want of water. Last year we made 110 bushels of oats to the acre.

The **CHAIRMAN**. How far west is that?

Mr. **PRATT**. Two hundred miles; from 190 to 210 miles.

Senator **REAGAN**. In what county?

Mr. **PRATT**. Taylor County.

The **CHAIRMAN**. You raise good crops there without irrigation?

Mr. **PRATT**. Yes.

The **CHAIRMAN**. How often?

Mr. **PRATT**. Once in every three or four years.

The **CHAIRMAN**. Then you have failures?

Mr. **PRATT**. Yes; we have four failures out of six there.

The **CHAIRMAN**. Then you must irrigate?

Mr. **PRATT**. Yes; that is the way we look at it.

The **CHAIRMAN**. What are the opportunities for irrigating there?

Mr. **PRATT**. I have not thought about that. Could we get water when it is needed, I know we could make splendid crops.

The following papers were ordered filed when received.

Adjourned.

FURTHER STATEMENT OF FRANK E. ROESLER, ON IRRIGATION UPON THE TEXAS STAKED PLAIN.

DALLAS, TEX., *September* 2, 1889.

The Great Plain, where traversed by the Texas and Pacific Railway, constitutes a table-land about 65 miles in width, widening out northwardly, and extending into the Pan Handle several hundred miles. Its most southerly point is about 60 miles south of Midland, Tex. Its outline is well defined, its edges consisting of rocky bluffs extending for hundred of miles, forming many bold promontories and shelters of coves. At some remote period of time its eastern edge was the shore-line of some great sea, which, as it receded eastwardly and southwardly, cut new shore-lines, converting the stretch of country between the plain and the Brazos River into a series of benches or table-lands, lying one above the other like the steps in a stairway. The Brazos River at the Texas and Pacific Railway crossing has an altitude of 750 feet, while the last step in the grand stairway, the eastern edge of the plain, has an altitude of 2,700 feet.

Before the creation of the Pecos Valley the plain seems to have been continuous with the eastern slope of the mountain ranges of New Mexico and western Texas. This would appear from the fact that the surface of the plain presents a gradual fall from the north and west toward the southeast, the altitudes from its western to its eastern edge being as follows: Douro Station, 3,100 feet; Odessa, 2,900 feet; Warfield, 2,875 feet; Midland, 2,780 feet; Marienfeld, 2,700 feet; the southern edge about 2,300 feet. Through some convulsion of nature a break in the strata was formed near its eastern edge, forming what is now known as Suphur Draw, in Howard County, and probably several other fractures will be found north and west several hundred miles distant. This would seem to be indicated by the fact that the strata of the plain are continuous, and that water is usually found in abundance below the limestone, and that this supply does not seem in the least to be disturbed by either heavy local rains or long periods of drought. The water seems to come for a distance of hundreds of miles, and wherever the limestone is penetrated the supply is permanent. The local rain-fall seems to find its way through the various "draws" to the headwaters of the Colorado and Concho Rivers, and is eventually carried to the Gulf of Mexico, or passes through Red River into the Mississippi. The dark colored "rises" of the Colorado River always indicate local rains in Central Texas, and the "red rises" heavy rains on the Staked Plain. These rivers carry off the surface drainage. The underground drainage, namely, the waters under the limestone strata, work their way to the San Marcos, San Antonio, Guadaloupe, Nueces, Sabinal, and many other rivers, which rise and fall at the same time that do the Rio Grande and the Pecos, both of which receive their waters from the mountain snows of New Mexico and Western Texas.

The "draws" above mentioned seem to be able-bodied rivers that have retired from business. In times gone by they have carried great volumes of water, and have cut their way through solid limestone ledges, their banks being well defined to this day, During heavy rains they resume business in a small way, occasionally drowning a flock of sheep that are feeding on their grass-covered beds. Generally the water is lost in a few days, having percolated through the sand to the limestone layer beneath, which is generally impervious. Most of these "draws" are filled with silt and sand blown in from the plain. They drain many hundreds of miles in area, and in many of them water in great quantity is found at a depth of 2 to 20 feet. Several could, without great expense, be again converted into flowing streams, carried to the higher lying lands, and be made to irrigate a considerable area. Mustang Draw, in Martin County, by the use of 5 or 6 miles of flumes, could probably be put to good use in this manner, as water in abundance is found at a depth varying from 2 to 6 feet. All the "draw" water will, of course, be surface water, derived from local rains.

The "underground water" is generally found at varying depth. At Marienfeld, on the eastern edge of the plain, at from 60 to 90 feet; at Germania, 10 miles west, at 45 to 60 feet; at Midland, 20 miles west, at 35 to 50 feet; at Odessa, 40 miles west, at 30 to 50 feet; at Douro, near western edge of the plain, none. In a few localities "joint clay," a water-proof material, on which the "underground" water rests, comes close to the surface. No water was found, though this material has often been penetrated to a depth of 500 feet. A few of the surface wells are brackish and several salty, but generally the water is good. Several springs containing soda, sulphur, or gypum water, as well as a few wet weather salt lakes, are also found on the plain. The only permanent running stream on the Staked Plain is "Running Water,', in Dickens County, a bright, sparkling stream, that suddenly breaks out out of the ground, ripples over a pebbly bottom for a distance of 10 miles and then mysteriously disappears, like many other streams west of the Pecos River, notably Leon Wells, Comanche Springs, Escondido, Limpia, and Toyah Creek, or the underground river near Castle Mountain, in Crane County, which is working its way to daylight by washing away the roof covering it, occasionally causing a part of it to fall in. A similar stream exists in the northern part of Crocket County, which was not known to exist a few years ago, though a recent cave-in exposed an abundant water supply 20 feet below the surface.

Nearly all the wells dug or bored in the "under ground" water, under the limestone, show a tendency to rise above the point where first water was reached. In some localities a rise of 20 to 30 feet was observed, showing that the supply is under considerable pressure. Borings at Odessa have shown five separate layers or deposits of water to exist between the surface and the "joint clay" 100 feet below. Between the Staked Plain and the Pecos River is an ancient fresh-water lake basin, known as "the White Sand Hills," which is covered with numerous ponds of pure fresh water. The supply is permanent, and said to be inexhaustible. The railway wells at Monahans, in this locality, furnish an immense supply. Altitude, 2,620 feet. The wells west of this and to the Pecos draw their supply from the seepage of the Pecos River. East of the Staked Plain the water supply in wells is variable as to quantity, quality, and depth. In Howard County good water is abundant in the southern part, rather deep in the northern part, and brackish in the town of Big Spring. In Mitchell County, generally good at 30 to 50 feet, sometimes strongly alkaline. Several wells bored are capable of furnishing 9,000 gallons of water per hour continuously. At a depth of 200 to 300 feet super-saturated salt brine, claimed to be chemically pure, is found in inexhaustible quantity, and a fine grade of salt is manufactured. The Colorado River carries water in its bed nearly all year round. Its water here is said to be brackish and salty. A chemical examination will have to determine whether or not the water can be used for purposes of irrigation.

PRODUCTS OF THE PLAIN.

Farming as a distinct business was begun as early as 1882, and that without irrigation. The highest yield obtained is as follows: Wheat, 25 bushels; rye, 22 bushels; corn, 65 bushels; oats, 50 bushels; potatoes, 150 bushels. Farming operations since 1882 have shown that all varieties of forage plants, including sorghum, millet, alfalfa, Johnson grass, rye, etc., do very well without irrigation, and can be relied on. Wheat, corn, and other crops which are grown especially for their seed, must mature at a specified time. If the rain-fall is timely a large crop will be made, but there is sufficient uncertainty to prevent their becoming (for some time to come, at least) the principal source of income. It is generally conceded that it is useless to plant a wheat crop after a dry fall. A large wheat crop can, however, be made if the country has had good rains in October and November. One good rain in April or beginning of May will secure the crop. It has been frequently observed that two adjoining fields of corn will show the greatest difference in the yield for the reason that the one crop was planted a week or two earlier than the other. The earlier planting would make 10 bushels, while the later planting made 65, though both received a good rain at the same time. The rain-fall of the plain varies between 18 and 42 inches, and this quantity regularly distributed would be ample to secure any crop; but its precipitation is irregular, and the farmer has unwillingly come to the conclusion that he must have an additional source of income in order to prosper.

The native grasses are abundant and nutritious, and most farmers have acquired more or less live stock, cattle, horses, or sheep, to make the annual income more certain.

The soils as a rule are very fertile, and some of the early settlers from California pronounced them well adapted to fruit-growing, provided water for irrigation could be had.

The drought of 1886 and 1887, more than anything else, brought the question of fruit-growing and irrigation to the foreground. Old wells, used for household purposes only, were increased in capacity, one-half acre gardens were put under irrigation, and found to be very profitable. Experimental orchards were established at Odessa and Marienfeld. Much of the nursery stock was obtained from California, and nearly every variety of fruit grown in the United States, excepting the citrous fruits, can be found on the plain. The experiments carried on for several years by private citizens, and by the experimental farms, have demonstrated that, in addition to all the standard American fruits, the commercial prune and all the raisin grapes and the fancy table grapes of California can be successfully grown. It is now generally conceded that the money-making crop of the Staked Plain will be the fruit crop, and the reasons given therefor are, *first*, that European table and raisin grapes can not be grown further east than the Staked Plain, owing to the humidity of the atmosphere in the lower-lying lands of the Mississippi basin or the Gulf shore.

Second. That all fruits mature fully and are free from blight, premature rot, and obnoxious insects; that all Western fruits contain more sugar and are sweeter and juicier than any of the fruits of the low lands.

Third. That the dryness of the atmosphere has the tendency to modify the effects of severe frosts, it having been repeatedly observed that a much less degree of cold would kill the fruit blosoms in central and eastern Texas, whereas a severe freeze, several degrees colder, on the plain would be perfectly harmless.

Fourth. That while the fruit crop of central and eastern Texas is frequently a failure, owing to excessive rains, this danger is not anticipated on the plain.

Lastly. The fine fruits of the plain are 1,200 miles nearer to the great cities than are those of California, and as the same varieties can be produced it is obvious that the fruit of the plain ought to be more profitable, as it will reach the market in better condition and costs less in the matter of transportation.

THE QUESTION OF OBTAINING AN ADEQUATE WATER SUPPLY IS PARAMOUNT.

The question as to the practicability of raising the finest of fruits is definitely settled. Cheap water is wanted. It can only be obtained in small quantities from wells and storage reservoirs, and the acreage that can be irrigated from each source of supply is limited. The development of the plain will depend largely upon the cost of securing and raising water for irrigation. What has been accomplished through private efforts in a small way only goes to show that present methods are too expensive, and that very few can avail themselves of irrigation by individual effort. Corporations with ample capital can secure sufficient water at moderate cost, but it is questionable whether men with money to lose can be induced to invest in enterprises where success is to some extent problematical. Moneyed men prefer to deal with known quantities. If it is known that a certain quantity of water can be had at a certain depth, that it can be reached at a certain cost, and put on the land at a certain cost per acre, and that the combined cost is sufficiently low to enable a farmer to profitably cultivate and pay for the improvement, there is no question but that the capital neccessary to make the improvement will be at hand. But to determine these points the money will not be forthcoming. As at least 95 per cent. of the arid lands must be irrigated from wells or remain uncultivated, it appears that the people of the arid region will have to look to the national Government for the information that is necessary to secure the investment of capital for irrigation of the plains away from the rivers.

On the Staked Plain but very little water will be needed, but when needed is needed badly. Continuous irrigation is not required. In the history of every crop there is a critical moment in which it is determined whether or not the farmer shall have a full crop, a half crop, or a failure. A rain-fall to-day makes his crop, a rain-fall two weeks hence does him no good. One or two, or possibly three, irrigations during the year, each equaling a two-inch rain-fall, would bring him a great harvest. More than that he will hardly need. In 1888 and 1889 he made a full crop without irrigation; in 1886 and 1887 he did not get his seed back, though the rain-fall of each year, if properly distributed, would have made splendid crops.

The acreage that can be irrigated from a six-inch bored well in a dry year, by using a ten-foot windmill, will be about five acres, varying with the rain-fall. By the use of a suitable storage tank the capacity of the plant may possibly be doubled, but at all events the acreage irrigated is very small compared with the cost of the outfit which runs between $200 and $350. Five acres under irrigation by a $200 plant, will cost the owner $40 per acre, and if he borrows the money, paying 10 per cent. interest, he practically pays a water rent of $4 per annum.

This expense is for water alone. If the farmer plants fruit trees and grape-vines he must have rabbit-proof fencing, which may cost him $10 per acre additional. Comparatively few new settlers will be financially able to incur such expense as is necessary for a good water plant, and if they do succeed in securing their water supply it will be at such cost per acre that very high-priced crops must be grown and successfully marketed to meet the interest on the investment to be profitable. The raising of the cereals and forage crops by irrigation will, therefore, be entirely out of the question, but if the cost of the water supply can be reduced, the growing of early vegetables, fine table grapes, early fruits, raisins, prunes, and the making of wine can be made profitable. In order to ascertain the cost of water supply on a larger scale, and also to learn what varieties of fruit are best adapted to the Staked Plain, a number of citizens of Dallas, Fort Worth, Colorado City, Marienfeld, and Midland, agreed to risk the sum of $5,000 in experimental work, and for that purpose organized the Marienfeld Fruit-growing, Gardening, and Irrigation Company. A study of the questions before them has led them to the conclusion that corporations with sufficient capital in hand can safely and profitably develop the plain, and furnish water, the necessary appliances for raising and storing the same, fence lands, build houses, plant trees and vines, market the products, for 25 to 50 per cent. less money than any individual can furnish the same materials, appliances, or conveniences for, and still make a fair profit on the investment.

The estimates on a section of land near Midland or Odessa, where the presence of water in sufficient quantity has been determined by previous tests, are given as follows:

640 acres of land, at $3 per acre	$1,920.00
704 fence posts, at 15 cents	105.60
1,408 stays 1x6 (704 feet of lumber)	35.00
7,200 lbs. Glidden barbed wire, at 5½ cents	396.00
21,220 feet 30-inch netting, 1¼ inch mesh, No. 19 wire	462.00
Freight on same	50.00
4 gates, staples, hardware	75.00
30 adobe or box houses, at $150 each	4,500.00
27,040 young fruit trees and freight, at 10 cents, for 160 acres	2,704.00
64,000 young rooted grape vines, at 5 cents, for 160 acres	3,200.00
Office of superintendent	250.00
Salary of superintendent three years, at $720	2,160.00
Wages, five farm laborers two years of three hundred days, at $1.25 per day	3,750.00
Surveying, freights, commissions, advertising, etc.	2,200.00
Farming implements, live stock, etc.	500.00
	$22,307.60

The total cost of improvement per acre will be $34.85, or $22,307.60 for the section.

All of the land is put in tillable condition, but only one-half is planted in trees and vines.

There is a delightful uncertainty as to quantity of water obtainable, size and capacity of wells, windmills, and storage tanks required. The estimate will vary with each section of land used. The estimate on a certain section of land which the writer has in mind is as follows:

Seven dug wells, tunneled in water-bearing strata, at $1,200	$8,400
Seven 30-foot windmills, pumps, towers, etc., at $700	4,900
Ten storage tanks, at $350	3,500
Six miles of wooden flumes, etc.; 95,000 feet lumber, at $25	2,500
	$19,300

An average cost of $31.10 per acre for water.

Adding together the cost of the improvements $22,307.60, and the cost of water supply, $19,300, we have a total cost of $41,607.60, or $65.01 per acre.

The foregoing estimate is an extra liberal one. Fruit-trees at wholesale figures can be had for cash as follows: Apple-trees, $3.50 to $20 per thousand; pear-trees, $100 to $200 per thousand; plum-trees, $100 to $150 per thousand; peaches, $30 to $50 per thousand; grape-cuttings, $2.50 to $5 per thousand; rooted vines, $10 to $100 per thousand; shade-trees, $10 to $150 per thousand. If the company making the improvements grows its own nursery stock, it can produce nine-tenths of the trees and vines at a cost of one-half to 4 cents, and many for much less money. The labor charged against improvements will also be employed on the water supply, and perhaps 25 per cent. gained in construction. The quantity of water required per year will be the equivalent of a rain-fall of 12 inches, the lowest annual rain-fall at Marienfeld being 18 inches. To give each acre the equivalent of a rain-fall of 30 inches, 12 inches, or 325,848 gallons, per annum must be supplied. To give a section 12 inches, 208,542,720 gallons must be furnished during the year, which can be furnished by five Knowless steam-pumps, raising 5,000 gallons per hour, or 120,000 gallons, per day each. A properly constructed well, costing $1,200, should yield double this quantity per day in the vicinity of Midland or Odessa, and in such event three wells may be expected to furnish the quantity of water for which seven wells are allowed in the estimate. If four-sevenths of the cost of construction can be saved, the cost of the water supply can be reduced to about $15 per acre.

A section of land improved and supplied with water as above outlined could be subdivided into 20-acre tracts and sold on easy credit terms to a fruit-growing colony. Each of the 20-acre tracts, according to the estimates above given, will cost $1,300, though it is the opinion of the writer that this amount can be safely scaled 25 per cent. If 50 per cent. be added as profit to the $1,300 the sum will still be from 25 to 50 per cent. less than local retail prices for the same material and labor. If the land and improvements were sold on ten annual payment terms, with 6 per cent. interest on deferred payments, the purchaser could easily meet his obligations, as one single acre in onions or grapes, and other fruit, should earn enough to make the annual payment. The investment made by a company of this kind would be eminently safe and legitimately profitable.

Another estimate on cultivation and irrigation of a section of land, only 160 acres being planted in trees and vines, and no houses being built for the settler, places the sum total at $23,555 or $36.85 per acre.

A 20-acre vineyard on the Rio Grande, carried to the third year's cultivation, is estimated to cost its owner $1,175, or $58.75 per acre. The difference in cost comes in in the increased price of the land, $25 per acre, and the fact that the owner does not own his water supply but must buy it. Besides, he must irrigate oftener and use more water, owing to the different character of the soil and the difference in the rain-fall, the maximum at El Paso being 16 inches per annum, and the minimum being 18 inches at at Marienfeld.

An acre in grapes three years old is claimed to produce 16,000 pounds to the acre at El Paso, which, converted into wine, is said to equal 700 or 800 gallons, selling at 75 cents to $1 per gallon. Shipping grapes sell at about 2 cents per pound, which would make the crop worth $320 on the ground. A bearing vineyard, three to five years old, is considered as worth from $300 to $500 per acre. Land on the Staked Plain sells at prices ranging from $2 to $5 per acre, is of easy cultivation, and produces fruits of the same kind and class.

On the Staked Plain and in the mountain valleys west of the Pecos there are many hundred places where flourishing fruit-growing colonies could be established, if only the location, quantity, and cost of the upland water supply were known, and this applies to the entire arid region extending from the borders of Mexico to the British Possessions. Millions upon millions of idle capital are lying in the Eastern banks awaiting investments that will secure a certain and reasonable interest. If competent information can be given on the subject (and who can be more competent than the National Government after due investigation?) much of this capital will become available, and a subsistence be furnished for the millions of American citizens now growing into manhood. These fruit-growing colonies will become small trade centers around which will cluster numerous other industries, such as the raising of live stock, dairying, the growing of wool, the development of mining industries, and of the wealth of fiber now annually going to waste in the mountain valleys of Western Texas.

The crowning work of the century in the way of national legislation will be the making of proper provision for the study of the underground water-supply for purposes of irrigation, and connected with this a study of the adaptability of the various soils to the most profitable and necessary crops.

The wirter would respectfully suggest to the honorable Senate Committe that legislation be recommended, to the end that observing stations be established under the joint control of the U. S. Geological Survey and the Department of Agriculture, at places, say, a hundred miles apart throughout the arid region. The observers placed in charge should keep a record of the rain-fall; a record of the temperature, of the wind movement; the period of germination and maturity of unirrigated as well as irrigated crops, together with information as to cost and profit of growing them; should furnish descriptions of existing streams, lakes, springs, dry water-courses, locations for reservoir sites, furnish history of existing wells, reservoirs, cost of same, and cost of appliances and methods of raising water either for ranch purposes or irrigation, describe the soils in their districts and the strata passed through in the different wells; in short, gather all possible information bearing on the subject of water supply, irrigation, and agriculture.

The observers should be supplied with suitable machinery to make test borings for water, and to determine the quantity of water available for purposes of irrigation under any given area of surface. (As long as the arid region is dependent upon the professional water-hunter, who, armed with a forked mesquite switch, puts in time at $5 per day tramping over the country until his employer gets tired, and then suddenly experiences a flea-bite, which he mysteriously calls a magnetic shock and points out a suitable location for a well, little progress can be made.)

The search for water must be systematically made, and the observer must be guided largely by the arrangement of the strata of his district. The presence of water having been determined, its quanity must next be ascertained, and for this purpose I have only one method to recommend, though perhaps better methods may be known to the U. S. Geological Survey.

The observing station should have at its disposal a prospecting diamond drill, which will preserve a cone consisting of every material penetrated; also a portable steam-pump capable of extracting 5,000 gallons of water per hour. Wherever the soil is so constituted that it will grow crops if irrigated, and a considerable area of surface lies favorable for irrigation the test for water should be made. If the water is found in limestone, it will probably run in veins or crevices. Drilling should be suspended and the steam-pump put to work. By observing the time required to empty the well, and the time required to refill, the capacity of the well per diem can be determined. After the quantity is known, it is important to know whether or not the capacity can be increased by opening up neighboring fissures and crevices, thus admitting more water. This can be done by exploding a quantity of dynamite in the bottom of the boring. If no better results are obtained the drilling should be continued to a lower deposit of water. If the quantity of water in the limestone is increased by the use of dynamite, five or six additional borings within a radius of, say, 25 feet should be made and a charge of dynamite exploded in each, which will have the effect of breaking the strata and practically making one well of the entire lot. If the quantity of water thus obtained is sufficient and economical for purposes of irrigation, the object sought for is obtained. The problem to be solved in the experiment is, whether more water can be obtained from combined wells in the fractured rock, than from the six or seven wells singly in the unbroken limestone.

As soon as the water-bearing capacity of the limestone has been determined, the drilling should be continued to the first water below the limestone. Water will probably be found in coarse sand or quicksand. If found at a reasonable depth, say at 100 to 200 feet, a few additional wells of same depth and diameter should be bored respectively 50, 100, 150, 200 feet distant. All these wells should be in line. The wells are numbered respectively 1, 2, 3, 4, and 5. If a steam-pump of 5,000 gallons capacity per hour be attached to the middle well No. 3, the water contained therein will be exhausted. If the pump has worked four hours, 20,000 gallons of water will have been raised. Measurements taken, say, four hours later show that the water in the well has again reached its normal level. If the well can be emptied and refilled every eight hours, the capacity of this well will be 60,000 gallons in 24 hours, sufficient to irrigate 2¼ acres per day. Next it is necessary to determine from how great an area this supply of water is drawn. All the wells should be measured and the normal level recorded, then the center well should again be pumped dry, and all the wells measured again as to their water levels. The center well will be found dry; the nearest wells on each side will show a great diminution in their supply; those more remote will also show a diminution, but not so great.

There will be a point where the well most distant from the center will show no loss of water. How far the wells should be apart or how many wells are necessary for the test can only be determined by the nature of the material from which the water is derived, a dozen wells 25 feet apart may be necessary in close-grained sand; less wells at greater distances in coarse sand or small gravel, and in coarse gravel such wells may be 100 feet or more apart. The point where there is no apparent loss of water is the radius of the area from which the water is drawn. If the test mentioned above shows no diminution 100 feet from the center well, the experiment determines the fact that 60,000 gallons of water can be drawn from within a radius of 100 feet in a given locality, and that a stated number of wells in said locality, 200 or more feet apart, can be relied on to furnish sufficient water to irrigate a given acreage, allowing a certain number of inches as the equivalent of the rain-fall needed to perfect a crop. The experiments can be carried on in a number of different ways, by measuring and weighing the material through which the water must pass, as outlined in a letter to the honorable committee, dated July 20, 1889.

The work should not, however, be discontinued after uncovering one or two layers of water, but should be carried on to such depth as the cost of raising the water for purposes of irrigation will warrant. It will remain for the observer to determine from how great a depth water can be pumped and be used for irrigation and still be within a reasonable expense. Another work for an observing station will be the making of test borings in the thousands of water courses, coulées, ancient river beds, draws, etc., scattered throughout the arid region and to ascertain what amount of water they carry and how it can best be utilized. All over the plains are hundreds of small land-locked basins that hold water part of the year but which is lost by evaporation and seepage. Some method will have to be devised to make this water available by raising it to properly constructed storage reservoirs where it can be kept until wanted, and last and not least are numerous underground rivers, whose course should be studied and laid down on the maps so that the water now going to waste can be raised to the surface and be utilized. The co-operation of the Department of Agriculture should by all means be secured for this work. A small experimental farm should be attached to each station and an effort made to determine what products can be most successfully grown and can be made profitable.

The foregoing is in short an outline of what might be done by Congress for the development of the open plains. I have confined myself more particularly to the Staked Plain of Texas, because I am more familiar with it, but the suggestions herein offered apply equally well to any part of the arid region that is distant from running streams or visible supplies of water.

As stated above there is too much uncertainty in the search for water to interest the investment of capital, but if the National Government will supply a reasonable certainty to the effect that a given quantity of water can be obtained from a given area, and that it can be raised at a certain cost per acre, there is no question but that all the private capital needed to develop irrigation from wells can be readily obtained.

PROPOSED EXPERIMENTS IN WELL-BORING.

[Explanation offered by F. E. Roesler, of Dallas, in paper addressed to Mr. Hinton, committee's expert.]

In your recent favor you suggest the propriety of elaborating a little on the plan of experiments suggested by me to ascertain the quantity of water present under a given area of surface. To make my views on the subject clearer I will endeavor to explain it more fully with this little diagram.*

EXPERIMENT No. 1.

On well No. 7: Section No. 23, block No. 37, township No. 5 south, Midland County, Tex.; open upland prairie, mesquite grass, no underbrush; surface soil; chocolate-colored sandy loam; nearest basin, arroya; draw, pond, or creek is Peck Spring and Salt Lake, N. 45, W. 13 miles; altitude, 2,780 feet.

Diameter of well, 8 inches; depth, 147 feet; surface soil, 15 feet; red clay mixed with sand, 15 feet; clear clay, 10 feet; marly limestone in small bowlders and nodules, 12 feet; compact, bluish-gray limestone, 18 feet; red coarse sandstone, 1 foot; wet white or gray sand, 10 feet; yellow clay, 2 feet (above this water); white or red clay, 15 feet; sandstone, gray or red, 3 feet; gravel water-bearing, 40 feet.

September 20, 1889.—Knowles's steam-pump at work six hours exhausted the well. Water line 6 a. m., 75 feet from surface; at 12 p. m. at bottom, 147 feet. Water extracted, at 5,000 gallons per hour, 30,000 gallons. At 3 p. m. measured water line at 100 feet; at 6 p. m., water line at 75 feet.

September 21, 1889.—Repeated yesterday's experiment with the same results. It appears that the quantity of water extracted will be replaced in about six hours.

NOTE.—(27,154 gallons will cover 1 acre 1 inch deep. Capacity of well will therefore permit 1 acre to be covered 1 inch deep every day. The lowest rain-fall of this locality being 18 inches, only 12 inches per acre per annum will be required to bring the average to 30 inches, which will be ample and sufficient. Twelve days' pumping will therefore do for 1 acre, and by using the well every day for three hundred and sixty-five days 30 acres could be supplied with 12 inches of water each; that is, pumping only six hours out of the twenty-four. If the pump works also during the night double the acreage could be irrigated. Allowance should be made for waste, excessive evaporation, occasional drought, and time lost an account of repairs to machinery, say one-sixth. It will be safe therefore to estimate the capacity of this well at 25 acres, pumping six hours per day, or 50 acres, pumping twelve hours per day.)

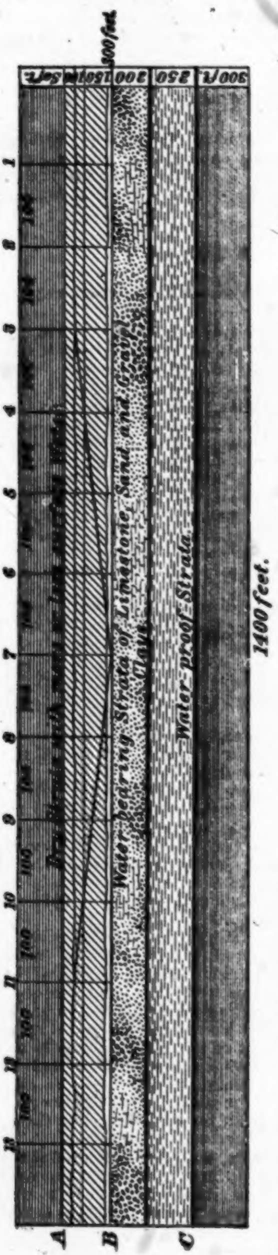
EXPERIMENT No. 2.

[Supposed copy of observer's note-book.]

September 23, 1889.—Measured stage of water in wells No. 1 to 13, inclusive. Found some slight variations, owing to difference in thickness of the layer of surface soil; the average of the water line is 75 feet. Set the pump to work on well No. 7, and exhausted the well in six hours, extracting, as heretofore, 30,000 gallons. Examined

---

*See next page.



Explanation: A. Surface soil and dry strata underneath to water line; B. A series of strata containing water (of varying thickness); C. Water-proof clays and other materials; Nos. 1 to 13, bored wells of uniform diameter and depth.

stage of water in all the wells with following results: Nos. 6 and 8, water line at 135 feet; Nos. 5 and 9, water line at 110 feet; Nos. 4 and 9, water line at 90 feet; Nos. 3 and 11, no difference visible; Nos. 2 and 12 and Nos. 1 and 13 unaffected. Three hours after above-described examination a second test was made with following results: Well No. 7, at 100 feet the water line; Nos. 6 and 8, water line at 85 feet; Nos. 5 and 9, water line at 75 feet; Nos. 4 and 10, Nos. 3 and 11, Nos. 2 and 12, and Nos. 1 and 13, water line at 75 feet.

It appears from the foregoing examination that all the water extracted from well No. 7 comes from within a radius of 300 feet from said well, as the wells more distant do not seem to be affected sufficiently to be apparent. It seems also that the principal supply of water is obtained from the 40-foot bed of gravel. The weight of 1 cubic foot of said gravel, having been previously thoroughly dried in an oven, is —— pounds; upon being thoroughly saturated with water and again weighed its weight was —— pounds. Deducting the weight of the dry gravel, there is a residue of —— pounds of water, —— gallons per cubic foot, and showing the holding capacity of the gravel. A drip, allowing as much water to fall on a cubic foot of said gravel as the same could absorb without overflow, demonstrated that in —— hours —— minutes a quantity of water equaling —— pounds, or —— gallons, could permeate and pass through a cubic foot of gravel. A similar line of experiment made with the layer of sand found at a depth of —— feet in well No. 7 demonstrated that the retaining and carrying capacity was only —— per cent. as to quantity of water absorbed per cubic foot, and that —— hours —— minutes were required for through passage of the water.

A circle of 600 feet diameter = 6.45 acres, will furnish sufficient water for 25 acres of land, pumping six hours per day. A second well should not be placed nearer than 600 feet from well No. 7. The experiment shows that only about one-half of the water-supply within this circle has been extracted. Pumps placed in wells Nos. 3 and 11 would extract about one-half of this remainder, but would not work to their full capacity, and therefore not be profitable.

The above is an imaginary page from the observer's diary, and will show the nature of the observations to be made. There will be many other questions of interest arising continuously, and should appear on his diary. The observer should be well posted in regard to pumping machinery and other matters pertaining to the raising and storage of water. Wherever there is a stretch of country presenting a uniform surface, and there is reason to believe that it can be made arable by experiments of this kind, it appears to me that it is worth while to try. I confidently believe that nearly all the mesa lands in New Mexico, Texas, and Arizona, that are remote from running streams, can be thus made available, but doubt seriously that private capital can be induced to make the experiments.

DIAGRAM OF PROPOSED WELL.

Dug wells on the Texas Staked Plain. Approximate arrangement and depth of strata in the well on the Haas farm, proposed to be enlarged for purposes of irrigation. The strata encountered vary in thickness in different wells within the distance of a mile. The data here given is approximate and not claimed to be accurate.

IRRIGATION—CENTRAL TEXAS.

[EXTRACT FROM REPORT OF W. F. CUMMINS, FILED BY THE STATE GEOLOGIST.]

The question of irrigation is one so immediately connected with the farming interest in this part of the State that every available supply of water, and every locality of suitable land for that purpose ought to be investigated. With this idea before me I have given the matter particular attention during the present expedition. While it is not absolutely necessary to the raising of crops that the land should be irrigated, yet the product may be greatly enhanced thereby. There are two sources of water supply; one is the utilizing the natural supply from springs and streams already in existence, and the other is to make larger reservoirs for the storage of the surplus waters of the creeks and rivers. I have examined the many large springs and the perennial streams of this country, and will mention some of them separately, so as to give some definite idea of the adaptability of all of them to the purpose of irrigation.

The first place examined with reference to irrigation was at Lampasas Springs. Here there is a constant and unvarying flow of water from the several springs of 1,440,000,000 gallons of water per day. All of this water can be very easily taken out of the channel and turned on the wide valleys below. In the first 3 miles below the springs there is a fall of 46 feet. The valleys of the stream are broad and level, so that there should be no trouble in getting water over the entire space. The soils are well-adapted to the purpose of irrigation, being black sandy, with subsoil that would retain moisture for a considerable length of time. Although this water is largely mineralized when first issuing from the springs it is not found to be detrimental to the growth of crops, nor does it injure the land after having gone a distance of a mile or two in an irrigation ditch.

There is land enough subject to irrigation in the valleys below to consume all the water supplied by these streams. This water might also be taken out of the Lampasas River at other places than immediately below the city.

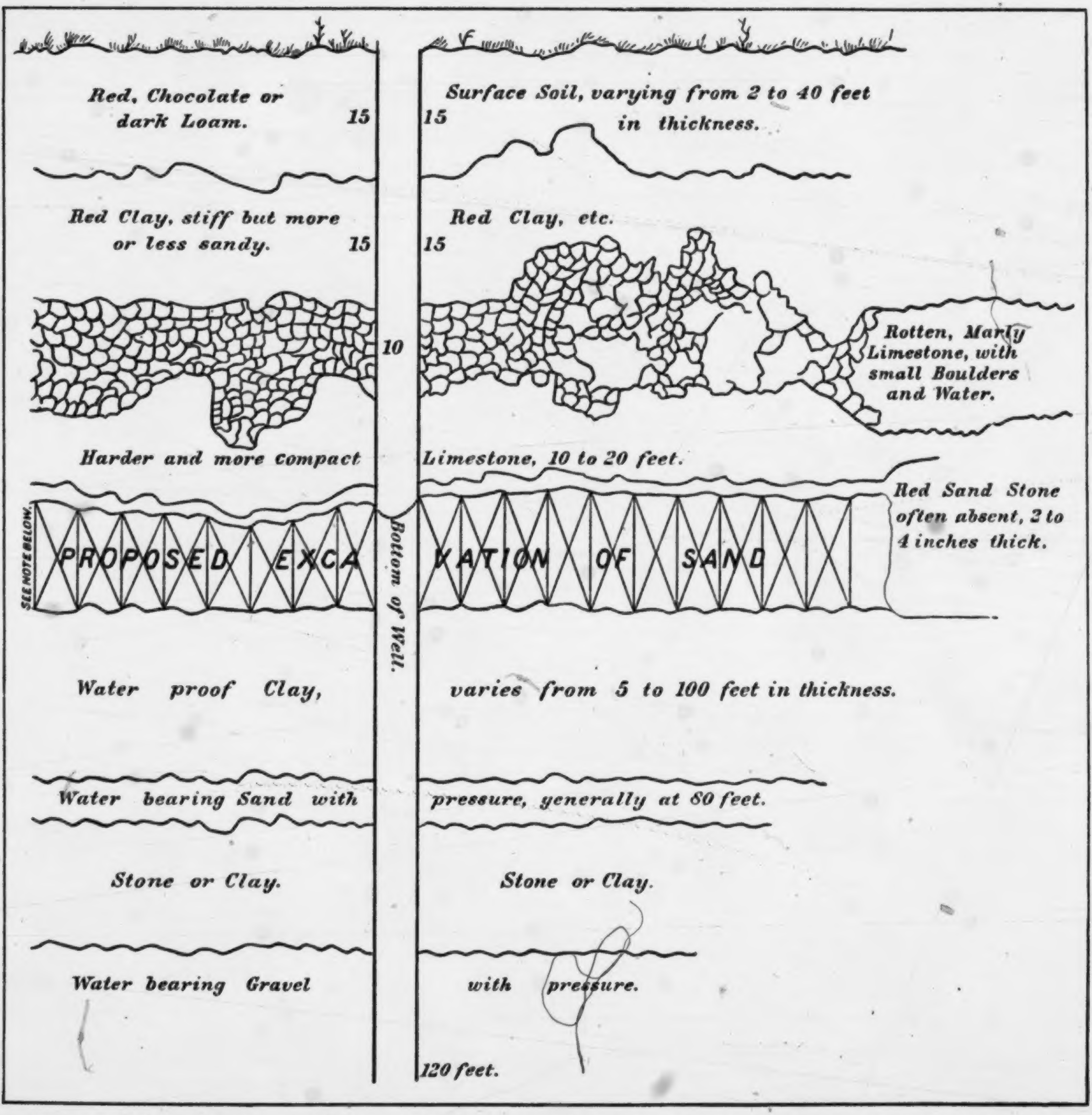
In San Saba County there are several springs along Cherokee Creek that might be used in a small way for irrigation, or the creek might be taken as a whole and used upon some of its broad valleys. The Cherokee Spring, at the head of the creek, furnishes a large amount of water, and at a very small expenditure the water could be carried to the broad valleys below. Already a dam has been constructed across the channel below one of the springs, and at the small expense of a few hundred dollars it could be extended so as to include the water from both springs. This spring is fresh and constant in amount of water it furnishes.

The Flemming Spring, 3 miles east of the town of San Saba, furnishes water to irrigate at least 300 acres of land if properly distributed. It issues from beneath the massive limestone of about the same height as the valley. Already a part of the water is being utilized for irrigating purposes. At one time it was the intention of a former owner to use all the water from the spring for irrigating his farm, but he has been restrained from doing so by an action brought against him by the owners of land below him on the creek made by this spring. A large part of the water now goes to waste.

The Hubbard Spring, a mile northeast of the Flemming Springs, is well situated for irrigating purposes, and furnishes about the same amount of water. It is also used in a small way for irrigation, but the most of the water runs to waste. There is plenty of land in reach of this water to consume it all by irrigation, but the riparian rights of the owners of land below on the stream have been asserted.

The large spring just east of the town of San Saba, which is now used for driving machinery in the flouring mill and for water-works, furnishes a sufficient amount of water to irrigate several hundred acres of land, but it is permitted to run into the river after performing the before-mentioned purposes. A small amount is taken out at the upper dam and turned into a garden and a small field.

On the lands of Mr. Sloan, 10 miles west of the town of San Saba, and on the south side of the San Saba River, a fine large spring bursts out from under the massive


Red, Chocolate or dark Loam.
15
15
Surface Soil, varying from 2 to 40 feet in thickness.
Red Clay, stiff but more or less sandy.
15
15
Red Clay, etc.
10
Rotten, Marly Limestone, with small Boulders and Water.
Harder and more compact
Limestone, 10 to 20 feet.
Red Sand Stone often absent, 2 to 4 inches thick.
SEE NOTE BELOW.
PROPOSED EXCAVATION OF SAND
Bottom of Well.
Water proof Clay,
varies from 5 to 100 feet in thickness.
Water bearing Sand with
pressure, generally at 80 feet.
Stone or Clay.
Stone or Clay.
Water bearing Gravel
with pressure.
120 feet.

NOTE.—This layer of sand varies from 7 to 20 feet in thickness and is found at a depth of 40 to 90 feet. In the Hass well at about 85 feet. Water supply inexhaustible and can be increased indefinitely by excavating the sand. Water from lower levels always rises to the level of this sand.

Report on Irrigation.

limestone rocks. This spring and branch made by it to the junction with the San Saba River is all on the lands of Mr. Sloan, so there is no one to set up a claim of riparian rights; hence all the water of this spring has been used to irrigate his farm of several hundred acres.

The Richland Springs, at the head of Richland Creek, in the western part of San Saba County, furnish enough water to irrigate several hundred acres, but the water has never been used for this purpose. These springs occasionally in very dry times go dry, but not until after the time when the crops are matured. The lands are good and of such a character as to be well adapted to irrigation. There are sixteen of these springs in San Saba County, and all of them might be used for irrigating the lands in their immediate localities.

The Colorado, Concho, and San Saba Rivers can all be utilized for irrigating their broad valleys and the adjacent plateaus.

The Colorado River would be the most difficult to divert from its channel, as the lands are generally much above the level of the channel. The valleys are of sufficient extent anywhere above San Saba County to consume all the water of the river, and are very fertile.

The waters of the San Saba are abundant, and no trouble would be experienced in taking the water from its present channel and conveying it to the valley above. The valleys are broad and fertile. They now produce fine crops of corn, wheat, oats, and cotton without irrigation, but this yield would be greatly increased by irrigation. There is, however, less actual need for irrigation along this river, and I may say in San Saba County, than in any other of the counties in which my observations have extended.

The Concho River and the country adjacent thereto are more adapted to irrigation than either of the rivers in the district described. The river is more constant in its supply of water, and the plateau of level land above the lower valleys is more accessible.

The South Concho River, Dove Creek, Spring Creek, and North Concho River all have their source at the foot of the Staked Plains. They all have very large springs at the head. None of these springs have a flow of less than 2,000 gallons of water per minute. Irrigation ditches have been taken out on all these streams, and thousands of acres are already under irrigation. In none of these streams has one-half of the water been utilized. The system of irrigation, if it can be called a system, is of the most primitive kind. The farming is mostly done by Mexicans for a share of the crop. Every man takes out what water he wants, and for as long a time as he wants it, letting the remainder flow back into the channel. The next man below him has built a ditch and takes out the water, and so on to the end.

Such is the character of the soil of these streams that they retain a large amount of moisture after having the water from the irrigation ditch spread over them, and numerous springs have broken out along the bank of the river since the plan of irrigating the lands has been put in operation, and instead of the water of the river being exhausted by taking it out and spreading it over these valleys, it is really stored for constant use. There is as much water in the river below the irrigated farms as there was before there was any water taken out. There is really more water now in the Lower Concho River than there was before these irrigation farms were made.

The only reason that can be assigned to this fact is that heretofore all the water was allowed to flow down the channel during the rainy season and at all other times, while now the surplus water is taken out and spread on the valleys above and forms reservoirs and supplies numerous springs with water which before only flowed during wet weather.

The advisability of storing the surplus water need not be discussed in a report like this. The only question that need be considered is whether it can be done successfully and the place where such storage can be made to advantage. It would be a very easy matter to find places along the San Saba River where dams could be made from one hill to the other and an immense amount of water saved for future use. This river runs, from head to mouth, through the massive limestone of the Silurian and Carboniferous formations, and it would be difficult to find places where the water could be stored in reservoirs except along the immediate channel of the river, owing to the height of the surrounding country.

The Colorado River would be more difficult to store water in its channel on account of the material over which it flows and the character of the soil in its immediate valley. But when once the water is taken from the channel it could be conducted to localities where immense lakes might be formed and water stored for future use.

The clays of the Carboniferous formation are impervious to water, and places could be selected where these clays would form the sides and bottom of artificial lakes of immense size. When the time comes for selecting localities for water storage there will be no trouble in finding such places to store the immense surplus of water that at times goes down the Colorado River.

The Concho River furnishes the best locality for utilizing or storing surplus water of any of the rivers, owing to the ease with which the water may be taken out of the channel and the extensive plateaus which lie contiguous to these streams.

It is possible to make an immense reservoir for the storage of water a few miles below the head of the South Concho River, and the water taken out and used to irrigate the Lipan Flat, a body of land constituting at least one-half million of acres. The lands in this flat are situated so that the water could be taken to any part of them. There is not a better place for such an enterprise in the State.

REPORTS FROM THE STAKED PLAIN AND PAN HANDLE COUNTIES.

[Forwarded by F. E. Roesler, of Dallas.]

ACT TO ENCOURAGE IRRIGATION PASSED BY THE TWENTY-FIRST LEGISLATURE OF TEXAS, 1889.

CHAP. 88.—[S. H. B. No. 298.] An act to encourage irrigation, and to provide for the acquisition of the right to the use of water, and for the construction and maintenance of canals, ditches, flumes, reservoirs, and wells for irrigation, and for mining, milling, and stockraising in the arid districts of Texas.

SECTION 1. *Be it enacted by the legislature of the State of Texas:* That the unappropriated waters of every river or natural stream within the arid portions of the State of Texas, in which, by reason of the insufficient rain-fall, irrigation is necessary for agricultural purposes, may be diverted from its natural channel for irrigation, domestic, and other beneficial uses: *Provided,* That said water shall not be diverted so as to deprive any person who claims, owns, or holds a possessory right or title to any land lying along the bank or margin of any river or natural stream of the use of the water thereof for his own domestic use.

SEC. 2. That the unappropriated waters of every river or natural stream within the arid portions of the State, as described in the preceding section of this act, are hereby declared to be the property of the public, and may be acquired by appropriation for the uses and purposes as hereinafter provided.

SEC. 3. The appropriation must be for the purposes named in this act, and when the appropriator, or his successor in interest, ceases to use it for such purpose the right ceases.

SEC. 4. As between appropriators, the one first in time is the one first in right to such quantity of the water only as is reasonably sufficient and necessary to irrigate the land susceptible of irrigation on either side of ditch or canal.

SEC. 5. Every person, corporation, or association of persons which have constructed or may hereafter construct any ditch, canal, or reservoir, for the purposes named in this act, and taking water from any natural stream, shall within ninety days after this act goes into effect, or within ninety days after the commencement of such construction, file and cause to be recorded in the office of the county clerk of the county where the head gate of such ditch or canal may be situated, or to which said county may be attached for judicial purposes, in a well-bound book to be kept by said clerk for that purpose, a sworn statement in writing, showing the name of such ditch or canal, the point at which the head gate thereof is situated, the size of the ditch or canal in width and depth, and the carrying capacity thereof in cubic feet per second of time, the name of said stream from which said water is taken, the time when the work was commenced, and the name of the owners or owner thereof, together with a map showing the route of said ditch or canal.

SEC. 6. Within ninety days next after the filing of said statement, the party claiming the right to appropriate the water shall begin the actual construction of the proposed ditch, canal, or reservoir, and shall prosecute the work thereon diligently and continuously to completion.

SEC. 7. "Completion," as used in the preceding section, is hereby defined to be the conducting of the water in the main canal to the place of intended use.

SEC. 8. By compliance with the preceding provisions of this act the claimant's right to the use of the water relates back to the time when the work of excavation or construction was commenced on said proposed ditch, canal, or reservoir: *Provided,* That a failure to file said statement shall in no wise work a forfeiture of such heretofore acquired rights, nor prevent such claimants of such heretofore acquired rights from establishing such rights in the courts.

SEC. 9. When any person, corporation, or association of persons, by compliance with the preceding provisions of this act, shall became entitled to the use of the waters in any river or stream, it shall thereafter be unlawful for any other person, corporation, or association of persons, except for domestic use by any one entitled thereto, to so divert the flow of water in said river or stream in such manner and to the extent of depriving said person, corporation, or association of persons in priority of the use of the water to which they may be so entitled.

SEC. 10. Corporations may be formed and chartered under the provisions of this act and of the general incorporation laws of the State of Texas, for the purpose of constructing, maintaining, and operating canals, ditches, flumes, feeders, laterals, reservoirs, and wells, and of conducting, transferring, and furnishing water to all persons entitled to the same, for irrigation and domestic uses, and for the purpose of building storage reservoirs for the collection and storage of water for the uses before mentioned, and for mining, milling, and stock-raising. All persons who own or hold a possessory right or title to land adjoining or contiguous to any canal, ditch, flume, or lateral, constructed and maintained under the provisions of this act, and who shall have secured a right to the use of water in said canal, ditch, flume, or lateral, shall be entitled to be supplied from such canal, ditch, flume, or lateral with water for the irrigation of such land and domestic uses: *Provided*, The party so entitled shall first make available his said land for agricultural or grazing purposes, and shall provide cisterns, wells, or storage reservoirs for water for domestic purposes.

SEC. 11. All corporations and associations formed for the purposes of irrigation as provided in this act, are hereby granted the right of way, not to exceed one hundred feet in width, over all public, university, school, and asylum lands of the State, with the use of the rock, gravel, and timber on the right of way, for construction purposes, and may obtain the right of way over private lands by contract. Any such corporation may also obtain the right of way over private lands by condemnation by causing the damages for any private property appropriated by such corporations or associations to be assessed and paid for as provided in cases of railroads.

SEC. 12. All surplus water not used or disposed of, as provided for in the preceding sections of this act, shall be conducted back to the stream from which it was taken. And all water sold or disposed of may be measured in inches, feet, or fractional portion of the whole supply, or distributed by the hour or acre system. But any person, corporation, or association of persons shall furnish water in the way and manner named in the contract or certificate issued to the purchasers of said water, so long as water remains unsold in the ditch: *Provided*, That the commissioner of agriculture, insurance, statistics, and history shall make a report to the legislature at its next regular session, and at each regular session thereafter, as to the cost and expense attending the construction and maintenance of canals, ditches, flumes, feeders, and wells for irrigation in various parts of the State, and accompany the same with a statement of the charges made for the uses of water by canal, ditch, and well companies, and the legislature shall at such times as it deems proper, either by direct legislation or by the creation of a commissioner or water inspector or inspectors with full delegated power, control and regulate the quantity of water which may be diverted by any water company or individual, when and in the manner in which it may be diverted, and may establish and enforce all such reasonable rules and regulations necessary and proper governing and controlling such corporations and water construction companies and persons operating under the provisions of this act, and may also control, regulate, change, and fix the charges for the use of water made by such ditch, canal, and well companies.

SEC. 13. All said persons, corporations, and associations shall have the right to run along or across all roads and highways necessary in the construction of their work, and shall at all such crossings construct and maintain necessary bridges for the accommodation of the public, and shall not affect or impair the usefulness or condition of said road or highway.

SEC. 14. Any person who shall wilfully or through gross negligence injure any irrigating canal or its appurtenances, wells, or reservoirs, or who shall waste the water thereof, or shall take the water therefrom without authority shall be deemed guilty of a misdemeanor, and for each offense shall be liable to a fine not exceeding five hundred dollars.

SEC. 15. Any corporation created and organized under the provisions of the general laws of this State or the provisions of this act for the purpose of irrigation shall have the power to acquire lands by voluntary donation or purchase or in payment of stock or water rights, and to hold and dispose of all such lands and other property, and to borrow money for the construction, maintenance, and operation of its canals, ditches, flumes, feeders, reservoirs, and wells, and may issue bonds and mortgage its corporate property and franchises to secure the payment of any debt contracted for the same: *Provided*, All lands acquired by said corporation, except such as are used for the construction, maintenance, and operation of said canals, ditches, laterals, feeders, reservoirs, and wells shall be alienated within twenty years from the date of acquiring said lands or be subject to judicial forfeiture.

SEC. 16. All laws and parts of laws in conflict with the provisions of this act are hereby repealed.

SEC. 17. Whereas it is necessary that irrigating canals should be built at once to afford water for irrigational purposes for the present year; therefore an emergency exists, and an imperative public necessity demands the suspension of the constitutional rule which requires a bill to be read on three several days, and that this act take effect and be in force from and after its passage.

[NOTE.—The foregoing act originated in the house, and passed the same by a vote of 69 yeas, 6 nays; and passed the senate by a vote of 21 yeas, no nays.]

Approved March 19, 1889.

STATEMENT OF JOSEPH TWEEDY, OF SAN ANGELO, TOM GREEN COUNTY.

[Secretary of the San José Irrigation and Power Company.]

Having been requested to place before the Senate committee some information in regard to the agricultural resources of Tom Green County, Tex., and how such resources may best be increased or improved by irrigation, I would briefly and imperfectly submit as follows:

Tom Green County, Tex., or perhaps, better to cover the points at issue, those portions of Tom Green and adjoining counties locally known as the "Concho country," comprises some 6,000 to 8,000 square miles in and below the foot-hills of the Staked Plains, or the water-sheds of the North, Middle, South, and Main Concho Rivers and their tributaries, and lies at an elevation above tide-water of from 1,600 to 2,500 feet. That portion of the tract towards the head-waters of the streams is rough and broken, and while affording excellent pasturage is generally unfit for agricultural purposes, except in the immediate river-bottoms, which are from one-half to two miles in width.

From and for some distance above the point, near San Angelo, where the various branches of the Concho unite to form the main Concho River, to its junction with the Colorado River, the valley widens out into broad plains with a gradual slope towards the east.

The soil is generally a chocolate or reddish loam, easily worked, of good quality and depth, and underlaid with clay, gravel, or the limestone formation characteristic of this section. The valleys are sparsely covered with mesquite and live oak timber, with pecan and elm lining the streams.

All of the streams mentioned above, together with Spring and Dove Creeks, tributaries of the Middle Concho River, are fed by never-failing springs, breaking out near the foot of the Staked Plains, which in the aggregate are estimated to furnish a minimum flow of from 200 to 250 cubic feet per second.

Owing to the abruptness of the upper water-sheds and the considerable grade ot the country toward the east (averaging about 10 to 15 feet to the mile) the streams rise and fall very rapidly after a rain-fall.

Rain-fall.—The average annual rain-fall for the past fifteen years, taken from the records of the United States Military Post of Fort Concho, has been about 20 inches, which on its face would seem to indicate a fair amount of moisture for agricultural purposes.

Owing however to its unequal and uncertain distribution during the year, and the generally extremely rapid precipitation, together with the prevalent hot and drying winds during the spring and summer, the actual benefit of the rain-fall for agricultural purposes can not be measured in direct proportion to the inches of annual precipitation, but must be taken with a considerable reduction.

Irrigation enterprises.—The first irrigation ditch in the Concho country was taken out by Taylor & Spears on the South Concho River, irrigating about 700 acres, and is still in successful operation.

The following is a partial list of the principal irrigation ditches and farms now in operation:

On Spring Creek, William Locky, 300 acres; T. McDonald, 400 acres; James Neill, 200 acres; J. T. McLane, 300 acres; R. F. Tankersley, 500 acres.

On Dove Creek, E. Stilson, 500 acres; San Jose Irrigation and Power Company, 1,500 acres; Scott & Ryan, 300 acres; and R. F. Tankersley, 400 acres.

On South Concho River, P. H. Moris, 200 acres; De Long Bros., 500 acres; Cochran & Wynn, 300 acres; A. Gardner, 300 acres; C. B. Metcalf, 900 acres; M. Sims, 300 acres; Berrendo Stock Company, 100 acres.

On Middle Concho River: J. R. Nasworthy, 300 acres; Capt. J. Foulkes, 900 acres; P. C. Lee, 400 acres.

On North Concho River: Phelan and Glenn, 300 acres; Jonathan Miles, 400 acres; in all about 9,000 acres.

Methods of irrigation.—All the dams heretofore built have been rough and inexpensive affairs, of brush and rock, of from 4 to 10 feet in height, designed simply to divert a portion of the natural flow of the stream into the ditches, which are usually from one-half to 1 mile in length from the dam to the lands desired to irrigate.

Irrigating by furrows is the system generally followed, except in small grain and grass, where the land is cut by low dikes into oblong "melgas" or lands, about 10 yards wide and 100 to 200 yards long, and the water run over each in succession.

By simply diverting the water from the streams by means of the rough dams above mentioned, a farm of 400 to 500 acres can, if favorably located, be put under irrigation at a cost of not to exceed $4 per acre. The cost of keeping dams and ditch in ordinary repair should not exceed 50 cents an acre per annum.

The cost of irrigating 1 acre of land, with the methods and appliances at present in use, is about 20 cents for each irrigation.

Duty of water.—Owing to large losses by leakage and present wasteful methods of irrigating the actual duty of water for ordinary crops is about 50 acres per cubic foot per second of flow during the irrigating season of, say, one hundred days. There have been seasons (notably the present season of 1889) when the natural rain-fall has been sufficient to mature the crops with little or no irrigating. As a rule, however, one, two, or even three irrigations are necessary to insure certain and abundant returns.

Values and rental of irrigated land.—Good dry farming land is worth from $3 to $5 per acre, but where the same land can be brought under a ditch, the value is increased to from $30 to $100 per acre including the water right. The irrigated lands are usually rented either for a cash rental of from $5 to $10 per acre, including the right to the water at stated intervals, or for a share, usually one-third of the crop.

Crops raised.—The usual crops raised, with their average yield, on irrigated and dry lands, gathered from the uncertain data at hand, are about as follows:

Crop.	Average yield on irrigated land.	Average yield on dry land.	Remarks.
Corn	40 bushels	10 bushels	Very uncertain on dry land.
Oats	50 bushels	25 bushels	Fairly certain on dry land.
Wheat	20 bushels	10 bushels	Do.
Rye	30 bushels	15 bushels	Do.
Barley	40 bushels	20 bushels	Do.
Sorghum	2 crops	1 to 2 crops	
Sweet-potatoes	300 bushels	None	
Irish potatoes	200 bushels		Uncertain on dry land.
Alfalfa	3 to 4 cuttings.	None	
Vegetables	April 15 to October 15.		Uncertain on dry land.
Fruit	All varieties		Some varieties do well on dry land.

Grapes do well on both irrigated and dry lands, although the yield is surer if they can be irrigated just when necessary.

Cotton has been planted to a limited extent for the past two years. That on the irrigated lands has been irrigated once the past season, and now promises a yield of not less than a bale to the acre, of extra long staple. Cotton on dry lands will also yield well the present season, although somewhat less than that irrigated.

In a general way, it may be stated, that while small grain (if planted in the autumn), some fodder crops, a few varieties of fruits, and probably cotton, will yield fairly well in a season of average precipitation of moisture. The yield is largely increased by irrigation; and that for all other crops irrigation may be considered almost a necessity.

Storage of surplus water.—Estimating the duty of water at 50 acres per cubic foot per second of flow during the irrigating season, the ditches now in operation will, in a dry season, divert nearly if not all the natural flow in the streams.

While undoubtedly under improved methods the duty of water will be somewhat increased, to materially increase the acreage under irrigation, there must be adopted some comprehensive system of dams or reservoirs in the upper valleys to store up all the water running to waste during the nine months when not in use, to be conducted by canals or pipe to the lower valley lands.

It is believed that available sites for reservoirs can be found on nearly all the streams, with capacity not only to store the normal flow, but also a large portion of the enormous volume of flood water.

Irrigation by wells.—But little has been attempted in the direction of irrigating from wells, except for garden purposes. Of the many hundred wells in the Concho country, nearly all are for stock or for domestic use. As a rule all wells are drilled and water found at from 25 to 200 feet, with an average depth of about 100 feet. The average capacity of wells sunk in this section has been estimated to be about 500 gallons an hour.

In a number of wells where they have encountered subterranean streams or rivers the yield seems to be limited only by the pumping capacity of the machinery applied.

The writer is informed that pumps of a capacity of 5,000 gallons an hour have been applied to several of these large wells without developing any sign of exhaustion, or lessening the flow.

There have been no attempts as yet to obtain artesian water, although a company is now being organized at this point (San Angelo) for that purpose. Should artesian water be found in sufficient quantities at a reasonable depth, it will undoubtedly be largely utilized for irrigation purposes.

All the lands now under irrigation lie in small detached tracts in the upper valleys or points where the water could most readily be diverted from the streams.

In the lower and broader valleys and plains there are very large and fertile bodies of land, aggregating, at moderate estimate, not less than 400,000 acres, favorably situated for irrigation purposes.

Should the General Government, by surveys of the head waters of the Concho Rivers, demonstrate the feasibility of a system of dams, with sufficient storage capacity, it is believed there will be no lack of private capital to take up the enterprise, and place a large portion of their lands under ditch.

STATEMENT OF E. W. KIRKPATRICK, OF McKINNEY.

In compliance with the request from the Warienfeld Fruit Company, I have, as a horticultural expert, during this month visited the Staked Plains and the Pecos Valley, of west Texas, for the purpose of examining the prospective interests of farming, fruit-growing, and irrigation of that district. I was most favorably impressed with every condition of climate, soil, and production. The climate is about everything that can be desired for the habitation of man and the maturing of the finest products of earth. The soil is uniformly rich and deep, with a strong flow of pure water below, ranging in depth about 30 or 40 feet. Foreign and domestic fruits grow to as great perfection here as in any country.

The altitude being about 3,000 feet, and the extent of these lands being hundreds of miles each way, the air is very pure, and almost constantly in motion, giving fine health and almost perfect development to the most valuable forms of animal and vegetable life. The dry beds of lakes, and the rivers and creeks which stretch through this country, and the rich alluvial red sandy loam of several feet, underlaid with clay, gravel, and constant running water of pure quality, indicates that this plain has at one time been of less altitude and well watered with lakes and streams. The whole surface is covered with rich grasses, beautiful flowers, shrubs, and small bushes.

While visiting these plains I saw many young, vigorous orchards and vineyards of the finest varieties of peach, plums, prunes, apricots, almond, and cherry trees; grapevines, berries, and other fruits showing remarkably large growth, fine specimens of fruit with perfect foliage and no sign of hurtful insect or disease. Vegetables, grain, and sorghum, and all these fruit-bearing plants, were maturing fine crops with little or no irrigation.

The Pioneer Canal Company, at Pecos City, with water from the Pecos River, is demonstrating the wonderful fertility of this soil by producing immense crops of grain, fodder, and vegetables. Since the savage has been driven away, and since the annual fires have ceased to sweep over this land, young timber is springing up everywhere, and the rain-fall, which is 18 to 36 inches, is being better distributed through the year, and if these influences could be accelerated by an entensive system of irrigation by wells and pools, it is my opinion that the waste places of west Texas would soon be converted into one of the richest and most desirable sections of our country, furnishing happy, prosperous homes for millions of our crowding population. During the last three months I have visited in eastern and southern Texas many horticultural fairs, and examined many of the finest orchards and vineyards in this State, but I have never tasted better flavored peaches, Kelsey Japan plums, fine European and native grapes, melons, potatoes, beets, etc., than those of the Staked Plains.

While at Odessa, the acme of the plain, I found sweet-potatoes in a cellar perfectly firm, bright, and sound, and which had been stored ten months. The present sparse population are growing rich with their large herds of fine sheep, horses, and cattle—which feed all the year on rich grass. This immense body of rich land belongs chiefly to the railroad companies and the State and can be bought on most reasonable terms. So soon as the possibilities of this large area can be demonstrated beyond cavil by partial development, extending through a series of years, then will this long neglected land be converted into one of the richest sections of our great country.

STATEMENT OF J. L. VAUGHAN, OF MERKEL.

Merkel is located in Taylor County Tex., latitude 32° 25′, longitude 23° 10′, and is embraced in the "subhumid district." The season of rains begins in March and continues until about the middle of June. The month of July is nearly always dry, and usually little or no rain falls from middle of June until middle of August. The midsummer rains, which nearly always come in August, are very copious. During the fall rains become less frequent and the winters are nearly always dry.

The wheat crop, if sown in October while the ground is still moist, springs up very rapidly and makes a good growth before the cold weather and dry winds of January set in. The absence of excessive moisture during the winter months is beneficial to wheat, rye, and barley, as there is less tendency to freeze out. The heavy spring rains of March revive the plants, and the frequent showers during the months of April and May mature the crop, while the dry weather in the latter part of June and in July is very favorable for the harvesting and threshing of the grain. The yield of wheat is from 15 to 30 bushels per acre. This crop could not be benefited any by irrigation. About 40,000 bushels of wheat were raised in this section this season.

For corn and oats the seasons are not always so favorable, as there are instances when the dry season injures them somewhat before they fully mature. Oats are more certain than corn, and under ordinary circumstances will average 60 bushels per acre. Corn generally averages about 30 bushels per acre. Of the cereals, corn is the only crop that would be benefited by irrigation, as it needs it most in the months of June and July, when it is usually dry weather.

Wheat is selling this season at 85 cents per bushel, oats at 50 cents per bushel, and corn at 40 cents per bushel. Rye and barley have not been much tried here yet, but as they resemble wheat they will be similar in their yield and culture.

The vegetable crops, while usually yielding well, would be greatly benefited by irrigation. It is almost impossible to raise Irish potatoes successfully in this district without some irrigation, and common garden vegetables will nearly all cease during the dry season, unless assisted by irrigation. Sweet-potatoes and the members of the melon family being of Southern origin, stand the dry weather well, and make the most wonderful growth in size with very little rain-fall.

The cultivation of orchards and vineyards would be greatly benefited by irrigation. The peach, nectarine, apricot, and plum grow very rapidly, but where they can be supplied by a moderate amount of water, either by surface or sub irrigation, they will double their growth of tree and yield of fruit. The fig will do well by a little irrigation and slight protection during the first winter. The apple and pear have not been a success, unless where they can be irrigated. The vine grows tolerably well, but with some irrigation it makes a very rapid growth and bears fruit of the finest quality. The absence of blight or mildew is very noticeable. Nearly all varieties succeed, but the mission grape seems to be the best adapted to irrigation.

There is a garden in Merkel where peaches, apricots, plums, persimmons, cherries, pears, apples, figs, pomegranates, and several varieties of grapes are growing and doing well; also in the same garden are strawberries, gooseberries, currants, blackberries, and raspberries; also a number of tropical plants and orchids. Bananas and dwarf species of orange grow and bear fruit, but have to be protected during the winter.

The rain-fall, as recorded at this station during this summer, is as follows: April, .23 inch; May, 2.68 inches; June, 6.33 inches, July 3.04 inches; August, none; September, 3.85. The rain-fall in June and July and absence of it in August this season is very unusual, as it usually begins earlier in the spring and ends in June. This has rather been an "off" year in regard to seasons.

The general topography of Taylor County is similar to the rest of the counties that lie adjoining the Staked plain. The surface of the county is rolling prairie, covered in places by a growth of mesquite timber, and in some places dotted with live oaks. The soil varies from a red to a dark, sandy loam, varying in depth from 2 to 7 feet, and is very productive. A range of mountains runs through the county from east to west. These mountains are about 300 feet high, are abrupt and steep on the north side, but on the south they slope off gradually. They are in fact the end of a plateau that slopes southward toward the Concho River. Several streams head in these mountains and run on the north to the Brazos and on the south to the Concho Rivers.

A large number of water-courses, which in wet seasons are torrents, but in dry seasons have no water, also have their heads in or near the mountains, and cutting across the prairie intersect the different streams. These are feeders during the wet season and help to make the sudden rises so remarkable in the Brazos and Colorado rivers in Texas.

Many of these water-courses could be used very successfully for the storage of water for irrigation purposes. The cost of putting dams up at intervals along them would not be great, and besides furnishing a valuable supply of water for irrigating purposes and for stock they would tend by their evaporation to make the air more humid and thereby increase the rain-fall.

The western part of Taylor County is remarkable for the inexhaustible supply of water that underlies the country for a distance of 30 miles north and south and 10 miles east and west. Merkel is located in the center of this water district, and has over fifty wells in the town that furnish an abundance of good pure water, which is free from alkalies.

STATEMENTS MADE BY CITIZENS OF MARTIN, GAINES, AND ANDREW COUNTIES.

[Forwarded by N. S. Schmitz, of Marienfeld, through F. E. Roesler, by whom, at request of committee, this northwest Texas testimony was obtained.]

I had the honor to call a meeting of settlers, of Martin, Gaines, and Andrew Counties, in northwest Texas, to the end of obtaining such information relative to irrigation, water supply, fruit-growing, and gardening, as well as raising field crops, for the use of the United States Senate Committee on Irrigation, as will enable said committee to form a correct opinion of our part of the State.

The meeting took place September 18 at the office of J. B. Konz, at Marienfeld, Tex., Dr. L. N. Moller, chairman; N. S. Schmitz, secretary.

The first witness examined was Mr. J. B. Konz; lives on section No. 13, township 1 south, block 36, adjoining the town site. Witness said the only way we can irrigate is from wells by the help of wind-mills and pumps; has one dug well 61 feet deep. Its costs about $1.75 per foot to dig a well. Thinks bored wells more expensive on account of the iron casing required.

Witness thinks an earth tank can be made anywhere hereabouts without much expense. He thinks he would use the clayey soil out of our natural basins and cover bottom of tank to the thickness of about a foot, and have it well tramped while moist. Thinks a great variety of fruits, especially the grape, can be successfully raised by irrigation. Has lived in this county seven years and one year in central Texas, near Austin; considers this section of country capable of producing fruit of better flavor than central Texas; considers fruit-raising very profitable, since owing to the fine flavor of the fruit raised here it will bring good prices. He thinks field crops uncertain without irrigation and doubts whether these crops would warrant the expense of irrigation. Says water can be found in liberal quantities almost anywhere in the vicinity of Marienfeld by digging or boring for it. Thinks a common well with pump and 12-foot wind-mill capable of irrigating 2 acres in vegetables and 6 acres in fruit-trees; considers it a day's labor to apply water for irrigation to 1 acre in vegetables. Does not think it safe to raise fruit or vegetables without irrigation.

The second witness examined was Joseph Gittinger, of Marienfeld. Lives on section 11, township 1 south, block 36, 1 mile from town. He believes in irrigation from wells. He applies it by letting the water run in open ditches over the ground. The ditches to be from 2 to 3 feet apart for vegetables. Has one dug well 80 feet deep, with pump and 12-foot "challenge" windmill. Pump has 3-inch cylinder and 1¼-inch pipe, and furnishes 10 gallons of water per minute. Made the well himself; used $30 worth of dynamite and caps. Pump and windmill have cost $130. Would recommend earthtanks, which he thinks will not leak when well tamped.

Witness considers this county and surrounding country well adapted for fruit-growing and gardening. Had fourteen years' experience with irrigation in San Antonio, Tex. Is sure this part of Texas is better than Southwest Texas or California if water can be applied to the crops. He is of opinion that grapes, onions, sweet potatoes, and tomatoes can generally be raised without irrigation, but they grow more perfect when irrigated. His well is inexhaustible. With his pump and windmill he can irrigate 3 acres in vegetables. By adding a large tank he could water double that quantity of land. He says it takes four hours to irrigate 1 acre in vegetables.

The next witness was J. B. Robertson, who lives on section 20, township 1, south, block 38, about 18 miles west of Marienfeld. Mr. Robertson and his brother C. H. Robertson have six wells. Five of them are dug wells, one a bored well 51 feet deep. The dug wells are from 35 to 45 feet deep. All these wells are inexhaustible. On section 20, where he lives, he has a double-action pump, with a 3½-inch cylinder, operated by a 12-foot "Halladay" windmill, capable to irrigate from 5 to 7 acres in vegetables. He runs the water in open ditches over the ground. Has had fifteen years' experience in irrigation in Southern and Central California. Considers soil as productive here as in California if water is applied. Has grapes and peaches now bearing that are as fine as in California. Other young fruit trees make as good growth as in California. Has irrigated land in this part of Texas the last four years. Has raised sorghum successfully without irrigation for three years on same land. Always found water wherever he tried. Dug wells have cost him $1.50 per foot.

A. Rawlins, Marienfeld, is a strong believer in irrigation from wells and reservoirs. He says he would recommend earth tanks, rendered impregnable with alternate coats of pitch, tar, and sand. Considers fruit-raising a very profitable business for this part of Texas. Says we can beat central Texas and California. Claims that irrigation is to be preferred to dry culture or any other mode. Thinks water can be obtained anywhere in this portion of Texas. Has a well 4 feet deep on section 24, township 1 south, block 37, 5 miles west of Marienfeld. He estimates that with a shallow well, with pump and windmill, the cost of a water supply for irrigating 5 acres of land, including a small tank, will be about $150; in a deep well it will be about $300. In his experience it will take from four to six hours of work to lead water over 1 acre in vegetables; if land be planted to fruit trees it takes less water and less time to irrigate it. He also says he never tried to raise anything without irrigation, not thinking it would do any good.

Dr. L. N. Moller, Marienfeld, was the next witness. He is in favor of irrigation from wells, and besides would recommend making reservoirs on the side of a slope wherever it is practicable to do so, and catch rain-water from elevated lands, and distributing it over land farther down these slopes. Has one well on section 15, township 1 south, block 36, 90 feet deep.

Witness thinks earth tanks can be made cheaply on high points, and filled from wells during the winter months, and the water thus gathered to be used in summer. Says he has no experience of his own in fruit-growing, but from his observations in California, Oregon, Nevada, and Utah and Washington Territories he considers this part of Texas superior to any of them. He thinks grapes and peaches will do as well here as anywhere. Witness further says: "I do not think central Texas can compare with this portion of the State as far as fruit-growing is concerned. I have lived there four years, and I find this part much superior, especially for grapes. I think everybody who attends to grape-growing rightly must become rich at it. I do not think grapes need much irrigation after the first year. I think alfalfa would do well without irrigation. I have seen it grow well on a side hill near Salt Lake, Utah Territory."

The next witness was Prof. G. H. Seymour, of Marienfeld. He thinks grapes will grow without much irrigation. Our peaches and grapes here have a very good flavor, and, I think, will remain free from diseases to which they are subject in more moist a climate. I think our fruit and grapes bear shipping long distances. I have great faith in the future of this country as a fruit-growing country.

Joseph Karl, Marienfeld, was the next witness. He thinks the best method of irrigation is with artesian wells; such wells could be sunk easily in Martin County and all over the Staked Plains. Has seen such wells in Hungary and Servia. Considers this portion of Texas excellent for fruit growing—better even than Hungary. Thinks we can raise wine as good as the Tokay of Hungary if we adopt irrigation. Considers grapes and fruits very profitable if raised by irrigation. Has planted rye, corn, and sorghum without irrigation. The rye was 4 feet high, but did not fill on account of drought. Corn made about 10 bushels per acre. Thinks an acre in fruit-trees can be irrigated from a well in two hours. Has been engaged in grape and fruit growing in this county for three years.

Isaac Gardener lives 12 miles northwest of Marienfeld; has three wells, one 28 feet deep, one 40 feet deep, and one bored well 63 feet deep. Has a pump and 10-foot "Halladay" windmill on 28-foot well, from which he can water twenty-five hundred head of cattle, equal to 25,000 gallons of water per day. Cost of boring wells, $1.50 per foot.

P. M. De Witt, living 18 miles west of Marienfeld, has three wells, one 20 feet deep, one 22 feet deep, and one 35 feet deep. Has one 12-foot "Halladay" windmill and one "Bird" mill. His wells are also inexhaustible.

Robert Bartlett, on his ranch 20 miles northwest of Marienfeld, in Martin County, has eight wells and seven windmills. The wells are from 35 to 63 feet deep and inexhaustible.

Frederick Sommers, Marienfeld, said: Witness lives on section 15, township 1 south, block 36, one-half mile west of Marienfeld. Has one well 70 feet deep, with pump and "Challenge" windmill, from which he watered one hundred head of cattle and irrigated about 1 acre in vegetables. Considers irrigation from wells a success for fruit-growing and gardening. Has lived here five years. Has raised field crops without irrigation every year, though, with the exception of sorghum, the returns were light, owing to dry summers. He believes in earth tanks.

Louis Kochs, Marienfeld, lives on section 17, township 1 south, block 36; has two wells both 85 feet deep and inexhaustible. On one of these wells he has a 10-foot iron turbine windmill. It furnishes about 600 gallons of water per hour.

George Matzec, Marienfeld, lives on section 25, township 1 south, block 36, 1 mile south of Marinfeld. His well is 70 feet deep and inexhaustible; has the greatest faith in northwest Texas as a fruit-growing country. His one and two year old grapes all bore fine fruit this season. Many of his two-year-old grapes have bloomed and are now bearing a second crop. He firmly believes in irrigation from wells. He considers this part much superior to Bohemia, his native land, as a fruit country; has planted tobacco successfully for several years with irrigation.

John Pagendarm, Marienfeld, lives on section 1, township 1 south, block 36, 2 miles north of Marienfeld; has grown vegetables successfully by irrigation for five years. His well is 110 feet deep; has pump and iron turbine windmill, 10-foot wheel; has sufficient water for a large herd of cattle and to irrigate 1 acre in vegetables. He believes in irrigation from wells and in fruit raising, especially the grape.

We have in Martin County quite a number of wells not mentioned in the foregoing; notably one on section 4, township 1 south, block 37, 8 miles west of Marienfeld. It is 6 feet deep. It has a chain-and-bucket pump capable of furnishing 5,000 gallons of water per hour. It is inexhaustible. Pumps by 1 horse-power. This pump was kept going fourteen hours in August, 1889, at a round-up, when it supplied water for eight thousand head of cattle. This well belongs to C. C. Slaughter, of Dallas, Tex. He also has a similar well in Mustang Draw, 18 miles northwest of Marienfeld. This well is 12 feet deep. Along Mustang Draw are five or six more wells from 10 to 15 feet deep that are considered inexhaustible. C. C. Slaughter has three wells on Sulphur Draw, at a place called Soda Springs, which wells are from 8 to 12 feet deep and inexhaustible. They are supplied with pumps and windmills and the water is secured in troughs for watering cattle. Soda Springs is 21 miles north of Marienfeld, in Martin County.

The first witness from Gaines County, Tex, was W. A. Quebedeaux. He lives about 100 miles northwest of Marienfeld. He has one well 30 feet deep, with a pump and 12 foot "Star" windmill. With a 4-inch cylinder and 2-inch pipe his well will supply and does supply seven hundred head of cattle. He says he has an earth tank 50 by 60 feet, which holds water without any protection except a strong wire fence to keep cattle out. Has stood for three years and is good for all time. Out of this tank he draws water into troughs for his cattle as fast as they need it. His windmill runs day and night and keeps large tank full. He does not farm.

The next witness from Gaines County was George Bell; he lives about 110 miles northwest of Marienfeld. Has three wells—one dug well 27 feet deep and one 40 feet deep. One bored well 51-feet deep. Has one "Star" 12-foot windmill, and one 10-foot iron turbine mill. They throw about 15 gallons of water per minute. Both dug wells are inexhaustible. He can not say anything about bored wells because he has not tried them yet. Can find an abundance of water anywhere in his vicinity by sinking a well. He never farmed any. Thinks this is a very good country for all kinds of fruit, but especially the grape.

Joseph Arnold, the next witness, lives also in Gaines County, about 100 miles northwest of Marienfeld. He has four dug wells, supplied with one 12-foot "Star" windmill and three 10-foot iron turbines. His wells are about 40 feet deep, and furnish about 10 gallons of water per minute each. Has one dirt tank about 200 feet in circumference, 6 feet deep. The earth is thrown up and a rough stone wall is built around it on the outside. His windmills pump water into this earth tank and he lets it run in troughs for the cattle to drink. He says earth tanks are a success in his vicinity. Never raised fruit; raised sorghum without irrigation in 1888, but it was too dry for it this season. His wells are inexhaustible. From these last three witnesses it was learned that the following wells are in Gaines County, Tex.:

On Mallet ranch there are twelve dug wells from 9 to 45 feet deep, mostly supplied with iron turbine windmills. Two of them have 16-foot "Eclipse" windmills. There are also on this ranch eight or ten earth tanks—the ground excavated and thrown up outside, and then fenced to keep cattle out. These tanks give perfect satisfaction. These wells are inexhaustible. In making them, when water is reached the manager puts a strong pump with 5-inch cylinder into the well to keep the water out as much as possible, so as to allow the workmen to sink the well as deep as possible. Mr. Hardgrove has three dug wells from 9 to 40 feet deep. He has one 10-foot "Halladay" and one 12-foot "Star" windmill. Joseph Campbell has two wells 30 feet deep. Has one iron turbine and one "Star." A. F. Crowley has two wells; both are open wells and inexhaustible. Lighe Estes has six good open wells, or dug wells, and windmills. J. Arneson has one well—"Star" mill. The cost of digging wells is about $2 a foot; boring, $1 a foot. In sinking wells about 18 inches of flint-rock is met. The balance is earth and sand-stone. Another witness, Mr. T. C. Estes, could not say positively whether he lives in Texas or in New Mexico, the line not being well established. He has a well 34 feet deep furnishing an abundance of water for his flock of sheep. He never found any rocks in digging. Mr. James Smith, of Five Wells Ranch, lives about 40 miles northwest of Marienfeld. There are eight wells and seven wind-mills on this ranch. One well is 15 feet deep; two are 45; the others from 50 to 60 feet deep. These latter seven are bored wells. The 15-foot open well furnishes water for one thousand five hundred head of cattle; the others have a capacity for five hundred head. They use five "Star," one "Eclipse," and one "Kirkwood" wind-mill and wooden troughs.

In sending this report now it is impossible to secure the opinion of the Rev. P. A. Peters, of Marienfeld, he being absent. The secretary, N. S. Schmitz, desires to say for him that the reverend gentleman has always considered the Staked Plains country the best fruit, and especially grape, producing country in America. Four years ago Father Peters had about one-half acre planted in grapes, from which he made quite a lot of wine last year. In 1889, out of this half acre, he made 174 gallons of wine, which connoisseurs claim to be equal to any they ever tasted. I have visited the vineyard of Father Peters several times this summer, once in company with a gentleman fresh from France, who, when told these grapes had never been manured, told me that in the champagne district near Epernay, where the finest of wines were produced, the grape does not make such vigorous growth nor bear fruit so young. Mr. Tripis, of Waco, Tex., a native of Sicily, Italy, who visited this vineyard also this summer, thinks this part of Texas excels every other country in grapes. Father Peters owns section 14, township 1 south, block 36. He has one well and pump, operated by a 14-foot "Challenge" mill. While he is the first who planted grapes, he also raises large quantities of vegetables by irrigation from his 98-foot-deep well. He farms extensively, and if his field crops do not yield so abundantly, owing to dry summers, he has absolute faith in the country whenever irrigation is applied.

As to soil, topography, and rain-fall.—Martin County and the attached counties of Gaines, Joacum, and Terry are on the so-called Staked Plains or Llano Estacado. The soil is mostly a chocolate-colored loam and red sandy land, both of great depth and fertility. The Staked Plains are an eleveted plateau, with an altitude of from 2,500 to 3,000 feet, extending about 125 miles east and west and 200 miles north and south. They are bounded on the west by the Pecos River and on the other three sides by a ledge of steep, rocky bluffs, from 50 to 100 feet high, and often of much greater elevation, and it seems from the abrupt and rugged outlines that this plateau has been lifted up by some convulsion of nature. From the top of these bluffs, forming the boundaries, stretches out an undulating plain of surpassing beauty, covered with a variety of rich grasses and traversed by long and gentle swells and depressions, strongly resembling those of the sea when settling down after a storm. This uniformity of surface, however, is broken at rare intervals by deeper depressions, so-called draws, which look like a river bed. Water, there is none, but it can be obtained in all these draws within from 5 to 15 feet from the surface. In order to illustrate how this land lays, I will say that a railroad could be built over this Staked Plain 100 miles long without either cut or fill, and still I do not believe there are 40 acres of land in one body that are perfectly level.

The rain-fall this year, if well distributed, would have been sufficient for all kinds of crops. There was plenty of moisture in the ground all winter for plowing; we had good strong rains also, early in spring up to March 1.

The following table gives amount of rain-fall to date. Since May I measured it in a Government gauge supplied to me by the Signal Service as its voluntary observer at this point.

Date.	How ascertained.	Inches.	Date.	How ascertained.	Inches.
Feb. 28	Approximated	1.50	June 18	Gauged	0.04
Mar. 1	do	1.00	June 21	do	0.63
Mar. 11	do	0.30	June 29	do	0.05
Apr. 10	do	0.50	July 2	do	0.23
Apr. 12	do	0.10	July 6	do	0.04
Apr. 13	do	0.10	July 7	do	0.14
Apr. 20-21	do	1.50	July 8	do	1.02
May 21	Gauged	0.49	July 9	do	1.60
May 22		trace.	July 10	do	0.04
May 23	Gauged	0.09	July 11	do	0.05
May 26	do	0.23	Aug. 10	do	0.04
May 28		trace.	Aug. 11	do	0.05
June 3	Gauged	0.01	September 14-15	do	1.54
June 6	do	0.21	September 15	do	0.14
June 9	do	0.48	September 17		trace.
June 10	do	0.20	September 21	Gauged	0.08
June 11	do	1.20	September 25	do	0.06
June 16	do	0.28	September 27-28	do	1.01

RECAPITULATION.

February	Approximated	1.50	July	Gauged	3.12
March	do	1.30	August	do	0.09
April	do	2.20	September to 28th	do	2.83
May	Gauged	0.81			
June	do	3.10	Total		14.95

STATEMENT OF GEORGE M. SWINK, OF ESTACADO.

IN RELATION TO THE PANHANDLE REGION.

The population of Crosby County is 600; that of Floyd, Dickens, and Motley Counties about 300 each; Garza, 100; Lubbock about 100. Surface of all these counties gently undulating prairies; soils principally dark sandy loams without exception fertile; grasses, mesquite predominates, some buffalo grass and abundance of hay grasses in the depressions. Altitude about 3,200 to 3,500 feet above sea level. Crops generally grown without irrigation are sorghum, millet, and forage, generally melons, garden truck, and vegetables of all descriptions. Several young orchards have been planted and some trees bore this year. Wild grapes, plums, and currants grow profusely along the breaks or cañons formed on the heads of the various water courses, generally tributaries of the Brazos River. Prospects for orchards on the open plain are excellent, and Mr. A. W. Lewis, near Estacado, has shown his faith by planting 80,000 young forest trees. His first orchard, consisting of peaches, pears, and apples, has borne an excellent crop this year, the flavor of the fruit being superior to that of any other part of Texas. This orchard is from five to six years old. Other orchards have been planted in the vicinity of Estacado by Messrs. Dr. William Hunt, Dr. W. V. Marshburn, Isaiah Cox, W. C. Dockum, Andrew Underhill, and others.

The neighborhood was settled in 1880, and known generally in Texas as the Quaker Colony. Since its settlement there has been enough rain-fall for all forage crops, though in some years the crop has fallen short, owing to delayed or too limited rainfall. It is generally the opinion of the people residing there that the rain-fall is increasing. As everywhere else in western Texas, there have been times where one good watering of a crop by irrigation could have been of great benefit. For purposes of irrigation there are very few water-courses that could be utilized, for the reason that the amount of running water is very limited, and secondly, that the next arable lands are somewhat remote from these water-courses. Some of these water-courses lie from 100 to 300 feet lower than the level of the lands to be irrigated; but if the capital could be secured to construct dams across these water-courses they could be made to hold back water extending from 10 to 20 miles back from the dam in a comparatively narrow channel. The land that could then be brought under irrigation would amount to thousands of acres on each side. The question of damming these water-courses, all of which carry large volumes of water during part of the year, presents no great engineering difficulty, the question being merely a matter of dollars and cents.

The principal drainage of the Plains country is in basins or depressions in the soil, some of which contain water during the entire year, others from six to nine months in the year. Many of them could be made absolutely water-tight, and nearly all could be used for irrigation by use of pumps or windmills and storage-reservoirs placed on the higher-lying land under cultivation. It would be simply a question of raising and storing the water. By applying the different means of irrigation available about nine-tenths of the lands in the county of Crosby could be cultivated by irrigation, and the same could be said of most of the adjoining counties.

At Epworth, Hale County, Mr. Alex. Jones has a large garden under irrigation from a well and a 12-foot windmill. The benefit derived from irrigation is shown in his crop, which brought him more cash money for garden vegetables than all the other gardeners have been able to obtain for their joint crops.

Water in wells is obtained in all parts where dug or bored for. The average depth is about 75 feet. In digging wells from 4 to 10 feet of soil are encountered, then generally red or dark colored clay 20 to 25 feet. Next usually water is found resting on limestone. This layer of water is not very abundant. Going through soft limestone a hard limestone is met with, then sandstone, and then water in the greatest abundance is obtained. It appears that this second water is part of an underground lake or river. No well in the second water has ever been known to be exhausted when used either for ranch or domestic purposes. In many places water in abundance is found at a depth of 40 to 50 feet. For the irrigation of small orchards and vineyards there is no question but that water can be had in abundance. By the proper use of 12 to 16 foot windmills and small storage-tanks from 12 to 13 acres could be placed under irrigation. The principal business of the country consists of stock-raising and wool-growing; but it is the opinion of the people that a farmer so situated that he could have some live stock, raise forage and food products without irrigation, and carry on a garden of 3 or 5 acres under irrigation, ought to do well in Crosby and any of the adjoining counties.

STATEMENT OF J. E. LUCE, OF CISCO, EASTLAND COUNTY.

There is probably about one-half of the land under cultivation in this county. The thrashers report this year for the county an average of a little over 20 bushels of wheat per acre. Owing to a want of rain-fall at the proper time the oat crop was cut short to about 20 bushels per acre, whilst with rain at the proper season the average would probably have equaled that of 1888, which was from 65 to 70 bushels per acre. The corn crop this year will probably average 35 bushels per acre, whilst with rain at the proper season it would have made 50 bushels per acre. If frost does not come too early our cotton crop will average about one-half bale per acre, whilst with the proper rain-fall this county would have yielded three-fourths of a bale per acre. The apples, pears, peaches, etc., which should mature during dog-days, are usually cut short for want of rain, and the later varieties are inferior to what they otherwise would be in consequence thereof.

It therefore follows that our farmers are in great need of water for their crops during July and August, and in some years a demand for water is imperative at a much earlier season. The rain-fall will probably average about 33 inches, and if properly distributed would be sufficient. I think the topographical engineer's report for this county will give the best locations for storing water. Of course, as Cisco is the largest town in the county, a deposit of water near that town would accommodate more people than at any other one point. From Cisco to the south and southwest line of Eastland County wells are usually got at from 3 to 40 feet, whilst north of Cisco to the north line of said county wells are rarely secured except at great depth, yet there are exceptions. There are also some springs.

There is no one irrigating in this county at present. We think that at many places dams can be built, with a 2-inch pipe extending through them, and a faucet in the end thereof, which can be used to advantage, and the water drawn off by pipes or ditches to the places required.

STATEMENT OF GEORGE BAUER, BIG SPRINGS, HOWARD COUNTY.

I have at present about three thousand fruit and shade trees, consisting of apple, peach, pear, plum, apricot, nectarine, cherry, quince, fig, and almond; also grapevines, blackberry, gooseberry, raspberry bushes. I commenced to plant my first trees in 1886 and 1887; about eight hundred fruit and shade trees. The drought destroyed most all of them, and those that were left were so stunted as to prove worthless. If I had had facilities to irrigate, I would have saved most all of the trees. During the fall of 1887 to 1888 I replanted with six hundred trees. During the drought of 1888 I lost four hundred. Discouraged with such poor success, I still gave tree-planting another trial in the season of 1888-'89. This time I set out two thousand five hundred trees. Through the best of culture and the best rainy season we had for years in west Texas I lost but few. I am now preparing to irrigate the coming season, for I can not rely on the natural rain-fall, and if a drought comes next season I will lose all of my trees. Had I been prepared to irrigate I would now have over one thousand fruit-bearing trees, instead of a few, every tree bringing an income of $2 per tree.

The soil and climate of this region are unsurpassed and adapted to produce the best of fruit, and of crops equal to California through proper irrigation, especially for fruit and garden crops for the Northern market.

For irrigation there are two means to be adopted: One is by damming the ravines to impound the rain-fall for use in the droughty season.

Nature has arranged this county for such reservoir irrigation. The other plan is to irrigate on a smaller scale; that is, through tanks and wells. Water is found at from 20 to 250 feet deep. Windmills are generally used for pumping. The cost of such a system for wells and tank would be about from $2,000 to $5,000, according to locality. Fully one-third of Howard County could be thus irrigated. The same would be correct for counties west of here. Irrigation would in a few years populate our present unsettled plains with a thriving population.

The Government, by establishing experimental stations for irrigation throughout the Southwest and West, would soon demonstrate the certain success of irrigation. Private capital would then develop this almost unknown region. Being close to the borders of Mexico, for political as well as commercial reasons this part of the United States should be developed and settled as rapidly as possible by the Anglo-Saxon race. Thousands of acres of fine lands can be reclaimed by irrigation to make homes for families, friendship will be strengthened, and commerce increased in both Republics.

STATEMENT OF W. J. MALTBY, OF BAIRD, CALLAHAN COUNTY.

The topography of this county is undulating.

There are estimated to be 16,000 acres in cultivation.

The yield in wheat is from 15 to 35 bushels per acre; in corn, from 25 to to 50 bushels per acre. Oats yield from 40 to 100 bushels per acre; cotton, from one-half to three-fourths of a bale per acre; all kinds of grasses, as far as tried, from 2 to 3 tons per acre, including millet, Johnson grass, and sorghum.

The value of these crops for the past year in this county is estimated at $200,000, including vegetables and hay products.

The annual rain-fall is 30.3 inches. The rain-fall for the months of January, February, March, and April, as well as November and December, is 1.50 inches.

March, June, and October are the months (and September) in which irrigation would be the most beneficial, as that would insure both a season for planting and fruitage of the crop.

There are about three hundred wells in the county, ranging in depth from 10 to 50 feet; average depth, 20 feet; usual cost, $1 per foot.

Sorghum, millet, and Johnson grass will grow without much water.

All the crops grown in this county would be doubled if water could be had on them at the proper seasons.

No artesian wells have ever been bored in this county, but the general opinion prevails that water for irrigating purposes can be obtained in all the valleys in the county at a depth ranging from 600 to 2,000 feet, and there is not a valley in the county that if irrigated but would more than double its yield of agricultural products. These valleys are numerous and are all so situated as that dams could be constructed and a large acreage irrigated in this way. The outlay to construct a few dams at various points need not be necessarily great, as the material for their construction is found in abundant quantities in all our hills adjacent to these valleys. If the proper season could be put in the earth at the proper time, there is no part of the United States that would surpass these valleys in the production of fruits and vegetables. Apples, peaches, pears, plums, and grapes all do well, especially the peach, pear, and grape, which as produced here are the finest flavored in the world.

If a few artesian wells could be obtained in this county by which the question of artesian water would be made certain individual enterprise would then do the rest, and our county would teem with population well-supported, for the products of this section will support a greater population than any other section, and it is the healthiest country known. Near the geographical center of the county, and just north of the divide of the waters of the Brazos and Colorado Rivers, an artesian well can be sunk which, if a success—and there is every reason to believe it would be—a vast body of land would be made almost in a garden, as it could and would all be put in cultivation. This I have had in my mind for years, and if artesian water can be obtained at this point, then not only in this county upon the north of this divide, but in all the adjacent counties, the question would be solved, except as to the depth, which would of course vary, owing to the altitude of the point where the well would be made.

STATEMENT OF C. H. EARNEST, OF COLORADO.

First, with respect to the topography of Mitchell County: The extreme eastern and northwestern portion of the county is high table-land, with a soil almost approaching black waxy, perfectly level, except where modified by basins or slight depressions in the general surface, in which water stands for a considerable portion of the year after once filled by rain-fall. This character of ground is limited within the bounds of Mitchell County, the most of this table-land being in Nolan County, to the eastward. West of this table-land begin the breaks or ravines which form the headwaters of Lone Wolf Creek and North and South Champlin Creeks. These streams flow southwestwardly to about the center and south of the center of the county, where they empty into the Colorado River. They are not running streams, except for a very short period after rains. They do however furnish an immense volume of water when it rains because of the large area drained by them.

The Colorado River runs clear through the county from northwest to southeast, being a running stream the year round, except for perhaps a month during a very dry season. It does not then cease running, but only loses itself in places here and there where the bed of the stream is sand.

West of Colorado River are the following streams flowing into the Colorado River and situate partially or entirely within Mitchell County, to wit: Willow Creek, Morgan, Wild Horse, Camp Creek, Beal's Creek, Hackberry, Dugout, and Rendrebrook. On the east side of the Colorado and in the southeastern portion of the county we omitted to mention Silver Creek, which is a running stream the greater portion of the year. The same may be said of Deep Creek, which rises in Scurry County and empties into the Colorado River about 3 miles within Mitchell County from the north line.

Reverting to the country west of the Colorado River, this is divided into table lands between the creeks and valleys along the creeks. Some of these valleys are as much as 2 to 3 miles wide, notably that of Morgan Creek. The soil of the Morgan Creek country is a red clay. Experience has shown that it is very fertile for the production of general crops, and will easily hold water in tank building. In the Rendrebrook, Beal's Creek, and Hackberry country the divides or intervening prairies are black or dark chocolate soils and very rich. Rendrebrook and Hackberry Creeks are furnished by springs at the head of each, furnishing a regular stream the year round, of four to five inches of water.

For irrigation we would think Hackberry preferable to Rendrebrook spring from the fact that the valleys of the former are greater in extent than those of the latter.

Second. Number of wells in the county. So far there must be as many as ninety to one hundred wells. The average depth is 100 feet. The wells around the town of Colorado are generally about 100 feet (from 75 to 100), the water rising in them from 30 to 60 feet. The shallowest wells are in the northern and eastern portions of the county. We know of no well in the county which, being as deep as 90 or 100 feet, can be pumped dry by a 12-foot windmill running forty-eight hours under a full head of wind. In the western portion of the county it is deepest to a good flow of water.

At the city water-works, 1¼ miles east of the business portion of the town, are two wells, only one of which is used and operated by a windmill—a 30-foot mill. The lessees of the works, Messrs. Fletcher & Caldwell, inform me that the water can not be exhausted by a constant use of this mill for any length of time. The only way in which it can be lowered at all is by attaching an engine, and they estimate the flow of either of these wells to be one hundred and forty gallons each to the minute. These wells are 190-foot bored wells.

Since the leasing of the works by Messrs. Fletcher & Caldwell they erected a 30-foot mill over one well, and during their lease of more than eighteen months they have not had to use their steam-engine as much as three weeks altogether, and they furnish the water supply for a city of 3,000 inhabitants.

This stream of water was found in boring for salt by the new salt company at the same depth, and it is believed that at the depth of 190 to 200 feet it can be found anywhere east of the Colorado River.

The salt wells, of course, are as deep as 940 feet. After striking salt they went this deep to get ample water. Mr. Blount, of the Lone Star Salt Works, tells me that their steam-engine pumping day and night has never lowered their salt well.

This volume of water, it will be remembered, is below the bed of salt and can be cased off. The stream of water at 200 feet and less is above the bed of salt, and is good water. The cost per foot of bored wells is now 75 cents per foot for the first hundred feet, and perhaps $1 or $1.25 per foot for the next hundred.

Third. No one here is farming strictly by irrigation. Several are gardening, fruit and grape growing by irrigation from shallow wells. Among them are C. H. Lasky, J. F. Clayton, A. M. K. Sowell, Mr. Wrigsell, Victor Dziedzioch, Fred. Schroder, H. C. Townsend, J. D. Martin, A. R. Earnest, H. A. Fowlkes, J. W. Holmes, W. H. Hughes, Durham Wulfjin, Ben Van Tuyl, H. B. Smoot, C. H. Earnest, and others. It is estimated that to irrigate 5 to 10 acres of fruit trees or grape vines, or both, the cost of fixtures complete would be not less than $1,000 for surface irrigation, the same as is used so far in this country. Irrigation by underground perforated tiling would add to the cost, but would very much increase the area to be covered perhaps twice or three times.

For the year 1889 there was no material difference between fruits irrigated and those not irrigated. But this has been a specially good seasonable year. Ordinarily the difference is remarkable where they are irrigated and well cultivated as well.

Fourth. The crops that will do well every year in this county without irrigation are sorghum and the ordinary forage crops and cotton. Three years out of five corn (Indian corn) will do well without irrigation; so also will potatoes, melons, etc.

Our irrigated fruits are superior to the fruits of central Texas, far superior in flavor, and are equal, if not superior, to the irrigated fruits of California. This statement is made from actual comparison of fruits raised this year in Mitchell County with those raised in central Texas, and upon the strength of statements of Californians who are here and who resided for a number of years in California. Our grapes are equal to the California grapes, and all varieties have been given a thorough test except the El Paso or Mission grape variety. The test as to this is limited but very satisfactory.

Mr. W. S. Marshall thinks that by using a 30-foot mill pumping water from a 200-foot well, with a tank constructed after the manner of the reservoir at the works of the Texas Salt Company (lined with pitch and tar), and with perforated tiling or some other cheap means of distribution of the water without waste, that 30 to 50 acres of fruit trees or grape vines could be irrigated to advantage.

As to whether the Colorado River or other streams in the county could be utilized by dams or storage tanks for profitable irrigation is a question which could be best answered by some one more familiar with irrigation. A rich area of country could be reached by any of these streams with a head of water far enough up to reach our upland prairies, and it would seem the plan would be a practicable one.

STATEMENT OF MARSHALL H. D. W. SMITH, JR., ASSISTANT ENGINEER OF THE TEXAS AND PACIFIC RAILWAY.

I would say that the most important streams on the Rio Grande division for irrigating purposes are the Brazos, the Colorado, and the Pecos Rivers. These are living streams, running at all seasons, and flowing through rich valleys susceptible of a high degree of cultivation if properly irrigated. The Brazos valley is accounted the best region in Texas for cotton and wheat, and is settling up rapidly throughout its entire length. The turgid waters of the Brazos hold in suspension vast quantities of rich detritus, which, if distributed over the adjoining lands, would greatly increase their fertility, and enhance the value of the riparian tracts especially.

The country along the Colorado River is as yet but sparsely stttled, being given up almost exclusively to the stockmen; but the rich chocolate loam of this section, particularly along the headwaters of the river, offer tempting inducements to the farmer. Here I have seen mesquite trees 30 inches in diameter, the normal growth of this tree rarely exceeding 10 inches. This in small tracts, where the water reached them by natural means.

So far as experience shows, the Pecos valley is very productive, and great hopes are entertained for its future. The Pioneer Canal Company, an incorporated institution, is now engaged in constructing a large irrigating ditch in this valley, which they will have in working order in the near future.

As to water from wells: Between Gomez and Arroyo flowing water impregnated with sulphur can be obtained at depths varying from 250 to 500 feet. Between Big Springs and Monahan's, where our road traverses the southern edge of the Staked Plains Plateau, a distance of about 100 miles, water can be found at 50 feet depth; though between Douro and Monahan's, 25 miles, the water is more or less saline. At Monahan's, however, where we have three shallow wells, the water is fresh and in unlimited supply.

The artesian well at Pecos is a strong flowing well, being 213 feet deep, and lifting the water to 30 feet above the surface by natural pressure; but we rarely use it for steaming purposes, owing to the presence of sulphur. We have at Toyah an abandoned artesian flowing well, 800 feet deep, useless for engines on account of its sulphur impregnation.

Our deep wells at Colorado and Van Horn, or wells elsewhere of similar depth, could not be made available for irrigating purposes, since the cost of raising water from such great depth would be so great as to preclude its use.

The San Martine Valley, around San Martine Station, enjoys an annual rain-fall unprecedented in western Texas. Two miles north of San Martine Tank water can be obtained at any time at a depth of 2 feet.

Two miles north of Carrizo Pass water can be found in great abundance at slight depths.

Antelope and Apache Springs, about 7 miles south of Kent Station, are large, bold springs, with a daily capacity of about 250,000 gallons.

Water stations of the Texas and Pacific Railway, Rio Grande Division.

Distance West from Fort Worth.	Name of station.	Source of supply.	Daily capacity.	Remarks.
Miles.			*Gallons.*	
0	Fort Worth	Artesian well and pond	75,000	Steam pump, well 389 feet deep.
2.60	Clear Fork	Clear Fork Creek	Unlimited	Do.
20.13	Aledo	Three wells	40,000	Do.
30.65	Weatherford	Well and siphon	18,000	Steam pump, well 43 feet deep; siphon from creek.
47.95	Rock Creek	Well and creek	Unlimited	Steam pump, well 41 feet deep.
55.21	Brazos	Palo Pinto Creek	do	Steam pump.
79.43	Strawn	Well	50,000	Steam pump, well 31 feet deep.
84.25	Canyon	Palo Pinto Creek	Unlimited	Steam pump.
92.52	Tiffin	do	do	Do.
98.57	Colony Fork	Well and creek	6,500	Steam pump, well 65 feet deep; water from well, Colony Fork Creek, and, in very dry seasons, tank cars.
121.37	Delmar	Pond	Limited	Steam pump.
137.80	Baird	Mexia Creek	Unlimited	Do.
139.25	do	Pond	Limited	Steam pump, pond one-half mile east of round house; capacity, 8,300,000 gallons.
146.68	Clyde	Two wells	10,000	Steam pump, wells 42 feet deep.
160.20	Abilene	Pond	Unlimited	Steam pump, pond formed by damming Cedar and Clear Creeks at their confluence.
178.20	Merkle	Well	40,000	Steam pump, well 48 feet deep.
199.74	Sweetwater	Sweetwater Creek	Unlimited	Steam pump, well also. Well was insufficient, and creek was dammed.
223.25	Lorraine	Well and pond	60,000	Steam pump, well 50 feet deep.
228.83	Colorado	Artesian well	24,000	Steam pump, well 143 feet deep.
237.92	Westbrook	Pond	Limited	Steam pump.
253.90	Iatan	do	Unlimited	Do.
267.61	Big Springs	Spring	100,000	Steam pump, distance south from tank to spring, 11,880 feet.
288.39	Marienfeld	Well	24,000	Steam pump, well 72 feet deep.
304.62	Midland	do	60,000	Steam pump, well 32 feet deep.
329.58	Odessa	do	50,000	Steam pump, well 47 feet deep.
362.96	Monahan's	Three wells	200,000	Steam pump, wells 52 feet deep.
399.24	Pecos	Artesian well	60,000	Natural flow; sulphur water. Well 213 feet deep used in emergencies only.
419.83	Toyah	Tank cars from Monahan's		Water in this vicinity strongly impregnated with sulphur.
443.46	San Martine	Spring	8,000	Steam pump.
488.40	Van Horn	Four artesian wells	Unlimited	Steam pump, 2 wells 600 feet deep; 1 well, 580 feet, and 1 well 550 feet deep.
521.99	Sierra Blanca	Tank cars from Van Horn		Southern Pacific Railway has artesian well here 930 feet deep; water slightly brackish. Maximum daily capacity about 24,000 gallons. Texas and Pacific Railway is now (October, 1889) sinking one here.

Principal streams crossed by Texas and Pacific Railway, Rio Grande division, with distances west of Fort Worth, in miles.

Stream.	Miles.	Stream.	Miles.
Clear Fork of Trinity River	2.61	North Fork Palo Pinto Creek	83.30
Do	20.18	Do	83.76
South Fork of Trinity River	20.41	Do	84.30
Do	21.28	Do	84.61
Do	26.93	Do	85.26
Do	27.80	Do	87.20
Do	28.09	Do	88.86
Do	28.67	Palo Pinto Creek (viaduct)	90.76
Do	30.11	Clear Fork of Brazos River	163.04
Do	30.60	Champlin's Creek	223.30
South Branch Clear Fork of Trinity River	32.59	Lone Wolf Creek	229.78
Do	33.57	Colorado River	230.37
Brazos River	54.55	Morgan Creek	235.04
Palo Pinto Creek	60.09	Pecos River	398.26
South Fork Palo Pinto Creek	77.70		

Water stations supplied from streams alone	6
Water stations supplied from wells alone	11
Water stations supplied from ponds alone	5
Water stations supplied from two or more sources	5
Water stations supplied from springs alone	2
Water stations supplied from tank-cars	2
Total number of water stations, Rio Grande division, this date (October 22, 1889)	31

THE KANSAS DIVISION.

ON TRAIN, NEAR DODGE CITY, KANS., *September* 11, 1889.

The committee met pursuant to the call of the chairman. Present: Mr. Stewart (chairman) and Mr. Jones; also Director Powell.

STATEMENT OF EDWARD D. TAYLOR, OF KINGSLEY.

The CHAIRMAN. Where do you reside and what is your occupation?

Mr. TAYLOR. I reside in Kingsley, Kans., and I am superintendent of public instruction of the county of Edwards.

The CHAIRMAN. Do you have any difficulty in raising crops in this vicinity for want of moisture?

Mr. TAYLOR. Yes.

The CHAIRMAN. How often do you raise a full crop here if you depend entirely on rain-fall?

Mr. TAYLOR. We have raised but two full crops since I have been in this western country—that is, in twelve years. We have only partial crops nearly every year.

The CHAIRMAN. Can you raise partial crops at all times—vegetables, fruit, and grains?

Mr. TAYLOR. We raise partial crops of grain and corn nearly every year, but we need irrigation for full crops. Apples and cherries will give a full crop without irrigation, but peaches freeze.

The CHAIRMAN. What are the means of irrigation?

Mr. TAYLOR. The Arkansas River is the only means we have in this neighborhood. There is a small creek here, called Coon Creek, that gives a little water.

The CHAIRMAN. How wide is the Arkansas valley—the low valley—before you get to the hills?

Mr. TAYLOR. On the north that valley runs 25 miles. On the south there are sand-hills near the river.

The CHAIRMAN. To what depth do you require to sink for water in this valley.

Mr. TAYLOR. On an average 40 feet. On the divide they have to go some 200 feet.

The CHAIRMAN. Are there some places less than 40?

Mr. TAYLOR. Some 20 and some 60.

The CHAIRMAN. In what formation do you find the water?

Mr. TAYLOR. In quicksand.

The CHAIRMAN. Does that extend all over the valley?

Mr. TAYLOR. Everywhere.

The CHAIRMAN. What do you say as to the quantity of water where you do reach it?

Mr. TAYLOR. There is more than could be exhausted by any ordinary pump. In one well we put in a steam-pump and it did not get down over 4 feet, when they got 400 gallons of water a minute; but the engine could not pump that more than one or two minutes; consequently they could not exhaust the well with that engine.

The CHAIRMAN. How much land could be irrigated with a single well with a good pump?

Mr. TAYLOR. I could not say of my own knowledge. The pump I speak of was such an absolute failure that they did not try to irrigate with it. It was said they could have irrigated 80 acres with that pump.

The CHAIRMAN. At what expense?

Mr. TAYLOR. I could not say as to that.

The CHAIRMAN. When you go back from the valley proper what is the character of the country in western Kansas?

Mr. TAYLOR. It is a rolling prairie.

The CHAIRMAN. Have you ever examined the rolling prairie with reference to the storage of water in ravines?

Mr. TAYLOR. Not with special knowledge in that respect, but I know there could be water stored in the ravines. I have seen ravines where men in wagons would be drowned during the time of the rains. The ravines could not be forded.

The CHAIRMAN. Does the rain fall in violent showers during the season?

Mr. TAYLOR. Nearly always in violent showers.

The CHAIRMAN. At what time do the showers prevail?

Mr. TAYLOR. In July and August; sometimes earlier; sometimes in March or April.

The CHAIRMAN. If you saved the water then would that be early enough for the irrigation of crops?

Mr. TAYLOR. Not unless there was rain-fall or snow during the winter to start the crops; that rain would not be early enough.

The CHAIRMAN. If you had plenty of water how early would you plant corn?

Mr. TAYLOR. In May or June.

The CHAIRMAN. Then water in July or August would help you?

Mr. TAYLOR. Yes.

The CHAIRMAN. How late could you plant potatoes if you had water?

Mr. TAYLOR. At the same time as other vegetables. These rains come usually in July and August, and they are too far apart then.

The CHAIRMAN. But if that water were stored you could do something with it?

Mr. TAYLOR. Yes.

The CHAIRMAN. Have any of the people who attempted to farm here left because they could not raise regular crops?

Mr. TAYLOR. Yes; many.

The CHAIRMAN. As to the town of Kingsley, has anybody left that on account of the drought?

Mr. TAYLOR. Yes.

The CHAIRMAN. How many?

Mr. TAYLOR. I presume five hundred.

The CHAIRMAN. Do you know the exact longitude of this place?

Mr. TAYLOR. I do not. We are near the one hundredth meridian.

The CHAIRMAN. How is it farther east from here? Is there more rain than there is here.

Mr. TAYLOR. Somewhat. I only know by what men tell me. They have better crops than we have here.

The CHAIRMAN. How is it west of here?

Mr. TAYLOR. Worse.

Adjourned.

DODGE CITY, KANS., *September* 12, 1889.

The committee met at 7 p. m., pursuant to call of the chairman.

Present, Mr. Stewart (chairman).

STATEMENT OF J. W. GILBERT, OF DODGE CITY.

The CHAIRMAN. How long have you resided here, Mr. Gilbert?

Mr. GILBERT. In this county, nine years.

The CHAIRMAN. Is there sufficient rain-fall here to produce crops without artificial irrigation?

Mr. GILBERT. No, sir.

The CHAIRMAN. What kind of crops can you produce here without irrigation?

Mr. GILBERT. Nothing very successfully, except perhaps sorghum, and of that not a full crop.

The CHAIRMAN. You can not produce the various cereals and vegetables and fruits without irrigation.

Mr. GILBERT. Not successfully.

The CHAIRMAN. What crops can you produce with irrigation?

Mr. GILBERT. Anything adapted to this latitude.

The CHAIRMAN. With full success?

Mr. GILBERT. Yes.

The CHAIRMAN. With irrigation, how much wheat can you produce?

Mr. GILBERT. From 40 to 50 bushels an acre, at least.

The CHAIRMAN. And how much barley?

Mr. GILBERT. I could not answer that question intelligently. I do not know.

The CHAIRMAN. You have not tried it?

Mr. GILBERT. No.

The CHAIRMAN. How is it with oats?

Mr. GILBERT. You can produce with irrigation as full a crop of oats as is grown anywhere.

The CHAIRMAN. Can you produce fruits here with irrigation?

Mr. GILBERT. The very choicest quality of fruits.

The CHAIRMAN. Of all kinds adapted to this temperate region?

Mr. GILBERT. Yes.

The CHAIRMAN. How is it with vegetables of different kinds?

Mr. GILBERT. They grow very finely with irrigation.

The CHAIRMAN. You can not produce them without irrigation?

Mr. GILBERT. No, sir.

The CHAIRMAN. What are the opportunities to irrigate this portion of Kansas—what is your water supply?

Mr. GILBERT. The Arkansas River; but we have found since we have been operating canals here that we are liable to be short of water at the critical time that it is needed for irrigation.

The CHAIRMAN. There is no water in the river that will flow in your ditch at that time?

Mr. GILBERT. No.

The CHAIRMAN. When do you require water?

Mr. GILBERT. During June, July, and August.

The CHAIRMAN. How wide is the valley of the Arkansas proper here before you get to the rolling part?

Mr. GILBERT. I think it would average 5 miles.

The **Chairman**. How deep do you have to sink in the valley of the Arkansas to strike water?

Mr. **Gilbert**. About 4 or 5 feet; though on what they call the first bottom not so far as that.

The **Chairman**. On the second bottom, including the 5 or 6 miles wide that you spoke of, how would it be?

Mr. **Gilbert**. I think an average depth of 6 or 8 feet.

The **Chairman**. Suppose you went 10 miles wide, how deep would you have to sink?

Mr. **Gilbert**. It would depend somewhat on circumstances; probably you would have to go to a depth of 75 to 150 feet.

The **Chairman**. That is, when you get on the uplands on the divide?

Mr. **Gilbert**. Yes.

The **Chairman**. In the valley, is there a good supply of this water that you find under ground?

Mr. **Gilbert**. We think it is unlimited almost.

The **Chairman**. In what formation do you find it?

Mr. **Gilbert**. In sand.

The **Chairman**. You have not sunk through the sand to know how deep it is, have you?

Mr. **Gilbert**. We are doing that now.

The **Chairman**. Have you any idea how deep it is?

Mr. **Gilbert**. The sands runs from 6 to 12 feet in depth.

The **Chairman**. Do you believe there is an underground river flowing in this sand?

Mr. **Gilbert**. Yes.

The **Chairman**. That is, the water that passes down in the dry season all mainly under ground?

Mr. **Gilbert**. Yes; all of it to every appearance.

The **Chairman**. Have you tried the experiment of lifting that to the surface in any way?

Mr. **Gilbert**. No. We want to experiment by going below the bed of the river for our water supply and then conducting it into reservoirs.

The **Chairman**. What is the fall of the river?

Mr. **Gilbert**. About 7 feet to the mile. That is about the general slope of the country.

The **Chairman**. Have you tried running a cut or tunnel at a less grade than the river, so that you could get a flow of water?

Mr. **Gilbert**. The canal we have in operation now has a fall of only 1½ feet to the mile.

The **Chairman**. I mean you have not run it into the ground to see whether you could intercept the flow of the water under ground?

Mr. **Gilbert**. No, sir; we have not undertaken that yet.

The **Chairman**. Do you line your ditch with anything to prevent seepage?

Mr. **Gilbert**. No, it is not necessary.

The **Chairman**. It is not necessary when you get it to the surface?

Mr. **Gilbert**. No.

The **Chairman**. But if you should make an underground cut, I suppose you would have to protect it?

Mr. **Gilbert**. It would not have to be protected until we should reach what we term a natural canal in the sediment.

The **Chairman**. In Texas they line them with tar and pitch.

Mr. **Gilbert**. I do not think that would be necessary here.

The **Chairman**. Have you tried pumping at all?

Mr. **Gilbert**. Not in canals. We are supplying the city here with water from a well. That well is 24 feet in diameter and about 10 feet in depth. We can pump from that well millions of gallons a day and not lower it at all. That proves to us very conclusively that a reservoir or well 40 feet in width and from a half mile to 1 mile in length, properly constructed, and with the water conducted from it properly, would supply water for a canal of almost any size.

The **Chairman**. And that you could convey by gravity onto the higher lands as you went along?

Mr. **Gilbert**. Yes; we would, for instance, go 10 feet below the bed of the river. With the fall that the river and the country has to the east, we would have to go perhaps 2 miles before reaching a natural canal. We would give the ditch a fall of 1½ feet to the mile, thereby gaining 5½ feet every mile we would go.

The **Chairman**. In that way you would get an underground flow?

Mr. **Gilbert**. Yes.

The **Chairman**. And the perfection with which you could take out the water would depend on your works, and how thorough you made them?

Mr. **Gilbert**. Yes.

The **Chairman**. Have you any means of estimating what extent of country you could irrigate with the waters of the Arkansas if you could intercept the underground flow?

Mr. **Gilbert**. We are undertaking to irrigate a territory that consists of about 800,000 acres, and we think we will be able to do it. The river makes a very large bend here, starting in at Dodge City and bending to the south at Speerville east of here, that would be 13 miles from the river. The ditch we now have in operation reaches the top of the divide a little north of here and runs along that divide from that point east, dividing the water between a net-work of creeks and this river. There is very nearly half a million acres in that net-work between the creeks and the river.

The **Chairman**. That would be all right for that amount of land. When you get away from the river bed, what is the topography of the country north, south, east, and west?

Mr. **Gilbert**. The topography is very smooth in the center of our divide, sloping to the east about 7 feet to the mile and sloping to the north and to the south about 16 feet to the mile. The draws that form the topography to the north and south are, as a rule, very even and rolling, not broken, making a very nice country.

The **Chairman**. By what means can the balance of the land be irrigated beyond what you can reach by your proposed ditch?

Mr. **Gilbert**. I do not know.

The **Chairman**. Did you ever consider the question of saving the storm waters in tanks or reservoirs?

Mr. **Gilbert**. I have thought of that; yes.

The **Chairman**. That is practiced in other parts of the world?

Mr. **Gilbert**. Yes.

The **Chairman**. What would be the opportunities here for that? Could ravines be found that could be dammed; does the topography furnish an opportunity for that?

Mr. **Gilbert**. Yes.

The **Chairman**. Have you plenty of creeks and "draws," as you call them, running through the country?

Mr. **Gilbert**. Yes.

The **Chairman**. At what season of the year do the storms come?

Mr. GILBERT. Our heaviest rains come during the middle of the summer. But they come with such a rush and come and go so quickly that we could not use them.

The CHAIRMAN. I understand that; but if you had means of storage you might utilize that water?

Mr. GILBERT. Possibly. I think, however, that if you take my proposition to irrigate 800,000 acres from the canals we have in contemplation and in actual operation, we could double that amount by taking the water from the river, as I suggest, to enlarge those systems, and, perhaps, put in canals. I think that could be done to better advantage, cheaper, and with more certainty, than by efforts to get an increase from other sources.

The CHAIRMAN. I am not talking about that now. Suppose you should exhaust the river, so far as Kansas is concerned, how much do you estimate you could irrigate with the river in the State of Kansas?

Mr. GILBERT. That I could not say. I could only give you an estimate of our territory.

The CHAIRMAN. From here down?

Mr. GILBERT. Yes.

The CHAIRMAN. How much from here down?

Mr. GILBERT. I would not be able to estimate that beyond what we have in contemplation.

The CHAIRMAN. You put that at 800,000 acres, and you said that perhaps more could be irrigated?

Mr. GILBERT. Yes. I think it might perhaps be extended to 1,500,000 acres. We could extend it back.

The CHAIRMAN. Suppose you could go on and exhaust the Arkansas River, how much would that irrigate—how much would it serve?

Mr. GILBERT. That is a pretty hard question to answer.

The CHAIRMAN. You have made some examination of the quantity of water. Of course you can not give it accurately, but I should like to have an estimate.

Mr. GILBERT. I think it would irrigate one-third of the State of Kansas.

The CHAIRMAN. One-third of the part requiring irrigation, you mean?

Mr. GILBERT. Yes, and that is about 40,000 square miles.

The CHAIRMAN. As to the other two-thirds that require irrigation, what opportunity would there be for storm storage?

Mr. GILBERT. I think there would be an excellent opportunity.

The CHAIRMAN. It is an open country, as I understand it, with draws, ravines, and divides?

Mr. GILBERT. Yes.

The CHAIRMAN. It is very similar to the other countries where they store water?

Mr. GILBERT. Yes.

The CHAIRMAN. There has been no examination of the country with a view to determine what could be done in that line?

Mr. GILBERT. Not that I know of.

The CHAIRMAN. What is the character of the soil away from the immediate river bottom, on those rolling lands where you would have to store water?

Mr. GILBERT. The opportunity is very good indeed. We have a reservoir north of us that covers an area of a little over 50 acres. It is 24 feet deep. That water will seep away and evaporate about 4 inches a day.

The CHAIRMAN. If the water falls during the summer, you would not have to retain it a long time before you use it?

Mr. Gilbert. No, it will go down seemingly for two or three days to the number of inches I spoke of, but not so much after that.

The Chairman. After the reservoir gets puddled, so to speak, it would probably not seep so much?

Mr. Gilbert. Probably not.

The Chairman. Did you puddle your reservoir at all?

Mr. Gilbert. Not at all. We did not do anything to prevent its seepage.

The Chairman. How long would you have to hold the storm water before you could use it? It falls right along in the summer, does it, usually?

Mr. Gilbert. Yes, usually, but perhaps there is more that falls in the spring. We always have good prospects for crops here, but we do not get rain enough at the proper time. Our heaviest rains come after the spring season.

The Chairman. Have there been any failures of persons who attempted to farm in this part of the country?

Mr. Gilbert. Yes.

The Chairman. Have any persons left it because they could not raise crops?

Mr. Gilbert. Yes.

The Chairman. Very many?

Mr. Gilbert. Yes.

The Chairman. How often do you have an exodus or period of departure from this part of the country?

Mr. Gilbert. There has been quite a general moving out twice since I have been here, that is, within a period of about nine years.

The Chairman. How many people went out from wetern Kansas?

Mr. Gilbert. I think about one-third of the population.

The Chairman. Each time?

Mr. Gilbert. Yes.

The Chairman. What became of those that remained?

Mr. Gilbert. They branched out into the stock business and different pursuits and managed to hang along until another favorable season came.

The Chairman. Is it practicable for a farmer to come here and make a living as a farmer without irrigation?

Mr. Gilbert. No, sir.

The Chairman. You mean that it is entirely impracticable?

Mr. Gilbert. Yes.

The Chairman. And every attempt has been a failure?

Mr. Gilbert. Yes.

The Chairman. And there have been two occasions since you have been here in the last nine years that a large portion of the population left?

Mr. Gilbert. Yes.

The Chairman. What made them come back again?

Mr. Gilbert. Some of them might thereby retain their land.

The Chairman. Did the same ones come back or did a new crop come?

Mr. Gilbert. Partly some of the old ones came, but a large majority, I think, would be new-comers.

The Chairman. Then they would get experience and leave?

Mr. Gilbert. That is about it.

The Chairman. State anything further that you think may be instructive to the committee.

Mr. **Gilbert**. As a reason why we are anxious to develop this reservoir system, I will say that the Kansas Water Works and Irrigation Company have invested about $1,000,000 in a canal here. We have a canal about 96 miles long, 45 feet wide, constructed to carry 5 feet of water. Our failure to get water from the river at two or three critical times this year has led us to investigate this matter of utilizing this underground water, and we think that if we could construct a reservoir at the head of our large ditch and the other ditches that we have in contemplation we could make a success. If we could demonstrate this fact and utilize this water that we know to be under the bed of the river, it would develop about 800,000 or 1,000,000 acres of land here that would be as choice as land anywhere. I wanted to speak of that in order to show you that we are in earnest about it.

The **Chairman**. In flood times there is an abundance of water, is there?

Mr. **Gilbert**. Yes.

The **Chairman**. Is there any way to divert that and hold it in reservoirs until you want to use it?

Mr. **Gilbert**. We might store it in reservoirs. We have about fifty reservoirs on the line of our canal that we could utilize to some extent. We have some reservoirs east of here. There are two that I think of now, natural reservoirs, that would cover an area of two or three sections of land each.

The **Chairman**. Are there no places above here where it could be stored and made into large lakes above your ditch?

Mr. **Gilbert**. Yes, that could be done.

The **Chairman**. In case you fail to get sufficient underground water, why would it not be a good plan to save these flood waters?

Mr. **Gilbert**. It would be a good idea, and that could be done to some extent.

STATEMENT OF M. W. SUTTON, OF DODGE CITY.

The **Chairman**. How long have you resided here?

Mr. **Sutton**. Thirteen years.

The **Chairman**. Have you given any attention to the subject of irrigation and have you observed it here?

Mr. **Sutton**. I have to a limited extent.

The **Chairman**. What do you say as to the capacity of raising crops without irrigation?

Mr. **Sutton**. I say it is a failure.

The **Chairman**. Do you know of any person who has tried it and left the country?

Mr. **Sutton**. I have lived here for the time stated and there have been two or three new crops of people that have come in here. Many of those who did come went away. For instance, in 1879 quite a good many people come into this Western country for perhaps two or three years before 1879. Then there came a season when they left, and they continued to leave up to the fall of 1880 or the spring of 1881. In 1882 new people commenced coming and continued to come. They rushed here in crowds and continued to do so until 1887. Now they are going back again, leaving the country quite largely. They came here, they saw the rich soils and the splendid climate, and they started in to plow and plant. Then the rains came in the spring and the crops grew magnificently on and up to, perhaps, the 1st of July, and then there was no more rain. The hot winds destroy the crops, as a rule. There are some exceptions, but as a rule they destroy the crops. People always think the next year will be better and so try on and on two or three years and then give it up.

The **CHAIRMAN**. That is the condition in western Kansas, is it—west of a line drawn across what point?

Mr. **SUTTON**. At Great Bend, Kans., and the failure from Great Bend west seems to be in proportion to the rise of the country.

The **CHAIRMAN**. It commences failing about how far west of Great Bend?

Mr. **SUTTON**. Perhaps at Great Bend, I would say.

The **CHAIRMAN**. It commences then about the ninety-eighth degree?

Mr. **SUTTON**. But the farmers raise pretty good crops in Barton County almost every year.

The **CHAIRMAN**. Some irrigation would do them good there?

Mr. **SUTTON**. Yes.

The **CHAIRMAN**. But as you go west it grows worse?

Mr. **SUTTON**. Yes.

The **CHAIRMAN**. And west of Great Bend it needs irrigation to make it safe to try farming?

Mr. **SUTTON**. Yes.

The **CHAIRMAN**. You have observed this river when it was up, have you?

Mr. **SUTTON**. Yes.

The **CHAIRMAN**. What is the volume of water running in the river at flood times?

Mr. **SUTTON**. I have seen this river, to the best of my judgment, 15 feet deep. I may be too high, but it has been 12 anyhow. Am I too high, Mr. Wright?

Mr. **WRIGHT**. It does not rise so high on the banks, but the quicksands wash out in the middle. When it rises 3 or 4 feet it is 10 feet in the middle of the river.

The **CHAIRMAN**. It is a vast volume of water, is it?

Mr. **SUTTON**. Yes, it is a vast volume.

The **CHAIRMAN**. If you could store the flood waters above how much land could be irrigated in western Kansas?

Mr. **SUTTON**. I can not give the number of acres, but I believe the Arkansas River would water that third of the State which lies west of this line, where we commence to need irrigation.

The **CHAIRMAN**. That is, if you could save the flood waters; if you could save the water that flows down the river?

Mr. **SUTTON**. Yes, and I think it could be pretty much all saved.

The **CHAIRMAN**. What chance is there for making large reservoirs above? Are you familiar with the stream above?

Mr. **SUTTON**. I have observed it. A little west of us and above this place the streams are running from the west to the eastward; they are also 12 to 15 miles apart, and are generally dry. Between these streams there is a divide, and from the top of that divide to each stream there is a gentle decline of the land. At the head of these streams, as far as my observation has gone, there is an immense plateau of salt land, and I think that with very little cost all of these flood waters could be carried on to those plateaus and stored there, and then run down these divides between these streams during the seasons of the year when it is most needed.

The **CHAIRMAN**. Would a survey by competent engineers showing the most available places for these reservoirs, etc., be regarded as beneficial.

Mr. SUTTON. I think it would not only be regarded as beneficial, but I am satisfied that it would be a success.

The CHAIRMAN. That is what we are inquiring, to see whether it would not pay to make these surveys. Leaving out of consideration now the Arkansas River, and considering only the other two-thirds that can not be watered by the Arkansas, what is the opportunity to store water for them?

Mr. SUTTON. I am not sufficiently well acquainted with the topography of the whole country to know. After you pass north here 65 or 70 miles I have not been over the country and do not know. In the times here when there is water in the Arkansas River, unless it is very low, there is sufficient water for any use and all uses, and when there is no water in the river there is no water for any purpose.

There is another thing to which I might call your attention. The Arkansas River is on a divide. The town of Meade Center, some 45 miles south of us, is some 35 feet lower than we are. The town of Jetmore, somewhat north of us, is 340 feet lower than we are, which in my judgment makes the Arkansas River capable of watering all this country on either side if there is a sufficient amount of water.

The CHAIRMAN. With water, what is the character of the crop produced here.

Mr. SUTTON. The crop produced here by water is superabundant. It is wonderful. The soil is very fertile, and only needs rain to produce any crop that can be produced in this climate, and to produce it in abundance.

There is another thing I wish to say: I believe that the homestead law is based on the wrong idea. It should be based upon improvement and cultivation and not based upon residence alone. As the law now stands, a man comes out into this country, settles on the land, and builds a little sod cabin. With $50 or $100 of improvements he can not cultivate much. Therefore very little of the land is cultivated, and very little improvement is made. The country is covered with a little short Buffalo grass; that is a sickly vegetation, at its best, and three or four days of hot sun and dry weather will ripen it. The country is all just the same as though it were bare, and there is no vegetation to keep the air cool. The hot wind that blows over the crop is manufactured right near the crops. As you well know, a field of corn will be burned a rod or two into the crop and the balance will be nice and green. You take trees and plant them out on a piece of land 40 rods wide and they will make a little stunted growth. Break up 40 acres and plant them in the center of that 40-acre piece and they will make a fine growth. Now, if this law required a man to break up 140 acres, even if he did not cultivate it, it would cover the field with vegetation and there would be less hot wind. If you break a piece of prairie land, and can go away, you can see it miles off afterward by reason of its greenness, while all the land around it is parched and dry.

STATEMENT OF R. M. WRIGHT, OF DODGE CITY.

The CHAIRMAN. How long have you resided in this city?

Mr. WRIGHT. Twenty-two years.

The CHAIRMAN. Have you observed the efforts made to cultivate the soil in western Kansas without irrigation?

Mr. WRIGHT. Yes.

The CHAIRMAN. Have they been successful?

Mr. WRIGHT. They have not.

The CHAIRMAN. Describe the efforts you have made and whether people have remained or not as a consequence of those efforts?

Mr. WRIGHT. As these gentlemen have explained to you, two or three crops of immigrants have come to this country in the last twelve or fourteen years.

The CHAIRMAN. What do you mean by two or three crops of immigrants?

Mr. WRIGHT. What I mean by that is this: different batches of immigrants have come into the country and about half of them, after two or three years' trial, have left. Some stay a little longer than others; some have remained four or five years and have then gone away, and a new batch has come in. That has repeated itself, I think, three or four times since I have been here.

The CHAIRMAN. Is it possible to farm in this part of the country—the western part of Kansas—west of Great Bend, without irrigation?

Mr. WRIGHT. It is only partially possible. They raise a very sorry crop here without irrigation.

The CHAIRMAN. Can a family make a living on the ground by farming?

Mr. WRIGHT. Not one out of five, I should say. Rain comes in streaks, here. Some cultivate the soil a little better than others, perhaps, and a few have made money but they are rare exceptions.

The CHAIRMAN. The great improvements have failed?

Mr. WRIGHT. The great improvements have failed.

The CHAIRMAN. Have you taken into consideration the possibilities of irrigation for western Kansas?

Mr. WRIGHT. Yes.

The CHAIRMAN. Have you observed the river from year to year?

Mr. WRIGHT. Yes.

The CHAIRMAN. What are the dimensions during the flood season, for example in the spring of the year, or whenever the water is highest?

Mr. WRIGHT. This river will average three-eighths of a mile wide, and an average depth of 6 feet.

The CHAIRMAN. With what fall?

Mr. WRIGHT. Seven feet to the mile.

The CHAIRMAN. That gives it great velocity?

Mr. WRIGHT. Yes. It seems to have much greater velocity when the current is in it.

The CHAIRMAN. The current is very rapid?

Mr. WRIGHT. Very rapid, indeed. You can not ford it.

The CHAIRMAN. If the flood water could be stored, have you ever considered how much land it would cover in irrigating?

Mr. WRIGHT. No, sir; but it would cover an immense amount of land. There is a terrible flow of water down this river. For eight months in the year it is full, and has plenty of water for everybody and everything. In dry seasons, such as we have had for the past two years, there is no water at all; that is, for four months in the year, for the last two years.

The CHAIRMAN. It dries up entirely once in every five years?

Mr. WRIGHT. Yes.

The CHAIRMAN. Even before they took any water at all out above?

Mr. WRIGHT. Yes. It is, say from the middle of August to the middle of October. Whether they have any rain or snow at all, it seems that atmospheric pressure brings the water to the surface, and it commences to flow and flows freely as soon as the weather gets cool.

The CHAIRMAN. Perhaps that is owing to a diminution of the extreme evaporation.

Mr. Wright. That may be so.

The Chairman. There is, also, I understand, an underground flow of water here?

Mr. Wright. A very large underground flow.

The Chairman. How wide is that underground river, so to speak?

Mr. Wright. I do not know; but I know that southeast of here, say 35 or 40 miles, it breaks out in very fine creeks. There is nothing in the world to produce that water and no place for it to come from, except from the Arkansas River.

The Chairman. If by any means that could be brought to the surface that would be of considerable aid, would it not?

Mr. Wright. Yes.

The Chairman. Outside of the country that can be irrigated by the Arkansas River, in western Kansas, are you familiar with the topography of it?

Mr. Wright. No, sir.

The Chairman. You have not been north and south?

Mr. Wright. Yes, I have been north and south, but have never taken much notice of it.

The Chairman. Is it rolling here and there?

Mr. Wright. Yes; there are many arroyos and creeks.

The Chairman. Could those arroyos be dammed and stored?

Mr. Wright. I suppose so.

The Chairman. You have not examined it with that view?

Mr. Wright. No. The underground water I think is inexhaustible.

Mr. Sutton (interrupting). For 35 or 50 miles on either side of the river, you have to go to the level of the river for digging wells. You can not tell how deep you have to go until you strike the sand.

Mr. Wright. I will have to correct Mr. Sutton a little on that. You can dig a well (there is a well here) 300 or 400 feet from the river, and I venture to say that the water in that well is 4 feet higher than the water in the river. At different places as you go up the hill-side that increases.

The Chairman. You do not have to go clear down to the bed of the river?

Mr. Wright. No. It rises considerably above the bed of the river. I think it is the flow from above that does that. It has the advantage of the flow of the river.

The Chairman. Still you think it comes from the river?

Mr. Wright. Yes. Say, for instance, if it flows in at a half mile above, that would be 3 feet pressure from above.

Mr. Sutton. That is, pressure from above in the manner of artesian water.

The Chairman. You have not stated what kind of crops you raise here?

Mr. Wright. We raise a very good crop here under the ditch.

The Chairman. Describe it.

Mr. Wright. It is a very good crop of corn, potatoes, and oats.

The Chairman. How much corn to the acre?

Mr. Wright. I have not gathered it yet, but I expect 40 or 50 bushels.

The Chairman. How much oats?

Mr. Wright. I think about 40 bushels. We did not get the water on the oats in time or we could get a good deal larger crop.

Mr. Sutton. The reason of that was that there was not water in the river, I suppose.

Mr. **Wright.** The potatoes are 60 bushels to the acre.

The **Chairman.** That is rather a small crop?

Mr. **Wright.** Yes; but they are the best potatoes I ever ate in my life.

The **Chairman.** This land is rich, and will raise good crops if irrigated?

Mr. **Wright.** Excellent.

The **Chairman.** What do you say of the climate?

Mr. **Wright.** It is the best in the world.

The **Chairman.** Was there much suffering on the part of those people who had to move away?

Mr. **Wright.** I can not deny that there was some little suffering, but our county has relieved many of them, and we would send them away sometimes when they could not get away from here themselves and could not do any more good.

The **Chairman.** How many times in the last twenty years have you had to help people out?

Mr. **Wright.** I guess about three times. The Santa Fé Railroad Company issued passes at two different times, I believe.

The **Chairman.** To the people who wanted to get away who had attempted to farm here and failed?

Mr. **Wright.** Yes.

STATEMENT OF JOHN W. SIDLOW, OF DODGE CITY.

The **Chairman.** How long have you resided in this vicinity?

Mr. **Sidlow.** Fifteen years.

The **Chairman.** What do you say as to the efforts of settlers to make farms here, and as to their success or failure?

Mr. **Sidlow.** The efforts have generally been a failure.

The **Chairman.** How many times have the immigrants tried it?

Mr. **Sidlow.** There have been about three different attempts since I have been in the county.

The **Chairman.** Have large numbers come?

Mr. **Sidlow.** Yes.

The **Chairman.** Throughout western Kansas?

Mr. **Sidlow.** Throughout the western part of this State.

The **Chairman.** What became of them?

Mr. **Sidlow.** I think in 1879 there were about two-thirds of the people who settled in the county and attempted to farm that had to leave.

The **Chairman.** What did the others do?

Mr. **Sidlow.** Some of them came with some means and were able to worry through some of the poor years, expecting that the crops would be better, and there were two or three years in which the crops were very good—that is, they were fair; and it encouraged the farmers to put in largely of crops. Then there would come a dry season, and what they had accumulated in two or three years was all used up by the failure in one of those dry seasons.

The **Chairman.** And they had to go away?

Mr. **Sidlow.** Yes.

The **Chairman.** Then there is no safety in farming in this vicinity except by irrigation?

Mr. **Sidlow.** I do not think there is.

Adjourned.

GARDEN CITY, KANS., *September* 3, 1889.

The committee met pursuant to call of the chairman.

Present: Messrs. Stewart (chairman), Plumb, and Jones of Arkansas; also Director Powell.

STATEMENT OF G. W. CONYERS, OF FINNEY COUNTY.

Senator PLUMB. Where do you reside, Mr. Conyers?

Mr. CONYERS. In the north part of Finney County.

Senator PLUMB. What is your occupation?

Mr. CONYERS. I am a farmer.

Senator PLUMB. Are there any ditches running through your part of the county?

Mr. CONYERS. Not through my part of it.

Senator PLUMB. How near are you to the nearest ditch?

Mr. CONYERS. About 5 miles to the nearest ditch that has ever had any water in it.

Senator PLUMB. What was the result of farming there without irrigation?

Mr. CONYERS. It was an entire failure.

Senator PLUMB. You could raise nothing?

Mr. CONYES. A little sorghum as feed for stock. That is the best we could do.

Senator PLUMB. You raised a little, but you can raise more?

Mr. CONYERS. Yes.

Senator PLUMB. Is there a sure crop up there?

Mr. CONYERS. Not a sure crop, by any means, without irrigation.

Senator PLUMB. Is any other crop a sure crop?

Mr. CONYERS. My experience is that rye is about as sure a crop as anything we can plant without water.

Senator PLUMB. How far is it to water?

Mr. CONYERS. About 20 feet.

Senator PLUMB. Have you a good supply?

Mr. CONYERS. We have an inexhaustible supply. I have a well bored with a 6-inch auger; I have a windmill on that well and have pumped 150 barrels of water a day from it; there seems to be no end to it.

Senator PLUMB. Have you tried irrigation by that means?

Mr. CONYERS. Yes; I have tried it from a tank in the garden, filled from that well.

Senator PLUMB. How large a garden?

Mr. CONYERS. A small patch.

Senator PLUMB. Could you, by duplicating these appliances, extend the area of irrigation on that place?

Mr. CONYERS. Yes; if I had any means by which I could get the water out. There is water enough on my place to irrigate a whole quarter section.

Senator PLUMB. By "means" do you intend to signify some pumping appliances different from what you have?

Mr. CONYERS. Yes; I have not power enough to irrigate any special amount of land.

Senator PLUMB. Could you get it by duplicating or triplicating your present pumping plant, such as windmills?

Mr. **Conyers**. Yes; but I have been farming so long without the security of irrigation that I have not the means now to get the appliances.

Senator **Plumb**. Have you any suggestions to make as to anything that can be done in the line of testing the conditions necessary to secure irrigation in your locality?

Mr. **Conyers**. No, sir; unless some plan could be arranged to elevate the water we have in the country up there. There is an abundance of water there to irrigate the whole country if we had some means of elevating it to the surface.

Senator **Plumb**. You need only an ordinary pumping plant?

Mr. **Conyers**. That is all; some power sufficient to raise the necessary amount of water.

Senator **Plumb**. You consider it a settled fact, then, that there is a sufficient body of water within 20 or 25 feet of the surface?

Mr. **Conyers**. I do. There is an ample supply there.

Senator **Plumb**. To what extent has this underflow been determined by your neighbors or yourself—through what extent of country?

Mr. **Conyers**. My place is 17 miles north of the river. I get my well water from the sand formation. When you go west some miles you get into land where they have to go 100 feet for water.

Senator **Plumb**. Do you think you are on a level with the Arkansas River at that 20 feet?

Mr. **Conyers**. I think so. I do not know that that is the case, however, having no way to determine, but my best judgment is that it would be on the exact level with the Arkansas River.

Senator **Plumb**. Have you no suggestion to make, then, as to anything that would be necessary to determine by further tests the existence of this water and the means of getting it to the surface?

Mr. **Conyers**. I think it could be tested here in this bottom or valley. The main thing that the people of this country want, I think, is to have it demonstrated that there is a supply of water here.

Senator **Plumb**. That has been demonstrated on your place, you think, in your locality?

Mr. **Conyers**. I think it has. I think if it was demonstrated that this water was supplied here in sufficient quantities capitalists would take hold of it and let us have a supply of water.

STATEMENT OF R. J. CLARK, OF GRAY COUNTY.

Senator **Plumb**. Where do you reside?

Mr. **Clark**. In the south part of Gray County, 50 miles southeast of here.

Senator **Plumb**. How long have you resided there?

Mr. **Clark**. Since 1884.

Senator **Plumb**. Where did you come from?

Mr. **Clark**. Directly from Illinois.

Senator **Plumb**. State in your own way what is in your mind concerning this question that we have been discussing as to that which, in your judgment, can be done in the way of irrigation and how to meet the situation in your county.

Mr. **Clark**. What can be done and how I do not know, but something must be done if this population is to be kept here. I came here in 1884, as I say. In 1887 we had a voting population of 1,500 men in our county. Some of those came for the purpose of speculation, a small number of them to prove up their claims, mortgage them, and make all the money they could and leave. A large proportion came here, however, to settle and with the determination to stay in this country. They have staid: First, they exhausted their own means to come here; secondly, it became necessary to mortgage their land; they did so; that money went in trying to hold up and improve this country; thirdly, the wants of their families compelled them to mortgage their stock. I am in such situation that I know for a fact that three-fourths of the personal property in Gray County to-day is under chattel mortgage, and that the mortgage money is gone.

Senator PLUMB. We want to know generally the situation down there.

Mr. CLARK. We have held up this country by publication in the papers. We have held it up until the people are ruined. Now, it is becoming necessary for the facts to be made known, let it be to the Government or whoever it may be.

Senator PLUMB. The question before us is as to the needs of the country, and what those needs are. In regard to the condition of things that would make agriculture highly profitable—that is another question.

Mr. CLARK. We have endeavored to hold up this section as a part of the State you represent, Senator. Now, it becomes necessary that you, as our representative, should know the true character of this region, so that you may report it as you hear it.

Senator PLUMB. Just state it in your own way. How long has it been since your people came to the conclusion that the natural precipitation of moisture would not do for crop purposes?

Mr. CLARK. We had been thinking that for two years.

Senator PLUMB. Upon what was the judgment of your people originally based that there would be sufficient precipitation of moisture?

Mr. CLARK. We had nothing to base our judgment upon. We came into this country. The beauty of it is unsurpassed, and the fertility of the soil, on thorough examination, with the applied moisture then found, proved to us that the richness of this soil also was unsurpassed. All we needed was moisture, and we hoped that there would always be sufficient rain-fall to produce crops. Up to the present time we have found sufficient to produce all crops except perhaps in April and July.

Senator PLUMB. It is not properly distributed?

Mr. CLARK. That is the trouble. Through April we have a spell of dry weather that cripples the wheat and oats so that they never recover.

Senator PLUMB. What is the elevation of your county above the sea-level?

Mr. CLARK. I do not know that I can answer that question, but I think it is about 2,800 feet.

Senator PLUMB. How deep do you go for water?

Mr. CLARK. From 100 to 200 feet.

Senator PLUMB. What streams are in your county?

Mr. CLARK. Crooked Creek in the south, and the Arkansas River in the center of the county.

Senator PLUMB. Is there any water in the Arkansas River now?

Mr. CLARK. No, not flowing on the surface.

Senator PLUMB. What has been the condition of the stream for the last two years?

Mr. CLARK. We have usually had a flow of water in June and July. Last year the stream went dry, and this year it has also done so.

Senator PLUMB. What in your mind is the course to be pursued to enable your people who are in the strait you have mentioned to maintain themselves where they are?

Mr. CLARK. I have only one fact to give. I live at present at Ingalls. Near that place is a dam, and the Eureka Canal goes out from there. That dam is very hard to hold. When the rush of water comes in the river it tears out the rock. The company conceived that they could dig a lateral from the main ditch below the dam, and, when the river is up high, they would let the water flow from the ditch and out into the river again. In digging that they had to dig from 4 to 6 feet deep, and they dug it in the southeasterly direction. The length of the ditch was nearly half a mile. When they got down to the level of the river they struck water. They kept scraping out the dirt until they came to water. The ditch is now dry. That went on, and they cleaned out that ditch to the river, and the water flowed out there through that lateral. It seemed to come up from the bottom and flow out through that. From that I gained an idea that by proper appliances—I do not know what they should be or how they should be constructed—but that by going into this river bottom at any point and excavating the earth perhaps 6 feet deep for a distance of 3 to 4 (or perhaps even 2) miles, whatever was necessary, you could get a constant flow of water out of this river at any point.

Senator PLUMB. In your judgment, would that be sufficient for all the adjacent country?

Mr. CLARK. I do not know how that would be.

Senator PLUMB. No estimates have been taken as to the flow?

Mr. CLARK. I am not mistaken as to the flow I have spoken of at Ingalls.

Senator PLUMB. But what I mean is that there have been no measurements as to what the extent of the flow is, or of the depth of the water?

Mr. CLARK. No.

Senator PLUMB. Have you any further suggestions to make about this matter? I should like to have you state just what has been in your mind as to the thing that could be done to meet the present emergency and also to meet future conditions.

Mr. CLARK. In Meade County, south perhaps 10 miles of where I live, they have flowing wells, fifteen or twenty, put down by private capital. Perhaps there might be flowing wells got all over Gray County. I do not know. There is no person there that has the means to put down those wells at the present time; their means are gone. The people in that section of the country are in a deplorable condition. If, perhaps, the Government should see fit to put down a flowing well I think that that would demonstrate the fact, and eastern capital might be brought in there and get wells.

Senator PLUMB. Do you know if the experiences had with the flowing wells referred to would warrant the expectation that if they were multiplied largely the flow would keep up? Has it done that so far?

Mr. CLARK. It has kept up; yes, fully. The largest well there has a 4-inch pipe. That well has been flowing since it was first sunk, and has been flowing full and with such force that when you take a bucket and hold it under it the power is so great that the water will overflow and you can only get a half bucketful from it. A gentleman has taken a large "draw" from it from which he has irrigated and grown trees; they are doing well. From that he has also flooded a field in which there are potatoes and all sorts of vegetables. In that field I can show you potatoes equal to any grown in Utah in size and flavor.

Senator PLUMB. Are those wells in the bottom?

Mr. CLARK. No, sir; they are up on the hill. The first well we got there was down on Crooked Creek. The other wells are scattered over that country.

Senator PLUMB. How deep are they?

Mr. CLARK. From 60 feet (that is the depth of the lowest well) to 150 feet, the deepest well.

Senator PLUMB. You could not get artesian wells in your county at that depth?

Mr. CLARK. No; our wells are, as I say, about 110 feet.

Senator PLUMB. Is there plenty of water in them?

Mr. CLARK. Yes.

Senator PLUMB. A very large quantity?

Mr. CLARK. Yes. You can not pump the wells dry after you get well into this stratum of sand. When you have gone down 3 feet into the sand, you can put all the appliances and pumps you please to it and you can not exhaust the water.

Senator PLUMB. Have you any further suggestions to make?

Mr. CLARK. Nothing, only that I should urge the matter of investigating our water supply strongly on the Government.

Senator PLUMB. Within what time must something be done by somebody to enable your people to remain?

Mr. CLARK. The men who are there now are anxious to stay. If they knew that the Government was going to take hold of the matter and demonstate the fact beyond question, so that this water may be raised to the surface, they would stay on, notwithstanding that their condition now is very bad.

Senator PLUMB. Could they stay three or four years if necessary to meet that condition; or perhaps two or three years?

Mr. CLARK. Well, I do not know whether they could stay so long or not, but they will stay until starvation drives them out.

Senator PLUMB. Of course, if the demonstration you speak of were made, and if one artesian well were got, within a few months we will say, the question would still remain as to the sinking of others and the obtaining of capital; and the further question—a very important one, however—as to whether the supply will keep on under the multiplication of the wells?

Mr. CLARK. I have no doubt whatever as to the supply of water. I think that if the Government took hold and sunk one well to demonstrate the fact, and then went to work to investigate the amount of water under this river (for we know that if the water is there it can be got out, and that it can be got out in quantities sufficient to wet this country thoroughly), why the people would stay. They will not have to stay very long. The east is now watching this committee. The people are watching this committee as you pass around. After you have gone and made your report to Congress, if that report is favorable, and Congress comes to the assistance of people here, they will feel certain that the Government is going to do something to demonstrate this great fact, and as soon as that fact is established people will come here from the east and buy these cheap lands. In that way many men that are here to-day between life and death will have an opportunity, if they wish, to let loose some of their land to those who have money. This country is settled up largely by old soldiers, men who have been to the front, and have done their duty by their country and the Government, and it looks now as if the Government should come to their aid and do its duty by them. I would like you to go into the country and see the true condition of things, not from my words, but from actual observation and sight. We have got through "painting" it, and we have got down to bed rock.

Senator JONES. You made a statement just now to the effect that people are hanging on here between life and death. I wish you would state in the first place how long you have lived in western Kansas?

Mr. CLARK. Since 1884.

Senator JONES. I wish you would explain to the committee (the other members may know all about it, I do not) how you first came here and how the other people first came here; what your information was, and what your experience was?

Mr. CLARK. This country was thoroughly advertised by railroad companies and land agents. In the first settlement this country was filled up by persons who had been in better circumstances and something had broken them down financially, or by an active set of young men who broke loose from their family relations and wanted to do something for themselves.

Senator JONES. About what time was it that that movement set in?

Mr. CLARK. It began in 1884 and continued until 1886. This country was all taken up from 1884 to 1886, or virtually so. A few pieces of land, perhaps, were left vacant, but only a few.

Senator JONES. Are the same people here now who came here then?

Mr. CLARK. Yes, to a large extent. Probably a majority remain.

Senator JONES. Has there been any material emigration from western Kansas by people who have come here and have abandoned their homes and left?

Mr. CLARK. In 1887 we had a voting population of 1,500 in our county. To-day the vote will run about 600. We had a class of people who came here merely for speculation. They came merely to take up this land, mortgage it, make all the money they could and go away. Those men went the first six months. The men who remained are the men who came here to make homes.

Senator JONES. I think you said that that was but a small percentage of the population?

Mr. CLARK. Yes, it was.

Senator JONES. What has been the cause of the great emigration of the other class of people who came here?

Mr. CLARK. The want of sustenance. Men who came here with limited means staid two or three years and could not raise crops, and the consequence was that they had to get out.

Senator JONES. Failure of the crops was the cause?

Mr. CLARK. Yes; and that is what is now about to drive the remainder of the population out.

Senator JONES. How have the crops been this year in this section of country? You have had an unusual amount of rain-fall this year.

Mr. CLARK. Yes.

Senator JONES. Have you had enough for your crops?

Mr. CLARK. We had, if it had been properly distributed. Our rains did not set in until April, and the wheat and oats were ruined by drought. Some hundreds of acres of wheat were caught in the drought, and it did not get high enough to mow.

The CHAIRMAN. What was the condition of the river in April? Was it high or low?

Mr. CLARK. In April we had water, and again in July. There are ten months of the twelve that are good for crops here. It is in April and July that we get caught.

Senator JONES. Is that on account of a small rain-fall in April and July, or on account of the greater demand for water in April and July.

Mr. CLARK. It is on account of the lack of rain in July.

Senator JONES. You do not have so much in July as you need.

Mr. CLARK. No.

The CHAIRMAN. How was the river last July?

Mr. CLARK. Nearly dry. There came a flood in the river, however, on the 12th of July, and we were ruined on the 14th of July. The 14th, 15th, and 16th of July are the days that ruined us this year. If we had had ditches at that time and had the water held in reservoirs so that we could have used it at the proper time we would have been much better off. The hot winds do not come from Texas or from other places 20 miles south of us. They generate right here. If we have a local shower here, twenty-four hours afterward the buffalo-grass has become again green. But where the local showers have not fallen the hot winds come on. Where they have local rains at the proper time the crops are right; but the great area of this country that did not have local rains is entirely destroyed; winds blew over us and destroyed our crops, but did not affect the crops of people at places where they have local showers; nor did it affect the people where they had local irrigation. This demonstrated beyond all question of doubt that all we wanted was moisture.

Senator JONES. Were there any experiments in agriculture before 1884 that would justify the settlement of this country for agricultural purposes?

Mr. CLARK. There had been to a limited extent. We came in 1884 and we found that many claims had been taken by men that came in 1876, 1877, 1878, and 1879. A few of those men who came tried agriculture and moved out.

Senator JONES. They had failed?

Mr. CLARK. They had failed.

Senator JONES. On account of the failure of crops?

Mr. CLARK. Yes; on account of the failure of the crops. Those who staid and went into the cattle business were able to remain.

Senator JONES. Then these representations that induced this immigration in 1884, as I understand you, must have been knowingly exaggerated; people must have been willfully misled into thinking that this country was good for agriculture?

Mr. CLARK. I think they were, as far as the railroad interests were concerned.

Senator JONES. At what prices were those lands in this country sold by the railroads?

Mr. CLARK. Five and six dollars an acre.

Senator JONES. On what terms?

Mr. CLARK. On long terms.

Senator JONES. Was no portion paid down?

Mr. CLARK. Yes; a part of the money was paid down.

Senator JONES. And the balance on long time?

Mr. CLARK. Yes. The land agents who advertised the country were new comers here the same as ourselves, and their advertisements were, I think, based on honor. In passing over the country they saw what a beautiful country it was here. The man who would plant a little sod and put it under moisture, would be readily convinced of the richness of the soil. Those advertising men, therefore, I think believed it, and the railroad men may have believed the same thing, although they were conversant with the land long before that.

I have here a card that has been handed to me by a gentleman who, I suppose, was here in 1883 and 1884. On that card he says, "Large crops." I would like the gentleman to be called to the stand to explain that. I do not know anything about it.

STATEMENT OF J. H. KELLY, OF GRAY COUNTY.

Senator PLUMB. Where do you reside?

Mr. KELLY. In the southwest part of Gray County.

Senator PLUMB. Do you live near Mr. Clark?

Mr. KELLY. No.

Senator PLUMB. Where did you come from when you came to that country?

Mr. KELLY. I came from the southwestern part of Ohio into Kansas.

Senator PLUMB. You may make any statement to the committee which you think bears on this subject of water supply for your section of the State, as briefly as you reasonably can. I suppose there is no necessity for your re-stating what Mr. Clark has already stated about the condition of the people. Of course, we can not take time for every witness to repeat everything.

Senator JONES. If those statements are in his opinion correct, he may say so.

Senator PLUMB. Yes. Dou you believe that what Mr. Clark said is correct?

Mr. KELLY. Yes; I think Mr. Clark has stated the facts of the case; and I believe, also, there is ample water. It is essential for the settlers of western Kansas to have that water.

Senator PLUMB. Where is the water?

Mr. KELLY. I think the water is in the earth, sufficient of it.

Senator PLUMB. Where is it with reference to being obtained; is it under the surface of the land?

Mr. KELLY. It is under the surface; yes.

Senator PLUMB. At what depth?

Mr. KELLY. I have sunk a well 96 feet deep, and I find ample water at that depth. I find a basin of water that is running, I think, as swiftly as the Arkansas River.

Senator PLUMB. In the bottom of your well?

Mr. KELLY. Yes; at 96 feet deep. I am on an altitude that is high on the divide between the Arkansas and Cimarron Rivers. I have been there for some five years.

Senator PLUMB. You think that water could be had for this section of the country at the depth of your well?

Mr. KELLY. No, I think not. I think you would have to go deeper. I think there is water sufficient, however, provided the people of western Kansas could afford the machinery which it would take to bring that water to the surface.

Senator PLUMB. You think there must be an artesian supply?

Mr. KELLY. I think so.

Senator JONES. Is your well an artesian well?

Mr. KELLY. No. But southeast of me 35 miles is Artesian City, on Crooked Creek, with an ample supply of water.

Senator PLUMB. What depth do they have to go there to get water?

Mr. KELLY. Fifty-five feet is the shallowest well. There have been four or five wells sunk at Artesian City, and the pressure will run, I think, about 2 pounds to the square inch.

Senator **PLUMB**. How much land do they irrigate at Artesian City?

Mr. **KELLY**. This is the first season in which they have attempted to irrigate land to amount to anything.

Senator **PLUMB**. What quantity do they now irrigate?

Mr. **KELLY**. I can not say; but they have irrigated enough to convince the people that the supply of water is sufficient. They have reservoirs for the dry period. They have produced everything; potatoes, cabbage, corn, rye, wheat, etc., at Artesian City.

Senator **PLUMB**. Your suggestion, if I understand you, is that it should be demonstrated that there is or is not artesian water under the surface of your section of country?

Mr. **KELLY**. That is my idea exactly. I am confident that there is sufficient water if it can be brought to the surface, and in the present condition of the people they require water very much. My idea is that the water is sufficient, and if the Government will take the matter in hand and demonstrate the fact that there is a sufficiency of water by making an appropriation to sink one artesian well, it will be a great thing for my section of the county. We know that in the Arkansas Valley there is ample water, but to concentrate the people of western Kansas into the Arkansas Valley seems to me a little absurd. At the same time many of our people are satisfied that if we bore into this stratum I have spoken of, the water will be found ample. That would mean millions of dollars to western Kansas. When I struck my well I dug 96 feet deep and came to running water, running as swiftly as the Arkansas River, running right through the quicksand and pebbles. It seems to me that the Government might go to work and sink one or more experimental artesian wells. They woud only have to go moderately deep.

The **CHAIRMAN**. What means have you taken to get the water to the surface?

Mr. **KELLY**. No means.

The **CHAIRMAN**. How did you get it to the surface?

Mr. **KELLY**. By going deep enough.

The **CHAIRMAN**. But how did you get it up?

Mr. **KELLY**. By pumping; by means of a wind-mill.

The **CHAIRMAN**. How large a wind-mill?

Mr. **KELLY**. The cylinder is 14 inches by 4 inches.

The **CHAIRMAN**. How large across is your wind-mill?

Mr. **KELLY**. It has a 12-foot wheel.

The **CHAIRMAN**. What amount of water does it throw up?

Mr. **KELLY**. I have never estimated.

The **CHAIRMAN**. Have you ever tried to irrigate a garden with the water?

Mr. **KELLY**. We keep a little reservoir besides my tanks, for cattle and so on. I put in a day and a half's work with the scooper and plow, to dam a little ravine to hold the water, and ran the water into that reservoir and it has been there all summer.

The **CHAIRMAN**. You do not make any further use of it than to water the stock?

Mr. **KELLY**. Nothing else.

The **CHAIRMAN**. You have not thought of elevating the water by windmill, storing it, and cultivating some land with it?

Mr. **KELLY**. Yes; I have thought a good deal of it, but I have not put it into practice.

The **CHAIRMAN**. Do you think it practicable?

Mr. **KELLY**. I do not know whether it is or not. I think it is practicable to irrigate that way, but we would have to go deeper than my well to do it. We would have to go down deep enough to get pressure or "head" enough to get the water to flow. I do not think it is practicable to get machinery to throw its water up at all—either windmill or engine.

The **Chairman**. Have you studied the question to see what has been done elsewhere?

Mr. **Kelly**. No; I have not studied it out, but I know that the water supply is ample.

STATEMENT OF R. O. JAMES, OF STEVENS COUNTY.

Senator **Plumb**. Where do you reside?

Mr. **James**. In Stevens County.

Senator **Plumb**. Where did you come from; from that county?

Mr. **James**. I came from Indiana.

Senator **Plumb**. What is your occupation?

Mr. **James**. I am a banker. Our farming community is not represented to-day. We had not expected you here until the 20th of the month or it would have been represented.

Senator **Plumb**. Have you heard the statement of Mr. Clark as to the condition of the people in Gray County?

Mr. **James**. Yes; I heard that.

Senator **Plumb**. To what extent does that compare with the condition of things in your county?

Mr. **James**. It compares about equally with the condition of things in a portion of our county. There are some parties in our county that have made a good living until this year. The county has been settled only about four years and this past year has been the most difficult of the four.

Senator **Plumb**. That is, the present season?

Mr. **James**. Yes. Since the 12th of July it has been "rocky" there, to use a western word. The farmers of our county believe that it can be irrigated by artesian wells.

Senator **Plumb**. Are there artesian wells in your county?

Mr. **James**. No; because we have not gone deep enough. We find water there at from 50 to 150 feet deep. We have three wells in our town, two squares apart, that give water at 80 feet. The 12-foot wheels of these wells are on day and night and have no effect to lower the pressure. The windmill has no effect whatever on the waters in the wells.

Senator **Plumb**. The farmers in your county who have done well down there, up to this year, have they had any irrigation to aid them?

Mr. **James**. No.

Senator **Plumb**. In what respect, then, are they better off than their neighbors?

Mr. **James**. We have two classes of land—one we call buffalo sod, the other is a sandy loam. The parties living on the edge of the sand have been each year more successful because it retains moisture. Mr. Kunz, a man who was an old farmer in the East and took care of his crop and worked diligently, and Mr. Nash, another man who worked diligently, made quite a success of their farms.

Senator **Plumb**. Have there been other farmers in your county that have been successful?

Mr. **JAMES**. Yes; there is another man who has been successful there in raising potatoes. He was on the edge of the sand.

Senator **PLUMB**. To what do you attribute their special success?

Mr. **JAMES**. They are, as I say, on the edge of the sand.

The **CHAIRMAN**. Is the sand lower ground than the other.

Mr. **JAMES**. No; higher if anything.

Senator **PLUMB**. The men, you say, who have been farming on the sand have done well?

Mr. **JAMES**. Not all of them. It is only in localities where there have been local rains. There are some men in the county who happen to have been in the local showers, who have had fair crops, while other men right near them have not had any.

Senator **PLUMB**. Then it is the question in the distribution of water that has made the difference?

Mr. **JAMES**. Yes. In the southern and eastern part of our county they are far ahead of the central, northern, or western. Last year we were far ahead of the southern. It seems to be as it happens.

Senator **PLUMB**. State what, according to your belief and that of your people, is within reach and necessary to make a secure water supply?

Mr. **JAMES**. Our people are all anxious to know if the Government will take steps to learn whether this water can be raised from below us for irrigation purposes. If the Government will test that, we think that private capital will come in. It is only a question of whether this is inexhaustible or not. Mr. B. E. Steely, of our town, has a well, and he claims that there are 225 feet of water in this well. It was dug and bored with a 2-inch auger. There is another gentleman 2 miles from town who has a well 240 feet deep, and has 70 feet of water standing in it all the time.

Senator **PLUMB**. Has that to be pumped up?

Mr. **JAMES**. There is a windmill running all the time; it fills his trough and it runs out.

Senator **PLUMB**. Is it the opinion of your people that that sort of thing will be enough for irrigation?

Mr. **JAMES**. It is their belief that it will afford great relief in that respect. Our belief is that the stratum of water will prove to be artesian.

Senator **PLUMB**. But you do not rely for this opinion of yours, as to the water supply, upon what has already been discovered; you think there is a vein below that is artesian?

Mr. **JAMES**. Yes; I think that the third stratum, probably at 1,000 or even 600 feet, will give us plenty of water. My opinion is that the stratum of water runs from east to west, and that it comes from the mountains. Whether it will be inexhaustible or not is a question, and that question we would like to have settled. I spoke of a few of our successful farmers. We have been in the rain-fall, but there have been many who have tried to be successful who have not been in the line of local rain-fall. Last year Stevens County supported itself and shipped some produce out; this year, if the people had all remained there, we could not have done it. If the people had all staid we could not have fed our cattle.

Senator **JONES**. I understood you at first to say that there were certain citizens, certain farmers, in your country that were prosperous; but I afterward thought that you qualified that statement by saying that there were some years when these farmers were prosperous and others when they were not—depending upon the rain-fall. How is that? Are there some men who have been uniformly a failure?

Mr. **JAMES**. It is changing around. Mr. Kuntz, south of town, the old gardener that I spoke of, has been there four years. The first year there was not much raised, because there were but few people in there until the spring, and there was not time to prepare, but Mr. Kuntz would plant his melons, potatoes, etc., and he told me yesterday that he had 9 acres of potatoes that he had planted back again that had not sprouted, and which he had planted back with the idea that there would be rains. Our July rains have been very short. Our August rains, until this year, have been suitable for some purposes.

Senator **JONES**. Are there any farmers in your county that have raised good crops of wheat this year?

Mr. **JAMES**. We have some gentlemen who can tell you more than I can. One old gentleman in the northwestern part of our county (Dr. Allen) said he raised 1,000 bushels of oats, rye, and wheat, but many have not been successful.

Senator **PLUMB**. One swallow does not make a summer. The fact that one man has not made a success this year proves nothing. My question is, has there been a farmer in your county who has uniformly made a good wheat crop since the land has been in cultivation?

Mr. **JAMES**. I do not think there is. It is a question in my mind whether the wheat crop has been thoroughly tried or not. The county west of ours has given a better trial than ours. Many of the farmers there do not seem to think that wheat will do well there, but many of them this year sowed more than has been sowed before. Last year one good flood over a good deal of land in our county would have made a successful crop. I do not believe that Indian corn would be the success that other kinds would be. All new countries have their ups and downs with regard to population. I have heard some men in other counties at one time say that they could not get away, and yet to-day they are the wealthiest farmers in the county.

The **CHAIRMAN**. With reference to the water you find by sinking wells—does that seem to be extensive?

Mr. **JAMES**. Yes, and we can not lower it by steam-pumps.

The **CHAIRMAN**. Have you ever considered the question of combining together and getting machinery of some kind?

Mr. **JAMES**. Yes, I believe that could be done to some extent, but whether the water is inexhaustible or not is what we would like to have tried.

The **CHAIRMAN**. In the particular stratum that you spoke of, do you think the water would be easily exhausted?

Mr. **JAMES**. I do not think it would.

The **CHAIRMAN**. Do you say you have considered the propriety of combining and getting water enough for a neighborhood by machinery?

Mr. **JAMES**. Yes; we have under consideration now a proposition to issue $15,000 of bonds for that purpose.

The **CHAIRMAN**. You want to get a $15,000 plant?

Mr. **JAMES**. The county, according to statute, has a right to donate $15,000 to any firm or corporation for that purpose.

The **CHAIRMAN**. How much will a wind-mill throw out?

Mr. **JAMES**. It is according to the wind and according to the wheel and many things of that kind. I do not know that I could say just what quantity of water it would throw out in twenty-four hours.

The **CHAIRMAN**. Have you people tried to save the water thrown out by wind-mills for the purpose of irrigating gardens?

Mr. JAMES. No. Mr. Cook, north of the town, has a fish-pond. To fill that he tells me that he pumps two days and stops pumping one.

The CHAIRMAN. He has not tried making a garden of 2 or 3 acres?

Mr. JAMES. No. Mr. Kuntz, last year, did irrigate a little garden. Our county has no river in it, although the Cimarron River touches us on the border. Its altitude is higher than ours and when there is water there there could be an irrigating ditch made.

The CHAIRMAN. Has it ever occurred to you to dam up the ravines and save the storm water?

Mr. JAMES. Yes. That is a good thought, but it has never been tried. Water can not be held successfully, however, on sandy land, although it can be on the Buffalo land.

The CHAIRMAN. The idea has occurred to you that you might save water for small irrigation purposes from the storm storage?

Mr. JAMES Yes, and if the water under the Cimarron is sufficient we could get enough. The water in the river itself is not sufficient for much. I am satisfied that we have water under us sufficient to irrigate 30 acres of every 160. That would be sufficient. I know men in our county that would give 1 acre of land to have another acre irrigated.

Senator PLUMB. I have no doubt that there is water there. It is only a question of getting it to the surface.

Mr. JAMES. I have thought that the putting down of one artesian well in each county would be a great blessing to the people.

STATEMENT OF G. H. ALLEN, OF RICHVILLE.

Senator PLUMB. Where do you reside?

Mr. ALLEN. In Morton County, at Richville.

Senator PLUMB. How long have you lived there?

Mr. ALLEN. Nearly four years.

Senator PLUMB. Where did you go from?

Mr. ALLEN. From Cowley County, in this State. I am originally from Massachusetts, but I have been in this State for thirteen years.

Senator PLUMB. State to the committee in your own way and as briefly as you can the suggestions growing out of your experience or observation which bears on the question of water supply in this section?

Mr. ALLEN. As to this country as an agricultural country I am convinced in my own mind that with the exception of the want of water here it is one of the finest agricultural countries in the entire West. I believe that with the soil we have in southwestern Kansas all the features are here to make it a successful agricultural country if we can have sufficient water.

Senator JONES. What will be the result if you do not have water?

Mr. ALLEN. Then we can not mature crops. That has been the experience. In the spring months we have sometimes had rain enough to mature the crops, and up to the middle of June in this year we had fair prospects. Then the rain-fall began to diminish, and in July the crops were almost entirely destroyed by drought for the lack of rain to mature the crops.

Senator PLUMB. How was it with wheat?

Mr. ALLEN. That was cut earlier. It was cut principally in June, but it was damaged by lack of rain. There were some fields that were pretty good, however; one man told me the other day that he had an average of 30 bushels per acre, and another had 21 bushels. These were the best fields in the county, but there was a lack of rain to properly fill out the crop. All the indications point to this as a good wheat country. It has a soil that is fertile. It has all the elements existent in the soil to make it a good agricultural country.

Senator **PLUMB**. We all understand that all that is wanted in this country is water. Now, what do you have to state in regard to the water supply?

Mr. **ALLEN**. In our county a well was sunk that was six hundred and sixty odd feet in depth, flowing 23 to 24 gallons per minute, but that was insufficient for irrigation purposes. It is my opinion, however, and it is that of others, including Professor Hay, the State geologist, that the country is underlaid with artesian water, and that by going deeper a stronger flow could be obtained. We have demonstrated that there is artesian water there at a certain depth, and it is believed that by deeper sinking a stronger flow can be got, perhaps 2,000 feet. Our people would like to have the experiment made.

Senator **PLUMB**. Has there been more than one well sunk?

Mr. **ALLEN**. No. The city is about sinking another in the immediate locality.

Senator **PLUMB**. In what material is this water found?

Mr. **ALLEN**. It is really a red sandstone near the surface; down about 200 feet it is a sort of quicksand.

Senator **PLUMB**. Has there been salt-water found?

Mr. **ALLEN**. There have been some indications of it.

Senator **PLUMB**. Would that be a good water for irrigation?

Mr. **ALLEN**. To some extent and for some purposes.

Senator **PLUMB**. State in your own way, and as briefly as possible, what you think is to be the source of the water supply there, and what you think the Government can do, from your own stand-point (without reference to what anybody else may think about it) to bring about that desired result.

Mr. **ALLEN**. The quickest means would be the sinking of artesian wells.

Senator **PLUMB**. You mean not for artesian wells in this flow that is already obtained, but for a lower flow?

Mr. **ALLEN**. Yes; for a stronger flow. The question whether artesian wells will furnish a permanent and sufficient supply is a mooted question and must be tested by actual experiment.

Senator **PLUMB**. Did Professor Hay, when there, say that there was a supply of salt-water, probably under the sandstone?

Mr. **ALLEN**. Yes; he said there would be probably salt-water there, but he did not say how much.

Senator **PLUMB**. If the water was impregnated as it is at Larned, for instance, would that be sufficient?

Mr. **ALLEN**. To a limited extent it would, but it is my opinion that it is not necessary to depend on that flow. I believe water would be found either below or above that salt-water at different depths to furnish artesian water sufficient for irrigation.

Senator **PLUMB**. You think there is another artesian stratum between the present flow and the salt-water below?

Mr. **ALLEN**. Yes.

Senator **JONES**. What do you base that opinion upon?

Mr. **ALLEN**. On the experiments in some other countries. It is stated that in some countries the first flow was never found to be so great as that below, and I furthermore base it on the opinion of Professor Hay, who is a good authority.

Senator **PLUMB**. Have you heard the statement of the condition of the people in Gray County as made by Mr. Clark?

Mr. **ALLEN**. Yes.

Senator **PLUMB**. To what extent does that correspond with the condition in your country?

Mr. **ALLEN**. The people of this country are depressed by bad crops in hard times, but I do not think that is a thing we should dwell upon.

Senator **PLUMB**. What has been the result of crops in your county for four years past?

Mr. **ALLEN**. Variable, more or less. Our best year for crops was our first year. That is three years ago; we raised more then than we have done since,

Senator **PLUMB**. Are there any differences growing out of the thoroughness of farming?

Mr. **ALLEN**. Yes.

Senator **PLUMB**. Some men do better than others?

Mr. **ALLEN**. Yes, I anticipate that will make some difference, but still we can not get along without more water. I think that an intelligent cultivation of the soil, coupled with the proper supply of water and at the proper time for cultivation, will make a great improvement. Our people are not all going to leave the country by any means. It is too good a country for that. We only want water at certain periods to help the growth of crops.

Senator **PLUMB**. Is there anything else that occurs to you?

Mr. **ALLEN**. I do not know that there is, except as to the manner of getting water from streams. In the valley of the Cimarron, which is a small stream, and is dry much of the year, there is plenty of water in the spring time. In the month of June this year we had an overflow of the stream there, and by tapping that stream several miles southwest water might be brought over the surface by ditches or aqueducts. The country gradually declines toward the east all the way from Colorado eastward. In our county the fall is about 20 feet per mile, so that the water could be easily carried. The country, however, practically is a level country. There are sufficient depressions to make local reservoirs of a small kind. However, those depressions and "draws" are usually of the lowest elevation below the surface of the country, and the work would be somewhat difficult, but there would be no difficulty in bringing water from farther west, in my opinion.

The **CHAIRMAN**. What do you think would be the depth you would have to sink to find surface water.

Mr. **ALLEN**. It varies from 40 or 50 to 100 or 150 feet.

Senator **PLUMB**. How abundantly do you find water when you strike it?

Mr. **ALLEN**. Quite abundant. We have not drawn on it for irrigating purposes in a way that would test its strength.

Senator **PLUMB**. Have you ever discussed the practicability of testing that and showing how much you had of it?

Mr. **ALLEN**. No; there has not been any direct discussion to settle that question, and of course all these questions have been touched more or less frequently and generally.

Senator **PLUMB**. Where do you suppose this supply comes from? Does it come from any river?

Mr. **ALLEN**. No; I do not think it takes its source from any river. It may be on the level of the Cimarron River, and the Cimarron River may be a part of that same flow.

Senator **PLUMB**. You say the Cimarron River had a good flow in the summer once. At what time was that?

Mr. ALLEN. I think about June.

Senator PLUMB. If you had had reservoirs would that have helped you considerably?

Mr. ALLEN. Yes; though if we had had reservoirs we could not have made them in our county; they would have to be farther west; but if we had the water stored above we could get it all over our county.

Senator PLUMB. Is it not possible, after all, that you could get a better supply of water that way than from any artesian well?

Mr. ALLEN. I will not say that; I do not know. I realize that that would take time to develop?

Senator PLUMB. What we want to know is the possibility of ultimately reaching that result.

Mr. ALLEN. Yes, I think there would be no question about that.

Senator PLUMB. You could supply considerable of the country in that way by damming up the tributaries of the Cimarron?

Mr. ALLEN. Yes, probably so.

Senator PLUMB. How wide a stream is it?

Mr. ALLEN. When it is pretty full it overflows its banks to the extent of half a mile wide, but the stream itself is not wide.

Senator PLUMB. We are talking about its flooding capacity.

Mr. ALLEN. In the spring time, when the snows are melting, there is usually a strong flow and the water overflows the banks of the river.

STATEMENT OF J. M. SLOAN, OF HAMILTON COUNTY.

Senator PLUMB. Where do you reside?

Mr. SLOAN. In Hamilton County, in the western part of this State.

Senator PLUMB. The Arkansas River cuts it through towards the center.

Mr. SLOAN. Yes.

Senator PLUMB. In what part of the county do you live?

Mr. SLOAN. In the central part; in the Arkansas Valley; at Syracuse.

Senator PLUMB. How long have you lived there?

Mr. SLOAN. Four years.

Senator PLUMB. Where are you from?

Mr. SLOAN. From Indiana.

Senator PLUMB. Please state the result of your observations in regard to the water supply of your locality.

Mr. SLOAN. We have two irrigating ditches under construction. The water supply of the river is nothing now, but it has never been that way before. There has never been a time before when a few ditches could not have been filled.

Senator PLUMB. What, in your judgment, is the reason for a diminution of the water supply in the river this year?

Mr. SLOAN. The lack of snow-fall in the mountains.

Senator PLUMB. You understand that during the last three winters there has been less snow than in any preceding year?

Mr. SLOAN. That has been my information. At the extreme western town of Coolidge they have artesian water 300 feet deep.

Senator PLUMB. In the valley?

Mr. SLOAN. Yes. We have tried it out of the valley, but can not get it.

Senator PLUMB. How deep do you go?

Mr. SLOAN. One thousand feet. We tried it out of the valley on the bluff. We struck several strata of water and there seemed to be no sufficient pressure in any of them. The water got up, but not to the surface.

Senator PLUMB. Was there a good volume of water?

Mr. SLOAN. Yes.

Senator PLUMB. Fresh water?

Mr. SLOAN. Yes, all good water.

Senator PLUMB. How far were you from the Arkansas River when you were at the side of this well?

Mr. SLOAN. About half a mile or three-quarters.

Senator PLUMB. Just off the bottom?

Mr. SLOAN. Yes; off the bottom within the town site.

Senator PLUMB. How high above the surface is the water at Coolidge?

Mr. SLOAN. Not very high. It runs about 20 gallons a minute.

Senator PLUMB. How many wells have they?

Mr. SLOAN. Two; then down 3 miles this side of Coolidge, on the other side of the river, they have another one which I have never seen, but I know it is an artesian well.

Senator PLUMB. With the same result?

Mr. SLOAN. Yes.

Senator PLUMB. State in your own way what your theory is about this matter of water supply for your county, judging, of course, from your observation.

Mr. SLOAN. I have no theory only the artesian theory. We would like to see that determined.

Senator PLUMB. You would like to see some wells sunk deeper, to see how far it would go?

Mr. SLOAN. Yes. We spent $7,000 on that well in our town and the digging of such wells to any extent is too expensive for our people.

Senator PLUMB. You did not try in the valley to strike a well such as they have at Coolidge?

Mr. SLOAN. No.

Senator PLUMB. Do you think that in ordinary seasons the ditches will have water enough?

Mr. SLOAN. Yes; if it was not for the law of Colorado forbidding ditches to come across the line, we would have large ditches. We have had a hard time here. The law of Colorado is that the water must be returned to the river before it crosses the line.

Senator PLUMB. You heard the statement of Mr. Clark in regard to the condition of the people in Gray County. To what extent does that correspond with the condition of the people in your county?

Mr. SLOAN. That is correct so far as concerns the men that depend on corn. The men that depend on stock get along fairly well.

Senator PLUMB. Cattle men get along very well?

Mr. SLOAN. Yes.

Senator PLUMB. But the men who depend on grain will want irrigation?

Mr. SLOAN. Yes; they must have irrigation.

Senator PLUMB. What forage plants have been tried here, and with what success?

Mr. SLOAN. Alfalfa where it has irrigation.

Senator PLUMB. But without irrigation?

Mr. SLOAN. Sorghum and millet.

Senator PLUMB. They have done pretty well without irrigation?

Mr. SLOAN. Yes; except this year.

Senator PLUMB. This year they all failed?

Mr. SLOAN. Yes.

Senator PLUMB. This year has been the worst in your experience?

Mr. SLOAN. Yes. Every year since 1884 they raised something. If the corn would not make grain it would make fodder.

The CHAIRMAN. Has your attention been called to the saving of the storm-waters?

Mr. SLOAN. Yes; we have thought of it.

The CHAIRMAN. Have any tanks been made in your part of the county?

Mr. SLOAN. Not to catch the rain-fall.

The CHAIRMAN. A good deal of water comes down that is wasted.

Mr. SLOAN. A good deal. The river flows past us many times when it is quite full.

The CHAIRMAN. And the small streams are also full very frequently?

Mr. SLOAN. Yes. One of those little streams will often flood a valley.

The CHAIRMAN. You have not considered the possibility of storing that water and flooding the land with it?

Mr. SLOAN. I have thought of it, but never saw it tried anywhere. There is a great deal of water coming down those streams and down this river; the water frequently washes the bridges away.

The CHAIRMAN. It is not necessary to make any experiments to demonstrate that that water is there?

Mr. SLOAN. No; the artesian water is there also.

The CHAIRMAN. But you do not know in what quantities the artesian water exists?

Mr. SLOAN. No; it is expensive to test it. It is only along the valleys in our county that it has been tested.

FURTHER STATEMENT OF R. O. JONES.

Mr. JONES. With reference to artesian water, while I think it would not be inexhaustible, and while I think there is plenty of it to do the irrigation that we need, I would say that last year at one time in our county one flood would have been all we needed. One flooding of the crops would have made a success of them. We had lots of crops during one time in the year, but the failure of water in July was very injurious. Had we had water at that time we would have had plenty of good crops. If we could irrigate as they do in California, where they have no rain at all for long periods, it might be that the artesian wells system might be regarded as not feasible. But we think it would be fair for the Government to try it.

FURTHER STATEMENT OF E. J. CLARK.

Mr. CLARK. I desire to add one word with regard to the artesian wells at Artesian City. Before they had artesian wells that country was covered wholly with buffalo grass. Since the location and flow of that well its constant stream and flow have killed out the buffalo grass, because that grass can not stand extreme moisture. Instead of the buffalo grass, there is to be found there to-day blue-stem or blue-joint grass standing 4 to 6 feet high.

Senator PLUMB. That will always occur where moisture increases. The buffalo grass gives way to blue-stem or blue-joint grass.

STATEMENT OF A. W. STUBBS, OF SANTA FÉ, HASKELL COUNTY.

Senator PLUMB. Where do you reside?

Mr. STUBBS. At Santa Fé, Haskell County, Kans., 28 miles south of here; I have lived there since May, 1888, and in Kansas about twenty-seven years.

Senator PLUMB. State the result of your observation as pertaining to the general subject of irrigation, especially in regard to the county in which you live.

Mr. STUBBS. We are exceedingly anxious to have more water. We believe that it is possible to obtain it from the Arkansas River. If it can be demonstrated that a flow of water can be got for irrigation from the river it would be a great blessing for our county. A survey has been made from our county to the Arkansas River, about Lamar, Colo. Water can be successfuly carried from the river all over our county, provided the supply is sufficient to warrant the construction of a ditch. What I should like to see, and what our people would like to see, is a demonstration of the fact that there is a sufficient supply of water in the river valley toward the construction of ditches.

Senator PLUMB. You are aware of the fact, as stated by a former witness, that the law of Colorado limits the flow of water found in that State to the uses of the people of that State?

Mr. STUBBS. That was stated, but it is a question in my mind whether it is true. Suppose a ditch should be constructed right up to the Colorado line and should be permitted to flow to that line, could that State forbid its flowing into Kansas?

Senator PLUMB. I am speaking about the law itself.

Mr. STUBBS. Well, then, does the law forbid it?

Senator PLUMB. That is my understanding of it.

Mr. STUBBS. And that is a question on which I am not posted.

Senator PLUMB. Is there any other supply that has come under your observation as available for that county?

Mr. STUBBS. There are artesian wells all around us, east, west, and southwest of us.

Senator PLUMB. Have your people experimented on that subject?

Mr. STUBBS. They have tried, but their means gave out and they have been unsuccessful.

Senator PLUMB. How far have they gone?

Mr. STUBBS. We have sunk a well 1,200 feet.

Senator PLUMB. Without finding water?

Mr. STUBBS. Without finding water that would rise to the surface.

Senator PLUMB. Did you find water?

Mr. STUBBS. We found some water at 200 feet and some at 400 feet with good pressure, and from there on we found water frequently, but without sufficient pressure to get to the surface.

Senator PLUMB. At what depth do you get ordinary well water?

Mr. STUBBS. It varies from 70 to 225 feet in our county.

Senator PLUMB. Is it very large at 225 feet?

Mr. STUBBS. Not very large at that depth.

Senator PLUMB. You do not get a large supply, then, until you get to about 400 feet?

Mr. STUBBS. No.

Senator PLUMB. And then it rises to 200 feet from the bottom?

Mr. STUBBS. Yes.

Senator BLUMB. Is it fresh water?

Mr. **STUBBS.** Very good, soft, fresh water.

Senator **PLUMB.** Has there been any survey or examination by scientific men which indicated that by going to a lower depth artesian water would be found?

Mr. **STUBBS.** No; there has not been, and we would very much like to have something of that kind done.

Senator **PLUMB.** What is the condition of farming in your county, and what, according to your observation, has been the condition of it since it has been settled?

Mr. **STUBBS.** We have some farmers, two or three in one locality, that have been successful, they tell me, every year in raising corn. With that exception I do not think that there is a township in our county that has been successful every year. The showers come as local showers. Last year it was very dry in the south part of the county, while there was plenty of rain in the north part to produce good crops. This year the eastern and central parts have been pretty well supplied with rains, while in our part it is very dry and some of the best farmers have had to leave the county because they could not raise enough even to feed their cattle.

Senator **PLUMB.** Have the storms been variable?

Mr. **STUBBS.** They have come in localities. I have been going back and forth to Haskell County since 1885, and have been watchful of the storms and made them a study. My observations are that the storms have flooded the streams. I have called attention frequently to the fact that when a cloud forms in the west, one rain-cloud comes down the Arkansas River and another goes down the Cimarron. They have had numerous rains when we had none on the divide.

Senator **PLUMB.** What have been the crops that your people have experimented with?

Mr. **STUBBS.** We have tried everything. I have made a special effort on my own farm. I have had thirty-two different things growing this year on my place. Some did well, such as Johnson grass, cattle corn, broom corn, and sorghum. I also raised pretty fair wheat this year. My corn is what you would call good here, but not what you would call good in eastern Kansas. It matured, however.

Senator **PLUMB.** Did you have millet?

Mr. **STUBBS.** Yes.

Senator **PLUMB.** Did that do well?

Mr. **STUBBS.** Yes.

Senator **PLUMB.** How did the precipitation of moisture in your county this year compare with the more favored parts of the section?

Mr. **STUBBS.** At Santa Fé we had as much rain as they had in any other part of the county.

Senator **PLUMB.** On the divide?

Mr. **STUBBS.** Yes.

Senator **PLUMB.** Then you think your part had the maximum of any part of the county?

Mr. **STUBBS.** Yes, I think so.

Senator **PLUMB.** You were at the experimental station yesterday and saw the cattle corn?

Mr. **STUBBS.** Yes.

Senator **PLUMB.** How did that compare with that grain raised in your county?

Mr. **STUBBS.** I have had corn just as good as that. We happened to have a rain that did not reach as far west in the county as where I live, and the winds that burnt others did not damage us.

Senator PLUMB. In your opinion do these hot winds originate locally, that is, do they originate near by?

Mr. STUBBS. I think they originate right on the ground. I have noticed them boiling up right in my face from the buffalo grass.

Senator PLUMB. You do not sympathize with the belief that they originate in Texas?

Mr. STUBBS. No. We have the largest body of smooth land in and adjoining Haskell County of any part of the United States. There may be on the Staked Plain a section that is somewhat similar. There is not a stream or even a ravine that could collect enough water for any irrigating purpose. The Cimarron rises about 1½ miles from the western end of our county, and with that exception there is no running water in the county during the year.

The CHAIRMAN. Is that in the western end of your county?

Mr. STUBBS. Yes. A survey has been made and a line run 100 miles west of us, and into Colorado, and the water has been taken out into a ditch in Colorado and brought across what they call the sand-hills. The water is on a high divide in Colorado, and the only thing necessary is to continue the ditch right into Kansas.

The CHAIRMAN. You do not think the law of Colorado ought to prevent the water from running?

Mr. STUBBS. I do not think it does. A man can not make a home in western Kansas and rely on rain-fall. Every man to-day in western Kansas is having a hard pull. Almost everything that he has is under mortgage, and it has been necessary for him to put it under mortgage in order to subsist.

The CHAIRMAN. Suppose that before that they had studied the best methods of getting water and devoted themselves to the subject, would they not have been in better condition to-day than they are?

Mr. STUBBS. Yes; I believe they would.

Senator JONES. If they had understood the conditions before they came here, would they come in such large numbers?

Mr. STUBBS. I doubt whether they would. We have a mixed population in Kansas; people from Dakota to Texas, and from Maine to California.

Senator JONES. It seems very clear that the people who came here to western Kansas did so without understanding the actual conditions.

Mr. STUBBS. The conditions at the time seemed to be such as to warrant their coming.

Senator JONES. Yes; but they were mistaken as to the actual conditions that existed.

Mr. STUBBS. Yes.

Senator PLUMB. Is there anything else that suggests itself to you?

Mr. STUBBS. Nothing else, except that I would like to see an appropriation made by the Government to determine the fact whether or not artesian water is available. Of course that is a question that we have no control over, but at the same time our people are anxious to have it tried. The parties who have bored our well are satisfied that the expenditure of some more money would result in finding more water.

Senator PLUMB. Is that well in such condition now as that, if additional funds were supplied, it could be deepened?

Mr. STUBBS. Yes. We have a thousand feet of 6-inch pipe standing there. There is a thousand feet of the well in good condition to start with.

Senator JONES. Have you no water in the thousand feet?

Mr. STUBBS. We have about 100 feet of water, but it does not flow out. It rises from the bottom because the casing is solid. The dirt packs around the casing.

The CHAIRMAN. You cut off all streams down to the bottom?

Mr. STUBBS. Yes; and we believe that in a lower stratum it would rise to the top. The wish may be father to the thought, but there are good indications to warrant the belief that that is true.

STATEMENT OF JOHN Q. A. NEWSOM, OF SCOTT CITY.

Senator PLUMB. Where do you reside?

Mr. NEWSOM. In Scott City, Scott County, which is the county adjoining this to the north.

Senator PLUMB. What is your occupation?

Mr. NEWSOM. I am a farmer and an inventor.

Senator PLUMB. What streams flow through Scott County?

Mr. NEWSOM. We have no live streams, except the Beaver, in that county.

Senator PLUMB. State the conclusions at which you have arrived in regard to the chances of an artificial water supply in your county. I assume, of course, that you believe that artificial water supply to be necessary.

Mr. NEWSOM. I do.

Senator PLUMB. State the result of your observations as to the sources from which that supply must come, if it is to be had.

Mr. NEWSOM. Having no live streams in the county we have to depend upon the water supply from outside streams, such as the Arkansas River. We have a water-way in the county which is the bed of an old stream that ran perhaps into an ancient lake. This lake is an old delta, and that fills up this old stream. It is called the "White Woman." It runs through Scott, Wichita, and Greeley, into Colorado. It rises in the eastern part of Colorado. It has water in our part of the county only where there are heavy rains. I live in a basin. The Beaver is a stream which heads up near Greeley County, and runs into Greeley and Wichita Counties, and perhaps into Colorado also. The fountain of that stream seems to rise from water close to the surface, but the erosion caused by the water has washed out cañons through Scott County, so that it would be impossible to divert that water immediately in Scott. I think that perhaps there is not enough water to pay for the trouble of attempting to make it useful in Scott. As to the other streamway it is doubtful whether there would be water enough there, unless the same lay high enough so that it could be tapped by a horizontal aqueduct, reaching into the water-line and conveying it down. I have not investigated that question.

Where I live my well is 18 feet deep to the surface of water. I have fine pure water, at a temperature of 54 degrees, which is extremely cold for that county. Our deep wells are warm and the shallow wells cold. My impression is that if we could get water it would have to come from the Arkansas River, unless we could construct a subterranean tap to the water-line and bring it to the surface. That is a question I have not investigated enough to give an intelligent opinion of what might be done. We need a water supply. As Mr. Stubbs has said, and as others have said, the people have left the county, and there is only a certain number who can stay by raising stock. If engines could be had of great capacity, higher up, that could raise the water a short distance to the surface, it would settle the question. But whether the water could be applied to public use or not, I do not know. A few farmers might join together and irrigate their land in that way, but when you contemplate a vast system of irrigation that should be beneficial to all people alike, and where all would be alike interested in it, it requires a more extensive system than is accessible to the people. If the Arkansas River has water enough, and aqueducts could be constructed to bring the water down, then we could get it into Scott County by canals, but the question is, Where shall we get the water? We have fine soil, rich in all the mineral constituents necessary to make fine crops, but it is lacking in the element of water, and in the vegetable elements.

Senator **PLUMB**. Is there a good crop of grass?

Mr. **NEWSOM**. An excellent crop of grass. In the locality in which I live there is what is called wild rye. There is periodical inundation of the basin in which I live, caused by the storms and head waters of the river. That makes a good growth of hay and some of the farmers in the locality have been able to raise a good crop of hay when the basin was flooded.

Senator **PLUMB**. Has there been any attempt to get artesian water?

Mr. **NEWSOM**. Not in our county.

Senator **PLUMB**. What is the source of supply, of which you speak, of the 18-foot well and similar wells in your neighborhood?

Mr. **NEWSOM**. The source of supply is sand, or clay, or lake-bed, or marl formation.

Senator **PLUMB**. Does it seem to be in a sheet of water?

Mr. **NEWSOM**. Yes.

Senator **PLUMB**. Is there a current to it?

Mr. **NEWSOM**. Yes, the current flows to the east. There is one feature about my well that I do not understand. It has been supposed by many people who lived in this section (the first settlers), that the water there was affected by the rise and fall of the water in the Arkansas River; I presume there are some who think that yet. My well is 14 inches lower now than when I moved there, two years ago last February, and I have thought that it was caused perhaps by the amount of water consumed in Colorado. I have asked other people about it, and I have not met with any one yet that has observed it in his own well, because the other wells are usually deeper than mine, and are usually covered up and can not be seen; whereas I can see exactly how much the water in my well varies. In the winter time my well will come back to the original point at which it was when I commenced; then, in February, again it falls. I take it that there must be some connection between our section and the Arkansas River.

Senator **PLUMB**. Do all the wells in your county reach up to the same level?

Mr. **NEWSOM**. I think they do.

Senator **PLUMB**. You think the deeper wells are at the same level?

Mr. **NEWSOM**. I think they are.

Senator **PLUMB**. While the water is warmer you think it is the same sheet of water?

Mr. **NEWSOM**. I think it is. The reason that the water is warmer I have attributed to the more rapid evaporation at the shallow depth and the slower evaporation in the lower depths. There are four degrees of difference in temperature between the water in my well and in the wells in other parts.

Senator **PLUMB**. If there is anything further that you wish to say about this matter we will be glad to have you state it as fully as you wish. Give us the results of your observation and the conclusions of your mind.

Mr. **NEWSOM.** I am very much interested in the success of the country and the prosperity of the people there. Every man of sympathetic feeling can not help being interested if he travels over that country and sees the amount of money that has been expended by those who have come to settle there in ignorance perhaps of the climate and of the conditions necessary to make homes. They evidently need some outside assistance in order to remain there. They have cast their lot there and all that they have is there. Any system that would bring that about would be a great blessing to those people.

There is one thing I would like to call the attention of the committee to. It is to a proposal—an extensive one—that has been discussed among our people, It may have been mentioned in your hearing. It is a proposition to irrigate from the Missouri River by striking it at one point in Dakota and bringing the water over the plains region here into the south. If that was a practical idea it would be a great enterprise for this country. If the lay of the country there is such that a large canal could take the water down it would be of great use here and would be of great use in the Missouri and Mississippi Valleys by preventing floods. We can utilize all the surplus water of these rivers and of the Yellowstone River that can be brought to us. It has been suggested that such a canal might be excavated and brought down. That would depend on the altitude and the fall that would be obtained in bringing it down. Your committee, of course, would understand whether that proposition would be worthy of entertainment.

Senator **PLUMB.** What has been the suggestion with regard to bringing the water across the other streams?

Mr. **NEWSOM.** There would have to be aqueducts constructed for that purpose. The question is whether it is a feasible proposition. Our people feel that it is. Our people feel that all the country between here and the Rocky Mountains could utilize that water in that way. The water could be utilized for manufacturing purposes also, when not needed for irrigation, by leading it into the Arkansas River, Smoky Hill River, the Republican River, Beaver River, and the streams that come out of the mountains. And you might carry it on to the Canadian River, the Cimarron River, and so clear on down to the Red River and the Staked Plains. Such a canal might be used also for moving heavy freights and might be made tributary to the deep-water outlets at the Gulf. I merely suggest this as a problem that comes under the scope of this investigation.

Senator **PLUMB.** Is there anything further that occurs to you?

Mr. **NEWSOM.** Nothing at this time, I think.

Senator **PLUMB.** If anything further occurs to you at any time, the committee will be glad to hear it.

STATEMENT OF L. D. BAILEY, OF GARDEN CITY.

Senator **PLUMB.** How long have you lived in Kansas?

Mr. **BAILEY.** Thirty-three years.

Senator **PLUMB.** How long have you lived in this part of the country?

Mr. **BAILEY.** Six years.

Senator **PLUMB.** You can state to the committee, in your own way, the results of your experience and observation here concerning the great question of what has been done and is doing here in regard to crops and the artificial water supply, present and prospective.

Mr. **BAILEY.** The subject is a very important one. My experience covers only six years here. The result of it is that with water we can raise anything. Without water there are some things that we can raise. With water I have never found a more fertile soil. My first experience here showed that we could grow an abundance of sweet potatoes, Irish potatoes, onions, and, in fact, almost everything but corn. That was in the fall of 1883. I have never seen better Irish potatoes than we had here, and there was an abundance of them ?

Senator PLUMB. Were they grown without irrigation ?

Mr. BAILEY. No; they had to be irrigated. But I have since raised some crops without irrigation; I think sorghum, millet, and cattle corn. I think those are reasonably sure.

Senator PLUMB. How about rye ?

Mr. BAILEY. Three years ago I grew a small patch of rye. I believe it can be made a profitable crop here by putting it in thoroughly and early, so as to take the chances of the rains. Still our prospects for farming without other sources of water supply than the clouds are not brilliant. Our prospects are not good unless we can get water from the river or from underneath the river. My well is 65 feet deep and is inexhaustible. It is on the thirty-eighth parallel of latitude. The railroad runs along that parallel for a good many miles, keeping on the north side of the Arkansas rise up to the State line and beyond. The road does not follow it all the way. I have known as many as one hundred teams (two-horse and four-horse) to water at my well at a single day and to use a good deal of water, but I never perceived that it made the slightest difference in my well. That, I think, is the general character of all the wells in this neighborhood. When you get down to where the water is there is an abundance of it.

Senator PLUMB. What is the depth of water in the well ?

Mr. BAILEY. I do not know.

Senator PLUMB. How deep does it stand below the lowest point of excavation ?

Mr. BAILEY. The well was there before I was. It had been abandoned and caved in to some extent. There never was any curbing there, and there never was any wall.

Senator PLUMB. Is there now ?

Mr. BAILEY. Not a particle of wall. It shows the peculiar character of the formation. The water never seems to come any higher or to get any lower.

Senator PLUMB. Is there a current there ?

Mr. BAILEY. I have not observed it.

Senator PLUMB. Is there sufficient water to be of service for irrigation if it could be lifted to the surface ?

Mr. BAILEY. I think enough could be drawn from that well to irrigate perhaps 2 or 3 acres, and I think a good many wells could be got from the same quarter-section.

Senator PLUMB. Are you apparently on the level of the Arkansas ?

Mr. BAILEY. I think so. I am on the highest land there is in sight. Mr. Spear's place, about a half mile west, is a few feet lower on the surface, and the well is about that much shallower. I think he went down 55 feet. There is a well a little way east of mine that is about 50 feet in depth, and on lower ground than mine. There is another well half a mile east that is about 53 feet, and on ground just a little lower than mine. A mile and a half farther there is another well that is about 52 or 53 feet in depth.

Senator PLUMB. Then you think that all that section of country is underlaid with the same sheet of water that flows on the Arkansas bottom, and in the channel of the Arkansas River ?

Mr. **BAILEY**. Yes.

Senator **PLUMB**. It is fresh water?

Mr. **BAILEY**. Yes. The formation changes after while; it is sand or gravel after you get to the water, but until you get there it is the kind of earth that you see at Kansas City. It stands without any walling, and is destitute of moisture. Yet in a well half a mile from my place the men who were digging found a root 10 feet deep about as thick as my thumb. I thought that remarkable, and suggested to them to follow it down and see how deep it went. They cut it off at a depth of 48 feet, and it was then about the thickness of a lead pencil. At 53 feet they struck water. That shows the peculiar character of that formation.

Senator **PLUMB**. Is there anything in your experience that shows where the artificial supply is to come from beyond that suggested by the water on your place?

Mr. **BAILEY**. The underflow of the water on my place is in my judgment just the overflow of the water from the Arkansas River, but I think there is an inexhaustible supply of water under this whole country. The sand in which water is found in the bottom of the wells about there seems to underlie this whole country; whenever you find water you find it under that sand; how deep that sand formation is I do not know; it is probably hundreds of feet deep, and is probably entirely saturated with water. My idea is that if we could cut down a section of ground here deep enough to strike that water and avail ourselves of the whole of its full volume, and then lead it out, we would find it very useful for irrigation. There is a fall of about 7 feet to the mile from the Rocky Mountains to the Missouri River. If we could avail ourselves of that fall we would have the benefit thereof by digging down to this sheet-water, this inexhaustible supply, at about the State line, and if we struck it at say 50 feet in depth, we would only have to go a few miles to spread it all over the surface. That theory may need demonstration, but I am inclined to take a good deal of stock in it myself. It may be practical to take that underflow and by availing ourselves of this uniform fall of about 7 feet in the surface of the land we could bring that water out and on to the surface to very great advantage.

Senator **PLUMB**. Is there anything further that occurs to you?

Mr. **BAILEY**. Nothing just now.

STATEMENT OF J. W. GREGORY OF GARDEN CITY.

Senator **PLUMB**. You reside in Garden City?

Mr. **GREGORY**. Yes.

Senator **PLUMB**. What is your occupation?

Mr. **GREGORY**. I am publisher and editor of a newspaper.

Senator. **PLUMB**. You have published some articles on the subject of artificial water supply in this section of the State, have you not?

Mr. **GREGORY**. Yes.

Senator **PLUMB**. Can you furnish copies of those to the committee?

Mr. **GREGORY**. I think I can furnish copies of the most important ones.

Senator **PLUMB**. You have some statistics on the subject, which you can let us have?

Mr. **GREGORY**. I have some figures that I can give you.

Senator **PLUMB**. Of course you understand that in the limited time at our disposal we can not very well go into the subject as thoroughly as you could go into it in writing at your leisure, but I should like you to state now in a general way your ideas in regard to it, and then supplement your statement by furnishing to the committe, in writing or in print, such other matter as you may have bearing on the situation.

Mr. GREGORY. Do you wish me to confine what I have now to say to the idea of obtaining a supply of water?

Senator PLUMB. Yes, generally to that idea, without the elaboration which you have given it heretofore in publication, because we can get it in more compact form by the method I have suggested.

Mr. GREGORY. Of course these are largely matters of opinion, and I would like to preface what I have to say by making one remark with regard to artesian wells and storage reservoirs, as applied to this country.

I believe that an immense amount of water can be obtained from artesian wells, and that a considerable amount can be saved by storage reservoirs, but the evidence that has already been presented before your committee shows that the expense and uncertainty attending the obtaining of water by means of artesians wells would be great compared with the amount of land that could be irrigated. No doubt a great deal of land will be irrigated in the course of time.

As to utilizing the storm-falls. the draws and ravines that are in this country are so few and scattered, and of such a character, and the basins that they would drain are so small, that the amount of water which could be stored and used from them would be very small indeed, and hardly appreciable, in western Kansas. The draws that are large, and drain a considerable area, so far as I know, reach down through this subterranean bed of sand, and it would be very difficult to store water in them. So that if in this southwestern country we could only rely on those two means of obtaining water we might as well, it seems to me, consider it a fact that it would be a great many years, perhaps centuries, before this whole country would be irrigated.

My experience and observation, however, have convinced me that there is an abundant supply of water easily available that will not only irrigate the Arkansas Valley but also the broad plains north and south of us that have been mentioned in your hearing by gentlemen from Scott, Haskell, and other counties. I refer to the supply of water which we know exists in this bed of sand that underlies not only the Arkansas Valley but reaches out to places on either side of it at a considerable distance therefrom. To undertake to utilize that by digging, as was suggested by one gentleman, to a depth of 50 feet, to bring that water to the surface, would cost so much that it would not be practicable; but by opening fountains along the Arkansas River, where the water is only about 3 feet below the surface, and taking advantage of the general fall of 7½ feet to the mile, water can be carried to the highest land in this part of the country, excepting occasional knolls, and the percentage of that would be very small.

I would like to present a few figures on which I base my estimate of supply. I do that as much for the benefit of the people here as anything else. The opinions expressed in these papers are the opinions that I hold, and which I have satisfied myself are correct. I have in my hand a letter from Mr. R. A. Steen, of La Junta, Colo., superintendent of water service on the western division of the Santa Fé Railroad. In answer to questions which I asked him about the middle of last May, he informs me that from Dodge City to La Junta, inclusive, the Santa Fé Railroad has fifteen supply wells that are an average distance of 15 miles apart. They have an average depth of 21 feet, the shallowest being 17 feet at Lamar, Colo., and the deepest 27 feet at Cimarron, Kans.; the average diameter of the wells is 16 feet; the average depth of water in the wells is 8 feet. There is but one of those that has a pumping capacity that tests the capacity of the well to any considerable extent; that is at La Junta, Colo. That well has a capacity of 255,150 cubic feet per twenty-four hours.

The most abundant supply of water in any of these wells is found at La Junta and Las Animas, Colo. I asked him this question: What is the character of the formation in which the water is obtained? His answer is, "Sand or gravel." Another question I asked him is this: Where water is obtained from strata of sand and gravel what is the total depth of the water-bearing stratum to the best of your information? To that his answer is: "At La Junta, about 10 miles east of here (this was written from another point on the road) we have wells sunk 8 feet in the gravel, but none of the wells reach through this subterranean water-soaked sand." Another question I asked him was this: If any of your wells obtain water from veins instead of sheet, state the circumstances. His answer is: "None; they all obtain it from the subterranean water-bearing sand or gravel; none of them pierce or go through it." I then asked him: If any of your wells obtain a supply from what is popularly named sheet-water, please state what is the lateral extent each way of the sheet water. To that his answer is: "At La Junta the water-bearing strata extend about 2,000 feet south of the river." He did not venture any further opinion. That gives some idea of the extent of this water east and west along the river, and shows that the depth is very considerable.

As to the extent north and south of the river, I addressed some questions to Mr. J. S. Humphrey, formerly water surveyor of our county, now residing at Findlay, Ohio, an educated civil engineer and a very conservative man, and one in whose judgment all people who know him will have great confidence. He says:

> I will give you all the facts that I know about the water supply in the Arkansas valley. In sinking the well of the Garden City Water-Works we struck water at 8 feet from the surface, in coarse gravel. This gravel had a depth of about 8 feet, at which point we came into a rather fine sand, which was not so good a water-bearing stratum as the gravel. We tested this to a depth of about 25 or 26 feet and could not detect any change. The construction of our well-wall was range rock-work laid in cement, so as to exclude all water except such as should come from the bottom of the well. The excavation of the well was stopped by direction of the council at 19 feet in depth. The capacity of the pumps is 1,000,000 gallons in twenty-four hours; the capacity of the well somewhat less; I do not now recollect how much less. If the well had a porous wall, say 16 feet deep, the water supply would easily be 2,000,000 gallons in twenty-four hours. I regard the water supply as inexhaustible. I believe that the water underlying Garden City is one sheet, extending from the southern edge of the sand-hills (that would be about 10 miles south) northward to some point between Scott City and the Kansas Pacific Railway.

Scott City is 38 miles north of here. Mr. Humphrey further says:

> In the Arkansas River valley is a river of water flowing eastward which can be tapped for irrigation at almost any point and the water supply is limited only by the capital at command. A clear water system of irrigation can be secured independent of the river, and which, once constructed, will not require the cleaning of ditches, and will prevent the spreading of weed-seed all over the land. Freshets in the river will not wash away the dams and sluice-gates. The Arkansas River valley has a great future before it, and those of you who can hold on will be amply repaid for so doing.

There is another thing that indicates the depth of this supply. Experimental boring was made here which extended to a depth of 900 feet. I obtained the facts in regard to it from a gentleman who superintended it for the county at the time and had his figures, but have lost them. I remember, however, that he found continuous succession of water-bearing strata to a depth of 120 feet under Garden City.

You have already had statements from other gentlemen, including a gentleman who lives several miles north of us, one who lives several miles south of us, and one from Scott City, showing that they had also struck this same subterranean sheet-water. In the river valley this water is only about an average of 3 feet below the surface.

In a letter from Mr. W. E. Trull, of Garden City, who was city engineer for a long time, after giving the depth of the city well, which is 19 feet, he states that its extreme supply for twenty-four hours, as shown by tests when he was superintendent of the water-works, was 800,000 gallons. He was in charge of the works for twenty-two months. That well is located in the second bottom. That surface is on an average 8 feet higher than the surface of this underlying supply of water. In the first bottom it is an average of 3 feet at some places, at others 4, and still others 5. Mr. Trull gives the average depth at which the water stands at this well as 12 feet, out of a total depth of 19. The average depth of wells in Garden City he gives as 18 feet. The average depth of water in the first bottom next the Arkansas River is 3 feet. He gives it as his opinion that the depth of this first stratum of water-bearing sand is 18 to 25 feet and that there is but a thin scale between that and the next.

I am satisfied that the State of Colorado can not deprive us of water by continuing in the dog-in-the-manger policy of preventing the water from crossing the State line. We can obtain a sufficient supply of water from the underground source, which would be out of their reach except by pumping, and if they resorted to pumping, there would be enough for our use and theirs too. Enough could be got by bringing this underground supply to the surface in less than a mile and, by penetrating the sand to a sufficient depth, it seems to me that the capacity of these wells could be much increased. We certainly could secure all the water we could use, the only limit being the amount of land necessary to irrigate and the amount of money necessary to irrigate it.

I am satisfied from the investigations I have made that the water to fill one of our large irrigating ditches can be secured in that way with less expenditure of money than would be necessary to put in dams on the Arkansas River, and also, as Mr. Humphrey suggests, free from the noxious weeds and weed-seeds that come down; and that we would have the water at the time we need it most.

I do not believe that it is practical for us to obtain this system of irrigation within a time that will enable it to benefit the people now here, unless the Government will take hold of the matter and see it done systematically and thoroughly, and also start the work. It ought to be done systematically, because otherwise there will be areas that will be furnished water by two or three ditches, more ditches than they need, while others will be neglected. Besides that, where it depends on private capital the people who own the land will have to pay or give up of their property a great deal more than they ought. You all know how matters of that kind work in reference to railroads, etc.; they often cost more than they are worth. So far as we are concerned here, it is better to lose half our lands than all of it, and have the water. But we can not make this a successful agricultural country without irrigation.

We do not think that in asking the Government to take hold of this matter we are asking it as a matter of charity, at all. Since the Garden City land district was organized in 1883 there have been paid to the Government for lands in that district $4,450,943.86. That is not exactly accurate, but it is within a few dollars of the exact amount. This district had paid a good deal of money into the Treasury before it was organized as a separate district. It was formerly a part of the Larned district, so that we will be fully justified in saying that the land in this district has paid into the Treasury of the United States $5,000,000, and if the Government will devote the one-fifth part of that sum to making this land habitable, I think you can safely rest assured that it will return in the way of taxable property alone, not saying anything of its value to the people, one-hundred fold the amount of the investment by the enlistment of private capital in the development of the resources of this country. I think that a very conservative estimate.

Senator PLUMB. Is it your idea that the Government should engage in furnishing the water?

Mr. GREGORY. My idea is that the Government should systematize the matter and start it. Beyond that I do not think the Government would need to go.

Senator PLUMB. How do you mean to "start it?"

Mr. GREGORY. In the first place, the Government should make surveys and establish where the high land lies between the streams, and fix the places where the underflow from the Arkansas valley and from the valley of the Cimarron, the Beaver, and the other streams can be most advantageously tapped and turned in to perhaps a long central canal. This is merely a theory, of course. But if a canal were established on the high land, for instance, near Garden City, and could go up into Colorado, it could be kept constantly filled by pools along the river, and the flow turned in from a main canal as soon as the supply could be raised to that point. South of us the same thing could be done. There is no question but what the water could be taken across the sand-hills at several places. I think the Government ought to appropriate money sufficient to make the start and see that it is systematically done, and should also regulate it after it is done.

Senator PLUMB. You mean that it should make the survey?

Mr. GREGORY. That it should make the survey, and also establish as many fountains or supply sources as are necessary to make a thorough demonstration of the practicability of the plan. We have these wells. We have within the present limits of Garden City a lake, the bottom of which is below the level of the river, from which water runs the whole year round. That is a practical exemplification of this system, showing that it can not help but be a success.

Senator PLUMB. Then in what way would that which the Government could do add to the certainty of the situation?

Mr. GREGORY. It would not add to the certainty, but you have already heard the condition of our people. If we must wait for the uncertainty of private capital, we must wait from five to fifteen or perhaps thirty years before we can make it a success.

Senator PLUMB. Do you think that private capital would go into competition with the Government?

Mr. GREGORY. No; but I think it would act in accord with the Government.

Senator PLUMB. What is the scope of your idea?

Mr. GREGORY. I can not say that I have developed it.

Senator PLUMB. You say that the Government ought to make surveys, and then that it ought to make these pools for the purposes of demonstration, but, according to your statement, it is demonstrable now.

Mr. GREGORY. It is.

Senator **Plumb**. Demonstrable from what can be seen as the result of the investigation of private parties?

Mr. **Gregory**. It is not a question of demonstrating it to us, but of demonstrating it to those who have money.

Senator **Plumb**. To what extent would the Government need to carry on the work in order to make that demonstration?

Mr. **Gregory**. It is impossible for me to say that; but I think the fact that the Government had taken hold of it would give it publicity and bring it to the attention of people who have capital—an attention that can not be brought about in any other way.

Senator **Plumb**. Do you think that if the Government were going to dig ditches, fountains, and so on, private capital would also go into it?

Mr. **Gregory**. I do.

Senator **Plumb**. In competition with the Government?

Mr. **Gregory**. No.

Senator **Plumb**. If the Government should have a fountain and a ditch and got its money by taxation from the people, of course it would not need any stockholders and would not pay dividends. It would either have to sell the water to the people, keeping up a corps of assistants here, or else it would have to give it to them, and if it gave it to them, of course no private capital could engage in it, because private capital could not afford to sell water in competition with those who gave it away. If the Government were selling the water, there would always be a pressure upon those of us who represent these people, as well as upon others, to constantly abate the charges, forgive the debt, etc.; so that no man would feel safe to invest money in that sort of competition. As you have given a great deal of attention to the subject, I would like you to address yourself to that point. I would like to see what your idea is as to just how and to what extent the Government ought, as you think, and could, with propriety, according to your notion, engage in it.

Mr. **Gregory**. I do not believe that the Government of the United States should go into the irrigation business at all as a matter of profit.

Senator **Plumb**. Nor as a matter of loss.

Mr. **Gregory**. No, nor as a matter of loss, but as a matter of right.

Senator **Plumb**. And to what extent?

Mr. **Gregory**. We consider that this land has cost us enough, and that the conditions have turned out so adversely and so differently from what was anticipated, that we are entitled to such consideration from the Government as that it shall put money enough into this matter to make a good agricultural country here.

Senator **Plumb**. What I want to know is how the Government should do that.

Mr. **Gregory**. The extent to which the Government should go would be, as I have stated, to the extent of demonstrating what should be done, and whatever works may be constructed by the Government need not be lost by any means, either to the Government or to the people.

As I understand it, this Government is of the people and for the people. We are a part of the Government, and expect consideration from it. Such irrigation works as I have mentioned might ultimately be turned over to the States or counties and communities, or to private corporations, but under such restrictions as that the price of water might be lowered.

Senator **Plumb**. Would that be any inducement to private capital?

Mr. **Gregory**. If the Government would invest $1,000,000 and allow private capital to take hold where the Government left off, in such a way as that they would make money out of it and let the people have the water, I do not see where the injustice would be.

Senator **Plumb**. Somebody has to do something about this matter, and we are here to get the opinions of the people. We want to know what they expect.

Mr. **Gregory**. If we had the assurance that there would be anything done at any early period, I am satisfied that the person to produce the plan would be on hand.

Senator **Plumb**. If we are to consider this question with the view of determining what we ourselves would recommend, we ought to know the desires of the people here on that subject.

Mr. **Gregory**. Just how the connection should be made, as to what would be expended by the Government——

Senator **Plumb**. But you have not yet answered my question. Do you think the Government should put in a ditch to supply water to the persons wanting it?

Mr. **Gregory**. Yes.

Senator **Plumb**. I did not know whether you wanted to do that, or to stop with the survey.

Mr. **Gregory**. I would not have it stop there by any means.

Senator **Plumb**. The Government, you think, should go to the extent of building a single ditch at least, to supply water to persons along the line of that ditch?

Mr. **Gregory**. I would not confine it by any means to a single ditch. I would not confine it to less than enough for these plains.

Senator **Plumb**. Then you think the Government ought to put in all the ditches necessary?

Mr. **Gregory**. I think it ought to begin the work and carry it on to a point where private capital would be ready to carry it on. I am satisfied that that will be a very early period. Any one who will come here and see the results of irrigation can not but be satisfied that there is an immense development in store for the country if we had the use of water.

Senator **Plumb**. That is common to the observation of all persons who have visited the country. Everywhere it is manifest that wherever water is applied by means of irrigation great and certain crops result. Of course, the people everywhere would be very glad to have the Government supply them with water. That brings up, however, the problem with reference not only to this immediate locality but as to all parts of the United States. If the argument is based on the idea that the people here have paid certain moneys for their land and that that is to be returned to them, of course, that argument is susceptible of pretty wide application.

Mr. **Gregory**. I would call attention, Senator, to one thing: We have no rivers to improve and no harbors to clean out. We have not asked for Government buildings, but we do ask for a chance to live.

Senator **Plumb**. The people of the East have also paid money to the Government, and the people in the eastern part of this State have paid money to the Government, and want to live. It seems to me that your argument should not be based on the idea that the people have bought a quantity of land for which they have paid.

Mr. **Gregory**. We will not, for a long time, ask for any Government building or river and harbor appropriations, which all the States to east of us have had in great plenty, but we will ask you to devote to our part of the country our share of the money to develop water supply.

Senator **Plumb**. That is your share of the money raised by taxation?

Mr. **Gregory**. Yes.

Senator **Plumb**. That will result in a mathematical calculation as to how much that money was.

Mr. **Gregory**. We want our share of it simply.

Senator **Plumb**. You want a fair computation on that subject?

Mr. **Gregory**. Yes.

Senator **Plumb**. Speaking of public buildings, I have no doubt that when the Government wants a Government building in Garden City it will build it, not because the people want it, but because the Government has need of it.

Mr. **Gregory**. Yes; I wish to say that the suggestions I make about the water supply are not to be considered as applying solely to this country, but are to be considered as applying also to the valley of the Platte. I think Major Powell shows that 25 per cent. of the arid and semi-arid lands of United States can be made fertile by the use of a small share of the water of the mountains. If we can use a part of the water that has gone down into the subterranean strata it will be an immense gain to the United States.

Senator **Plumb**. I understand that your theory of the duty of the Government is not limited to this locality at all. I understand your idea is that wherever the circumstances require it the Government should do the work.

Mr. **Gregory**. The Government should begin it.

Senator **Plumb**. That opens up a great question, because this condition of things exists over one-third of the area of the United States.

Mr. **Gregory**. Well, none of us know the cost of the work. A gentleman in Garden City, Mr. Moon, has excavated a reservoir for the purpose of manufacturing ice. That reservoir, I understand, cost something less than $1,000. It is of such depth that it reaches about to the surface of this underground water supply. It is nearly in circular shape. If that were extended and made, say, 25 feet or 40 feet across, and made much longer, the same amount of money would provide a great deal more of a reservoir than when the dirt has to be moved so far as in the case of a circular pool.

Senator **Plumb**. Would it be practicable to use that for the purpose of experimenting to demonstrate the general result?

Mr. **Gregory**. It would be available as demonstrating a result of a reservoir in connection with it. The quickest and cheapest thing I know of would be to clear out and do a little work in this lake I spoke of in this town. It would not take much money to see in a small way what could be done. I do not believe that if we wait for results to come from small showings we will ever have the general result that ought to come to the people as a whole. While we might here at Garden City obtain results to answer our purpose very soon, we do not feel satisfied with having the matter stop there. We want to see our neighbors east, west, south, and north of us have as much benefit as they can.

Senator **Plumb**. You do not think that on a demonstration of this kind private capital would be induced to make investment?

Mr. **Gregory**. I think that it may be, but it would be so slow that by the time it would be done the capitalists and monied men would have the land and would have the profit that the poor people ought to have.

Senator **Plumb**. You mean that it would not be done quickly enough?

Mr. **Gregory**. Yes.

Senator **Plumb**. Is there anything further you wish to state?

Mr. **GREGORY**. Nothing further than to impress upon you as far as possible the very great importance of their being something done; also the fact that if we depend upon private capital we depend on it to make development for somebody else and not for ourselves.

Senator **PLUMB**. You may, of course, supplement what you have said by submitting in writing any data that you think will throw light on the subject.

The **CHAIRMAN**. What amount of land do the people here generally have—how large are the farms?

Mr. **GREGORY**. There is hardly any one here who has less than 160 acres. As to the farmers I think it will be fair to say that among those who came early each man would have about 320 acres of land, because almost all of them took a homestead and pre-emption claim and also a timber claim. But perhaps at the present time that would not be the case. Perhaps 160 acres would be the quantity.

The **CHAIRMAN**. Are you aware that a person does not need as much irrigated land as other land?

Mr. **GREGORY**. We are aware that a person can make a good living on 10 acres of this land.

The **CHAIRMAN**. If the Government did not do this, would it not be practicable for the people to join together and contribute some of their land toward the building of a ditch?

Mr. **GREGORY**. If we could get the men to supply the money and the water I do not think there is a man in this country that would not give 80 acres out of his 160 to get water. If he had to go as far even as 120 he might do that; but we do not think it is just to the people to require that of them.

The **CHAIRMAN**. I did not allude to that, but whether there was any way out of the difficulty except the Government way.

Mr. **GREGORY**. There is that way that I have just spoken of, but it is a very hard way.

STATEMENT OF A. T. MOON, OF GARDEN CITY.

Senator **PLUMB**. Where do you reside?

Mr. **MOON**. In Garden City, Kans.

Senator **PLUMB**. How long have you resided here?

Mr. **MOON**. Since the spring of 1885.

Senator **PLUMB**. What is your business?

Mr. **MOON**. I am engaged in the ice business.

Senator **PLUMB**. Have you given some attention to the question of the artificial water supply in this section of the country?

Mr. **MOON**. I have had no great experience in irrigation, but as to this question of obtaining water from the subterranean supply I have made some little experiments in the way of excavating an ice pond and got information in that way.

Senator **PLUMB**. State what your information is.

Mr. **MOON**. In the winter of 1886 I excavated a pond on what is known as the first bottom. The pond contains about 2½ acres, and the excavation is an average depth of about 3 feet. We took off all the surplus down to the sand. It was perfectly dry and easily worked until we came to the sand. When we came to that the water rose and made it very muddy and hard to work. We did not get it so deep as we intended to get it.

That pond is supplied from a natural lake about a half mile above. The bottom of the natural lake is probably a foot below the sand in the river. There is a continual stream flowing all the year round. The volume of the stream varies a little every season. It is about the lowest now that we have ever seen it. In the dry season it does not flow as much as in the spring or in the wet season, but it has never been known to go dry. I filled this ice pond from the branch which flows down from the natural pond above. The fall is sufficient.

Senator **PLUMB.** Would there be any difficulty in digging it out to the depth of 10 or 15 feet, and getting out the sand?

Mr. **MOON.** Yes; I think there would be some difficulty in doing that.

Senator **PLUMB.** Does the sand flow with the water?

Mr. **MOON.** It does to some extent, but not very much.

Senator **PLUMB.** It is not a quicksand, then?

Mr. **MOON.** No; I would not call it that.

Senator **PLUMB.** Is there gravel in it?

Mr. **MOON.** There is some gravel, but we drove through it with teams. Further excavation may be possible there, but we did not make it.

Senator **PLUMB.** You think the water in this lake or pond is got by flowage from the lake above?

Mr. **MOON.** There are some who think the lake above is supplied by a spring, but I do not see why we should have a spring in the middle of a lake-bed. It looks to me as if it came from the level of the river.

Senator **PLUMB.** Does that water from the lake above flow in a channel, or is it a general sheet of water following the trend of the river?

Mr. **MOON.** The channel follows the trend of the river. This natural channel looks as if it had been cut out some time by the river. It was probably an arm of the river. I have dug down on the east side of the lake, and I find this same sheet of sand on each side, which, it seems to me, did away with the theory that there was a spring in the lake.

Senator **PLUMB.** You regard it as settled that in a large portion of this bottom here the water is found on the same general level as the bed of the river?

Mr. **MOON.** Yes; I think it is also true that in an excavated pond the water will rise higher than it is found to be in the river.

Senator **PLUMB.** You think it will rise above the level of the water in the river?

Mr. **MOON.** Yes; probably by capillary attraction. The water is higher in our pond than in the river, which is only about 2 rods distant.

Senator **PLUMB.** How much higher?

Mr. **MOON.** I do not know exactly how much, but I know it rises higher. Of course other sources contribute to it, and the water coming from above has something to do with it.

Senator **JONES.** How much higher than your pond is the natural lake to which you have referred?

Mr. **MOON.** About 5 or 5½ feet. The upper end of it is from a mile to a mile and a half farther up the river, and the natural fall is toward the artificial pond.

The committee here took a recess of an hour, after which the session was resumed, the same members being in attendance.

STATEMENT OF WILLIS BRYANT, OF SCOTT COUNTY.

Senator PLUMB. Where do you reside?

Mr. BRYANT. In Scott County; about the center of it.

Senator PLUMB. How long have you resided there?

Mr. BRYANT. Three years and a half.

Senator PLUMB. Where are you from?

Mr. BRYANT. Montgomery County, in eastern Kansas.

Senator PLUMB. Please state to the committee the result of your observation in regard, first, to the necessity for an artificial supply of water in this section of the country, and secondly, as to the method by which it can be obtained.

Mr. BRYANT. There is no doubt but that they need a little more water here; yet they have raised quite a considerable crop there this year; good wheat, very good oats and rye, and some very good corn. With a little assistance in the way of artificial water they would have a very good crop there this year.

Senator PLUMB. What is the annual average precipitation in your part of the county?

Mr. BRYANT. About 14 inches, I think, on an average.

Senator PLUMB. Not more than that?

Mr. BRYANT. No; it runs a little higher some years—as high as 18 or 20 inches.

Senator PLUMB. About how high has it been this year?

Mr. BRYANT. It is 13 inches, about.

Senator PLUMB. Is it distributed pretty evenly?

Mr. BRYANT. No; the rain is local rather than general.

Senator PLUMB. Is there any particular part of the county that from year to year has more than any other part? Is there more precipitation along the streams?

Mr. BRYANT. There is probably a little more. Last season a better crop was raised in the north part of the county. This season it has been pretty generally distributed all over.

Senator PLUMB. What do your people chiefly raise?

Mr. BRYANT. This year our people are commencing on wheat.

Senator PLUMB. Is it a fair crop, and is the wheat full?

Mr. BRYANT. It is a very good crop, and of full wheat.

Senator PLUMB. Have they tried spring wheat?

Mr. BRYANT. No. In addition to the wheat, they have rye and corn, and cattle-corn. They have also some alfalfa, though not very much. Early potatoes did very well this year.

Senator PLUMB. Please state the result of your observation in regard to the chance for an artificial water supply?

Mr. BRYANT. About the only hope that our people look for is the storage of the rain-fall and the assistance of the Amazon ditch now being constructed, which will irrigate about one-third of the county.

Senator PLUMB. That is supplied from the Arkansas River?

Mr. BRYANT. Yes.

Senator PLUMB. If you get all the water you can irrigate the area you have named?

Mr. BRYANT. Yes; engineers are now surveying with the view of making storage reservoirs to take care of the water that comes down in the fall and winter. Some have an idea that they might get relief from artesian wells. Nothing of that kind has been tried there.

Senator PLUMB. At what depth have they found water?

Mr. **Bryant**. At 50 feet depth in the towns. It is pretty much the same all the way round. It seems to be sheet water.

Senator **Plumb**. That is found all around the valley of the Arkansas River?

Mr. **Bryant**. Yes.

Senator **Plumb**. You are on the water-shed of the Smoky Hill?

Mr. **Bryant**. Yes.

Senator **Plumb**. From what direction must the artificial water supply come?

Mr. **Bryant**. From the Arkansas River.

STATEMENT OF J. A. WILSON, OF KEARNEY COUNTY.

Senator **Plumb**. Where do you reside?

Mr. **Wilson**. In Kearney County, Kans.

Senator **Plumb**. That is the county adjoining this?

Mr. **Wilson**. Yes; on the west.

Senator **Plumb**. How long have you resided there?

Mr. **Wilson**. Two years.

Senator **Plumb**. Please state to the committee the result of your observation in regard to the necessity for an artificial supply and the source from which it might be obtained, as well as the method of obtaining it.

Mr. **Wilson**. I have seen the irrigation from the ditches within reach of the Arkansas valley proper, and have also noticed the natural fall of water. My idea is that the best agricultural country could be reached by storing the waste water that passes through the draws.

Senator **Plumb**. You mean what falls on the hills, on the surface of the earth?

Mr. **Wilson**. Yes.

Senator **Plumb**. Is the topography of the country such that storage could be carried on on a large scale?

Mr. **Wilson**. It seems to me that it is. There are large "draws," some of which are a mile wide, and the water could be stored there so as to give a surface reservoir of 50 to 100 acres perhaps.

Senator **Plumb**. What you speak of as a "draw" is what we know generally as a ravine, is it?

Mr. **Wilson**. Yes.

Senator **Plumb**. You mean that by closing the mouths of those ravines or draws, and getting the water naturally belonging to them, you would get enough water to aid materially in irrigation?

Mr. **Wilson**. I think so.

Senator **Plumb**. At what time is this water to be had?

Mr. **Wilson**. It falls in the early spring, except during the last season. I notice that it has fallen in August and September and in the winter time. More falls in the spring and fall than at other times. There has been waste water that has washed out the embankments and ditches several times this last season.

Senator **Plumb**. Have you had any experience with artesian water in your county?

Mr. **Wilson**. No.

Senator **Plumb**. Are there any artesian wells in your county?

Mr. **Wilson**. No.

Senator **Plumb**. Have any efforts been made to obtain them?

Mr. **Wilson**. No.

Senator **Plumb**. What reliance can be placed upon the water in the Arkansas River?

Mr. **Wilson**. From what I have heard others say, they have now a greater slope of country subject to irrigation than the surface supply of water will warrant.

Senator **Plumb**. That is, the present ditches can not supply the lands that lie under them?

Mr. **Wilson**. No.

Senator **Plumb**. Is that because of the short supply of water in the rivers this year compared with former years?

Mr. **Wilson**. The two seasons that I have been here they have had failures of crops for want of water.

Senator **Plumb**. What, in your opinion, is the occasion of there not being sufficient water?

Mr. **Wilson**. There not being sufficient rain-fall, or there having been a limited snow-fall in the mountains.

Senator **Plumb**. Is there any other suggestion you wish to make on this subject?

Mr. **Wilson**. I will only state that I am enthusiastic on this theory of the reservoir system. We have great natural advantages by reason of the natural fall of slope of the land, and the ravines or draws. I believe the water could be very easily stored in sufficient quantities to irrigate the land.

Senator **Plumb**. What proportion of the land do you think would be irrigated by storing the water which is the result of storms at seasons of the year other than the growing season; that is, what proportion of the water that descends goes to waste in the season of the year when it is not needed for irrigating the crops?

Mr. **Wilson**. I think there is sufficient to irrigate all the land.

Senator **Plumb**. You think the annual precipitation is sufficient if it could only be used at the proper season of the year?

Mr. **Wilson**. I think so.

Mr. **Clark**. I should like to have the privilege of asking a question. I wish to ask Mr. Wilson by what means he would lift the water out of a low draw to irrigate the table-lands above?

Mr. **Wilson**. I would not undertake to irrigate the lands above. I would irrigate the lands below. I suppose that that water to be carried out and utilized to the best advantage should be carried out in hard tiles. The soil is all sandy around here and absorbs water very rapidly. To conduct it out overland through ditches would waste a considerable portion of it. I think the water should always be taken out from the bottom, so that you could utilize all the water in the mountain lakes or reservoirs, and that it should be taken out by means of hard tiling, with proper machinery for shutting it off at the proper times.

Mr. **Clark**. Then you do not expect to irrigate the small valley below the draw?

Mr. **Wilson**. We have a natural fall in this country of 8 or 9 feet to the mile.

Mr. **Clark**. Is it a fact that if you took it along the river or stream in this country where the draws come in, and were to carry it by a flume, each half mile you would come to another draw—if so, how would you pass over that draw?

Mr. **Wilson**. A system of reservoirs would, I suppose, have to be arrangedfor, to accommodate the country, and if they struck another draw they would have to arrange to get a fall of 2 or 3 feet for the water.

Senator JONES. There is no practical difficulty in that. Everywhere water is carried in flumes above water-courses.

Mr. WILSON. If water is carried by proper machinery so that it will not be wasted by absorption and evaporation it can be carried to the proper place.

STATEMENT OF W. E. HUTCHINSON, OF ULYSSES, GRANT COUNTY.

Senator PLUMB. Where do you reside?

Mr. HUTCHISON. In Grant County.

Senator PLUMB. In what part?

Mr. HUTCHISON. At Ulysses.

Senator PLUMB. How near are you to the Arkansas River?

Mr. HUTCHISON. The northern part of our county is 12 miles from the Arkansas.

Senator PLUMB. Please state to the committee the result of your observation; first, as to the necessity for an artificial supply of water in your county, and, secondly, your view as to the source from which that supply must come if it is to be obtained.

Mr. HUTCHISON. I have been in Grant County two years, and I see the need of having something to help out the crops. We have an early spring. A superabundance of water comes along then; in July and August we have little or no water. There is great need of an artificial supply. My idea is that we will have to get that from the Arkansas. It is very shallow to water in our county, and probably an artesian system would have to go deeper than in other places.

Senator PLUMB. How deep do you have to go for water?

Mr. HUTCHISON. On the west half of the county about 40 feet, and on the east half about 100.

Senator PLUMB. Is there an ample supply then?

Mr. HUTCHISON. Yes. Some people say that in digging wells the augur would drop 1½ feet, and sometimes as much as 6 feet.

Senator PLUMB. Does the water rise pretty well up in the well?

Mr. HUTCHISON. Quite a distance.

Senator PLUMB. There have been no artesian wells dug in your county?

Mr. HUTCHISON. No. The sand hills lie between us and the Arkansas and there might be difficulty in getting the water across, though not a great deal, I think.

Senator PLUMB. What success have your people had with their crops?

Mr. HUTCHISON. The crops are only a partial success. This year we have not had half a crop.

Senator PLUMB. What is your principal crop?

Mr. HUTCHISON. Corn. We raise oats sometimes. Alfalfa does well in the wet part of the season, but it is no good after the dry season commences.

Senator PLUMB. Have you tried sorghum, cattle-corn, or other fodder crops?

Mr. HUTCHISON. Yes.

Senator PLUMB. So far as any known fact is concerned, your reliance is on the Arkansas River?

Mr. HUTCHISON. Principally. We have two streams, the Cimarron and Bear Creek, from which water is easily obtained and we have often thought of making reservoirs and retaining the water when there was an excess of it. Bear Creek could probably supply all our county. It would be down grade.

Senator **Plumb**. Is there anything further you wish to say?

Mr. **Hutchison**. I do not think there is.

STATEMENT OF J. C. GUY, OF HAMILTON COUNTY.

Senator **Plumb**. You reside in Hamilton County, I believe?

Mr. **Guy**. Yes.

Senator **Plumb**. How long have you resided there?

Mr. **Guy**. Between one and two years.

Senator **Plumb**. Where were you from, originally?

Mr. **Guy**. From Missouri.

Senator **Plumb**. In what part of the county do you live?

Mr. **Guy**. At Syracuse, in the center of the county.

Senator **Plumb**. Please state the result of your observation as to the necessity for an artificial water supply in that county, and the result of your observation as to the best method of getting it.

Mr. **Guy**. My view of the necessity of getting a water supply is very decided. We have a little over half a million acres of arable land in that county that is susceptible of irrigation, with water; and without water it is almost worthless. We have about 70,000 acres running through the center of the county that could not be irrigated. In the western part of the county we have good artesian wells to the depth of 300 feet, but I do not think they would be sufficient to irrigate any considerable amount of land for agricultural purposes.

Senator **Plumb**. How many wells have been sunk there?

Mr. **Guy**. I think two or three.

Senator **Plumb**. What is the flow from those?

Mr. **Guy**. I do not know. They are in the western part of the county, in the town of Coolidge.

Senator **Plumb**. What, in your judgment, is to be the source of supply for artificial water?

Mr. **Guy**. Our opinion there generally is that the only really practicable plan would be that of storage reservoirs.

Senator **Plumb**. Taking the water out at the time that there was an abundance of it, and storing it?

Mr. **Guy**. Yes; principally.

Senator **Plumb**. And also storing that which fell during the season of the year when there was no need of the water?

Mr. **Guy**. Yes. There are times in the year when a great deal of water runs down the Arkansas River, and during that time we might store it in the reservoirs. In that county there is a sheet of water that underlies all the bottom land. You can obtain it by boring, digging, or driving, at from 12 to 15 feet from the bottom. That supply is supposed to be inexhaustible, though we have no information on the subject.

Senator **Plumb**. Those two sources, then—the water that flows under the surface along the Arkansas bottom, and that which is a result of precipitation and flows down the Arkansas River during the season—would be the two sources of supply?

Mr. **Guy**. Yes.

Senator **Plumb**. Does the topography of the country afford places for storage to irrigate the county?

Mr. **Guy**. Yes. Along the course of the river there are various long ravines that might be filled from the river. About 3 miles from the river you come across a nice level plateau—a beautiful country with an excellent quality of soil. I believe that is a better quality of soil than the soil on the bottoms.

Senator **PLUMB.** Are there natural depressions on the elevated tablelands?

Mr. **GUY.** Yes; although these storage places would have to be made some distance above and the water conducted down.

Senator **PLUMB.** Is the land in your county chiefly entered?

Mr. **GUY.** No; I do not think there is one-half of the county that has been entered and proved up.

Senator **PLUMB.** I do not mean the final proof, but the quantity of land on which filings have been made. You know that when a man gets a piece of land and files his claim for homestead entry, that is called an "entry." Most of those lands have been filed on, I suppose?

Mr. **GUY.** Yes.

Senator **PLUMB.** Have the parties left there?

Mr. **GUY.** Yes. A few years ago we had four or five thousand; today we have not two thousand.

Senator **PLUMB.** Do you think the people have finally abandoned the land?

Mr. **GUY.** They have gone away to seek employment—to get a livelihood. They could not raise a sufficient amount of crops to sustain them. They took the land in good faith, and have tried very hard to remain there.

Senator **PLUMB.** You think, then, that those people mean to come back?

Mr. **GUY.** They mean to come back if provision could be made by which they could make a living. I have never seen a man go because he wanted to go, but because he was compelled to go; he had to make a living.

Senator **PLUMB.** There is no doubt about the country being good if you had the water.

Mr. **GUY.** We have a good country, and only lack water.

Senator **PLUMB.** Have you any further suggestions to make to the committee on this subject?

Mr. **GUY.** I have no suggestions further than this, that the project is too great for private enterprise, and if the Government will appropropriate as much money toward bringing those lands into cultivation as they have appropriated for reclaiming the swamp lands along the various rivers of the country, I think we can have in southwestern Kansas one of the best countries in the world.

STATEMENT OF H. K. LESTER, OF SYRACUSE.

Senator **PLUMB.** Where do you reside?

Mr. **LESTER.** At Syracuse, Hamilton County, Kans.

Senator **PLUMB.** When did you go there?

Mr. **LESTER.** In June, 1873.

Senator **PLUMB.** You are one of the original Syracuse colonists?

Mr. **LESTER.** Yes.

Senator **PLUMB.** How many are left of the original colony?

Mr. **LESTER.** Three families.

Senator **PLUMB.** Out of how many?

Mr. **LESTER.** There were originally twenty-five families.

Senator **Plumb**. When did they commence leaving?

Mr. **Lester**. It must have been in the fall of 1875 that they began to go.

Senator **Plumb**. You have had the benefit of sixteen years' residence in that country. What do you say as to the necessity of an artificial supply of water in order to make agriculture possible?

Mr. **Lester**. I am satisfied that eventually the country will be all right without irrigation, but that there is a necessity for it now.

Senator **Plumb**. What, according to your observation, will be the most natural or the main source of supply for that irrigation?

Mr. **Lester**. If it were in accordance with the existing laws of Colorado, I should say that one great source of supply would be the Arkansas River and the establishment of a system of reservoirs. During the sixteen years that I have been there I have not seen the river so low as at present, unless it was in 1883, and last year. In other years it has seemed to me there was an abundance of water in the river for all practical purposes. In regard to the formation of those reservoirs, I have on several occasions seen the river at Syracuse when over 160 acres of land would be overflowed with water to an average depth of 2 feet, from the rains that came down the creek at Syracuse. It seems to me possible that such water might be used. There might be a system of storage to hold that water. Not at that place alone; but creeks abound there; and at Highland, about 16 miles northeast of Syracuse, Mr. Hadley told me that he saw from 300 to 400 acres of water in the depression, and it looked like a lake, All the water holes are probably filled now.

Senator **Plumb**. Has there been any modification of climate since you have been in that country?

Mr. **Lester**. The most that I have remarked is the growth of vegetation over the sand hills. Those were entirely bare, or the major portion of them were, when I went there. They are now covered with vegetation. The rain-fall, I think, is also better distributed. One farmer I know raised 30 bushels of wheat to the acre a little north of Syracuse.

Senator **Plumb**. You think, then, that in the average of the years since you first went to this county there has been a better distribution of rain-fall than when you first went there?

Mr. **Lester**. I think so, and that is the trouble with rain-fall; it is not that the quantity is too great so much as that the distribution is defective.

Senator **Plumb**. Do you know what the average rain-fall is in that county?

Mr. **Lester**. I do not remember. The first ten years after I went there we never had a rain in January or February, to my knowledge, but of late years we have begun to have rains then.

STATEMENT OF E. L. HALL, OF FINNEY COUNTY.

Senator **Plumb**. Where do you reside?

Mr. **Hall**. In Finney County, about a mile and a half from here.

Senator **Plumb**. Where did you come from?

Mr. **Hall**. From Ohio and Indiana.

Senator **Plumb**. You have been engaged in farming since you have been here?

Mr. **Hall**. Yes.

Senator **Plumb**. Are you under ditch?

Mr. **Hall**. Yes.

Senator **Plumb**. Please state to the committee as briefly as you reasonably can the necessity for irrigation and your judgment as to the means of getting it.

Mr. **Hall**. In the fall of 1885 I came to this county to look up a new location. I took in several of the Western States in my examination. I entered some land in Scott County, about 35 or 40 miles north of here. It was good valley land and I thought I could make a good farm of it. I intended putting about 40 acres of it into orchards. I commenced digging a well and got moisture 3 or 4 feet down, but from that down it was as dry as dust. I made up my mind that I had made a failure. The older a tree gets the more water it requires. I abandoned that thing at once and came here on the ditch. On a ditch I can raise any kind of vegetables or grain or anything else, while away from a ditch nothing of any account can be raised. A man might possibly keep stock by the stuff he raises there, but that is all.

Senator **Plumb**. Does the moisture from the irrigation penetrate deeper than it did originally?

Mr. **Hall**. If you irrigate a piece of land one year it does not need so much moisture the next year.

Senator **Plumb**. You do not know whether the water penetrates the subsoil?

Mr. **Hall**. It will go down to the sand below.

Senator **Plumb**. How about the upland?

Mr. **Hall**. I do not think it will affect the upland.

Senator **Plumb**. Your observation is, then, that irrigation is needed here?

Mr. **Hall**. Yes.

Senator **Plumb**. What do you say as to the means of providing it?

Mr. **Hall**. It appears to me that there might be some arrangement made with the State of Colorado by the United States to store that water if the United States Government were to control it. Plenty of water comes down this Arkansas River to irrigate this whole country, and yet it goes to waste now.

Senator **Plumb**. Do you think enough went down this season?

Mr. **Hall**. This season the river has been up four or five different times, full, nearly to the bank. The ditch I have been on will irrigate perhaps 3,000 or 4,000 acres of land, and enough water goes down that river in one day to fill this ditch for a whole year, I think.

Senator **Plumb**. That is your judgment as to the source of supply of water for irrigation?

Mr. **Hall**. Yes; I think there is plenty of water that can be stored in one place or another to answer every purpose here, and make this a great country.

Senator **Plumb**. Is there anything further you wish to say on the subject?

Mr. **Hall**. I believe not.

STATEMENT OF T. J. JONES, OF GARDEN CITY.

Senator **Plumb**. Where do you reside?

Mr. **Jones**. At Garden City, Kans.

Senator **Plumb**. How long have you resided here?

Mr. **Jones**. Eleven years.

Senator **Plumb**. How long have you lived in Kansas?

Mr. **Jones**. Twenty-three years. I first came to this valley as mail-agent on the road, sixteen years ago last spring.

Senator **PLUMB**. You have lived in this country nearly ever since it was settled, I suppose?

Mr. **JONES**. Yes; I was one of the first four or five persons that came here.

Senator **PLUMB**. Please state to the committee, in your own way, the necessity of irrigation, and your view as to the method by which that object can be obtained?

Mr. **JONES**. I soon found out that we could not raise crops here successfully and rely upon having them every year, without some artificial supply of water. Some years we could get good crops of one kind by planting early. We might get early corn, for instance, by planting early, but we could not depend on it. I made up my mind that we could save some of the water. I have built over 500 miles of ditches in this and adjacent counties already. That is, I projected them and helped to build them. We have not water enough now to warrant our building any more or even keeping up the repairs on those we have.

Senator **PLUMB**. The Arkansas River is the source of supply?

Mr. **JONES**. Yes; when it does supply.

Senator **PLUMB**. What is the occasion of the lack of supply from the Arkansas this year?

Mr. **JONES**. The defective supply of snow on the mountains and very light rains. When we have a big rain above it comes down in immense quantities and passes away. If it came steadily we have an abundance of water to irrigate the whole country here.

Senator **PLUMB**. If the waste-water were saved would it supply the ditches?

Mr. **JONES**. I believe it would supply all the ditches and all the land adjacent for 100 miles each side of the one-hundredth meridian. Then I think that much of it goes to waste by seepage through the country. it is about fifty miles wide, probably.

Senator **PLUMB**. Is that the uniform width?

Mr. **JONES**. No; but an average width. It runs from 70 to 30 miles, as nearly as we can tell.

Senator **PLUMB**. That would require, of course, many more ditches than there now are?

Mr. **JONES**. Yes.

Senator **PLUMB**. What amount of land could be irrigated by the existing ditches if the water were abundant?

Mr. **JONES**. I can not say as to the number of acres, but I should think about twenty or twenty-four townships could be watered by extending the laterals from the present ditches.

Senator **PLUMB**. By the present water supply?

Mr. **JONES**. By the present water capacity of the ditches—not by the supply.

Senator **PLUMB**. Do you mean Government townships, or municipal townships?

Mr. **JONES**. Government townships.

Senator **PLUMB**. What proportion of a county?

Mr. **JONES**. One-half of a good-sized county?

Senator **PLUMB**. Are any of the ditches now in existence giving a full supply of water?

Mr. **JONES**. None; not all the season. If we had some way to bring water across the line from Colorado—if our Colorado neighbors would divide with us—I think we could have a good deal more. Somebody has said that it was unlawful, according to the law of Colorado, to bring water across the line. I do not think that is so. If the Colorado ditches had given us a prior right we would have had abundance. The Colorado ditches that have been lately built have been taking the supply of water. I have been up and down a good deal, and have been making close observation of that fact.

Senator PLUMB. Then your suggestion of the plan to meet this difficulty is the storing of the water at the time that it flows down, unused?

Mr. JONES. Yes.

Senator PLUMB. State how you would get reservoirs.

Mr. JONES. There are several ways of getting water: one by taking it from beneath the surface, another by rain-fall as it reaches the ground, and the other by getting it from the river. As to taking out the water from the river, I believe that can be done, but many people do not understand how much water is needed to irrigate land. The land here is sandy, and it would take a good deal of water to supply it. Another great objection to building a canal, or something to get the water out with, is that the quicksand makes it very difficult to keep it. It would have to be walled with a still wall.

Senator PLUMB. That only relates to the expense and time of getting it.

Mr. JONES. Yes. That is hardly the proper way to get the water, I think. The other way I mentioned is by building dams across the ravines, etc. The first year or two the seepage is very great, but after a few years of holding the water the evaporation will soon become slight. I think the farmers would in that way save themselves a great deal of hardship.

Senator PLUMB. Is the configuration of the country such as that on the upper level there would be facilities for natural storage?

Mr. JONES. Yes; the table land comes up to a point. The highest point in it is a backbone that averages from 1 mile to 5 miles wide. If water could be stored or gathered from there in these little ravines that come down, a great deal of irrigation could be had from below. You would get sufficient water for the pipe, but not sufficient to water the country.

Senator PLUMB. Many incidental advantages would grow out of that; for example, the facility it would offer for the planting and growth of trees.

Mr. JONES. Yes; and the precipitation would be so great that we would have more rains.

Senator PLUMB. What do you think of having reservoirs to catch the surplus waters of the Arkansas River?

Mr. JONES. Every man in this country will acknowledge that the rains do not penetrate down to this sheet-water. It only wets down from 3 to 6 feet. All must concede then that the water comes from the mountains. Instead of trenching and getting it out of the bowels of the earth, you must gather it where it is kept, and take it out on the highest lands and distribute in that way. In that way we all can have water and abundance of it.

Senator PLUMB. These reservoirs, in order to answer the purposes of distribution, would be mainly on the highlands?

Mr. JONES. Yes.

Senator PLUMB. Would you carry the waters up on the ridges and distribute them from there to the valleys?

Mr. JONES. Yes. If you have a bird in the hand it is better to hold on to him than to let him go with the expectation that he can be caught again. If you get the sediment settled the seepage after a year or two will be very slight. We have to wait until we get an overflow of the river in order to get the ditches filled.

Senator PLUMB. Is that sediment also carried onto the soil?

Mr. JONES. Yes; it is very fertile and distributes itself very nicely. It is equal to a coating of manure.

Senator PLUMB. Is there anything else you would like to say on this subject.

Mr. JONES. It appears to me that there is only one practical way for the Government to do in getting irrigation for this country; that is, to build a large canal on each side, taking it from the base of the mountains, and taking all the water of the Arkansas River and saving it in these reservoirs. The Government would have to charge a price for it—say so much a foot—in order to protect those who have already put the ditches in.

Senator PLUMB. You mean that the Government should make the main ditches and let private individuals take out the laterals?

Mr. JONES. Yes. It would be foolish for the Government to expect to fill irrigating ditches and expect to keep them up. Let these main ditches be on the divides and let them save all the water of the Arkansas River. It has been suggested to me that the seepage would be less on them than on the bottoms.

Senator PLUMB. Would the ditches on the uplands have a steeper grade than those on the bottom lands?

Mr. JONES. No; the level of the country is generally the same.

Senator PLUMB. Would not the water scour and cut away the land?

Mr. JONES. The land is very solid and it takes an immense current to cut the banks. I have seen places where the fall is at the rate of 10 or 15 feet and yet the soil is so compact that we can not get too much fall.

Senator PLUMB. Does the porcelain lining to the ditch wash?

Mr. JONES. That does not wash. It stays in. By constructing a canal as wide as the Arkansas River you only need to have it 5 feet deep.

Senator PLUMB. Would not the evaporation be greater?

Mr. JONES. If you want to get less evaporation or seepage you will make your canal narrower; but at an expense, I would say, of $2,000 a mile, you can save every drop of water after you get it up. There would be more expense on the heavy places.

Senator PLUMB. You would be obliged to have reservoirs made at convenient points?

Mr. JONES. Yes. I can get the capital needed to develop all these ditches if we are sure of water. There is no question about that.

Senator JONES. Are you still owner of a number of those ditches?

Mr. JONES. I have some interest in them; very little.

Senator JONES. Do you sell the water-right annually or altogether?

Mr. JONES. Year by year.

Senator JONES. Have you any objection to stating the average cost per acre, to the land under the ditch, for the construction of the ditch? When you lay out a ditch do you expect to irrigate a certain amount of land? What would be the total cost of the ditch, if distributed evenly, to be paid for by the land-owners?

Mr. JONES. That would be very difficult for me to say, for I never kept any account of it in that way.

Senator JONES. Can you approximate it?

Mr. JONES. It depends on how you are fixed about machinery and everything of that sort. With the modern way of getting out water, if the lay of the country is good, and if it could be taken out without bad cuts and fills, it might be taken out at a cost of 50 cents an acre, provided you had enough of it. It depends on the amount you get. But as to the cost of taking it out the way we have had to take it out and the amount of water that the ditches will give for irrigation, we have been letting it at $1 an acre on an average.

Senator **JONES.** That is $1 an acre each year?

Mr. **JONES.** Yes; but we have not had enough to make a dividend on that, because we have taken it out, as I say, under disadvantages and have had some experience about it.

Senator **JONES.** Have you any objection to stating the cost of your ditches?

Mr. **JONES.** I did not keep an accurate account, but I can give you the cost of a ditch 102 miles long. I have 137 miles of laterals completed with flumes and everything connected with it. It has cost me about $50,000.

Senator **JONES.** It is 100 miles long and cost $50,000.

Mr. **JONES.** Yes.

Senator **JONES.** What is the size of the ditch?

Senator **JONES.** At the head it would average about 30 feet at the bottom and about 40 feet at the top; it is 4½ feet deep.

Senator **JONES.** How much land could be irrigated by that ditch?

Mr. **JONES.** If we had water to keep it going all the time, and if people would use it judiciously and would know how to use it, I believe it would irrigate 300,000 or 400,000 acres of land. We can generally get along by one good flooding of water. That is, we can raise almost any kind of crops by having the water just at the right time. One flooding will give a man almost certainly a good crop. Some crops want more, perhaps, but two floodings, with the amount of rain-fall that we have, gives a certainty.

Senator **PLUMB.** Is it not usually calculated in this western country that the amount of water necessary to supply an acre of land is about a miner's inch?

Mr. **JONES.** The way they use water here that quantity will not do it. It will take about 1½ inches for the first year and after the first year it will take about 1¼ inches. Perhaps after using it for several years a miner's inch might do, by judicious use of the water; but our land is such that we have to flood it all over. We can not perforate or let it go by seepage through the ground, and it is better to let a big supply of water go all over. We are learning a good deal by experience here in regard to the use of water.

STATEMENT OF A. B. COCHRANE, OF SCOTT COUNTY.

Senator **PLUMB.** Where do you reside?

Mr. **COCHRANE.** In the south part of Scott County, although I have lived in the northern part.

Senator **PLUMB.** About how far north?

Mr. **COCHRANE.** About 20 miles north.

Senator **PLUMB.** How long have you lived where you are now?

Mr. **COCHRANE.** About six months.

Senator **PLUMB.** How long have you lived in this section of the State?

Mr. **COCHRANE.** This is my sixth year.

Senator **PLUMB.** State your idea as to the necessity for an artificial supply of water and the source from which it can come.

Mr. **COCHRANE.** The necessity is illustrated by this fact, nearly every section in Scott County is good tillable land, and nearly every section has had three settlers on it in turn. Take Lake Township, for example, it will not cast 40 votes at the next election. Valley Township is the same way. Other townships are in the same fix. The people expected to make homes there and have tried, but they were obliged to go away.

We have had rain every week from the time the snow began to go away until the 1st of July, then it stopped. It has been so every season since I have been here. If the forepart of the season was good the last part was a failure. I am acquainted in the eastern, southern, and northern portions of the county, and I know there is no corn to speak of except a very few fields in the eastern or central portion of the county. In the south there is quite a wide strip where the stalks do not stand more than 3 feet high this season. Oats have done a little better than formerly.

Senator **PLUMB**. How is it about wheat?

Mr. **COCHRANE**. Where wheat has been cultivated properly it has done somewhat better. I have heard of some 17 bushels to the acre, but that is the exception. Generally it is from 7 to 12 where they have harvested and thrashed.

Senator **PLUMB**. How is the artificial supply of water to be got, in your judgment?

Mr. **COCHRANE**. I should think the water needs to come from the mountains. In the northern part of Scott County the wells are usually 100 feet deep. A large portion run from 125 to 150. In the southern portion they are from 30 to 50 feet generally, so that it would seem that either artesian water will have to be secured or it will have to come from the mountains. The land lies in good shape to carry water. There are little ridges from 10 to 20 or 30 feet above the general level. The surveys show that the water will follow those.

Senator **PLUMB**. Is the topography of the country such that the water can be stored?

Mr. **COCHRANE**. Some could be gathered in that way and brought to the lowest lands, but the general level could not be reached, I think, by water gathered off the highest ground. There are a good many farms that could be supplied perhaps by water gathered off other lands near by. But the land generally is so level that it would be difficult to reach the greater part of it. The land is pretty nearly all mortgaged. The people have been compelled to mortgage it in order to get something to live upon. If they could get water those that have gone would come back again.

Senator **JONES**. When did those people go there who live there now?

Mr. **COCHRANE**. Some of them went three or four years ago.

Senator **JONES**. Had there been a settlement there prior to that time?

Mr. **COCHRANE**. There had been a little trial about Scott Centre, as it was called. A few settlers had tried it there in 1879, I believe, but gave it up.

Senator **JONES**. That was the first settlement, was it?

Mr. **COCHRANE**. Yes, except ranching along the creeks and the prairies. They did not make any effort to do any farming.

STATEMENT OF FRED. BROWN, OF GRANT COUNTY.

Senator **Plumb**. Where do you reside?

Mr. **Brown**. In Grant County.

Senator **Plumb**. How long have you resided here?

Mr. **Brown**. About four years.

Senator **Plumb**. Will you state to the committee your views regarding the necessity of an artificial water supply and the means of getting it in your locality.

Mr. **Brown**. Most of our settlers came into Grant County about four years ago. They were an industrious class of people, men of indomitable pluck and determined to make a home there. Last year we had an almost total failure of crops. This year they will not cast over 200 votes in the county. Our population is reduced from 4,000 to 1,500, and we feel that something must be done. We are satisfied that we can not stay there very long unless something is done. We have deluded ourselves with the hope that turning up the soil and exposure to the sun, deep plowing, etc., would bring an abundance of moisture, but we have ingloriously failed in all that. This year is the hardest year we have had. Other years we have had enough feed for our stock. This year we will not have half enough to feed them. Everything is burnt up on the stalk. The corn is burnt up without any ear having got started, all because of the lack of moisture when we want it. Everything is very uncertain in the way of crops there and most of our people have gone.

As the gentleman who preceded me has told you, the land is mostly mortgaged, but the people will undoubtedly come back if they see they have any show. I am satisfied that Mr. Jones's idea is a good one, to bring the water from the mountains and store it in reservoirs. The utmost economy should be practiced with the water supply we have. There is enough water running down the Arkansas to irrigate 100 miles on each side, and we can not afford to waste one drop of it. In Grant County we have what seems to be a natural basin for water where Bear Creek enters the sand hills. It would be almost a natural reservoir for all our county. Bear River is a flowing stream in Colorado and the water disappears when it comes into Kansas.

Senator **Plumb**. Is there anything further you wish to say?

Mr. **Brown**. I might say that in the last three months there have not been more than two or three days at a time when the prairies of our county have not been burning.

Senator **Plumb**. To what depth do you go for water on your place?

Mr. **Brown**. From 40 to 200 feet. There is a sunk well at the edge of the sand hills where this basin enters. It is a cavity of about 150 feet across the top. From the top of the sand down to the water would be perhaps about 30 or 40 feet. There is a vast basin of water there of unknown depth. That is supposed to be the subterranean passage of Bear Creek. It goes along through the sand hills and there are a couple of lakes over there that are supposed to be a part of that connection.

STATEMENT OF D. J. BELL, OF FINNEY COUNTY.

Senator **Plumb**. Where do you reside?

Mr. **Bell**. In Finney County, 5½ miles north of this city.

Senator **Plumb**. How long have you resided here?

Mr. **Bell**. Six years next spring.

Senator **Plumb**. Please state in your own way what is your view with reference to the artificial supply of water and how it is to be obtained?

Mr. **BELL**. I have no great knowledge of irrigation; only what little I have seen since I came here. Where we can irrigate we can raise as much of everything as we want. Where we can not irrigate, everything is a failure.

Senator **PLUMB**. Are you under a ditch now?

Mr. **BELL**. Yes; there are 30 acres that I can not irrigate because I have not fixed the ditch. I have about 50 acres in which the crops are exceedingly fine.

Senator **PLUMB**. Is it your conclusion from experience, then, that irrigation is necessary?

Mr. **BELL**. Yes. Men can not live here without it, unless they are stock raisers. There are a few ranchmen scattered about the country.

Senator **PLUMB**. What in your judgment is to be the source of supply for this water?

Mr. **BELL**. My opinion is that the only source of supply is the Arkansas River, and in order to make a constant supply there would have to be reservoirs. Without them we can not get along very well. None of us get the amount of crops, even at the best, that we ought to get. We will have water plentiful one week, and none the next week. Some times we will be a month without water.

Senator **PLUMB**. How many times do you need to irrigate during the growing season?

Mr. **BELL**. My crop has been principally alfalfa since I have been here. I would like to cut that every thirty days, water it once and then cut it, water it immediately after cutting and in thirty days it would be ready to cut again.

Senator **PLUMB**. How much water do you contract for, or how much do you expect to get according to your contracts with the ditch, per acre?

Mr. **BELL**. I find that for alfalfa it is best to put in a box that carries 80 inches of water. I contracted for 40 inches, and the contract was that I should get water half the time in that box. If I could have got water half the time it would have given me an abundance, more than I needed. I think a square inch, constantly running, will more than supply all the necessities for an acre of ground. A cubic inch, perhaps, you might call it—I mean a stream measuring 1 inch up and 1 inch across.

Senator **PLUMB**. Have you anything further to suggest?

Mr. **BELL**. Nothing further.

STATEMENT OF W. H. FRENCH, OF KINSLEY.

Senator **PLUMB**. Where do you reside?

Mr. **FRENCH**. In Kinsley, Edwards County, this State.

Senator **PLUMB**. How far is that east of here?

Mr. **FRENCH**. Eighty-five miles.

Senator **PLUMB**. How long have you resided there?

Mr. **FRENCH**. Five years.

Senator **PLUMB**. State the condition of things in your county with reference to the necessity for an artificial water supply, the efforts made to get it, and the source from which in your judgment that supply will have to come.

Mr. **FRENCH**. There is a portion of the county to which irrigation would be very beneficial. There is another portion of the county that requires none, and can not be irrigated. There is a range of sand hills that follows the curve of the Arkansas River and goes through Edwards

County. On the southeast of these sand hills there is a valley of sandy land in which they raise crops every year and only occasionally fail to make the crop. This year corn will average from 30 to 45 bushels an acre in that valley; wheat 35 bushels an acre. On the north side of the river the case is entirely different. It is rolling upland, similar to the country here. From Garfield station (a station about 14 miles east of Kinsley) westward the crops are a failure. There is a canal that has been built from Ingalls east of here, that runs along the course of the river and ends near Kinsley or Oberly.

Senator PLUMB. Is that the Soulé ditch?

Mr. FRENCH. Yes. Last year they had a little water, and those who had land right by the ditch raised very good crops—some very good corn and large cabbages. There was a piece of land there that furnished 75 bushels to the acre. For some reason that land did not furnish anything this year. The water this year has been entirely insufficient. People have concluded that without irrigation they can not do anything, but there is no manner of doubt that if they had an abundance of water they could raise enormous crops.

Senator PLUMB. In what way could the water be supplied to that locality?

Mr. FRENCH. If the ditch had been sufficient in the first place, they would have had more water than they did have, but the trouble seems to be that the water is insufficient in the river. It is taken out of the river up in Colorado, and it never reaches down there. They are building another ditch. There is an underground flow near Dodge, and that is supposed to be enough. I do not think, however, that they will get enough water. If the water that gathers in the mountains, and in the different draws or cañons throughout this country, could be saved by means of reservoirs, there is water enough passing through the country to irrigate the country. An immense amount of water passes off by means of freshets. I have had some experience on the Pacific coast. They have there an abundance of water, somewhere in the neighborhood, for irrigation. In this country it is altogether different. We have very few sources of water.

When water is first put on the land it takes a good deal of it to go around. In the course of a few years the ground fills up, and, after that, the water goes back to the river again. In Colorado I understand that when they undertook at first to irrigate the ground it took a good deal of water, but that afterwards it did not take so much. I hardly think, however, that that will work on so extensive a scale as they think.

There are a number of draws all over this country where basins could be made at slight expense. The water might be saved and conveyed from a main ditch and other ditches. That is one thing that could be done at moderate expense. The expedient of damming up the cañons in the mountains could be resorted to. There is a large reservoir in the cañon of the Wasatch Mountains that furnishes the water for Salt Lake city. That plan might be resorted to, and reservoirs formed that would save the overflow and get an abundance of water. It looks to me as though that were the only source of supply for this country. Unless some system of irrigation is devised for the extreme western half of this State, farming, as carried on in the eastern part of the State, will not work, although it is a good stock country. They can raise some good crops here with water, and it seems to me that the people of this country should adapt themselves to the condition of the country, and raise the crops that the climate and soil are adapted to.

The people in our part would object to any system of irrigation that would take the water out of the country. The system of underground irrigation, if it could be accomplished, would take the water up in this part of the country. The whole county would then be dried up. It seems to me that that would be very injurious to the lower portion of the valley. I do not think, either, that it would furnish a sufficient amount of water to accomplish the object. The best plan, I think, is to store the water that comes here in the times of floods and freshets. That would probably involve the expenditure of millions of dollars, and could then be done only by the Government. If private citizens could be induced to invest money in such a scheme it would be different, but it is too large at the start for private capital to come in.

STATEMENT OF STEPHEN ROOF OF FINNEY COUNTY.

Senator PLUMB. Where do you reside?

Mr. ROOF. Twenty-five miles south of here.

Senator PLUMB. State what you may deem of interest regarding the inquiry before the committe.

Mr. ROOF. With regard to the ditch company at Ingalls, near Spearville, this is the second year of its operation. They have had trouble with their dam. This summer they had a cut-off, relieving the ditch to save the dam in case of a freshet.

With regard to irrigating this country, if the sub-water is taken out to any great extent and distributed all over the country it will be but a short time before it will get back into the soil. There is no fear of our drying up the soil by taking water from 6 or 8 or 10 feet beyond the bottom of the Arkansas River. The level of the river as far as we go, shows sand out on the plains. The depth of our wells is very close to the level of the Arkansas River so that we have here a reservoir of from 200 to 400 miles wide.

Senator PLUMB. You think, then, that if there had not been a misfortune to the mouth of that canal you would have water.

Mr. ROOF. Yes.

Senator PLUMB. Where is the new ditch that Mr. Soulé is proposing to dig?

Mr. ROOF. Is starts out east of Dodge.

Senator PLUMB. On the north side of the river?

Mr. ROOF. Yes; I think so, but I am not certain about that.

Mr. FRENCH. They are building a ditch on the south side of Dodge to run back into Dodge again. If they make a success of that, they will build another ditch below Dodge, running along the bank of the river.

Mr. ROOF. The great trouble here is from the last of June into July.

Senator PLUMB. What is the annual precipitation about Dodge?

Mr. ROOF. It is 20.77 inches; that is the average for thirteen years.

Senator PLUMB. What is the maximum?

Mr. ROOF. We have had as high as 33 inches and as low as 10 inches. If we could get the water distributed through the latter part of June and July we could complete any crop. We have completed wheat on about 6 inches of rain after the 1st of April until the cutting.

Senator PLUMB. How much did it yield?

Mr. ROOF. Five acres yielded 46 bushels; 10 acres, badly hurt by the frost, was considered a total loss, but yielded 56 bushels; 2½ miles north and west there were 18 acres that yielded 20 bushels of No. 2

wheat, prime. We have but very few general rains throughout this country. After four years' residence here I expect heavy rains, probably 3 to 4 inches at a rain, from the 1st to 10th of May. This year we did not get them in my section. We need but little help here. If by storing we could save water in the spring, and the freshets did not come down to disturb things, we would be all right. Colorado can not continue to hold this water more than a little while.

STATEMENT OF J. C. FUGATE, OF GARDEN CITY.

Senator **PLUMB.** You may state anything that you think will be of interest to the committee in regard to irrigation.

Mr. **FUGATE.** I simply desire to say a word in regard to this underground flow. We came here four years ago. I took a Burt wheel 1 foot in diameter. We got down to sand, but could not reach water until we drove through the sand. We drove through it and tubed about 1¼ inches. We watered three thousand sheep and two thousand five hundred head of cattle, beside our horses, from that well without any perceptible lowering of the water. That was out here 5 miles from the river, where we went 43 feet for water.

I also want to say one word about the water from below; there is surely a supply of it there that is inexhaustible.

STATEMENT OF W. R. GRACE, OF GARDEN CITY.

Senator **PLUMB.** Please give the committee any information you may have, and your views regarding the subject of their inquiry.

Mr. **GRACE.** It has always seemed to me that we could get water from the river here by a system of reservoirs, say a reservoir for each ditch. If you will go up on the bottom and sink a reservoir 35 to 40 feet and tap that you will find it very serviceable. I speak of water from a single ditch. From this well here at the water-works they had four pumps, but they had to quit because they could not get the water out.

There is a ditch across the railroad at this place, and they could run that full without exhausting the water. If it were so that we could get a well down and make it 100 feet square there is enough water to keep it full all the time, and there is plenty of land to be watered. If you once get the flow started it will run. By doing that we could have an abundance of water, and that, I think, would be more practical than by going across to Colorado.

STATEMENT OF ROBERT HAY, OF JUNCTION CITY.

Senator **PLUMB.** What is your name, occupation, and residence?

Mr. **HAY.** I am geologist to the Board of Agriculture for the State of Kansas, also a fellow of the American Geological Society. I reside at Junction City, Kans. For several years past I have given attention to the water-bearing strata of western Kansas and neighboring parts of Nebraska and Colorado, and have also studied the evidence of rain-fall.

Senator **PLUMB.** Pray tell the committee in your own way the results of your studies and observations.

Mr. **HAY**. There is no reliable evidence as to the rain-fall of most of this region. Seven years' observations at Fort Wallace gave an average of 19 inches per annum; this before any settlement of the country. Fourteen years' observations by the signal service at Dodge City, ending with 1887, gave an annual mean of 21 inches. Wallace is just east of the one hundred and second meridian; Dodge just west of the one hundredth meridian. Other rain-fall records are only for a single year or at most two.

In eastern Kansas rain-fall averages from 30 to 40 inches per annum. It is generally believed this rain-fall has since settlement been modified—not increased—in its distribution. There are now fewer heavy storms and a greater number of rainy days. This is attributed to the cultivation of the soil and planting of trees, which retain the moisture to be given off by the slow process of evaporation rather than by flooding the stream beds and valleys.

The active settlement of Kansas west of the one-hundredth meridian only dates from 1883; a few counties were organized as far back as 1871 and 1872. The rain records at Dodge City show great fluctuations, the smallest amount of precipitation in one year being under 11 inches. Settlers in the West already believe that the breaking of the sod has produced modification of distribution, as in the eastern part of the State, and the water is retained for a longer time in the soil. It is certain that dew falls much oftener than in the beginning of settlement. In years of the average rain-fall cereal crops—wheat, oats, maize—can be grown if the precipitation is at the right time. In eastern Kansas half the annual rain-fall comes in the four months of April, May, June, and July. Crops fail mostly by irregular—not necessarily deficient—rain-fall in June and July, and sometimes in May. If there is a week or more without rain in July the maize is in danger. Similar privation in June will damage the small grain. In western Kansas the dry time in July sometimes extends from ten to thirty days. It is in these times that the hot winds blow, and then the damage is irreparable. In reference to the growing of crops, these periods in June and July may be called the critical time. Irrigation that would water the land every five days would save them.

Senator **PLUMB**. From whence would you derive the supply for such irrigation?

Mr. **HAY**. The Arkansas River supplies abundance of water at this time. Other witnesses will testify as to the extent to which this river is available. The Cimarron can also be used.

The Smoky Hill River, the Republican, and, to a less extent, the Saline and the Solomon, though not mountain streams, may probably be used. There is, moreover, a certain formation that absorbs the rain-fall of the plains and yields it again in wells all over the high-prairie region at depths of from 40 to 200 feet. The rivers last mentioned are rivers of the plains. They do not come from the mountains, but they have permanent water below where their channels have cut through the formation mentioned. This bed is of Tertiary age; by that I mean the last of the three great periods into which geologists divide the process of world-making. These formations are probably Miocene, or the latter part of the Tertiary period. It is in places known from its appearance as the Mortar-beds; other parts are gravelly conglomerate. I have called this formation the Tertiary grit. It yields water to numerous copious perennial springs. From such springs Spring Creek, in Meade County, is kept a running stream, and about a third of its water is being now utilized to irrigate 400 acres of land. Preparations are being made to utilize nearly the whole of this stream. Similar use may be made of the waters of the rivers above mentioned. The precise areas where such use can be made will have to be determined by surveys in three States—Kansas, Colorado, and Nebraska.

In Meade County, in the valley of Crooked Creek, north by east from the county-seat, the Tertiary grit, apparently broken up somewhat by erosive influences, has been covered up over an area of several thousand acres by an impervious, soft, bluish clay. This clay having been pierced by drills has given numerous artesian flows of excellent water, serviceable for domestic purposes, and abundant for local irrigation. One farm has three wells which yield an aggregate of 98 gallons per minute. On another farm is the largest well; it yields 66 gallons per minute. There are upwards of eighty wells ranging from the above down to 25, 10, 6, and 2 gallons per minute. Some are being used for irrigation, but none to their full capacity. Two on the farm of B. F. Cox (who was the first to obtain the artesian water), yielding together nearly 20 gallons per minute, are used to irrigate 4 acres and to supply a large carp pond. Mr. Cox considers he could successfully irrigate 10 acres if he used the water to the best advantage.

The conditions on which the artesian flow depends in this region are simple. The water-bearing stratum (Tertiary grit) has an outcrop on the edge of the high prairie where it absorbs the rain-fall. On the side of the valley slope it is covered with the impervious clay, and the wells afford it outlet at levels below the outcrop. Below the lowest wells there is a break in the covering of clay and water escapes in springs.

As the Tertiary grit is found all over the plains region, at least from the Arkansas to the Niobrara, it is probable that a repetition of these conditions might be found and other artesian flows be made available for irrigation.

At Coolidge, and near that town, both in Colorado and Kansas, there is another group of artesian wells. They are all nearly 300 feet deep. They obtain their water from a bed much older than that supplying the wells of Meade county. The formation is a sandstone of the cretatious period, known as the Dacota. To the east, this does not out-crop nearer than to the north of Dodge City. To the south it outcrops within 20 or 25 miles, but the general dip of other strata suggests that the outcrop that would take in the water yielded to the Coolidge wells should be to the northwest. This outcrop has not yet been found. It is not unlikely that other parts of the region may have artesian flows supplied by the Dacota sandstones, but the fact that the same sandstones have been pierced at Syracuse, 16 miles east of Coolidge, without such flow, shows that there is a breach in the continuity of the subteranean conditions, which indicates that the phenomena are local. It is not improbable that the local conditions may be repeated elsewhere, and areas of such repetition may possibly be found by geological examination. The largest well at Coolidge gives 100 gallons per minute, and is used for the fire-service of the city. Other wells yield 50 gallons and less, and are well situated for irrigation.

Fifty miles to the south, at Richfield, in Morton County, is another artesian well. The water comes from a depth of 600 feet, and is taken from beds of Triassic age, which are older than the Dacota strata yielding the water at Coolidge. The flow at Richfield is small, only about 6 gallons per minute, and the water is considerably mineralized, so much so as to have medicinal qualities, not enough to hinder its use for irrigation. Another well is being drilled to find, if possible, a larger flow. The depth to the water, and perhaps the small flow, indicate a distant outcrop of the strata. This outcrop has not been found. It is presumably to the northwest or west in Colorado. It could be found by a careful geological examination, and probable estimates formed as to the location of other wells. In the known outcrop of Triassic or new sandstone beds to the east (over 100 miles) they do not show themselves as good water-bearing strata; but in their development at Great Bend, as shown in a deep boring there, there is one stratum that should carry water well. It does not yield water there. It might elsewhere under other conditions. The well at Great Bend gives an artesian flow of salt water from strata of Dacota age. The flow is only 6¾ gallons per minute.

At Larned is the largest artesian flow in Kansas. Besides some waste, 250 gallons per minute were measured. It is, however, highly mineralized, being a strong brine. It comes from a depth of over 400 feet, and seems to be from the top of the Triassic strata. The Larned well is so situated that it would be suitable for experimental decision of the question as to how far saline waters could be used with advantage in irrigation. Its proximity to the Arkansas River would allow of dilution of the brine to any required extent. The source of the salt is an interesting problem. If it is the salt beds below, then the water comes from a greater depth actually than is indicated by depth of the well. The wells at Great Bend and Larned are both east of the ninety-ninth meridian.

Senator **PLUMB**. What, in your opinion, is the value of artesian water for irrigation?

Mr. **HAY**. In estimating the value, due notice must be taken of their mineral properties. Usually, the mineralization increases with depth. Excluding the salt wells, this is well illustrated by the three groups of artesian wells previously noted. The Meade County wells have the purest water; those of Coolidge are next, and Richfield comes third. This is in the order of their depths. With regard to the quantity necessary for irrigation in the region between the hundredth and the hundred and third meridians, the rain-fall must be taken into account, and also the evaporation. There are at present no data for estimating evaporation. During the hot winds it must be excessive, but they last for only brief periods. It may be assumed that the annual evaporation is less than the rainfall, because the rivers of the plains do carry away some water.

Instead of using the second-foot or acre-foot, which is the unit of quantity for measuring streams used by Mr. Gilbert and others in Utah and elsewhere, I have assumed a flow of 100 gallons per minute as the basis of calculation. This is about two-ninths of the second-foot.

Our Kansas unit of 100 gallons per minute, then, would flood 5¼ acres to the depth of 1 inch in one day. Neglecting the fraction, this would allow 50 acres to be covered with water 1 inch deep every ten days. This is equivalent to a rain-fall of 36½ inches per annum. This is amply sufficient for any crops raised in this region. The rain-fall of the district may be counted on to more than supply the loss by wastage from canals. Thus, an artesian well, yielding 100 gallons per minute, may be relied on, therefore, to thoroughly irrigate 50 acres of land in the region indicated. A well of 10 gallons would suffice for 5 acres. It would be necessary in the critical period, June and July, to irrigate oftener than once in ten days. Half an inch every five days instead of 1 inch in ten days, would suffice to continue plant growth without injury, and this could easily be done. In some cases a storage reservoir might save the water of December for use in July.

Though I have shown that the flow of the artesian wells above described depends on local conditions, yet it is also true that repetition of these conditions in parts of the wide area I referred to, may be expected, and that at comparatively small cost thousands of acres may be irrigated by means of artesian wells.

Senator PLUMB. In what way can the General Government by legislation or otherwise help on this work?

Mr. HAY. It would seem reasonable that the Government should cause such geological survey to be made as would determine the areas where artesian water may be probably obtained, and, in some cases, decide it by boring. The investigations made with respect to the artesian wells previously described do not warrant the belief that the water bearing strata obtain their supply from the Rocky Mountains. The inquiry of the committee must be of great service in arousing public and legislative attention, and the irrigation survey in progress should be rapidly continued. The information it will give our people will invite capital, of course, and greatly stimulate the farmers to co-operation.

The following papers were received and ordered filed with the Kansas testimony. The committee then adjourned.

FURTHER STATEMENT OF J. W. GREGORY, OF GARDEN CITY, IN RELATION TO THE ARKANSAS RIVER UNDERFLOW.

While a certain degree of success in farming has been found possible west of the one hundredth meridian in the southwest, still we take it for granted that all will concede the proposition that irrigation has proven a necessity—an absolute necessity—to general success.

We can not afford to spend the best years of our lives attempting to open this region to agriculture, without the assistance of a certain water supply. If such a system can be secured, we wish it at once. To the pioneers who have borne the hot wind and the blizzard, driven out the buffalo, the wild horse, and the coyote, taken the risks and conquered the wilds, belong of right the fruits of their labors. If they are to enjoy the benefits of the development of this region, it must be accomplished without delay. Every resident of southwest Kansas and southeastern Colorado knows this.

Now can any practical system of irrigation be speedily secured?

In the solution of such a question as this the first thing and the matter of greatest difficulty is to get rid of the impracticable plans which inevitably will be advanced.

Drawing upon the head waters of the Missouri and the Yellowstone by an immense canal which shall skirt the mountains, crossing streams and ravines in its course, has been suggested. While this might be done at some future time, the immensity of such a work and the time and incalculable expense necessary render it impossible within a period which would make it worth while for us to think about it as a practical solution of our present and pressing difficulties.

Artesian wells have been found in parts of this region. Do they furnish the solution to the problem? Let us test the matter as far as we can. It is better to lean upon no staff at all than upon a broken one, because leaning upon a broken stick insures a fall. It is better that we should give up the battle at once and seek new fields of labor than that we should spend our time and strength upon that which will yield us in the end only disappointment and defeat.

Henry Stewart, civil and mining engineer, the pioneer writer upon the subject of irrigation, says this of artesian wells:

"The idea that artesian wells may be made a source of supply for completely irrigating large tracts of land, if ever held by any over-sanguine persons, must be abandoned. For partial irrigation they may be made available, but the quantity of water needed for the irrigation of a few acres of land only, in localities where there is no summer rain-fall, as upon our western plains, is far beyond the capacity of any artesian well to supply, unless it be one of extraordinary volume.

"It is very important that the quantity of water needed for irrigation should be accurately estimated. A mistake in an estimate may lead to the construction of inadequate works and the useless expenditure of much money. Estimates generally err upon the side of insufficiency rather than otherwise, and much error has been spread abroad by persons and journals having considerable influence. * * *

"An artesian well 6 inches in diameter would give a stream of 28 square inches, and would deliver 32 quarts per second, if the flow were at the rate of 4 miles an hour. Such a well would furnish an inch of water per day for 28 acres, or an inch a week for 196 acres, which would be a very insufficient quantity to irrigate dry, open soils in places where the climate is arid. The cost of such a well would be at least $5,000 to $10,000, or more than the value of the land when irrigated."

These statements, coming from a recognized authority upon irrigation, are corroborated by our experience. Consider what the successful wells in southwest Kansas have cost, figure out what they will irrigate—even at the most liberal estimate—and it will be seen that they will probably cost far more than the land they will irrigate is worth; because, further, in considering the development of the country by such means, the uncertainty of striking water must be taken into consideration. At Garden City, at Syracuse, at Santa Fé, at Springfield, and other places are expensive "dry holes." These things will, of necessity, be taken into consideration by capitalists—must be considered by any one, when figuring upon the chances of irrigating from artesian wells. Beside, the multiplication of such wells in close proximity soon causes all to cease to be flowing wells and become only pumping wells. This is proven at Denver and elsewhere.

Let it not be supposed that we would oppose the sinking of all possible artesian wells. We all must rejoice at every such development. Each such thing helps at least a little; but southwest Kansas contains about 9,250,000 acres of land, nearly all of which is cultivable; and as not less than 30,000 artesian wells would be needed to irrigate the whole, even if the system were successful, costing in the neighborhood of three hundred millions, it is evident that, for any system that shall be of general benefit, we must look further while being glad to have the help of all such wells as may be had.

"Storage reservoirs" in the mountains and the conservation of "storm waters" have been greatly urged of late as the means of providing the necessary water supply. That storage reservoirs for the conservation of the mountain waters will be worth all they can reasonably cost to those regions near enough to the mountains to be benefited is certain. Neither will the citizens of southwest Kansas grudge the expenditure of the estimated cost of fifty millions by the Government, or twice as much if necessary, to secure storage reservoirs which shall save the heavy precipitation of the mountain ranges and apply it to the soil—both for the benefit of those who may use it for irrigation, and also of those on the lower courses of the great rivers, who will thus be relieved of a vast surplus flow of water, which becomes, year by year, a greater menace and danger to them.

But what will such storage reservoirs do for us? Let us take account of a few "pointers." Maj. J. W. Powell, chief of the U. S. Geological Survey, estimates that when all possible sources of water supply for purposes of irrigation are utilized, but 25 per cent. of the lands requiring irrigation can be served with water. This is not encouraging to people so far from the mountains to depend upon such a source of supply. On each side of the Arkansas River, in Colorado, lies a vast plain of rich land yearning for irrigation. Roughly estimated, there are not less than 8,000,000 acres of land in these two areas. If but half of it is susceptible of irrigation, that would make 4,000,000 acres which must, according to Senator Plumb, eventually be satisfied before Kansas can expect to use any of the water coming down the Arkansas, whether it be stored melting snow or storm water. If the Arkansas River should furnish a stream of water 1,200 feet wide and 4 feet deep, flowing at a speed of 3 feet per second for one hundred days in each year (it has not furnished one-fifth that amount this season), that would furnish but two practical irrigations per year to 2,500,000 acres. As a matter of fact, the average total water supply of the Arkansas River, for the next five years, at least, will not, if all utilized, furnish safe and reliable irrigation for more than 1,000,000 acres of land each and every year, and there are already ditches constructed and projected in Colorado covering land sufficient to use at least all of the practical supply. The fact is, eastern Colorado, adjoining Kansas, is as much in need of a prompt and effective solution of the problem of a water supply as is western Kansas. Stewart, the authority already quoted, says of the Arkansas valley:

"The nearest crest of the water-shed on the north side of the river is 45 miles distant, on the south, it is much more distant. If we calculate a territory only 90 miles wide and 500 miles long, depending upon this river, it would contain 28,800,000 acres, requiring 1 cubic foot per second per 100 acres, 288,000 cubic feet per second. To supply this there would be required a river nearly 2 miles wide and 10 feet deep, flowing 2 miles an hour, with no allowance for loss by evaporation and percolation. The Arkansas is not one-fifth of this capacity and could not supply one-tenth of the territory."

What of the storage of storm waters that fall on the lands in which we are interested? Here is probably the worst impracticability yet suggested.

To begin with, we lay down this proposition: That there is not enough surplus storm water, collected or wasted, in all southwest Kansas in twelve months to furnish practical irrigation for 5 per cent. of the land. Then more than half of all that is collected, collects in basins where it can not be utilized for irrigation, and any reservoirs constructed to save the remainder would cost many times what the land they would irrigate would be worth. Supplemental to some other water supply, they would be of great value, well worth what they would cost, because they would supply the seepage and evaporation over a large area, thus making a large net gain in the water supply. It is only that such a supply alone would be practically exhausted by the inevitable waste of evaporation and percolation that renders it useless as a sole source of supply.

These propositions are fully demonstrated both by facts which are familiar to all residents of the Southwest, and also by practical test.

It must be conceded that storm waters to be stored and used for irrigation must be caught in something of the nature of what we call in this part of the country a "draw," that is, it must be a depression with an outlet which may be closed by a dam to hold back the waters, and through which they may afterward be let out as needed upon the land below. Waters caught in a deep, bowl-shaped basin, without an outlet, are more inaccessible for irrigation than if at the bottom of a well. Where, then, can be found draws which may be converted into storage reservoirs for storm waters? Only along a narrow strip of land north of the river in Hamilton and Kearney, Gray and Ford Counties, and probably in still narrower strips of rough land along the Cimarron, the Pawnee, the Whitewoman, and the Beaver. Not 10 per cent. of the total area of this region could thus be utilized for the construction of such storage reservoirs, and not only would the waste in such draws from soakage be very great, on account of the nature of the formation, but the water would have to be carried to such a distance in order to get it out upon land susceptible of irrigation, that it would be practically used up in transit. There is no part of the country offering such advantages for reservoirs of this kind as the northwest part of Ford County and northeast Gray, and here the Eureka Canal has had a large number of such reservoirs in use for the past two or three years. The ditch and reservoirs were constructed by the Gilbert Brothers, who have had charge of the work and watched the development and operation of the works from first to last. Mr. G. G. Gilbert, being asked as to the supply of storm waters collected in these draws, fully corroborates the foregoing statements as to the inadequacy of such reservoirs as a primary source of supply. Being finally asked how much land he could depend upon irrigating from these storage draws, unaided by water from the river or some other source, he answered promptly: "None whatever."

As an ounce of practical and intelligent experience is worth a ton of untested theory, we regard this as settling the status of storm storage reservoirs in this region. As accessories, to make up for the various wastes of evaporation and percolation, they will be valuable. Without an additional source of supply, they are absolutely without practical value.

As for digging out little 5-acre ponds all over these level prairies, as has been gravely advised, there is not one of our farmers but can say at once that such holes might as well be dug in the crest of Chimborazo or the heart of Sahara for all the practical good they would do us, unless there is first some source of supply aside from the rains. They would simply be dry, unsightly, costly holes, useless and in the way. The storm waters which fall upon more than nine-tenths of the area of southwest Kansas do not run off into streams. They go straight down and up. Ask a resident of Finney County how much rain-water gets into the river from the entire area of the county, aside from what falls upon the stream and its immediate banks, and in one small draw in the eastern part of the county, and he can truthfully answer, "Not a bucketful."

The entire county of Haskell, with adjacent parts of Grant, Finney, Gray, Seward, and Meade compose a vast plain with an area of about 15,000 square miles in which there is not a single stream, nor place for one. None of the rain-fall flows off from it. The major portion of every other county in the entire district is similarly conditioned. North Finney, Kearney, and Hamilton and south Greeley, Wichita, and Scott contain an almost unbroken plain still larger than the above. In the adjacent parts of Colorado the same vast undrained areas are found. Whenever there is a sufficient rainfall upon these plains to fill a 5-acre pond upon each 40 acres with surplus surface water, the ponds will not be needed, for there will be rain enough to dispense with irrigation and replace it with a system of drainage.

Can we then secure a supply of water sufficient to irrigate this vast and rich region by the help of the artesian wells and storage ponds? Let us see.

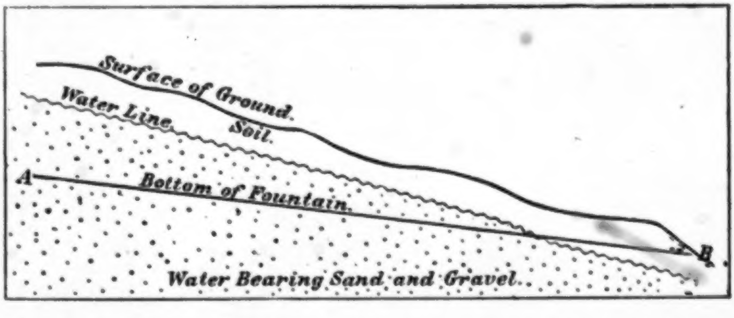
Underlying the whole Arkansas Valley is a vast sheet of water of unknown average width and depth. Every well in the valley and within a few miles upon the upland—except in a few localities—penetrates the "sheet water." From Dodge City, Kans., to La Junta, Colo., the Santa Fé Railroad has fifteen large wells. They all penetrate the sheet water and none go through it. So says Mr. R. A. Stein, superintendent of the western division of the water service. The water-works well at

Garden City goes into the sand to a depth of 11 feet and soundings to a depth of 25 feet more did not "touch bottom." The experimental boring made here at Garden City in 1888, passed through a depth of 320 feet of water, soaked sand and gravel.

P. W. Conyers's well, 17 miles north of the river in Finney County, strikes the sheet water and so does the well of S. G. Morris, 15 miles south of the river in Gray County. These are only given as examples. Scores more might be mentioned. J. S. Humphrey, a practical civil engineer, who has given some years to the study of the matter, estimates that the sheet water extends from the south side of the sand hills, 10 miles south of Garden City, to a point at least 60 miles north. W. E. Trull, who was for a long time city engineer, and closely observed the same matter, is convinced that the sheet water is not less than 30 miles in width. It would not be reasonable to suppose that it did not at least extend to the northern edge of the river valley, and to the south side of the sand hills which skirt the river on the south, which would make an average width of at least 12 miles. What may be the average depth of this vast reservoir of sand and gravel saturated with water is not determinable from the slender data at hand, but it is safe to assume that it is more than 20 feet. That a steady current flows eastward through the porous strata of sand and gravel is a well established fact and undisputed. It has been observed for years and by hundreds of people. In many wells the current is plainly perceptible, and in all, any chance bit of wood or handful of chaff or leaves blown in by the wind, floats to the east side of the well.

All these facts are of utmost importance to us, because they prove that, underneath our feet, a broad and deep stream of water slowly passes down the slope, compared with which in volume the visible stream is as an infant to a giant. Let us gather an idea of the capacity of this subterranean stream to supply us with water.

Carefully conducted experiments, made in the past few days, show that a single square mile of this sand, 20 feet deep, contains about 209,000,000 cubic feet of water, enough to flood 19,200 acres of land to a depth of 3 inches. While it would be practically impossible to drain any given area of these substrata completely, it is well known that they yield up their waters with great readiness. The Garden City Water-Works well, before referred to, is but 25 feet in diameter and penetrates the water-bearing stratum but 11 feet, and water can enter the well only at the bottom, the walls being of rock laid in cement, yet it will furnish 800,000 gallons of water per day. If, then, the half of these subterranean waters can be utilized to a depth of 10 feet over an area of 5 miles wide, enough water can be obtained to flood one-half of the land for 40 miles on each side of the river to a depth of 3 inches. In practical use, if one-half the land can be irrigated, the rest will be included in pastures, roadways, high places, etc.



This diagram represents a cross-section of a 2-mile stretch of river bottom land in which the slope of the surface (which is 7½ feet per mile) is purposely exaggerated in order to make the method of obtaining water easily perceptible to the eye. The upper irregular line represents the surface of the soil, the wave line next to it representing the surface of the saturated sand and gravel which lies from 1 to 2 feet below the top of the ground and extends down to a great depth. Let the line *A-B* indicate the bottom of an irrigating fountain, and it will be seen that water which will rush into it, as into a well, at *A*, will readily run out upon the surface at *B*.

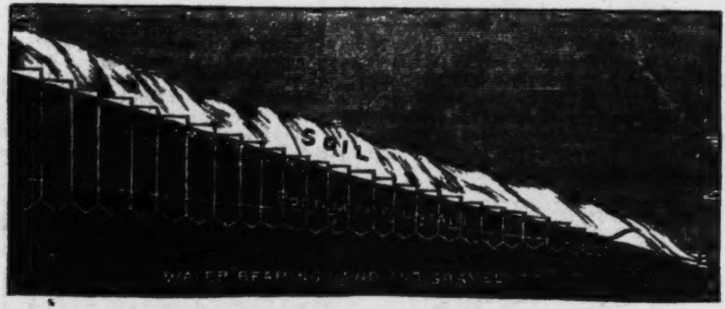
Can this water supply be obtained; and if so, how?

As is well known, this valley and adjacent plains have a slope to the eastward of 7½ feet per mile. In the river bottoms, the surface of the soil is but 3 feet above the surface of the underlying water over large areas. Great pools or fountains can be opened into this subterranean water supply and the accumulating waters run to the surface in ditches having a fall of, say, 2 feet per mile. The accompanying diagram illustrates the method.

The surface of the ground and the surface of the underlying water are indicated. Let the line *A-B* represent the bottom of an open fountain, having a fall of 2 feet per mile, and it will readily be seen that water from 10 feet below the water line at *A* could be discharged into a ditch 2 feet deep, only 2 miles distant at *B*. The bottom of the fountain at *A* would be 13 feet below the average surface of the river bottom lands. To discharge water from that point into a ditch 2 feet deep at *B* would require it to be raised 11 feet. This the difference between a fall of 7½ feet per mile and a fall of 2 feet would accomplish in 2 miles.

A fountain or pool thus excavated, 40 feet wide and a little more than 2 miles long, gradually deepening to a depth of 10 feet below the water-line, would have an area capacity one thousand times larger than the Garden City well. If it could supply a proportionate extreme output of water, it would yield 800,000,000 gallons of water per each twenty-four hours. And while it could not be expected that one-half such proportionate yield could be had steadily, yet if it should yield a supply of but 10 per cent. as large in proportion it would produce water enough to cover 1,000 acres per day to a depth of 3 inches, making a total irrigation capacity of 30,000 acres per month, or 360,000 acres per year. Granting a loss of nearly one-half of this supply from soakage and evaporation in ditches, fields, and storage reservoirs, still two thorough irrigations per year would be assured to 100,000 acres of land from such a fountain. From data already obtained, we feel justified in stating that such a supply, including the cost of making fountain, canals, storage reservoirs, etc., including all ground and right of way for same, can be obtained at a cost of less than $100,000, or not exceeding $1 per acre to be irrigated. Should time show that the cost will be even ten times as great, it will still be below the average cost of depending upon "storage, storm, and torrential" sources, and will pay enormously.

HOW THE WATER IS OBTAINED.



In this drawing, which represents a longitudinal section of part of a "fountain," the slope of the land is exaggerated in order to make the method of obtaining water plainly apparent to the eye. Let the drawing represent a stretch of 2 miles of Arkansas River bottom, which has an eastward fall of 7½ feet per mile; hence, the surface at C is 15 feet higher than B. The underlying bed of water bearing sand and gravel, averaging 3 feet below the surface, is indicated. If the fountain be excavated so that the bottom will have an eastward fall of 2 feet per mile (indicated by the line A B) the bottom will be 11 feet below the surface at C, and 8 feet below the water-line, so that the water which rushes into the fountain from bottom and sides will readily flow out upon the surface of the ground at B. This plan is in operation in several places and is thoroughly successful. The drawing shows, in outline, sheet piling, which is used as one means of walling such a fountain.

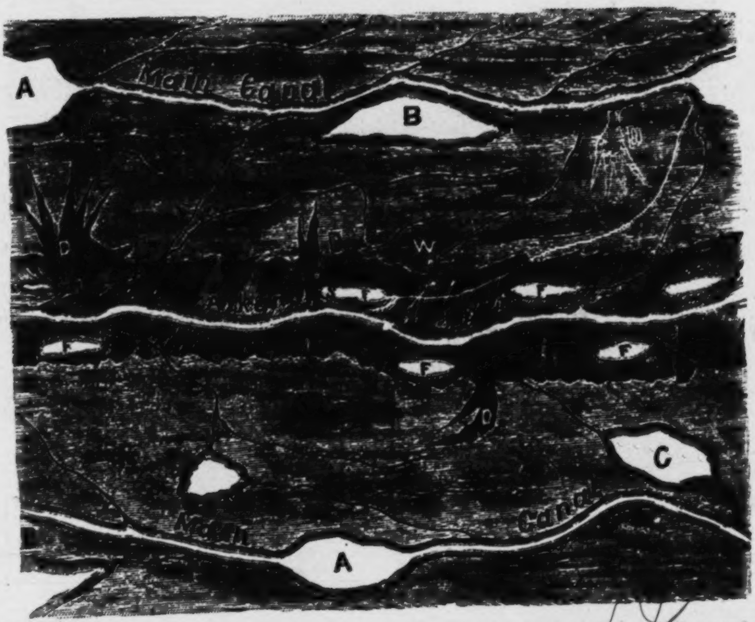
Of the objections that may be interposed to this theory of obtaining water for irrigation, we will here notice but one: "Will not such a pool fill up with sand?" The numerous large wells so long in use along the river show that curbing at the sides is required, but that the sand will not fill up from below.

All the points as to abundance, steadiness, permanence, and cost of the supply have been considered, and we are prepared, we think, to meet all possible objections with facts, figures, and demonstrations that can not be controverted.

We may as well meet the facts and face them. Nothing can be gained by shutting our eyes to the inevitable and clinging to exploded theories. To do so is to invite disaster and bitter disappointment. Without the utilization of this vast underflow, artesian wells, the rivers, ditches, and storage reservoirs will only starve us on broken promises and hopes deferred. By prompt and united effort, all southwest Kansas and southeast Colorado (whose necessity is just as great) may so add to the present resources for water as to make the future one of certainty and most abundant success. And such a demonstration in the Arkansas Valley will lead to the development of similar vast and heretofore unused resources for irrigation in other parts of the West.

To secure speedy and systematic development will require govermental attention. A central system of main canals and storage reservoirs should be laid out upon the highest ground on each side of the Arkansas River, these twin systems reaching well up into Colorado. Into these, any number of great fountains, opened into the saturated substrata, may be made to pour torrents of water the year round, keeping them full and ready for service at all times. Neither long delay nor great expense will be required. With the work thus laid out and systematically begun, private capital may soon be brought forward to take up the work in a way that while it will pay the capitalists, will also give the greatest benefit to the sturdy pioneers who are entitled to greatest consideration. Without governmental action, the development will undoubtedly take place in time; but in a hap-hazard and uncertain fashion and with such delays as will result in incalculable loss to the people.

How can it be done? A large main canal should be provided on the highest ground on each side of the Arkansas River, reaching from the mountains, or nearly so, in Colorado, past the one hundredth meridian in Kansas; these to be kept upon the highest land and to be connected with available storage reservoirs, thus making two grand chains of storage canals and lakelets, reaching clear across the arid region. Then open supply pools from the underflows and lead the waters to these storage systems, where it could be made available for all parts of the land needing irrigation. A supply once stored, no part of the great plains need ever be without its ample supply of water right at hand. The accompanying rough sketch illustrates the method suggested. While storm waters, surplus from the mountains, and the flow of artesian wells would all lend their aid, it must be apparent on the most casual observation

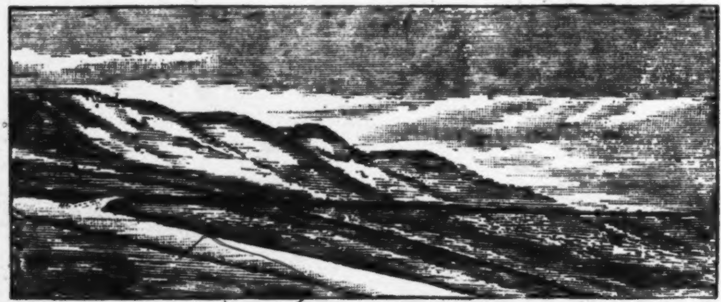


NOTE.—This view illustrates the method by which the underflow of the Arkansas Valley may be utilized to irrigate the lands for many miles on each side. By means of fountains opened on each side of the river alternately (as at F F), not only the underflow water, but all that coming down the river, all the surplus storm waters caught in "draws" or ravines (as at D D), and all surplus from artesian wells (as at W), may be stored so as to have an abundant supply always ready for use in all parts of the region to be irrigated, by means of systems of main storage canals and storage basins. These main canals should be constructed on the highest land on each side of the river, utilizing for storage purposes such large depressions as fall in the line of a main canal (as at A A), or to one side (as B B), or on the line of a supply canal (as at C). A glance at this plan will show how necessary it is to a general development of irrigation in a large scope of country to have *all* development made a part of a general system, under general regulations. As the plains are in reality a vast hillside, such a system of storage canals and reservoirs will furnish steady water-power to an incalculable amount; and this power, by means of electricity, may be transmitted to distant points.

that the steady gush of the inexhaustible waters of the underflow, day and night, the year round would be of vastly greater significance. We only need refer *en passant* to the immense amount of water power such a system would develop—sufficient to cover the land with factories, and heat and light the homes of the people by electricity. With such a system of water supply once developed, this valley of the American Nile will support in comfort at least thirty millions of people.

It is the duty of the Government to take hold of this matter at once for a host of reasons. Private capital would develop the whole in time, but piecemeal and in a desultory and unsystematic way. Some favored localities would be crossed and recrossed by a superabundance of ditches, crowding and interfering with each other, while other portions would be neglected wholly or for long years. The cost to the people in delay and overcharges would be more than the entire cost of the system. The interstate feature can be handled only by the national Government.

HOW WATER RUNS UP HILL.

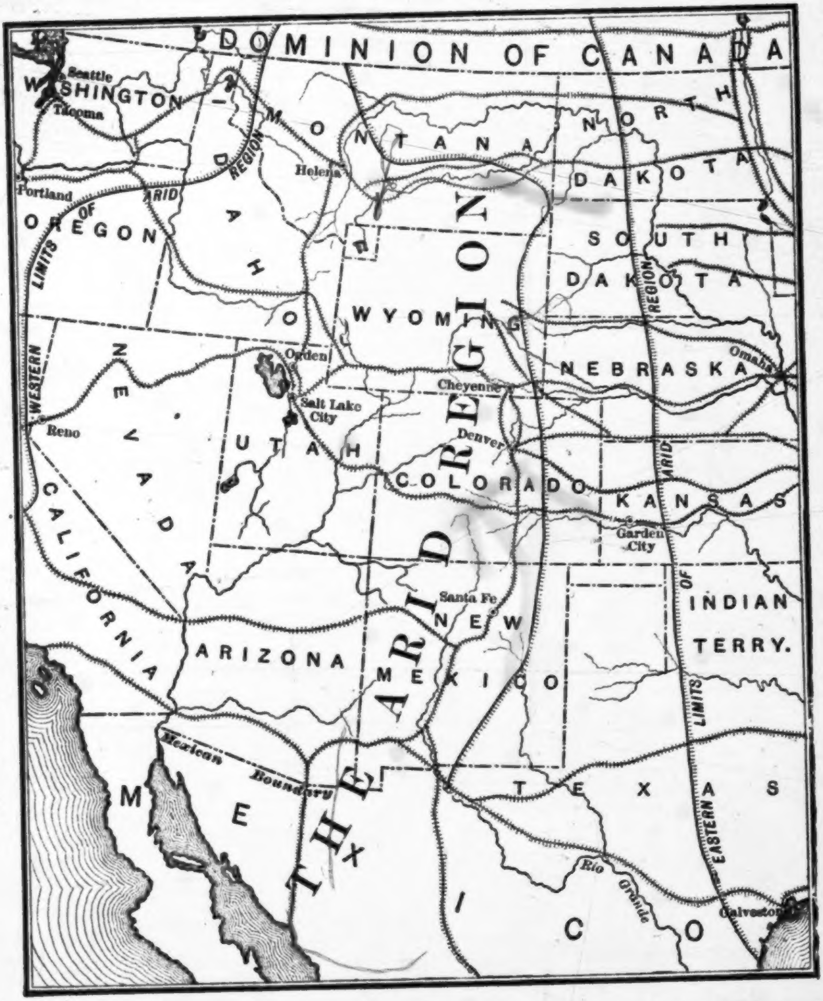


NOTE.—Many people find it difficult to understand how water, used for irrigation, runs from the Arkansas River, which is in a valley, out upon the highest upland. It is the rapid slope of the surface of the plains which makes this an easy matter. The general surface falls 7½ feet per mile from west to east. If a ditch be cut from the river, as shown in the drawing, with a fall of 1½ feet per mile, it will climb 6 feet higher up the slope every mile, and yet have a good current.

Not only would national assistance insure the speedy and systematic development of the whole, but it would justify a proper regulation of the cost of water to the consumers.

It would not be necessary that the entire development should take place in a year or two, even if such a thing were possible, but so much would be assured from the first that any part, whenever constructed, would be in harmony with the final whole, and the waste of time, energy, and money be reduced to the minimum.

A MAP SHOWING THE UNDERFLOW'S CHIEF DOMAIN.



DOMINION OF CANADA
WASHINGTON
Seattle
Tacoma
Portland
OREGON
IDAHO
MONTANA
Helena
NORTH DAKOTA
SOUTH DAKOTA
WYOMING
NEBRASKA
Omaha
Ogden
Salt Lake City
Cheyenne
Denver
UTAH
NEVADA
Reno
CALIFORNIA
COLORADO
KANSAS
Garden City
Santa Fe
NEW MEXICO
ARIZONA
INDIAN TERRY.
TEXAS
Galveston
Rio Grande
Mexican Boundary
MEXICO
THE ARID REGION
LIMITS OF ARID REGION
WESTERN
EASTERN LIMITS OF ARID REGION

NOTE.—This map shows the generally accepted boundaries of what is known as "the arid region," and between the two shaded lines on the right is shown the strip of country which will be most benefited by the development of the vast subterranean sources of water supply for irrigation, which may be tapped and utilized in hundreds of places, not only in the region thus outlined, but throughout the entire territory in which irrigation is needed. The lands which will thus be furnished with irrigation are in very large proportion smooth as to surface, possessing soil of great depth and exceedingly rich, and having a fine climate. They are too far from the mountains to secure a reliable supply of water from torrential sources, and, at the same time, they already contain many settlers who have been tempted, or gone mistakenly, beyond the boundaries of humid areas. Hence, the underflow will not only furnish to many million acres of rich land the only sure means of irrigation, but will turn the sorrow of many thousand toiling settlers into joy by giving to their arid homesteads the means of the highest degree of fertility and a certainy of much greater success in farming than can be secured by natural rain-fall.

STATEMENT OF CHARLES MANKART, DIVISION ENGINEER UNION PACIFIC RAILWAY.

There are no artesian wells on the Kansas Division. Our water supply is obtained from wells varying in depth from 13 to 260 feet, and from running streams. I am unable to ascertain the cost of the wells as the motive power and construction department has no record of their cost, neither is there any record in the superintendent's office.

I send herewith a statement giving description of wells, quality of water, etc., at our water stations between Wakeeney (just east of one-hundredth meridian) and Denver.

Union Pacific Railway, Kansas Division. (Main Line.) Description of water supply west of the one-hundredth meridian.

Location.	Source of supply.	Diameter.	Depth.	Quality.	Nature of supply.	
		Feet.	*Feet.*			
Collyer	Well	*14 †20	100	Fair	Good	Standard tank, 16 by 24, capacity 50,000 gallons.
Buffalo Park	do	20	110	Good	Medium.	Do.
Grinnell	do	*10 †16	130	do	Good	Do.
Oakley	do	‡14 †20	112	Fair	do	Do.
Monument	do	16	81	Good	Medium	Do.
Lisbon	do	10	30	Bad	Good	Do.
Wallace	Creek			Fair	do	Do.
Weskan	Well	12	130	Good	Poor	Do.
Cheyenne Wells	do	§6	200	do	Good	Do.
Kit Carson	do	12	41	Poor	do	Do.
Aroya	do	20	22	Very bad	do	Do.
Mirage	do	16	13	Fair	do	Do.
Hugo	do	24	26	Bad	do	Do.
Lake	do	15	21	Fair	do	Do.
Agate	do	24	80	Bad	do	Do.
Deer Tail	do	10	16	Poor	do	Do.
Byers	do	20	34	Bad	do	Do.
Watkins	do	10	16	Good	do	Do.
Magnolia	do	10	24	do	do	Tank 14 by 16, capacity 13,200 gallons.

L. AND C. DISTRICT.

		Inches.	*Feet. In.*			
M. P., 166.5, near Hoxie.	Sand Creek.			Good	Good	
Menlo	Well	‖7	133 7	do	do	
Colby	do	‖7	119 8	do	do	

*Top. †Bottom. ‡First 70 feet. §6-inch pipe. ‖Pipe.

STATEMENT OF WATER SUPPLY BY ATCHISON, TOPEKA AND SANTA FE RAILROAD COMPANY.

[Addressed to Mr. Hinton, engineer expert with the committee, by A. A. Robinson, second vice-president.]

In compliance with request for information concerning the water supply on the Santa Fé System west of the one hundredth meridian, for use of the Senate Committee on Irrigation, I take pleasure in inclosing the following:

Brief statement of our water supply.

Copy of analyses of certain waters.

Blue print of condensed grade profile. (As the profile does not show the lines recently constructed I suppliment it with a list of elevations above sea of controlling points.)

I regret I can not furnish you with profiles of all the new lines, but we have no condensed profiles, none but on the large scale of 400 feet to 1 inch, to copy which would require too long a time.

MIDDLE DIVISION.

The only part of this division lying west of the one hundredth meridian is on the Great Bend Extension of the Chicago, Kansas, and Western Railroad, lying west of Ness City, and covering a distance of 91 miles.

There are four water stations on this part of the line—located at Beeler, Dighton, Modoc, and Crisby.

At Crisby the source of supply is a well 97½ feet deep, and furnishing 2,000 gallons per hour.

At Dighton there is a well 18 feet in diameter and 65 feet deep, and at Modoc the well is 16 feet diameter and 102 feet deep. At Beeler the source of supply is a small stream which has been dammed. From this dam to the tank there is a pipe-line 1,100 feet long.

At each point steam power is used.

SOUTHERN DIVISION.

The only part of this division lying west of the one hundredth meridian is that part of the Panhandle extension within the State of Texas.

Water stations are located as follows: At Clear Creek, 7 miles west of Glazier, where the water is pumped by steam from the creek. At Miami, where there is a well 51.5 feet deep, which furnishes 40 gallons a minute. West of Codman, where water is pumped by steam from the creek. At Panhandle City considerable time and money has been expended to secure an adequate water supply, but the result has not been satisfactory. A well was dug and drilled to a total depth of 560 feet without getting a sufficient supply. The company now hauls water from the Miami tank.

In a test well sunk at Panhandle City, water was struck in sand at a depth of 341 feet. The water rose 18 feet, with a flow of only 5 gallons per minute or 7,200 gallons per day. At Glazier a well has been sunk for section house uses, and good water obtained at a depth of 20 feet.

WESTERN DIVISION.

From Dodge City to Cañon City—From Pueblo to Denver.

From Dodge City to Cañon City the railroad lies in the valley of the Arkansas River, and, with the exception of Pueblo and Coolidge, the water supply is obtained from wells varying in diameter from 18 to 30 feet, and in depth from 15 to 40 feet. Steam is the power used at all of the water stations with the exception of Syracuse, Prower's, and Taylor's, where windmills are used.

At Pueblo water is obtained from the city water-works company, which company obtains its supply by pumping direct from a reservoir which is filled by an open ditch from the Arkansas River.

At Coolidge water is obtained from an artesian well recently completed. This well is almost 300 feet deep, and the flow is something like 100 gallons a minute.

The following are the water stations between Dodge City and Cañon City: Dodge City, Cimarron Pierceville, Sherlock, Lakin, Kendall, Syracuse, Coolidge, Granada, Lamar, Prower's, Caddoa, Las Animas, La Junta, Carlin, Nepesta West of Boone, Pueblo, Taylor's, and Clelland. Total, 20. Between Pueblo and Denver there are the following water stations, viz: Piñon, Fountain, Colorado Springs, Pring, Castle Rock, Sedalia, and Denver.

At Colorado Springs water is obtained from the local company. At Castle Rock water is pumped from an open box sunk in the bed of East Plum Creek, and at Sedalia the water is pumped from a bored well, the well being 300 feet deep, and the pump placed at a depth of 120 feet from the surface.

At the other stations above named water is taken from wells, which are of the same class as those in the Arkansas Valley. The flow of water, while not so great as in the valley, is sufficiently ample for the company's present needs.

NEW MEXICO DIVISION.

From La Junta, Colo., to Wallace, N. Mex.

At Timpas and at Iron Springs there are wells located on the bank of Timpas Creek, a steam-pump being used at the first-named and a wind-mill at the last-named station. At Thatcher there is a well located some distance from the railroad, with a pipe line extending from the well to the tank. The supply has proved so meager that the well has been practically abandoned, and now water is hauled from Trinidad. At

Hoehne there is a well on the bank of the Purgatoire River and the power used is both steam and wind. At Trinidad the supply is obtained from the local company. At Starkville and Morley water is obtained from Clear Creek and conveyed to the tanks through iron pipe. Springs at the head of Clear Creek are the source of supply and one or more dams serve to collect the flow from the springs. At Lynn water is obtained from wells and springs located at various distances, none exceeding a mile, and by pipe lines conveyed to a pressure tank at the railroad. At Raton, the site of extensive shops of the company, a well on Raton Creek and various springs on the high ground surrounding the town furnish the supply. Steam is used to force the water from the well, while from the springs gravity does the work.

At Otero, Dorsey, and Maxwell City the supply is obtained from wells on the bank of Red River, steam being the power at Otero, while wind-mills are used at the other two. At Springer there is a well near the Cimarron River, with both steam-pump and wind-mill. At Colmor we have a well and wind-mill. At Wagon Mound springs are the source of supply and gravity does the work. At Shoemaker's a steam-pump forces the water from a well on the bank of Mora River. At Las Vegas water is obtained from the local company, whose source of supply is the Gallinas River. At Bernal gravity brings the water from several springs. At San Miguel and Rowe wells are located on the bank of the Pecos River and steam furnishes the power. At Lamy gravity brings the water from a well in Apache Cañon. Gravity is also employed at Los Cerillos, where there is a well on the bank of the San Marcos Arroyo, and at Wallace, where there is a well on the bank of Santa Fé Creek. At Santa Fé a wind-mill is used, a well furnishing the supply.

RIO GRANDE DIVISION.

From Wallace, N. Mex., to El Paso, Tex.—From Rincon to Silver City, also Magdalena, Lake Valley and San Pedro Branches.

At Bernalillo there is a well 12 feet deep; at Albuquerque, one 12 feet deep; at Los Lunas, one 15 feet deep; at Sabinal one 15 feet deep; at Alamillo, one 13 feet deep; at Socorro, one 16 feet deep; all with steam and wind-mill. At San Antonio, one 15 feet deep; at San Marcial one 15 feet deep; at Lava, one 342 feet deep, with steam power. At Engle there is a spring several miles distant from the railroad. From this spring the water is forced by steam power into a reservoir located on the divide between the spring and the railroad. From this reservoir the water passes by gravity into the tank at the station.

At Rincon there is a well 14 feet deep; at Randall, a well 14 feet deep; at Las Cruces a well 18 feet deep; at Canertillo, a well 9 feet deep; and at El Paso, a well 24 feet deep, steam being the power at each station.

At Hatch there is a well 19 feet deep, with steam power.

At Florida gravity brings the water from a spring 27,000 feet distant from the tank.

At Deming there is a well 67 feet deep, the power being steam.

At Crawford there is a well 41 feet deep, fitted with a wind-mill.

At Siver City the supply is obtained from the Silver City Water Company.

On the Magdalena Branch there is a gravity line 5 miles long at Water Cañon, the source of supply being a spring, while at Magdalena steam power is used, the water being obtained from a well 28 feet deep.

At Osceola, on the Lake Valley Branch, there is a well 136 feet deep, and there is both steam power and a wind-mill. At stations where there is both steam and wind power the steam is only used when the wind fails to supply.

At Engle the water is raised 310 feet into the reservoir, which, as above said, is on the divide and about 2 miles from the spring and about the same distance from the tank.

Lava, Engle, and Upham are stations on the Jornado del Muerto, and at each station an effort was made to secure an artesian supply but without success. At the Engle well salt water was struck.

Upon the New Mexico and Arizona Railroad, extending from Benson, Ariz., on the Southern Pacific Railroad to Nogales on the boundary between the United States and Mexico, water is obtained at the following stations, viz: Benson, Contention, Brookline, Elgin, Crittenden, Calabusas, and Nogales, and in each instance the source of supply is a well and the power steam.

On the Senora Railway, extending from a connection with the New Mexico and Arizona Railroad to Guaymas on the coast, there are the following water stations, viz: Nogales, Agua Zarca, Imuris, Magdalena, Llano, Caibo, Pesqueira, Hermosillo, Torres, Artiz, and Guaymas. At each of these stations, with the exception of Imuris, the source of supply is a well and the power steam. At Imuris water is obtained by gravity from the river Casita.

The Senora Railway lies wholly within Mexico.

Partial list of elevations above sea-level.

	Feet.
Ness City, Kans	2,268
Beeler, Kans	2,479
Dighton, Kans	2,769
Grigsby, Kans	2,931
Scott City, Kans	2,979
Modoc, Kans	3,139
Coronado, Kans	3,275
Leoti, Kans	3,307
Crosby, Kans	3,448
West Line Wichita County, Kans	3,470
Higgins, Tex	2,576
Glazier, Tex	2,608
Canadian, Tex	2,347
Miami, Tex	2,751
Codman, Tex	2,892
Paten, Tex	3,345
Panhandle City, Tex	3.458
Cañon City, Colo	5,321
Pueblo, Colo	4,656
Colorado Springs, Colo	5,990
Palmer Lake (Divide), Colo	7,231
Denver, Colo	5,188
Walter Cañon, N. Mex	6,008
Magdalena, N. Mex	6,557
Kelly, N. Mex	7,149

These elevations are on top of rail at station.

Table 328.—*Wells on the Atchinson*

[In Kansas, Colorado,

WATER

Stations.	Laboratory number.	Date.	Organic matter.	Silica.	Alumina and iron.	Carbonate of lime.	Carbonate of magnesia.	Carbonate of sodium.	Carbonate of potassium.	Sulphate of sodium.	Sulphate of potassium.
Topeka Shops	C. 55	May 2, 1884	.875	1.166	.641	11.752	1.499	.580	....	5.[illegible]15	......
Grand Hole, S. Pedro C. Co.	C. 76	June 10, 1884	1.408	2.507	.642	5.948	1.100	28.909	3.920	......	2.960
Opate	C. 93	July 17, 1884	trace.	.519	trace.	17.138	1.800	......	....	10.425	1.549
Alton	C. 94	....do	1,728	1.167	.778	12.636	5.023	4.983	....	5.023	.656
Peabody (tank)	C. 104	Sept. 24, 1884	trace.	2.924	1.464	30.324	......	......	....	6.638	.837
Pueblo (railroad tank)	C. 106	Aug. 9, 1884	..do .	1.213	trace.	14.804	......	......	....	9.416	3.014
Pueblo (city reservoir)	C. 107	....	do .	.431	.297	3.521	.816	.328	.428	.216	......
Hillsboro	C. 180	June 25, 1885	.229	.580	trace.	41.047	......	......	....	8.309	2.150
Nickerson	C. 181	Nov. 12, 1884	trace.	.510	..do .	.959	3.310	......	....	4.076	1.788
Raymond	C. 182	....	1.297 volatile.	.777	.282	8.812	2.333	.928	....	6.482	.980
Dodge City	C. 183	Nov. 20, 1884	trace.	3.031	.948	8.455	8.496	......	....	3.366	2.193
Speareville	C. 184	....do	..do .	2.686	trace.	7.225	1.580	.716	.302	......	......
Ellenwood	C. 188	Nov. 24, 1884	..do .	.980	.200	7.980	2.669	3.254	....	2.112	1.794
Great Bend	C. 189	Nov. 22, 1884	..do .	.464	.464	6.500	2.233	......	....	13.094	2.441
Peabody	C. 194	Nov. 30, 1884	..do .	2.328	1.169	31.929	......	......	....	16.472	3.560
Iron Springs	C. 197	Feb. 5, 1885	..do .	.968	.621a	18.060	12.921	2.620	....	28.918	6.628
Kinsley	C. 198	Dec. 4, 1884	..do .	.841	.730	15.994	......	23.564	....	......	5.490
Larned	C. 199	....do	.116	.620	.987	10.640	......	......	....	9.202	1.874
Benson	C. 204	Dec. 20, 1884	trace.	.777	.519	6.731	3.366	......	....	......	......
Lawrence	C. 205	Dec. 22, 1884	..do .	1.753	.443	36.298	7.440	......	....	......	......
Lava	C. 228	Jan. 20, 1885	.778	7.492	1.546	40.220	......	......	....	38.622	9.420
Iron Spring (new spring)	C. 237	Jan. 24, 1885	trace.	.134	3.234	28.212	......	......	....	30.320	
Iron Spring (railroad tank)	C. 238	...do	..do .	.952	.600a	17.840	1.6[illegible]	......	....	35.428	
Kansas River at Topeka	C. 242	Jan. 28, 1885	.716	1.016	.980	13.409	1.625	......	....	4.177	
Kansas Riv. at Lawrence.	C. 243	....do......	.802	1.140	.340	15.080	.600	......	....	4.729	
A. T. Well, Lawrence	C. 244	Feb. 12, 1885	1.010	.808	1.449	32.827	1.551	......	....	7.016	
Silver City (railroad tank)	C. 255	Mar. 4, 1885	trace.	2.292	1.720	43.546	14.324	......	....	29.794	
Deming (railroad well)	C. 256	Mar. 3, 1885	......	......	......	......	......	......	....	......	......
Nickerson	C. 257	Mar. 7, 1885	.046	.138	.102	15,620	4.198	......	....	36.247	
Iron Spring (new spring)	C. 264	Mar. 9, 1885	trace.	.126	3.031	26.620	......	......	....	28.748	
Hudson, hot spring	C. 270	Mar. 19, 1885	..do .	1.552	.502	4.448	2.624	......	....	13.547	
Nickerson	C. 271	Mar. 23, 1885	..do .	.868	.141	10.729	1.131	......	....	3.229	
Gypsum Mills, 6 miles northeast of Wallace.	C. 284	Apr. 6, 1885	..do .	2.040	1.436a	60.472	......	......	....	213.834	
Maxwell	C. 285	....do	..do .	.384	1.157	17.106	11.337	......	....	15.254	
Florida	C. 306	Apr. 15, 1885	......	......	......	......	......	......	....	......	......
Rincon	C. 307	Apr. 30, 1885	1,788	1.550	.519	14.721	3.095	......	....	22.410	
Water Cañon	C. 308	....do	......	......	......	......	......	......	....	......	......
Osceola Well	C. 309	....do	......	......	......	......	......	......	....	......	......
New well, Topeka	C. 320	May 19, 1885	1.167	1.169	.882	11.939	3.632	......	....	2.012	
Kansas River at new well, Topeka.	C. 321	....do	1.164	1.459	.901	11.956	4.094	......	....	2.089	
Topeka Water Works	C. 330	June 11, 1885	.291	.732	.583	10.204	1.878	......	....	1.583	1.307
Upham	C. 332	June 15, 1885	trace.	1.258	.406a	8.001	3.449	9.751	.732	75.233	......
Carpenter's Smelter near Silver City.	C. 341	July 2, 1885	..do .	.585	.344	15.450	5.848	......	....	2.580	5.246
Kiowa, No. 1	C. 350	Aug. 3, 1885	.772	1.289	.516	10.883	5.158	9.109	....	8.820	
Kiowa, No. 2	C. 351	....do	trace.	.778	.315	7.193	5.442	11.659	....	2.120	
Las Vegas Well, Wood Preserving Works.	C. 347	July 31, 1885	..do .	.289	trace.	13.507	2.186	2.546	.821	4.875	......
San Pedro C. and C. Co	C. 381	Sept. 21, 1885	5.627	1.922	3.844	22.948	30.195	......	....	193.685	
Dorsey Spring, 2 miles E	C. 385	Oct. 10, 1885	.188	.776	.194	8.166	1.800	......	....	3.122	
Silver City (new well)	C. 390	Oct. 31, 1885	trace.	.233	[1].465a	10.730	3.732	.117	....	6.532	
Kiowa (new well)	C. 391	....do	.974	.395	[1].270a	12.522	......	......	....	7.702	
Dodge City	C. 395	Nov. 21, 1885	trace.	2.336	.577a	14.975	5.377	......	....	17.106	
Iron Spring, section house well.	C. 396	Nov. 27, 1885	.727	.570	.422a	2.641	2 503	47.652		......	5.850
Medicine Lodge	C. 409	Jan. 7, 1885	.811	1.167	[1].583a	25.079	......	......	....	11.539	
Spring Creek, Medicine	C 418	Jan. 2[illegible], 1886	trace.	.291	.291a	9.326	1.956			9.369	
Elm Creek, Lodge	C.414	....do	..do .	.306	.306a	11.611	1.880			5.472	
Peabody (new well of water works).	C. 452	May 20, 1886	..do .	.581	.873	13.082	3.237			12.113	
Argentine (pump house).	C. 425	Feb. 5, 1886	1.749	1.142	.776	20.022	......			2.219	
Argentine (white house).	C. 424	....do	1.551	2.365	.387	22.683	1.584			2.949	

---

[1] Trace of iron.

Topeka and Santa Fé Railway.
and New Mexico.]
ANALYSES.

Sulphate of magnesia.	Soluble carbonates sulphates chlorides of soda and potassium.	Chloride of sodium.	Sulphate of lime.	Carbonate of iron.	Totals.	Remarks.
....	....	7.463	....	....	29.921	
....	....	3.284	....	....	50.678	Not poisonous, but supposed to be. Red sediment is iron and organic matter.
7.739	....	1.652	....	....	40.882	
....	....	1.830	....	....	33.824	
21.868	....	3.097	3.250	....	70.406	Poor. Large per c. sulphate of magnesia.
9.063	....	5.032	2.403	....	44.965	
....	....	1.619	....	....	7.656	Extra good.
21.000	....	3.579	20.180	....	97.074	Poor. Large per c. sulphate of magnesia.
....	....	8.939	4.842	....	29.424	
....	....	6.413	....	....	28.304	On account of organic matter unhealthy for drinking.
....	....	4.720	10.549	....	41.758	
....	....	1.489	....	....	13.908	Extra good.
....	....	2.982	....	....	21.981	A good water for comparison.
2.082	....	3.598	....	....	30.876	
20.482	....	3.942	1.431	....	81.313	Poor. Large per c. sulphate of magnesia.
4.520	....	....	....	2.500	77.756	Poor. Large per cent. of hard salts.
22.298	....	12.846	16.127	....	97.890	Poor. Large per c. sulphate of magnesia.
3.999	....	1.631	.087	....	29.156	
....	20.449	....	....	....	31.842	
....	38.003	....	....	....	61.937	Combined sulphuric acid. 10.356 grains.
37.142	....	7.820	62.420	....	205.460	Over 70 per cent. insoluble matter. Purification necessary.
25.200	....	2.375	12.609	....	102.084	Very poor.
14.490	....	2.780	....	2.680	76.392	Poor.
.820	....	7.143	....	....	29.886	
2.056	....	7.905	....	....	32.661	
6.107	....	20.126	....	....	70.954	Will corrode brass fittings.
7.105	....	15.699	....	....	114.480	Poor. Large per cent. of hard salts.
....	....	....	....	....	16.329	Extra good.
....	....	20.920	....	....	77.271	This water must have a strong tendency to foam.
23.403	....	2.316	11.240	....	95.484	Poor. Large per cent. of sulphate of lime and magnesia.
....	....	2.286	....	....	24.959	Note large per centage of silica.
3.812	....	8.261	....	....	28.171	
67.888	....	20.676	22.665	....	389.021	On account of large per cent. of Epsom salts, injurious to health, if used too freely.
5.039	....	13.163	....	....	63.440	
....	....	....	....	....	19.040	
.417	....	14.364	....	....	59.464	Per c. of scale-producing material small on account of large per c. chloride and sulphate of soda. This water will attack brass and corrode fittings of that material.
....	....	....	....	....	13.024	
....	....	....	....	....	18.079	
.263	....	5.757	....	....	26.821	
.277	....	5.763	....	....	27.704	
1.694	....	5.145	....	....	23.417	
....	....	20.420	....	....	119.250	Poor. Will corrode brass fittings.
.034	....	4.300	....	....	34.387	
....	....	15.025	....	....	51.579	
....	....	3.874	....	....	31.381	
....	....	1.450	....	....	25.674	
....	....	86.470	....	....	274.691	Poor. Unhealthy for drinking purposes. Will corrode brass fittings.
3.080	....	1.281	....	....	18.607	Good.
....	....	1.633	....	....	23.442	Good both for drinking and boiler purposes.
15.280	....	7.795	.916	....	45.853	Poor water on account of large quantity of sulphates. Will form hard scale.
3.742	....	5.792	....	....	49.905	
....	....	23.418	....	....	83.792	Poor. Will corrode brass fittings.
27.098	....	9.612	....	....	75.887	Poor. Large per c. sulphate of magnesia.
....	....	2.677	....	....	23.910	Good
....	....	2.419	....	....	21.994	Good.
....	....	2.435	....	....	32.321	Fair.
2.231	....	1.603	....	....	29.742	
2.762	....	2.556	....	....	36.887	

The terms good, fair, and poor indicate the value for boiler purposes.

STATEMENT OF GEORGE H. WEST, OF GREELEY, COLO., IN RELATION TO SOUTHWEST KANSAS.

We beg to submit the following information, covering those counties in Kansas south of the third standard parallel and west of the ninety-eighth meridian, embracing an area of 16,520,000 acres, of which fully 15,000,000 acres are suitable for agricultural purposes, relying for its best results upon irrigation.

At least 90 per cent. of this land is underlaid by subterranean flows or reservoirs of water, available from wells by means of mechanical power. The application of an economical method of raising this water would produce more immediate and general benefits than any other system, making from 60 to 75 per cent. of the entire area at once reclaimable by private enterprise.

Along the Cimarron River and its tributaries are 350,000 acres of first bottom lands, with abundance of water within 20 feet of the surface; while at least 500,000 acres in the Arkansas Valley will afford an exhaustless supply of water for ordinary irrigating purposes at 10 feet. The valleys of the Beaver, White Woman, Pawnee, Walnut, and their tributaries will afford 1,000,000 more acres of land, with an ample water supply from 15 to 30 feet. Outside of the valleys sheet water is found, from 30 feet to 100 feet, with an average depth of about 60 feet; excepting limited areas, including portions of nearly every county west of the ninety-ninth meridian. Embracing nearly all of Haskell County and a narow strip west through the counties of Grant and Stanton and east through Gray, Ford, Kiowa, and Pratt, extends what is known as the deep-water belt, or high divide. Another such area extends west through the counties of Garfield, Finney, Kearney, and Hamilton, along the fourth standard parallel. In these belts water lies at depths generally exceeding 100 feet. Outside these narrow belts the larger portion of the entire area is underlaid by a water supply, available to a mechanical method of raising it. The water is almost universally found running through gravel beds with a uniform current towards the east.

Neither coal or wood is found in the territory embraced in this report, and prices are governed by the length of haul and competition between lines of railroad. At Garden City the best Cañon City coal sells at the scales for $6.75 per ton, Trinidad coal $5.90, and Cañon City pea coal $4.65 per ton. No slack is sold, and we are unable to get the price of same to include in this report. Garden City is not a competing point, and the above are about the maximum rates on fuel along any line of road; while at competing points good fuel for steaming purposes can be bought much cheaper. The western half of the State has meager railroad facilities, but development through pumping or other system of irrigation would be followed by the extension of present lines through that section into the great coal deposits of Colorado and New Mexico, southwest of us.

No pumping system or irrigation has been tried, and the surface streams are totally inadequate to furnish an extensive water supply for a system of canals. The Arkansas River is the only stream that can be utilized in that manner, and the present demand upon it renders farming more hazardous than will justify further development in that direction without the application of a storage reservoir system, or in tapping the water-bearing strata with underground canals—taking advantage of the universal trend eastward. Such a system will be necessary to reclaim the high divides mentioned in this report, and will call for reservoirs of enormous capacity, as those lands, being uniformly unbroken, storage basins must be made at great distances from the areas to be watered.

The underground water supply will rapidly increase instead of diminish, as the water used will largely be absorbed by the soil, and percolation from above be added to the present sources. The water lost by evaporation will be replenished by the rain that will be enabled to soak into the soil, instead of wasting upon the impenetrable sod of our prairies. Most of Kansas has demonstrated that breaking the sod and continued cultivation of the soil will eventually result in the complete saturation of the dry soil, that almost invariably exists from the sod to the sheet water. The almost entire absence of clay beds and other impenetrable substrata will permit of the complete saturation of the soil down to the present water levels, making a storage reservoir of incalculable magnitude, proportionately increased by each additional demand upon it, and capillary attraction, now almost entirely absent, will soon be established.

By determining at once the practicability of mechanical means of raising water from our wells, these results can be accomplished by private enterprise in time to benefit the classes who most need aid and encouragement, and who are utterably unable to wait upon the action of the Government in devising and executing a more elaborate system of storage and canals. A pumping system will permit of individual enterprise and general adoption at once. Any system dependent upon the construction of expensive canals, reservoirs, subdrainage, or other methods involves unavoidable delay of governmental action, or in inducing capital to come to our relief. To demonstrate that a pumping system can be practically and economically applied will greatly reduce the area of arid lands to be reclaimed, and afford a proportionate increase of the available water for that purpose.

STATEMENT OF SECRETARY M. MOHLER, STATE BOARD OF AGRICULTURE.

That portion of the State of Kansas west of the one hundredth meridian, as well as some portions east of it, may be classed as semi-arid, and would be vastly improved by irrigation.

The topography of the country also is such as to admit of irrigation on an extensive scale.

The difficulty, however, in the way is, the country is destitute of water. There are no streams in that section of any consequence, and the only possible means of getting a supply of water is either from the clouds by gathering the storm-water as it falls or from the interior of the earth by artesian wells.

In my judgment irrigation by means of storm-water gathered into reservoirs is impracticable except on a small scale. The chief, and I think the only, hope of irrigation in that country is by means of artesian wells. Such is the opinion also of the settlers there.

The underground water supply of the west is mainly obtained in two formations, the Tertiary grit and the Dakota sandstones, which in some localities are so situated as to give artesian water of good quality from comparatively small depths. Other water but much mineralized is obtainable at greater depths.

There is a series of irrigation canals in the Arkansas Valley, and it is possible that the flood water of that river could be stored to irrigate larger areas. It is believed also that the Cimarron and the Republican Rivers would supply water for irrigation of large areas of extreme northwest and southwest.

The crops of the western half of the State are substantially the same as east, only that sorghum and rice corn do better than maize. Tree planting has begun and the State has established a forestry station in Trego County, but too recently to give results yet.

In the judgment of many parties I have met with it would be a good thing for the Government and that country to solve the problem as to the practicability of irrigating by artesian water by sinking wells in different localities. If it were once demonstrated with reasonable certainty that artesian water could be had, private capital would be invested in developing the artesian water resources of that section.

This idea, it seems to me, is of sufficient importance to merit attention.

[*Papers inclosed by Mr. Mohler.*]

STATEMENT OF ROBERT HAY, OF JUNCTION CITY, ON NORTHWEST KANSAS, ITS TOPOGRAPHY, CLIMATE, AND RESOURCES.

[Prepared for the State Board of Agriculture.]

A State whose boundaries are so little irregular as those of Kansas could have its northwest quarter or other similar portion marked off with definite lines if area only required to be noted. The northern line of the portion under consideration would in this case be the Nebraska line, which is the fortieth parallel of latitude, and the south line would be the parallel of 38¼ degrees. The western boundary is of course the Colorado State line, or the one hundred and second meridian, and its eastern boundary would be a meridian line whose longitude is 98° 20′ west of Greenwich. This eastern line passes through the counties of Jewell, Mitchell, Lincoln, Ellsworth, and Rice, while the southern boundary is nearly coincident with the line of the Santa Fé branch roads from Lyons and Great Bend, or the Missouri Pacific line to Colorado, through the counties of Rice, Barton, Rush, Ness, Lane, Scott, Wichita, and Greeley The area so defined has slightly over 20,000 square miles.

If, however, geographical features be taken into account, and not merely area other boundaries might be used for a district that might properly be called northwest Kansas. One convenient area might so be named which should contain all the region north of the Smoky Hill River from the Colorado line to its confluence with the Republican, near Fort Riley, in Davis County. This region would be curtailed in its southern extent as compared with the previously defined area, but would make up by increased easterly extension. Another district well marked topographically would be the region between the Smoky Hill and Republican Rivers. This district, while having considerable southeastern extension, includes parts of Colorado and

Nebraska. A better area for topographic description would be the drainage area of the Republican and Smoky, but this would include larger areas beyond the limits of the State, while its southern line would be singularly near the parallel of 38° 30′.

In this paper it will not be possible to give detailed treatment of even the smallest of the areas defined above, yet in dealing with the larger features, both topographic and geologic, the larger areas will have some notice.

The entire region here considered belongs to that part of our country known topographically as The Plains, or The Great Plains, but it has within it all the varieties of surface just mentioned, and the valleys of its water-courses are conspicuous features.

The fact least noticeable by ordinary observers, yet the one on which all other topographical facts are dependent in northwest Kansas, is that there is a general increase of elevation of the country westward. Of course, the least thoughtful traveler or settler is sure of this as soon as he has observed that all the larger streams of the region have an easterly course. It is also to be observed when the attention is directed to the subject when traveling on the comparatively level country—the high prairie—above the river valleys of the district. In this situation it will always be noticed that the western horizon is higher than the eastern. It is also to be observed when looking across the greater valleys that the northern plateau is higher than the southern one; *i. e.*, that there is an increase of elevation northward as well as westward. The former, however, is not so marked as the latter.

The direction of the streams indicates the elevation. The elevation is the cause of the direction of the streams. Examining a map of the region from the Mississippi to the Rocky Mountains, we find that between the Platte and the Arkansas rivers are a number of others streams, whose sources do not reach the mountains. The principal are the Smoky Hill and the Republican, whose highest gathering-grounds are in eastern Colorado, separated from the mountains by the Platte Valley. These two streams are seen to diverge, the one to the north the other southerly, and, entering Kansas, pass into the region we are discussing. As these streams diverge it is seen that others originate, of considerable length, but tributary to them at last, and occupying the region between them as these lie between the Platte and Arkansas. There is a repetition on a small scale in the sources and courses of the Saline and Solomon, of the conditions under which the sources and courses of the Smoky and Republican were formed. Looking further east, another repetition of the same forms is seen in the Neosho and Marais des Cygnes, between the Arkansas and the Kaw, continued into the Missouri. This repetition of drainage-forms points to continuity of similar forces through long periods of time and persistence of the same conditions through wide areas.

The rivers, then, of northwestern Kansas are rivers of the plains—they are not mountain streams—and hence lack mountain snows and mountain rains as sources of their waters. Besides this difference in their water supply they have a very important difference in the form of their beds. The mountain stream is more rugged, steeper, and narrower as its nears its source. The river of the plain has a shallower, broader depression the higher it gets, and besides having less water its bed becomes scarcely noticeable at all as a valley. The valleys of the Saline, the Solomon, the Prairie Dog, the Sappa, and the Beaver become in Thomas, Sherman, Cheyenne, and Rawlins counties little more than depressions in a great rolling plain. The valleys of the Smoky and the Republican are the same a little farther west in Colorado.

Another characteristic of these river valleys is that at some distance down their courses, where they have decided depth and running water, they are more abrupt—in some places rugged—on their southern slopes than on their northern, and the tributaries on their south sides—right bank—are shorter than those from the north. This is of course referable as to its cause to the fact before mentioned of the increase of elevation northward.

This leads us to observe that the valleys themselves—all in the region—are the result of one cause—erosion. They have been cut out by the action of the streams now running through them, aided by the frosts and winds, and all other weathering agencies of ages past. Further, the differences in the character of a valley in different parts of its course are due to the differences in the material, the cutting away of which forms the valley, and which is the substance of the earth in different parts of the great plains. Of these differences more will appear further on.

A fact in the structure of the valleys that is noticeable by the least observant is the prevalence of *bottom land* in the lower parts and its gradual restriction in area and diminution in depth as we ascend towards the sources of the streams. This bottom land is usually level, with a gentle slope laterally—*i. e.*, upwards from the river, but with a marked exception in many places near the stream; that is, it is *there* higher than a little farther back, and this is manifestly due to the manner of its deposit. The whole material of the bottom land is what has been held in mechanical suspension in the water of the stream when in flood—sand, gravel, mud—

and has been deposited by the retiring waters, the finest material held longest in suspension being deposited in the gentle ridge near the stream. There is another evidence of this seen in the places where the recent workings of the stream have left the bottom in the form of overhanging precipices whose vertical sides show horizontal markings of sand, mud, or other alluvia alternated with black bands of vegetable soil, showing that at those stages of its existence there was freedom from flood for a sufficient number of years to allow the grasses and other vegetation to grow and decay and leave the carbonaceous material—humus—similar to that making the present surface of the bottom. These level bottoms are not usually the lowest bottoms of the river. They are no longer the flood plains, but are permanent as to their height, wasting away by present action of the stream as to their area. The flood plains of to-day are lower, usually more irregular, and becoming higher with each year's flood deposit. They are formed by the material from above, the high prairie as well as the older bottom, by the deposit of each year's flood. These present flood plains may be called the true first bottom. The level bottom occupying a higher position is the second bottom formed as first bottom when the stream was at a different level, and there is often a third bottom back from the stream 15 or 20 feet higher than the second bottom, and showing a similar condition of things in a period still further back. These phenomena—of the three series of bottom lands—may be observed in the narrow valleys of Big Timber in Cheyenne County, and of Beaver in Rawlins County, the Beaver of Scott and Wichita counties, valleys farther east of the Sappa, the Prairie Dog, the Solomon, the Saline, the Republican, and the Smoky. It is noticeable that the second bottom of one part of the valley becomes the third of a region lower down.

Of the streams themselves, *i. e.*, the main ones, we notice, in connection with the above facts, that they are at present occupied only in cutting away and redistributing the material of these bottom lands which they formerly deposited. In very few places in all northwest Kansas is any stream engaged in wearing away bed-rock. The South Solomon in eastern Osborne County is doing it a little; the Prairie Dog shows a little of the rock-bed near mill-dams, and this is true of the Saline and other streams.

In all the region there are no lakes. A few old river-beds, occasionally connected at flood-times with the present streams, are the haunts of fish or wild fowl, but there is no sheet of water anywhere wider than the present streams. A few of these old river-beds have encircled a piece of higher bottom that by courtesy is called an island, as at Long Island, in Phillips County, and such areas have timber. All the rivers east of the ninety-ninth meridian have timber. The Solomon has a little into Rooks and Norton Counties and the Prairie Dog has a few trees nearly to the one hundred and first meridian, and the Big Timber Creek has some in Cheyenne County; Beaver creek, in Rawlins; the Sappa, in Decatur; and also the Southern Beaver, in Scott County. But this region is essentially a prairie country. The valley of the Republican, from Jewell County to Fort Riley, and the Smoky, from Ellsworth to the same place, have abundance of timber. The trees natural to the country are oak, ash, elm, cottonwood, box-elder, walnut, locust, and hackberry; the ash, cottonwood, box-elder, and locust going farthest west. The red cedar is found as far west.

Taking the most extensive definition of our district, a strip from 15 to 20 miles in width across the eastern end of northwest Kansas from Washington to Rice County might be called comparatively a rough district, the great valleys being bounded by precipitous bluffs of hard limestone or ferruginous sandstone and the smaller ones being rugged ravines. Another strip, like the former, widening southerly from Jewell and Smith Counties across Mitchell, Osborne, Russell, Ellis, and Rush, being much smoother in the slopes of the hills. Again, a strip across Phillips, Norton, Graham, Sheridan, and Trego into Scott might be called rough, and the most western counties have a decidedly smooth contour. But these descriptions are only comparative, and parts of these districts would illustrate the opposite term.

The general increase of elevation westward is due mainly to newer geological formations being added as we proceed in that direction. We shall see further on how all the topographical features are influenced by this, but the increment itself is mostly so gradual that its relation to the geology is not seen by the casual observer except in one instance, where the added series of formations make a conspicuous step on the prairie. This is where the limestone of the Fort Benton rocks comes first into view as we go west. In the valley of the Smoky, in Ellsworth and Russell counties, in Lincoln back from the Saline, in Cloud and Mitchell on the Solomon, these are seen capping the bluffs away back to the high prairie—a distant ledge and step higher than the underlying sandstones, and showing promontories and ridges with table tops scarcely less marked than those of the massive limestones of the lower courses of the Republican and Smoky Hill Rivers. This is a prominent feature of the topography for scores of miles.

There is a very interesting feature in the topography of the most western part of northwest Kansas, particulary in Sherman, Wallace, Logan, Greeley, Wichita, and

Scott Counties. It is the existence of depressions not connected with other valleys, basins having no outlet, separated from the general drainage of the country. Some of these seem to be in a line, and suggest an old river valley filled up with alluvial dams.

The main facts of the topography are—

(1) Gradual increment of elevation westward.

(2) Similar, but less marked, increment northward.

(3) The entire region forms part of the "Great Plains."

(4) None of the streams have their origin in the mountains.

(5) The streams all belong to one system, lying between the valleys of the Arkansas and the Platte, which are mountain streams.

(6) The valleys of the streams are all the results of erosion, having been cut out of the body of the "plains" by the streams and the other agents called "weathering."

(7) The character of the underlying rock and distance from highest part of the "plains" have resulted in two smooth and two comparatively rough districts, with mounds and bluffs—all hills of erosion.

(8) The upper parts of the river courses are without permanent water.

(9) The lower parts of the river valleys have more or less timber.

(10) The difference of elevation from a river valley to adjacent high prairie is not over 300 or 400 feet anywhere. In the west the valleys are mere depressions.

(11) There are basins in the western part not connected with the system of river drainage.

The source of most soils is the actual degradation of the geological deposits of past years by the action of rain and moisture, heat and frost, running stream and stirring wind. Some rocks, even the harder ones, have by these agencies been broken up in fragments and dust on the spot where they have lain for ages. Seeds of plants buried in this débris have rooted and grown, and by their chemical force and mechanical action have aided in still further breaking up the rock, and then their own decay has added substance to the soil thus formed, and it has gradually increased in thickness. A soil so formed is said to be sedentary. It is on the spot where as a soil it first began to be. Running water, and sometimes the wind, will carry off soils so formed, and also the rocky débris before it becomes soil, and redeposit it on the flood plains of rivers or on sand-banks and shores of the sea, and then plants taking possession convert them into soils as before. Such soils are said to be transported. Other designations are used for particular kinds, but all fall under these two main heads. Northwestern Kansas has soils of both kinds. The bottom-lands—first, second, or third—of creek or river valley are all transported soils. The great bulk of the high prairie and the sloping uplands have sedentary soil. The transported soils are of mixed ingredients; the dust of limestone, the grains from sandstone or granite, the mud from dissolved shales are all mixed in the composition of the river bottoms, and the most finely comminuted matter is in the best physical condition for furnishing plant-food. The sedentary soils are, on the other hand, composed mainly of the ingredients of a single bed of rock.

This is largely true of the principal soil of northwestern Kansas. The smoothly rolling high prairie, with its short buffalo-grass, has scarcely any depth of black soil or humus, such as is looked upon as the standard of value in soils, and which is often characteristic of bottom-lands. But underneath the sod of the prairie is the tertiary marl before described, which, though a rock in technical geological phrase, is a lake silt, composed of limy materials, sand, and clay. Turn it up with the subsoil plow, bring it from the excavation of a cellar, or from a well 100 feet deep, and in it plants will grow, and grow well. The rolling prairie of Cheyenne, Sherman, Wallace, Greeley, and the rest of the remote western counties have this subsoil as an everlasting resource. West of the one hundredth meridian this is the principal soil of the region. The valleys of the rivers are comparatively narrow, and bottom-land is not so plentiful. Coming east, the valleys widen, and besides there being more bottom-land, there are wider areas of slope where the substance of the sedentary soils is formed from older formations in all the soils of the Upper Smoky, the Walnut, the Saline, and the two Solomons. Still on the high prairie to the east of the limits above suggested is the sedentary soil of tertiary marl, and still traces of it on the highest lands farther east than middle Kansas.

But in these eastern parts—Smith, Osborne, Russell, Rush, Mitchell, Cloud, Ottawa, Saline, Ellsworth, and Rice counties—if bottom-land does not actually preponderate in area, yet transported soils occupy quite the half of the counties, as the smaller valleys are numerous and the river valleys broad and grand. Valleys are settled first. Sheltered from winds, they attract the pioneer; they give response to the touch of the plow. Their cultural features soon set off their natural advantages, and, the population increasing, all other advantages also increase.

On some of these slopes there are soils that are thinner, and as far as arrangement of material is concerned not in the best condition for plant-food. On these slopes the grasses are thinner and coarser. Some of them are on the exposures of shales. Where these are clayey shales they are at first intractable to the plow, and are in wet weather the most adhesive of muds. They are locally called adobe or gumbo soils, and are found on the slopes of Russell, Osborne, Smith, and other counties where the blue shale of the Niobrara has outcrop. Yet these soils, after being once broken, are not infertile nor continuously intractable, but do not seem to have much power to resist drought. The area of these soils is not large.

Another class of soils of the less valuable kind are those that are gravelly. They have their source in the disintegration of the Tertiary conglomeration. They occur in unexpected places. Occasional mounds in the valleys and slopes of higher prairie are made of gravel that support but a scanty herbage, and indicate the former presence of the older Tertiary formation when its actual presence is no longer realized. Some of the higher mounds of grit have this bare, gravelly soil, but the entire area so covered is not great. The mortar-beds of the grit supply a sedentary soil, which gives a moderate hold to blue-stem and other grasses, and will probably supply a hold for forest trees.

The geology, the topography, the soils of northwestern Kansas are as favorable to the pursuits of man as can be desired. The climate needs some remark. Most of the settlers' trials come from the climate. Can it be modified to suit him better, or can he adapt his ways and his work to its peculiarities?

Climate may be considered under three heads: Temperature, precipitation, winds. We will notice each separately.

The *Temperature* of the Northwest may be fairly described as continental. That is, it has a wide range from summer to winter. The observations made in the region are too few to give much reliable material. It may, however, be said that while there are many days in winter that are below zero, yet it is not continuously so even in January. The severity of the winter is frequently broken by milder days. In summer the temperature rarely goes above 100° Fahr., but it is for some time in the nineties. The mean annual temperature is probably about 53° Fahr., but the position of isotherms it is not possible to state with exactness. Eight stations on the Union Pacific, from Brookville to Ogalallah, give a mean average for 1887 of 56°. Observations from the northern counties, and for more years, would probably reduce this. One of these stations gave 113° for the maximum and −15° as the minimum for the year. The lowest winter temperature given is −20°. It may be said that the highest temperature of the summer is not unbearable on the high prairie, and that the maximum given above is not duplicated anywhere in the region.

Precipitation.—This term includes rain-fall, snow-fall, and dew. In the early days of settlement there was a very little dew in northwestern Kansas; there is now much of it, especially in the spring months. The quantity of dew is not measureable except by a statement of the number of days on which it occurs. Further on we shall notice the probable significance of the increase of dew. Rain and snow are classed together under the term rain-fall, 10 inches of the latter being about equivalent to 1 of the former. Whatever the quality of soil or skill of the farmer, it is necessary that moisture shall be within reach of growing crops. If there is no rain-fall there must be irrigation, as in Egypt, or the land will be a desert. Again, the rain-fall must not only be sufficient in quantity, but it must come at the right time. The rain-fall of Kansas generally is greatest in the four growing months—April, May, June, and July—more than half the year's precipitation taking place in those months. The quantity falling is less, however, in western than eastern Kansas. Rain records have not been kept for any length of time in this region with any regularity, but seven years at Fort Wallace, in the extreme west, before any settlement of that or the neighboring counties (1875–1881), shows an average annual rain-fall of very slightly under 19 inches.

Five stations in Saline, Ellsworth, and Russell Counties give an average in 1887 of 25 inches. It would appear that the annual rain-fall is not too small to support vegetation or make prosperous the operations of the farmer, for good crops have been raised in the counties of Norton, Decatur, Rawlins, Cheyenne, Sherman, and others of the extremely westerly counties, as well as farther east, when it can not be said that there was exceptionally large rain-fall. But there is a defect in the rain-fall that seems to be climatic, and which, if it be moderated in the future, will only be so very slowly. There is in many western counties a spell of dry weather of two to four weeks in duration in July. This results often in damage to the corn crop. Wheat may have been harvested in fair quantity before this, and green crops, turnips, millet, sorghum, will do well from rains in August. If this fact be recognized, and corn of rapid maturity be planted very early or very late, this damaging time may possibly be defied.

Good farming and persistent breaking of prairie, planting of trees, may gradually improve the hot season, but the present generation can scarcely hope to benefit by it; but by going around the difficulty and putting to best use "the early and latter rains" they may not suffer so much as by simply farming on methods that were good in the rainy East or South.

Winds.—The prevalent winds of the region are north and south, south predominating largely. On the high plains of the more western parts there are, however, more variations to east and west than in eastern Kansas. The winds blow most of the time. There are few quiet days. The breezes make bearable the heats of summer. There are, however, two winds in western Kansas that are unpleasant and damaging or dangerous. Fortunately they are never long continued. The first is the blizzard of winter, rarely felt before Christmas, never after the end of March. It is unusual to have more than one or two in the season, and they do not last more than forty-eight hours. They are the mere fringes of the snow-storms which in the States and Territories farther north are so terrible. The other wind which is never welcome is the hot wind of summer, coming mostly from the south. It is this wind that is usually held more responsible for damaged crops than the lack of rain in July. But the two facts coincide often, and so give the maximum of damage. It is after one or two weeks of hot sun that the hot wind blows. It lasts one, two, or three days, and sometimes more. Corn-fields are literally burned up; those whose cultivation is the poorest suffering first and most, so that the poor settler whose single team is not strong, and has therefore not done the best work, and who may be depending on a single crop, sees his season's work wasted. The remarks made above about the choice of crops to raise apply here as well as in view of rain-fall. There has long been an opinion that the hot winds came from the far south and southwestern Territories. Settlers in western Kansas and those who have traveled much on the plains are of the opinion now that many of them are of local origin. Two facts may be mentioned that sustain this view: One is that sometimes the winds come straight from the north or west and is encountered suddenly, and its origin can be seen in the intense radiation of heat from burnt prairie, or otherwise bare earth or thinly-covered with vegetation; secondly, the failure of crops from this cause is not universal, but in streaks and patches. Counties as far removed from one another as Smith and Sherman and Scott this last season have had districts where all corn was destroyed and others where there has been a good yield. Still there are hot winds that come on gradually and last long enough to show that they are of distant origin and wide-spread influence. It is fully believed that the local hot winds will be modified and ultimately terminate by the persistent cultivation of the soil, the breaking up of the prairie, the planting of trees. Rain-fall may not be increased, but humidity will be more distributed through the season and the intense reflection of heat diminished.

STATEMENT OF O. ST. JOHN ON THE PHYSICAL CONDITION OF SOUTHWEST KANSAS.

[Forwarded by the State Board of Agriculture.]

The region especially referred to comprises the counties lying south of the Arkansas River and West of Medicine Lodge River, viz: Morton, Stevens, Seward, Meade, Clark, Comanche, the western portion of Barbour, Kiowa, and those portions of the counties of Ford, Finney, and Hamilton lying south of the Arkansas, including the disorganized counties of Gray, Arapahoe, Sequoyah, Grant, Kearney, and Stanton, embracing an area of about 10,000 square miles, or 6,400,000 acres, wholly comprised in the Arkansas drainage system.

The Arkansas, which forms the northern boundary of the district, has a general course a little south of east from the point where it enters the State, in Hamilton County, some 70 miles north of the southwest corner, for a distance of 132 miles, to the eastern border of Ford County. Here it is deflected to a northeasterly course, forming the great bend, which embraces the almost as extensive, fertile, and populous region comprised in the counties of Stafford, Pratt, Kingman, Harper, Sumner, and portions of Sedgwick, Reno, Rice, Barton, Pawnee, and Edwards, lying to the east of the present district.

The Arkansas, along this part of its course, receives very few affluents on either bank, and none of these are of considerable size, save Bear Creek, which rises to the west of the State line and drains an important fertile area within the limits of Hamilton county. Many of these affluents, before reaching the river, sink in the loose soil that composes its broad bottom plain, and Bear Creek on entering the belt of sand hills that borders the south side of the valley, ends in a deep basin or sink, whence its waters percolate by underground channels to the main stream. Few of these streams afford permanent supply of water, and during the greater part of the year, except here and there the presence of water-holes, their beds are marked by a ribbon of sand. The Mulberry, in Ford County, is the next largest stream on the south side of the river. None of these streams to-day have any timber, except a few scattering trees along the courses of some of the north-side affluents in Hamilton County. Indeed, along the banks of the Arkansas only a slender belt of cottonwoods is seen in the same quarter.

The greater part of the district is watered by the Cimarron, which enters the State near the southwest corner in Morton County. Flowing northeasterly a distance of about 60 miles to the southwest portion of Finney County (or the southeast part of Grant County), it swerves to the southeast, crossing Seward County diagonally, and enters Indian Territory near the middle of Meade County, whence it flows easterly some 30 miles, just south of the State line, to the middle of Clark County. At the latter point the stream bends to the north, flows through the southeast portion of Clark, and finally leaves the State in the southwest part of Comanche County. The great bend to the west embraces nearly the whole of Stevens County, a gently undulating plateau traversed by no considerable drainage channels. Indeed, all the principal affluents of the Cimarron within the limits of the State gain the stream upon its north bank. In the west the North Fork and its tributaries drain the southern and northern portions of Hamilton and Morton counties, gaining the main stream in the southeast part of Finney (near the southeast corner of the disorganized county of Grant. In the middle section Crooked Creek drains a large area, including Meade and the southeastern and southwestern portions of Finney and Ford Counties. In the eastern section Six-Mile, Big Sand, Bear, Day, Bluff, and Cavalry Creeks and their numerous affluents drain Clark and the western portion of Comanche, to the east of which the drainage flows to the Medicine Lodge and South Fork of the Arkansas.

The Cimarron rises far to the west in the region of the eastern plateau extension of the Raton Hills, in northeastern New Mexico, where indeed its volume is much greater than it is along that part of its course within the bounds of Kansas. It is here a small brook only a few yards wide, and in places during a portion of the year its waters are lost in the sandy bed. In early summer its low banks are sometimes overflowed. The above-mentioned affluents mostly afford pools the year round, and like the larger stream they are subject to overflow from the heavy local rains that occur during the summer months. In the past these pools were the resort of the herds that pastured the adjacent plains, and the Cimarron Valley was, until recently, entirely occupied by stock ranches and thousands of cattle. The recent immigration of agricultural communities has changed all that, and to-day the valleys and plains are dotted with every description of domicile from the "dug-out" and sod-house to plank and stone dwellings, and the uncultivated prairie is everywhere covered with smaller herds and flocks, which are furnished abundance of pure water from wells.

As was surmised from the results of the few experimental tests made prior to 1884, abundant supply of good water may be obtained in wells almost everywhere in the region here referred to. The subterranean sources that supply the wells are encountered at variable depths, ranging from a few feet to above 300 feet. The water stratum apparently forms a shallow basin, the center of which lies in the southern portion of Finney County, where at present are found the deepest wells. The almost absolute assurance of reaching water by digging or boring certainly greatly lessens the hardships of the necessary expense in seeking water by this means. The pleasant custom often followed by some of the settlers of locating their dwellings on adjacent corners of quarter-section tracts, forming snug little hamlets, makes it possible to reduce the cost of a deep well to the individual by making one excavation supply the needs of four families. The reported failures to reach water are very few, and over far the larger part of the area the average depth will probably fall short of 100 feet. In no instance does the water in these wells rise to the surface, and generally it stands only a few feet above the point of inflow.

The water of the Cimarron is slightly brackish along the lower portion of its course in the State, as is also that of Salt Fork, but this in no respect injures it for stock purposes. Beyond the limits of the State the former stream expands into wide shallow flats, which receive annual deposits of salt from the evaporation of the overflows, which it is said have accumulated in places to the depth of a couple of feet, and where the natural product may be shoveled up by wagon-loads. All the tributary streams afford good water, some derived from springs, which, though not of very frequent occurrence, are met with at various points. Spring Creek, a west-side tributary of Crooked Creek, in the southwest portion of Meade County, is supplied with a clear flowing current from numerous springs along its upper course. At Evansville, in the southeast corner of Comanche County, a copious spring issues from the tertiary gravels on the borders of a pretty little valley tributary to Indian Creek, at the Comanche Cattle Pool's Ranch. And elsewhere in the district springs appear in the valley sides or are recovered by means of shallow excavations.

The shallow depressions characteristic of the gently undulating uplands that so widely prevail in this southwest region very generally form receptacles for the accumulation of the surface drainage of more or less considerable areas, which for a part of the year at least are converted into shallow ponds, and the remainder of the season appear as vegas of dark green herbage. Even the larger of these basins, like Deep Basin and Wild Horse Lake, in the southeast and northwest portions of Finney and Meade Counties, which when filled to the brim by the rains of the early season are very pretty little bodies of water, are known to become dry during the fall and winter months. There are other pools and sinks, like that in the course of Bear Creek, which is said to be a deep funnel-shaped basin formed in the loose soil of the sand hills, affording a perennial supply of water. In the valleys of the Cimarron and some of its tributaries small alkali basins are met with, but these comprise areas of inconsiderable extent, and are indicated by the usual efflorescence emanating from the soil composing their margins and beds. Some of these pools are very pretty features in the valley landscape, like those in the north tributary valley of the North Fork of the Cimarron above Ulysses, which are frequented by a variety of water fowls in the spring and autumn months.

* * * * * * *

Far the greater part of the district comprises a gently undulating prairie, with a moderate southeasterly declivity in the direction of the drainage courses which furrow the surface. While the altitude ranges between 1,500 and 3,300 feet, culminating in the upland summit between the Cimarron and the Arkansas on the western border of the State, the relative elevation of the uplands above the stream levels rarely exceeds 200 feet. The Arkansas occupies a broad shallow valley comprising an immense area of level bottom-land, usually presenting two low benches, the narrower of which forms the present flood-plain along the margin of the stream, and which affords valuable meadows. The stream itself presents a very uniform appearance—a broad sandy bed threaded by shallow channels, and bearing grassy islets, and confined within low earth-banks. In places the bars are composed of gravel; elsewhere treacherous quicksands prevail. The melting of the snow in the mountains about the sources of the Arkansas fills its banks brimful of turbid, sediment-laden water in early summer, when the volume of the stream is at its greatest. The bordering uplands present some variety of grassy declivity, generally long, gentle slopes, retreating in the vicinity of tributary valleys, where the bottom-lands present magnificent expanses of level plain, elsewhere approaching the stream in low bluff declivities broken by rocky ledges. To the west the bluffs become somewhat more abrupt, showing one or more limestone terraces.

While the foregoing features are met with along the north side, quite different appearances obtain on the south side of the valley throughout the course in the district. This is due to the presence of sand, which, in the course of comparatively recent times, has accumulated to such extent as to form a nearly uninterrupted belt of sand hills of variable width, 1 to 10 miles, along the south border of the valley, and presenting marked contrast to the soil-mantled slopes of the opposite side. The surface of the sand-hills belt exhibits the uneven contour of downs, and that their origin is attributable to the action of winds as the transporting agent, seems highly probable. Although their surface is to-day clothed with a more or less dense growth of herbage, a sort of rank, brown-topped bunch-grass being the characteristic prevalent variety, in places still exist patches of loose, bare sand, where the tireless action of the winds may be witnessed under conditions identical with those encountered along the sea-board. The surface rises into irregular hillocks, with intervening and often quite deep basin-like depressions, having no connection with the infrequent drainage channels that traverse the belt, and south of Garden City they culminate in elevations at least 100 feet above the Arkansas. From these elevated points the contour of the sand hills may be best observed, presenting an irregular, rolling belt, strongly contrasting to the gentler undulating, smooth, buffalo-grass-carpeted plains to the south, as also the north-side uplands. Many of the basin-like depressions in the sand hills are based upon a firm, brown soil in no way distinguishable from that prevailing in the adjacent prairie surface, and like it also in being covered by a mat of buffalo-grass. The occurrence of these remnants furnish additional evidence bearing on the inference respecting the comparatively modern formations of the sand hills, and their probable encroachment, through the agency of the winds upon the earlier formed prairie surfaces that once swept down in gentle slopes from the upland levels into the valley.

The sand hills, though unfit for agriculture, are by no means barren wastes. They are more or less densely clothed with a variety of grasses which afford fair pasturage, and abundance of water doubtless may be obtained by means of wells. The belt varies in width from 3 or 4 miles at the State line to about 10 miles at a point south of Lakin, to the east of which it as gradually diminishes in width until in the vicinity of the Mulberry it forms but a narrow belt. East of the Mulberry it again increases in magnitude, a wide arm drifting from the bend in the Arkansas between Dodge City and Kinsley, in an easterly direction across the northern tier of townships in Kiowa County. A gently undulating plain stretching east and west from Wendal in Edwards County, intervenes between the south range of sand hills and the narrower belt bordering the Arkansas, between which latter and the river occurs a wide and exceedingly fertile valley plain upon which are located many fine farms. Water is obtained at moderate depths in wells, as is also the case in the sand-hills belts in this quarter.

South of the sand hills stretches the great upland plain that extends over to the Cimarron. Its surface features present a more or less gently undulating contour, marked by broad, low elevations and intervening wide levels. A remarkable uniformity in the character of the soil obtains over the greater part of the area, consisting of a slight brown, fine loam, possessing the constituents of fertility, and tractable under cultivation. Bordered on the south by the Cimarron, along which the upland breaks in more or less abrupt declivities, it is traversed by many valley depressions occupied by tributary streams, and which exhibit a variety of appearances. In the northwestern section a considerable area is tributary to Bear Creek, which opens out into a wide shallow valley, bordered by comparatively moderate grassy slopes; farther west the valley narrows, and the stream is excavated in the Cretaceous sandstones that often outcrop in the low bluff ledges. The stream itself is deeply eroded into the soil, and for a portion of the year its course is marked by a dry, sandy bed.

South of Bear Creek the drainage of North Fork of the Cimarron has fashioned similar valleys, separated by low, sometimes gravelly, ridges, and showing at intervals low bluffs along their courses. The lower course of the North Fork is hemmed by steeper upland slopes, rising in benches, and the bottom-land is somewhat sandy. The stream flows between steep, grassy banks, and even its bed is often grassed over like the meadow swales along its margin. South of the Ulysses the upland on the south rises about 100 feet above the valley, the south-side brink commanding a fine view of the Cimarron Valley. This upland flat extends far to the southwest between the parallel courses of the main and lesser streams, averaging about 5 miles wide, and generally occupied by recently commenced farm improvements.

Water, which is not abundant the year round in the streams, is reached in wells at various depths in the region here referred to. In the upland between the Cimarron and the North Fork, wells reach depths of from 50 to 170 feet, as in the vicinity of Taloga and Frisco, and at Richfield 50 feet. To the north of the latter place in the uplands south of Bear Creek, the depth varies from 100 to 170 feet; the latter depth was reached at Johnson City. To the north, in the valley of Bear Creek, the depth diminishes to 60 feet, as also to the east in the vicinity of Shockyville and Surprise, where water is obtained at 35 to 75 feet. But in the uplands north of the latter valley the depth reaches 170 feet.

The Cimarron, throughout its course within the limits of the State, occupies a well-defined valley, and is bordered by low meadow intervales, sandy and gravelly benches, and grassy upland slopes, which rarely reveal the nature of the strata in which the valley is excavated. Along the upper portion of its course, in Stevens and Morton Counties, the border slopes attain elevations of 75 to 125 feet. The higher acclivities occur along the north side of the valley, and present, as seen from above, a range of quite abrupt bluffs running out into high rocky points dominating the valley, as at Point of Rocks, a few miles east of the State line. The valley gradually deepens to the east, and below the confluence of the North Fork the border slopes attain an elevation upwards of 200 feet, exhibiting interesting effects of weather action on the soft variegated strata composing the bluffs. The lower course of the river within the State flows through a wider, shallower valley plain, which, in Clark County, is occupied by belts of low sand-downs, and hemmed by gentle acclivities, broken here and there by low rocky bluffs, like the gypsum bluffs on the borders of Clark and Comanche Counties.

The considerable area embraced in the great bend and lying between the Cimarron and the State line on the south, comprises an undulating upland, the surface features of which are very similar to those met with to the north. This area includes Stevens and the southeastern and southwestern half of Morton and Seward counties respectively. The surface drainage is performed by shallow draws, which, on the eastern and more abrupt border, debouched into deeply-eroded ravines, which score the edge of the upland on that side. This plain gradually rises from the edge of the Cimarron Valley southward, culminating on the southern border of the State, where it is loaded with heavy accumulations of sand, forming characteristic low, irregular, hills. This sand-hills belt is apparently similar in origin, as it is also in position, to that traversing the northern townships of Kiowa County on the Arkansas, previously mentioned, or an offshoot from the sand-hills at the west end of the great bend of the Cimarron. The plain is hemmed on the north by sand-hills which form a nearly uninterrupted belt, 1 to 3 or 4 miles wide, following the south side of the Cimarron Valley, presenting the same characteristic features as elsewhere ascribed to the sand-belts, their rolling conformation of surface, old prairie basis, and mantle of herbage with which they are clothed. But in the latter section, the drifting of the sand has extended the area of the sandy loam soil, which forms a wide, outlying belt flanking the sand-hills, and encroaching on the fine loam lands characteristic of the original prairie surface, as met with in the central portion of the area. This sandy loam, characterized by strips of blue-stem and bunch-grass, interspersed with patches of buffalo-grass, is fertile, and capable of growing excellent crops, as the past season's experience affords ample proof. Twenty to thirty bushels of sod-corn per acre were produced on this soil, besides other cereal crops and vegetables, and the various sorts of native and fruit trees thrive as well in these situations as upon the ordinary prairie soil. Water collects in shallow pools, affording temporary supply for stock, and excellent and abundant supply is obtained in wells at depths of 75 to 130 feet. At Hugoton, near the center of this area, water was reached at 80 feet; to the east and west the depth of wells increases.

Isolated and considerable areas of sand also occur on the east side of the Cimarron, along the edge of the uplands bordering the valley. In the latter quarter similar modifications in the original character of the upland soil, due to the encroachment of sand upon the adjacent prairie surface, are met with, as have been already noted, on the south side of the valley. These sand-hill areas continue eastward past the confluence of Crooked Creek, to Big Sand Creek, in Clark County, beyond which they occur in low hillocks occupying the widened valley plain.

A large part of the upland plain lying to the northeast of the Cimarron, embracing the northeast portion of Seward, the southern portion of Finney (or the old county of Arapahoe), and nearly the whole of Meade County, belongs to Crooked Creek drainage. The western portion of this area presents a gently undulating surface, with a light-brown, fine loam soil, and clothed with a luxuriant growth of buffalo-grass. The sources of Crooked Creek furrow the surface with shallow draws, with grassy beds, and pools of water. Within Meade County the valley gradually deepens, with gradual border slopes, and occasional groves above the north bend. The Arkansas-Cimarron watershed is here crowded far to the north—the summit lying less than 12 miles south of the former stream, and presenting a broad, low, undulating upland, scarcely more conspicuous than that separating the Mulberry from the Arkansas, which, southwest of Dodge City, scarcely exceeds 175 feet above the latter stream. In the region of the great bend the valley forms a broad vale, from which the surface gradually rises into the general upland plains on the east and west, in the midst of which are situated the villages of Wilburn, Pearlette, and Fowler. The stream here shows reaches of water between low, grassy banks, and margined by meadow intervales. To the south the valley becomes deeper and the border slopes steeper, with occasional exposures of rock. Below Meade Center, in the vicinity of Odee, the borders become quite abrupt, rising 150 feet above the stream, and cut by deep ravines. Several pretty little spring-fed streams here descend the west slope, their valleys widening on approaching the main valley, with extensive meadows of blue-stem. Along the lower course of the stream its waters sink in the sands composing its bed.

In the high prairies of the southern part of Finney County, water is obtained in wells at depths ranging from 65 to 336 feet. The greatest depth of the water-bearing stratum is found at Santa Fé, about midway between the Arkansas and the Cimarron, the average depth of wells in the region being about 160 feet. To the east, in the slopes occupying the great bend of Crooked Creek, water is reached at depths of 30 to 50 feet.

East of Crooked Creek a similar undulating upland forms the dividing ridge between that stream and numerous smaller affluents flowing southeasterly to the Cimarron, and curving round to the northeast, it merges into the high prairie of the main watershed that extends eastward along the northern border of Clark and Comanche Counties. East of Meade Center the summit reaches an elevation of about 100 feet above Crooked Creek. To the east the surface descends in a succession of broad, low undulations, gradually becoming more and more broken as the water-courses deepen their channels. The sources of Big Sand, Bear, and Bluff Creeks, in the northwest portion of Clark County, score the upland with deep ravines, giving the declivities a rugged character strongly contrasting with the tamer topographical features prevalent to the west. However, the lower courses of these streams flow through broad valleys, separated by undulating low uplands based upon the gypsiferous red-beds, which impart to the warm loam soil its peculiar color. The aspect of that arm of the highlands separating the Big Sand and Bear Creek drainage from Bluff Creek is peculiarly broken, showing high, dome-like hills, mesas, and headlands, commanding a most instructive view of their deeply eroded banks, the lowlands of the Cimarron and the upland heights far to the south beyond the limits of the State. Except the more broken belt at the sources of the streams, and which afford good pasturage, and the sandy intervales bordering some of the streams, the region possesses fertile soil, and is well adapted to agriculture. In the lowlands the soil is a warm, reddish loam, while in the highlands a light-brown fine loam occurs, identical with that prevalent in the region to the west. In the latter quarter water is found in wells at depths of 75 to 125 feet east of Meade Center, and at Letitia, in Clark County, 109 feet; in the lowland section, wells vary from 20 to 75 feet in depth.

Bluff Creek, the easternmost important tributary of the Cimarron within the State, drains an area of over 500 square miles, in Clark and Comanche Counties. The main stream, as also its principal affluents, Kiowa and Cavalry Creeks, rises in the great divide, the first few miles of its course being bordered by gentle upland slopes. As the stream deepens its bed in its southeasterly course through the northeast part of Clark County, it is confined between steep bluffs, and lower down in the vicinity of Lexington, the valleys widen, with long intervening slopes between the intervale and the upland heights. Below the confluence of Kiowa Creek, whose sources have similarly scored the southern flank of the divide, it presents a broad valley expanse, occupied by low, gently-undulating bench-lands, offering inviting agricultural locations, and finally merges with the more or less sandy plain bordering the Cimarron, in the southwest corner of Comanche County. The wide west-side slopes, after leaving the highlands, are composed of a reddish-brown soil, which also occurs in the low uplands between Bluff, Day, and Bear creeks. The east slopes are more sandy, and the summit traversing the central portion of Comanche County, and forming the watershed in which the Nescatunga, or Salt Fork, of the Arkansas rises, bears a belt of low grassy sand-hills lying between Coldwater and Nescatunga. Cavalry Creek is bordered by moderate upland slopes, which along the lower portion of the valley terminate above in a line of low bluffs which form the western rim of the broad shallow flats about the sources of Salt Fork. The ridge reaches an elevation of about 225 feet above Bluff Creek, and is an interesting geological feature, being based upon the gypsiferous red-beds, and crowned by a remnant of the lower Cretaceous.

The Salt Fork of the Arkansas, and its numerous affluents, perform the drainage of the central and eastern portion of Comanche County, and the southwest portion of Barber County. The main stream, which rises in the upland flats east of Cavalry Creek, flows easterly along the north border of the southern tier of full townships to near the east line of Comanche County, and thence southeasterly beyond the limits of the State. The upper course is merely a deeply-eroded draw, traversing the shallow, basin-like plain known as "Koller Flats;" but below Avilla a few miles, the stream is bordered by intervales and hemmed by bluffs, which gradually become higher, descending the stream to the eastward, and in the vicinity of Evansville the south side presents buttes and lines of precipitous bluffs, with a heavy coping of light-gray gypsum, resting upon red-beds. Several affluents gain the stream upon both banks, those to the south deeply scoring the north declivity of the highlands extending east from the Cimarron along the State line. The north-side upland is also drained by several tributaries which occupy pretty little valleys. The most important of the latter is Mule Creek, which drains the northeast portion of Comanche County and the western border of Barber County. Throughout the greater part of its course it occupies a well-defined valley, the sandy flats bordered by sloping benches that rise into the steeper declivities of the neighboring uplands 150 feet or more above the stream. Like the other tributaries, the stream is a clear, rapid, shallow current, its tortuous course lined with trees, indicating the rapid declivity of the stream-bed. The whole region above alluded to is clothed with a luxuriant growth of native herbage, the uplands occupied by the nutritious buffalo grass, and the valleys with bluestem meadows, affording abundance of hay. The undulating uplands here present a greater variety of soils, due to the diversity in character of the subjacent geological formations from which they are derived. With the exception of the sandy intervales bordering the water-courses, and the arm of sand reaching eastward from Cavalry Creek valley, the general character of the soil is a warm, fine loam, in places gravelly, and generally fertile.

The uplands east of Mule Creek, in the western portion of Barber County, present a much more rolling surface. The drainge channels are deeply eroded into the peculiar red deposits prevalent in that quarter, and certain sections present quite broken and even rugged surface features. Yet, even here, the narrow summits of the ridges separating the streams often expand into undulating areas, affording favorable locations for farms, as is the case in the upland between the Cimarron drainage and that flowing north into the Medicine Lodge. The latter stream, a clear, rapid brook, winding between low banks over a sand and gravelly bed, here occupies a beautiful valley, hemmed on the south by precipitous red bluffs, capped by a heavy ledge of gypsum, which form the edge of the broken uplands which rise into heights 200 feet or more above the stream. The space between the foot of the bluffs and the stream is occupied by a sloping bench, from which the red escarpment rises to a height of about 150 feet above the valley. The slope on the north side more gradually rises into the great divide, and is unbroken by conspicuous bluff escarpments. Toward its sources, in the southern part of Kiowa County, the stream flows in a broad, shallow valley, from which the surface gently rises into the neighboring upland summits. Indeed, Kiowa County presents a remarkably uniform undulating surface, except the southern tier of townships, in which the south-flowing streams take their rise, the erosion of their beds having produced a more rolling surface contour.

STATEMENT OF MARTIN ALLEN, OF HAYS CITY, ON HOW TO INCREASE AND PRESERVE THE WATER SUPPLY.

Suppose the prospector to be where the surface is reasonably level, and the depth to the water level be 60 feet, and shale is found at one-half this distance. Abandon that prospect at once and try, say, 100 feet therefrom, and if the shale is here found at 46 feet deep, go another hundred feet in the same direction and he will have a reasonably sure thing of getting water at 60 feet and above the shale. With this system of prospecting and its various modifications, adapted as they may be to each particular case, good sweet water can very generally be obtained in central Kansas by digging or boring for it. In some places, however, there are high, smooth localities with the best of soil, where the water is very deep, and other places where the shale is more persistent, and still others where the natural water is not good. In all such cases there is one simple and efficient remedy, that of putting in one or more cisterns, as may be needed. These may be an excavation in the ground, walled on the sides (which may be either square or circular), and well cemented, being covered by an arch or other suitable device. They should be so located that the water can be led into them by a furrow or other device, when such cistern can be very readily filled each winter or spring from the melting snow led from a drift, that can always be depended upon for a supply as sure as the snow falls and the wind blows, by using a fence, a row or two of trees, corn or sorghum stalks, or even weeds, to stop the fullest fury of the winds and snow with it. In this way there need be no failure to obtain at reasonable cost an ample supply for household use of the best of water. If it be not clean or clear enough, a simple brick wall through the center of the cistern—filling it from one side and using from the other—will cure the difficulty. If the cistern is shallow, as it should be for ease in drawing water, and it becomes too warm for drinking, an occasional hundred pounds of ice dropped in during summer will cure this trouble.

In my first knowledge of central Kansas it had scarcely a furrow plowed in its surface, and the one rule most arbitrarily enforced was the annual burning off of the grass. Sometimes this was begun as early as July or August. This grass was very short, with none of the tall sorts, or any weeds. The earth itself was very hard and compact, much like a field used to corral a large herd of stock in a wet time. It turned water almost equal to a shingle roof. These were years of extreme floods, and practically without the "dews of heaven." Since, however, we have a few plowed fields as reservoirs to hold water, and have put an end to the wholesale burning of the grass; the vacant land is much heavier coated, and with a large increase in the tall sorts. Weeds also abound wherever they can get a foothold. These all tend to prevent the old-time flow of water into the streams and out of the country, as well as to prevent rapid evaporation. They often gather snow drifts on level land (when before it blew away); this melts and soaks into the ground.

The result of all these influences were without any perceptible increase in the annual rain-fall. Places that were bare only a few years ago are now well covered with herbage; the atmosphere is more moist, trees are now succeeding that could not a few years ago be coaxed from one year's end to another; cellars can now be dug with a spade, or plow and scraper, when a dozen years ago the pick would have been the only effectual tool, and the genial dews are no longer strangers to us.

Among the elements that may here be mentioned as valuable aids in the retention and preservation of water are, plowing the soil or breaking the crust so that water may the more readily penetrate it, which may be followed by subsoiling or trench plowing, so that a surplus of water at any time may the more readily sink down deeply, where it will be held in reserve for the time of need, and not be forced from necessity to pass rapidly over a hard and often sloping surface toward the sea.

Saving the natural growth of grass from being burned has from actual observation a most wonderful effect, not only in preventing the free passage of water following a rain-fall out into the neighboring streams, but to prevent evaporation as well. To understand these matters in their full force, the observer must, as I have done, both examine adjacent burned or unburned lands at time of and closely following a rapid rain-fall. And again, put a breaking-plow into both burned and unburned lands just at a time when it is getting too dry to break land with ease. * *

May not the plowing of a single furrow in the stubborn sod for a mile in length over the level plain be followed with taller grass, weeds, and even the taller sunflower along its line? When the snow comes a drift is found to the leeward of this line, and when it melts the water soaks into the ground; and thus is an additional supply, for the time being at least, preserved.

Again, let us, in working or making our public and private roads, do just the opposite of what the people are compelled to do where the surface of the whole country is more level and therefore moisture more abundant. Indiana and Illinois annually spend large sums of money to get rid of their surplus moisture along their highways; in other words, to cure their mud-holes by various devices of ditching, draining, filling, and putting in bridges, culverts, etc. All these are among what are known as public improvements over vast areas of the Eastern and Middle States, but deemed quite unnecessary in Kansas, especially in the central and western parts, that are supposed to be suffering from the want of moisture.

Now let us in making and working all our public and private roads, whether we need them or not, make dams wherever such roads cross over slight depressions. These will be found very numerous—say from three to five for each mile. But for the sake of argument let us suppose that there are only two to each mile of road and a road on every section line: this calculation would give to the western two-thirds of our State the enormous number of 212,800 such dams. And suppose these on an average to each cover one-fourth of an acre, and to be an average depth of 1 foot; the vast amount of water that can be retained by this simple method can readily be figured out.

STATEMENT OF H. R. HILTON, OF TOPEKA, ON MOISTURE ECONOMY.

One theory of general acceptance is that the loosening of the soil more freely admits the air, which gives up part of its moisture when brought in contact with the cooler soil. This theory will be true while the soil is cooler than the atmosphere, but when the atmosphere is cooler than the soil, which will generally be the case between midnight and morning, than the soil must, on the same principle, give up part of its moisture to the atmosphere. In striking a balance the greater gain would probably be with the soil, but the actual gain of the moisture obtained from this source will not account for the benefits that frequent loosening of the soil confers when showers are infrequent and temperature high; and we must attribute the good results that follow, not to the moisture robbed from the atmosphere, but rather to that saved and economized in the earth.

The location of Kansas, between the fortieth and thirty-seventh degrees of latitude, subjects it to high temperature in the midsummer months; and if an interval of two or three weeks occur without rain—and this is to be expected in July and August—then the best methods that the intelligent farmer can devise are necessary to tide the growing crops over these trying times. The injury that would result from the exposure of the corn crop—now one of our greatest staple products—to these intervals of dry, moisture-exhausting weather, can be very much modified, if not obviated, by knowing the capacity of the soil on the farm to receive and store water beneath the surface, and how this water is drained away from the surface soil to various depths in the substrata and pumped back to the surface again to supply the wants of the growing plants.

Of the rain-fall over a large area of the country it is estimated that less than one-half finds its way back to the sea, more than one-half being evaporated back into the atmosphere again. No tests have been made in Kansas to determine what percentage of the rain-fall is drained off in our streams, but owing to the larger acreage of unbroken primitive sod than of cultivated land, the surface drainage will naturally be greater than in countries where the greater part of the soil not covered by native timber has been cultivated at some time in the past. Eastern Kansas, owing to larger relative acreage cultivated, probably drains off less than half its rain-fall, while western Kansas drains more than half. The water drained from a deeply cultivated field will, however, be much less than the average of the country and the amount evaporated from it much greater. Only in instances when the rain-fall is excessive within a given time will there be much waste by surface drainage from a well-cultivated field. What escapes is mainly by subdrainage. We may say, therefore, that the rain-fall drained out of a country is, so far as the growing crop is concerned, rain-fall wasted or lost, and the rain-fall that is held in the soil and evaporated back into the air again is rain-fall utilized or saved.

The water in the soil not drained into the streams is evaporated at the surface or transpired by the growing plants. By the law of capillary attraction water ascends through the spaces between the fine particles of sand or clay, from the reservoirs below. The finer the sand or particles of clay, the smaller will be the spaces between, and the higher water will rise through these small nature-made capillary tubes. In very porous or friable clays or coarse sand or gravel the height that water will rise by capillary attraction is limited. The quantity of water raised in a given time depends on the capillary power of the soil. If fine and capable of raising water 20 to 25 feet, the process will be slow. If capable of raising water 10 feet, it will be much more rapid, the quantity being gradually reduced as the height is increased.

The same law applies to the drainage of the water from the surface and storing it after a fall of rain. The surface soil to depth cultivated takes in the water rapidly until fully saturated. If rain continues falling faster than the subsoil will absorb it, than the surplus must waste at the surface. The amount stored for future use is determined by the nature of the subsoil and capacity to absorb. If the capillary spaces are small, drainage will be slow; if large or coarse, it will be rapid. The law that elevates the moisture to take the place of that evaporated at the surface also draws or sucks the water down from the surface to the water reservoirs, or water level below, after each rain. It follows the law of supply and demand, ascending or descending as the point of greatest deficiency is at the surface or at the water level.

* * * * * * *

A stratum of gravel within 15 to 25 feet of the surface works an injury to the growing crops in a very dry season, unless it is constantly filled with water. This also will be true of solid rock, or anything that tends to break the capillary connection between the level to which the water drains and the surface.

Keeping in mind this law, let us take, for example, a corn-field in the month of June. The ground between the corn rows has recently been cultivated and the soil to depth cultivated is loose and finely pulverized. A thunder shower common to that month gives an inch of rain-fall. The ground to the depth cultivated rapidly absorbs the water until fully saturated. One-fourth to one-half of the additional rain that falls at that time will probably waste at the surface, because the compacted subsoil can not drink in the water as rapidly as the loosened surface soil. After the shower the subsoil, if not impervious clay, will gradually drain the water out of the surface soil, part of it to be drained off through springs into the streams and part of it to be held in reserve and returned again to the surface. The effect of the heavy thunder shower on the soil of many of our Kansas farms is to pack the soil. This packing establishes a capillary connection between the subsoil and surface, and permits the moisture to come to the surface, thus exposing it to the hot sun and air and rapid evaporation. To prevent this great waste the capillary connection with the surface must be broken by cultivation just as soon after the shower as the land is sufficiently drained of surface moisture as to be worked with a cultivator. The soil thus loosened and pulverized acts as a mulch, covering the compact soil underneath, in which the larger roots of the corn plant are lodged.

The point of evaporation is at the surface, where in July and August the mean temperature is fully as great as that of the air. The high temperature rapidly dries out the surface soil, and would rapidly exhaust what was stored in the substrata did we not take prompt measures to protect our reservoirs by cultivation. The moisture rises just as far as the soil is compacted, and finds its upper limits at the roots of the plants, where it is needed. The mulch of two or three inchesof loose soil forms a cool covering to protect it from the evaporating heat at the surface. The moisture in the subsoil is thus saved and economized for future use.

I feel confident that the experience of many farmers will confirm the statement that on clean ground, where the suppression of weeds does not figure, the corn that has been cultivated as soon after every packing rain as practicable has given the best results.

As we study this law of capillary attraction and understand the important relation it bears to successful farming, we must be impressed with the importance of a better knowledge of the physical properties, not only of the surface soil we cultivate, but also of the substrata. The method of cultivation will depend on the nature of the surface and the subsoil.

The law of capillary attraction as applied to development of the corn-plant and the conservation of moisture can be summarized by a homely illustration.

The corn plant is the pump; the temperature is the pump-handle; the water stored in the subsoil the well; the capillary tubes the pipe connecting pump with well; cultivation of soil is the packing at joints of leaky pipe-stem to prevent waste. The pump-stroke is determined by the temperature—slow in May, a little faster in June, and a long, rapid stroke during high temperature in July and August. If a pump that is being worked hard fails to throw water by reason of shortage of water in the well, its mechanical parts are injured, so when the hot days of July are at the pump-handle and the moisture is not supplied at the plant's roots as rapidly as it is being transpired through its leaves. then injury is wrought to the plant. The curling leaf in the heat of the day tells us plainly that the pump-handle is working too vigorously—that the supply of water in the reservoir is not equal to the draughts upon it. The return of the corn plant to its normal condition in the cool of the night tells just as plainly that the water supply is equal to the demand. But the corn plant can not recuperate many times from such overdrafts and if relief does not come in shape of a timely shower or lower temperature, the plant shows sign of distress in the "firing" of its lowee rleaves and whitening of the tassel. In a time when the reservoir is low and temperature high the advantage must be with the smallest-sized pump on the varietyof corn that exhausts the water supply slowest.

The luxuriant growth of the corn plant and of every species of vegetation during the showery months of May and June is something to which we "point with pride" as evidencing a very rich soil, and yet this great fertility that in normal seasons shows such wonderful productiveness is a source of injury to the corn plant in dry seasons like those of 1887 and 1888 in western Kansas. The height of the plant, thickness of stalk, and rich profusion of leaves require for sustenance an amount of moisture proportioned to the size of the plant. The ranker the growth of plant the greater its demands on the supply of water in the soil and the more quickly will the supply be exhausted.

If it is desirable, then, to economize moisture during our rainy and growing season, to carry our unmatured crops as far into the dry months as possible before ripening them, does not this suggest deeper plowing, thus increasing the capacity of the soil to receive and retain the rain that falls, and prevent the waste at surface? Except in very sandy soil, or in land where the subsoil is very porous, every field should be "subsoiled" at least once in ten years. Subsoiling is very necessary in prairie lands recently brought into cultivation. Our virgin prairies are "hide-bound" by the tramping for many years of great herds of Buffalo. Plowing 6 or 8 inches does not break through the hard upper crust and open the pores in the earth's skin. It requires subsoiling to aid it, and this should be as deep as plow and power can do it.

Subsoiling 12 to 15 inches will increase the rainfall of Kansas by saving nearly all that is precipitated over the land so plowed. Intelligent cultivation to conserve the moisture, as well as prepare and supply food to the plant, will greatly increase production.

Keeping constantly in mind the law of capillary attraction, it is easier for us to understand what an important part the buffalo played in producing an arid climate suited to their life and wants. The constant tramping of their feet year after year manufactured a clay roof over the soil of the greater portion of the plains. It was almost water-proof. The rain-fall, probably as great then as now, was rapidly carried into the streams and out of the country to the sea. What little found its way into the soil was soon evaporated because of the capillary connection with the surface afforded by the trampled soil. Only the buffalo grass, with its long, slender roots penetrating deep into the earth and capable of maintaining its existence on a limited supply of moisture, could survive in such a hard-packed soil. This buffalo-trodden, sun-baked soil, aided by the bleached color of the buffalo grass, reflected the sun's heat back into the atmosphere, producing an arid climate even in seasons when the rain-fall, if utilized, would have been sufficient for crop production. The pioneer settlers following close upon the retreating buffalo, or large cattle herd, had to dig their cellars with a pick. Fifteen years later a cellar could be dug out of the unbroken prairie on similar ground with a spade. The effect of the winter frost is to loosen the surface soil. With no buffalo or cattle at hand to trample it firm again and stop the threatened leaks the spring rains worked into the soil a little, softening the surface. Each succeeding winter's frost and summer's rains, when left to work out this problem in their own way, undisturbed by wild or domestic animals—for the pioneer settlers had but little live stock—changed the nature of the prairie sod by making it more mellow and receptive, taking into the soil more of the rain-fall than was possible when the prairies were under the régime of the buffalo.

A ranker growth of grass followed the mellowing of the surface and increase of moisture in the soil. The fire-guards of the settlers; the prairie-wagon trails, and the patches of breaking here and there, all combined to protect the grass against prairie fires and promote the preservation of the grasses. These in turn shaded the ground more from the sun and retarded the drainage of the water from the surface by holding it in check. Thus the ranker grass on unpastured and unbroken land aids in storing the rain-fall and in preserving it when stored, so that after ten or fifteen years cellars can be dug with spade, where formerly the pick was used. If the condition of the soil could be so much modified by simply "resting" the land from wild and domestic animals, how much more benefit must follow the breaking up of the prairie sod, which, after a few years' cultivation, opened the pores in the earth's skin and induced a more natural, healthy action of the system.

The blue-stem grass covers more than double the area of Kansas that it did thirty years ago. It has always followed in the wake of settlement, and rarely preceded it. It could not find a foothold in the hard, dried-out soil of the buffalo grass. As the ground gradually softened and increased its water absorbing and saving qualities the blue stem increased. We find it in advance of settlement only in the sand hills or sandy river bottoms that, owing to small per centage of clay, do not pack like the level prairie lands. Here the rain-fall was absorbed rapidly, and the substrata seem also to have wonderful capillary power in raising moisture from below. The blue stem selects the most moist spot on the prairie for a beginning—first a few spears, next season a little larger, many nuclei are started, and these grow and spread, smothering the short buffalo by its ranker growth, till the whole surface is covered.

It is noticeable that where the blue stem has taken possession of one-half of the ground, and is fenced off for pasture and stocked with cattle, that the buffalo grass more than holds its own against the encroachments of its stronger neighbor; but if a similar tract is kept as meadow and free from stock that the work of substitution goes on and the blue stem prevails. Buffalo grass thrives and spreads on a tramped and compacted soil; blue stem requires the loosened and moistened soil for its best development.

The arid climate of the plains comes more from the tramping of many feet than from any other single cause. Entirely remove the herds and keep out the prairie fires and the climate of the plains will be modified. I do not pretend to say that the rain-fall will be materially increased or that it will be sufficient for all the agricultural products of that latitude, but the rain-fall utilized will be largely increased, the heat radiated from the surface will be less, the average mid-day temperature will not be so oppressive.

The natural drainage of the soil of Kansas, like that of all the trans-Missouri country, is superior to that east of it. The soil under deep cultivation will absorb a very large percentage of the rain that falls—at least four-fifths. The soil of central and western Kansas has a more perfect natural drainage than in eastern Kansas, excepting in some of its river bottoms. An average rain-fall in central Kansas of 25 inches will be equal to 30 inches in eastern Kansas, because of its better drainage and storing capacity and the better subsoil for raising water by capillary power, and we find the average production taken for ten years fully as great in central as in eastern Kansas.

Western Kansas averages less than 20 inches of rain-fall. This fully utilized may be sufficient for special crops requiring minimum supply of moisture; but whatever benefit, if any, that might result from deep cultivation with this rain-fall there is no doubt that central Kansas will be the beneficiary, for this cultivation and increased storage of the rain-fall on the frontier will temper the winds coming from the south and west to the country lying to the north and east.

I want to make one or two points a little clearer in regard to the water not getting up through shale. I am now talking only about the water that falls. If the water can not come up through the shale, it can not go down through it, and if it does go through it can come back again. Here is a body of gravel, say 20 feet below the surface. When it is full of water, the soil is moist. As quick as the rain falls it goes down very rapidly; but if that dries out in the warm summer and the soil is more or less dry all the way through, when you have rain it goes down very slowly; it would be good drainage until you get that all moistened and full of water again. When there is no moisture down below, the water will not drain down, and is then evaporated very rapidly. I forgot that point, and I want to call special attention to it; that when the soil is moist all the way down the soil drains naturally and rapidly; but when it is dry and there is gravel underneath you have got to have this full of water in order to suck it down.

STATEMENT OF ALFRED A. WOODWARD, SURGEON U. S. ARMY, OF FORT LEAVENWORTH.

That I believe practically the whole of what is generally known as the sage-brush country can be brought under agriculture by a system of wells reaching the deep water-bearing levels, and that, speaking generally, this would be less costly and more efficient than canals drawn from natural water-courses. But each large topographical section must present its own engineering problem.

I have no intelligent opinion to express as to the strictly sandy deserts. I believe, further, that the systematic cultivation of forests on the plains, and their preservation on the mountains, will materially aid in the distribution, if not in the actual increase of the annual rain-fall.

Attention is invited to the propriety of planting forests with the view of breaking the sweep of winds, especially from the south, whose course in the summer is so frequently followed by general desiccation. Such belts on a large scale, as suggested by Col. Charles F. Adams, jr., of Massachusetts, will probably materially modify the climate of Kansas and Nebraska in its relation to agriculture.

STATEMENT OF L. R. HARE, FIRST LIEUTENANT, SEVENTH CAVALRY, U. S. ARMY, FORT RILEY.

When I first went to Dakota in 1874 it was then considered impracticable to plant potatoes on high ground; experience since has shown the fallacy of such an assumption. The "Gumbo" grounds in the vicinity of the Black Hills produce as fine potatoes and vegetables allied to the potatoes as can be produced. Some of the lands in Arizona and New Mexico are especially adapted for producing onions and allied plants, but I know of none of these lands that would be at all useful unless water could be supplied.

I have not had sufficient experience in Kansas to justify a conclusive report, but I am satisfied that through the greater number of years a "dry spell" occurs which if it could be bridged over by artificial means would make a wonderful difference for the better in the result.

STATEMENT OF J. L. POWELL, SURGEON AND CAPTAIN, U. S. ARMY, OF FORT SUPPLY, IND. T.

It has been my privilege to traverse on horseback the greater portion of the arid belt located in the area of Texas, Indian Territory, Kansas, Colorado, Nebraska, Wyoming, Montana, and Dakota, and I dare say there are few persons who have been raised in the productive regions of the Atlantic or Pacific slopes, where all the conditions of rain-fall, temperature, etc., combine, under the operation of a regular cyclical law to give variety to the pursuits of man, who would not, at first sight, assume that every foot of territory east of the Rocky Mountains and situated in the area indicated would be utterly worthless for any purpose save that of grazing, and very much of it not even for that. Such were my impressions some sixteen years ago, upon the occasion of my first experience on the Western plains while serving as medical officer to various commands operating against hostile Indians. Since then I have had an opportunity of watching and noting what can be accomplished by courage and enterprise, even in a section so forbidding as that which it is proposed to consider, and the result has been to cause a material modification of my views, and to suggest to me a chain of possibilities for this Western desert, so to speak, which I think are neither visionary nor impracticable.

Wherever agricultural or horticultural pursuits have been attempted under the least favorable conditions the results have been more than gratifying, indeed surprising. Every measure of success, however, has had its concomitant of failure, which, I think, may be largely attributed to a wide-spread fallacy that prevails as regards an increasing rain-fall over the Western prairies. To my mind the data do not justify an affirmative conclusion on this point, and the results have been not only damaging but cruel.

To those who have fixed their homes in the valleys and near the banks of the small streams that here and there traverse the plains, the results have not been so unsatisfactory, and where they have been so situated as to make available for purposes of irrigation the water supply, which though exceedingly limited and circumscribed in extent, it has proved to be the only thing needful for the raising of every variety of farm and garden product. As long as the climatic conditions, chiefly as respects rainfall, continue as they are farming and garden pursuits must be confined to the narrow acreage of the villages, while the broad and expansive mesas will continue to produce the tough buffalo grass without hope of reclamation, save by artificial agency, and just so long prove to be the rock upon which the hopes and spirits of many a hardy pioneer will be dashed in a vain endeavor to extract from their parched surface the means of a livelihood.

From what has been said it will be readily understood that the amount of land available as homes for the annually increasing tide of immigrants to the West, constitutes but an insignificant portion of the millions of acres embraced within the territory that was formerly termed the "Great American Desert."

When it is considered that but one condition is necessary to bring this whole region, alike valley and plain, into a uniform adaptability to all the pursuits in which a rural people engage, the question of means to the end is one which assumes the highest importance and merits the wisest and most serious consideration.

It is admitted that the soil possesses all the elements of fertility. How then shall be supplied the other essential for successful tillage? What method, in the absence of the requisite amount of rain-fall, which is the marked peculiarity of the region in point, and by which circumstance it is so distinctly differentiated from all others, can be thought of or suggested as a substitute for cloud precipitation? There is but one source from which it is possible to derive the needful moisture that must nourish and sustain the farmer's crop, until seed time and harvest have passed, and this is to be found on the lofty peaks of the Rocky Mountains where nature has established a perpetual reservoir in the great snow heaps that are there annually collected and dissolved away and then sweep on unimpeded and unutilized to the ocean.

By taking up a map of the United States and tracing a line from its most northern boundary to the Gulf of Mexico and about midway between the Mississippi Valley and the Rockies, one will be struck with the number of water-courses of various size that will cross it as they make their way eastward, following the tread of the great watershed that they would be supposed to drain. Like the waters, however, that make the Colorado and Columbia Rivers, they, too, come from the mountains and not from the plateaus, through which they flow, for the amount of precipitation that annually falls on the great plains east of the Rockies is too small and too infrequent to require a channel to take it to the sea. What there is of it is quickly absorbed by the arid soil on which it falls. It is a remarkable and striking fact, then, that while these same plains that we are now considering are so parched and barren, on account of an almost entire absence of rain-fall, comparatively speaking, there periodically flows across them a volume of water that can only be described as incalculable. The annual rise and fall, uniform and at stated periods, of the Yellowstone, the Missouri, the Platte, the Arkansas, and other water-courses that have their sources in the great mountain chain that stretches north and south across the western portion of the United States, confirm this statement.

American enterprise, alert and ever on the lookout for a theater in which pecuniary recompenses will be the reward of energy properly applied, has already grasped the situation and at various points we hear of private or corporate measures being set on foot to utilize in the reclamation of the barren lands of the West the great waste of waters that annually runs to the sea.

Some three years or more ago, while on duty in the State of Colorado, I had an opportunity of becoming acquainted with a project that was inaugurated by a joint stock company for diverting a portion of the waters of the Arkansas River from its proper channel, for purposes of irrigation, by means of a canal, the exact dimensions of which I can not now recall. This canal, starting from a point well up to the foothills, that loom up towards the west, so as to give it sufficient elevation as it advances eastward to distribute its supply over the plateaus that skirt the valley of the river, has been the means of opening up and introducing to new pursuits a great portion of the immense acreage of that region that heretofore has been considered as little less than a barren waste.

I am informed that the project has been attended with signal success, and that now on the open prairie are to be seen thriving homesteads, dotting the landscape, and yielding to their owners, by the process of irrigation, for which they are charged a certain rental, an ample return for their labor and investment.

I know of and have heard of other similar instances, but on a smaller scale, illustrating the efficacy of irrigation in regenerating the barren lands of the West. Since commencing to formulate the thoughts that I here present, in connection with the subject under consideration, I have come across the following extract which I clip from a popular magazine. Speaking of irrigation in Idaho, the writer says.

"Lands that are irrigated always produce large crops regardless of the seasons or of rains or drought; but it is not alone in regions devoid of rain that irrigation is profitable. It is an absolute necessity in some places, but also a great help to agriculture everywhere. Thus what would seem a curse often turns out a blessing in disguise. Idaho, where irrigation is an absolute necessity, now offers the farmer an absolute advantage over ordinary land with the average rain-fall of the east. There is no seed, labor, or crop lost by dry or wet seasons. The farmer in Idaho, being obliged to resort to irrigation, is quite independent of the weather. He can make his crop early or late at will, and can have his land wet or dry, as suits his convenience, for plowing, cultivation, or harvesting. Under these circumstances crops are usually of superior quality, and therefore bring higher prices. The ditch companies are extending their operations in the vicinity of the Boise River with most gratifying results, so that now Idaho valleys can not be excelled by any region east of California for the production of fruit. The sage-brush lands are soon turned into fruit farms, and the amount of fruit produced annually far exceeds that on unirrigated lands. Yet in future the most profitable use to which the irrigated lands will be put will be the growing of hay for winter feeding of stock, and the millions of acres of southern Idaho now awaiting irrigation will bring great profit to their owners, as well as to the irrigating companies who propose to carry the water to fertilize the land, which is really of fine quality and lacks only the water to make a successful and profitable field for stock-raising."

Thus far what has been said has been chiefly to indicate the advantages that will follow upon the introduction of a general system of irrigation in the arid region of the West.

But there are certain conditions in connection with it, which, in view of a possible infringement upon private and vested rights already established by long tenure and recognized under law, may require to be conserved and guarded by such measures as can only be applied by Congressional enactment. Especially is this likely to be the case with reference to the great arid region east of the Rocky Mountains. May it not happen that by the diversion of the waters for irrigation, as in the manner indicated on the Arkansas, the time may come when those who live below the points where the irrigating canals tap the main streams may feel the damaging effect of this wholesale depletion? It is true this state of things is likely to be experienced only during what is termed the dry season when the rivers are low.

During the spring thaw the volume of water flowing away from the mountain-sides would be vastly more than enough to meet the requirements of a much denser population than is now settled in the West. It would be well, then, to inquire into the feasibility of devising a sytem of storage by which a portion at least of the water that now yearly runs to waste could be held at different points along its pathway to the sea, to be distributed for such purposes as it may be required as the summer season progresses.

I believe the suggestion is a perfectly practicable one, and that the end can be attained by a series of dams, the construction of which, though beyond the pecuniary possibilities of private enterprise, would be a matter of small moment if fostered by national aid. By the method proposed it is not unreasonable to hope and expect that districts now far away from any living stream of considerable size may ultimately have the benefits now possessed by more favored localities. In the possibilities of a combined system of irrigation and water storage I believe is to be found the only hopeful and promising outlook for the barren lands of the West.

Granting now that the argument on the lines laid down is based on the logic of facts, there are certain theoretical questions, in connection with the subject, which before bringing this paper to a close it may be worth while to consider. It is accepted as true, that the primary source of all precipitation is the ocean, consequently the heavy rain-fall that takes place on the western coast of the United States is but a return of the aqueous vapor that has been taken up by the prevailing winds from the evaporating surface of the Pacific and conveyed over the land. But why should not this heavy precipitation occur this side the line of the Sierra Nevada and Rocky Mountains as well as beyond?

The answer is to be found in the known fact that temperature decreases with elevation, so that these wind and air currents in their endeavor to leap the mountain ranges are carried up to the snow line, and being further chilled by the cold sides of the mountain have all their moisture squeezed out of them, to be returned to the earth in the shape of snow or rain. But suppose these air currents, laden as they are with moisture, could escape these mountain barriers and be conveyed over the arid region that is giving us so much concern, is it not reasonable to infer that from time to time they would be taken by force of cyclonic aspiration and those variations in temperature that produce aerial circulation to the higher strata of the atmosphere where condensation would occur? The theory appears a plausible one at least, and the suggestion brings us back to a consideration of the effect that so large an evaporating surface as would be developed by the impounding plan that has been pointed out would be wrought on the present climatic conditions that prevail. It is not unreasonable, I think, to assume that it would be marked, and that we might justly hope and expect that a greater, more gentle and equable, precipitation would take place everywhere, while those violent electrical phenomena that are the accompaniments of an excessively dry atmosphere would grow much less frequent in their manifestations.

The foregoing thoughts, rather hastily prepared, are respectfully submitted. If they contain a single valuable suggestion in assisting the committee to a satisfactory solution of the problem before them I shall be glad, for I feel that to assist in promoting in the least degree the development, the grandeur, and the resources of our common country should be the pride of every American.

STATEMENT OF F. M. SHELTON, OF STATE AGRICULTURAL COLLEGE, MANHATTAN, KANS.

[Being those portions of a report forwarded by the college regents of an inquiry recently made by the professor of agriculture which relate to the advisability or otherwise of irrigation in western Kansas.]

For many years, but particularly within the last eight or ten, the question of the settlement and agricultural occupation of the western and drier portions of the State has engaged the earnest thought and effort not alone of those directly interested as owners and cultivators of these lands, but of scientists, publicists, and even moralists, whose interest in the theme is based on the broad ground of public good. The efforts at the settlement of western Kansas do not make a cheerful chapter in the history of the State. The scores of abandoned farms, with their ruined "dug-outs" and other small improvements seen in all these recently-settled western counties all speak of brave efforts ending in futility. It is noteworthy, however, that great and far-reaching as the disasters of the last three years have been to the plains farmer, there have been many exceptions to the rule of failure. Here and there in almost every community may be found cultivators who have been reasonably successful; farmers who have made steady if not rapid headway in freeing themselves from debt and improving their stock and home surroundings.

From the fact that the settlement of western Kansas has progressed with various interruptions for twenty or more years, it would seem that there must have accumulated, particularly with successful farmers of this region, many valuable facts the outgrowth of much experience, and that these facts, if brought to the attention of inexperienced settlers, would certainly prove of great value to them. With this thought in mind I was instructed by the board of regents of the Kansas State Agricultural College to proceed to various points in western Kansas, there to meet farmers and others interested in the problems involved in this investigation, and ascertain from them, as far as possible, facts for use in this report.

During the month of October I visited Ellis, Trego, and Wallace Counties, on the

Union Pacific Railway, while a little later on the line of the Atchison, Topeka, and Santa Fé my inquiries were extended to Ford and Finney Counties. If my acquaintance with plains farming had been limited to the information picked up in the course of these few trips I should consider my qualifications for the work meager in the extreme. In justice to myself, I think that I may say without risk of egotism that an experience of sixteen years as a farmer and teacher of farming in central Kansas, and as a lecturer before farmers' gatherings, many of which were held in the region in question, to say nothing of a very extensive acquaintance, personal and by correspondence, with farmers of every section of the State, and the numerous excursions made during the past summer with the sole view of studying the condition and prospects of agriculture in western Kansas, have furnished large opportunities for the study of this subject.

The journey from the east to the west line of the State, and on to the crest of the Rocky Mountains, is steadily one of ascent, the rate of increase in elevation increasing enormously as we near the western limits of the State. Thus, at Kansas City, on the Missouri River, the altitude above sea level is 763 feet; at Manhattan, 118 miles west, it is 1,042 feet above sea level; at Ellis, 302 miles from the Missouri River, it is 2,135 feet in altitude; while at Monotony, a station on the Union Pacific Railway a few miles distant from the Kansas-Colorado line, an altitude of 3,741 feet is attained. Coincident with this change in elevation, a gradual but none the less striking variation in scenery, climate, and the character of the soil and its productions is noticeable. The soil changes in color from deep black in the east to light brown or yellow in the west; the grasses become shorter and thinner on the ground, while timber trees are not only much less numerous, but are scrubby, stunted, and gnarled, and their growth is strictly limited to the immediate vicinity of water-courses. Several counties in the extreme west are reported to have no native forest trees of any kind. These are not mere seasonal, superficial, and temporary indications which the agriculturist may safely disregard; they are fundamental facts, due to differences in elevation or position in respect to the more elevated regions west, and to variations in climate. They have existed since long before historical times, and are certain not to be changed by the agency of man. The variation in rain-fall, the fact of chief importance to agriculture, as progress is made west, strikingly illustrates the general trend as well as the nature of the varying conditions above referred to. Thus, at Fort Leavenworth, the annual rain-fall is 38 inches; at Topeka, 32; Manhattan, 30; Salina, 29; Fort Hays, 22; Wa Keeney, 19; and Fort Wallace, 13 inches, omitting unimportant fractions in each case.

The plain inference from these facts seems to me to be that the agriculture of western Kansas, whether practiced with or without irrigation, must differ from that which experience has shown to be best for eastern Kansas. The grand mistake made so far in the attempt at the settlement of western Kansas, and the cause of nine-tenths of the failures and distress that have so repeatedly overtaken the people of that unfortunate section, has been the practical assumption by them that crops and a system of farming that have proved successful in a region having 32 inches of rain-fall could accommodate themselves to a section which was watered with less than 20 inches of annual rains.

Western Kansas differs from the eastern portion of the State in well nigh all essential agricultural conditions. In elevation, character of soil, rain-fall, and natural products there is between two sides, or rather ends, of the State not merely a difference, but a radical and fundamental divergence. And these differences will be in the future essentially what they have been in the past. Of course, seasons will vary here as elsewhere. Occasionally, as in 1860, 1874, 1881, and 1887, the plains climate will be carried east to the Missouri River or beyond, and, again, not unfrequently the humidity of the eastern section will pervade the whole State and the region westward even to the mountains; but this fact will remain, that what the climate of any section in the State has been in the past twenty-five years that it will be during the next quarter century. I speak with a fair knowledge of the literature of this subject and a considerable acquaintance with the agricultural history of our State, and I have no hesitation in saying that there is no warrant in history or local experience for the well nigh universal belief that "deep plowing," "foresting," "turning under the buffalo grass," building "reservoirs" will each or all ever change the agricultural conditions which the settler of any section finds when he begins these and other improvements. The common notion that a change of climate will come as a result of growing more trees and cultivated plants seems to me wholly due to false logic; vegetation is due to climate, and not climate to vegetation.

Except in the case of limited tracts of land flanking large streams like the Arkansas, no general system of irrigation is possible in western Kansas. Water for use for this purpose on an extended scale is wholly or in great part wanting. Such streams as the Smoky Hill, the Cimarron, the Beaver, the Solomon, and their larger affluents might furnish water for irrigation upon a small scale, but the quantity of water available for this purpose is sure to be small during the season when it is most needed.

In the lower valleys, where water may be had by means of shallow wells, it would doubtless be possible to practice irrigation upon a considerable scale by means of powerful pumps of the Huffer pattern; but this is at present wholly a matter of speculation. The cost of such pumps and machinery, to say nothing of fuel, puts the system quite out of the reach of the average settler. Moreover, irrigation, even where water for this purpose is ample, is almost certain not to succeed in a region where rains are sufficient for a crop—where, in short, artificial irrigation may be suspended. Artificial watering on a large scale is always expensive. To build dams ditches, and the apparatus of irrigation, and to keep these in repair, involve a very large investment of capital. It is unlikely that the farmer will make this large outlay for occasional use only; but even if the plant has been constructed, it is almost certain not to be in repair for immediate use at the critical time when the rains cease to fall.

The very first thing that the farmer of western Kansas must learn is to take that region, not for what he hopes or dreams it will be, but for what it is. We may not, like the evolutionist, ask and obtain cycles of time in which to demonstrate a theory. He has at his command at most a few years; and even if it were true that the cultivation of the soil may materially effect climate, it is most unlikely that this change would be noticeable in the course of one brief life-time. The settler must then give practical recognition to the fact that the climate as well as the soil of western Kansas, whether better or worse than that of regions further east, radically differs from that of the East. As a result, whatever efforts men may make to the contrary, there will ultimately certainly obtain a different system of agriculture in western Kansas from that practiced in the East. What this system will be must, in so far as details are concerned, be largely a matter of speculation; the general plan, however, seems to have been plainly indicated by the experience of the past few years.

Stock-raising must be the basis of plains farming. Even if grain crops for immediate marketing could be safely counted on it is doubtful whether, considering the remoteness of this section from ultimate markets, and the high price of freights, whether the business can be made a paying one. Moreover, the farmers who have made stock-farming their chief reliance have generally been successful. The men who have been compelled to flee from western Kansas have almost to a man been exclusive grain-raisers. The stockmen have stayed, and, as a rule, they have flourished.

The Eastern idea that a farm of 160 acres is sufficient for the maintenance of a family must, upon the plains, outside of irrigable regions, be forever abandoned. Where outside pasturage is not accessible the plains farmer ought not to limit his operations to a smaller farm than 640 acres, and in most cases 1,000 acres will not be too large. Upon such large farms the native grasses, supplemented with rye and wheat pasturage, and sorghum and corn fodder and millet hay, will keep a herd of cattle or flock of sheep of sufficient size to make a profit from the operations of the farm well nigh certain.

STATEMENT OF AUSTIN P. LOWRY, OF BIRD CITY, CHEYENNE COUNTY.

Having been a former homesteader in this Cheyenne County, Kans., since its settlement in 1885, I feel myself somewhat competent to suggest what is best to be done by aid from the civil government to overcome, in a great measure, the effects of the scorching rays of the sun upon our growing grain. In this county there are numerous streams in which the water flows the entire year, chief of which is the south fork of the Republican River. It enters the county about 5 miles north of the southwest corner of the county, running diagonally to the northeast corner, near where it forms a junction with the north fork.

With the exception of Timber Creek, which only has a flow of some 9 miles, there is no other running water in the county south of the Republican.

The fall of the Republican is said to be 17 feet to the mile, but I doubt if it is even half that much. The average flow of water for the year would scarcely go over 4 feet.

The river is narrow, 150 to 200 feet wide; the valley from 1 mile to 1½ miles wide; the river very generally in the center of the valley with low banks; an abundance of rock and sand along the south side. The difference in the rain-fall in this county is very perceptible.

On each side of the river for some 5 to 8 miles much rain has fallen every year, and the settlers in that line have not had a failure of crops, while those farther from the river have lost their crops twice since 1885.

This fact surely shows the influence of the water in the river upon the atmosphere and consequent rain-fall; hence it is my opinion if five or more dams or reservoirs were erected across the river bottom it would extend the rain-fall all over the county as well as into Colorado and Nebraska.

I believe such dams should be constructed across all these running streams in western Kansas and the surplus water retained here. I have no faith in artesian wells.

We see and know what the quantity of water is which flows down these streams, and it is our privilege to detain it, or a portion of it. The General Government should aid the settlers, who are manfully fighting for the subjection of this great plain, and it can not do us a greater benefit than to furnish the money to erect the dams to store this surplus water. The settlers are all in favor of this project, and I sincerely believe it will solve the hot-wind problem in western Kansas and eastern Colorado if carried out.

STATEMENT OF JOHN G. STEFFEE, OF WICHITA.

ARTESIAN WELLS, RAIN-FALL, AND IRRIGATION IN SOUTHWESTERN KANSAS.

Southwestern Kansas is more than 100 miles in length and an average of over 60 miles wide, and comprises nearly 6,000 square miles, or upwards of 4,000,000 acres of land. It is larger than the new territory of Oklahoma, and larger than the combined area of the States of Connecticut and Rhode Island.

It will be admitted without question that the rain-fall in this section is deficient and irregular, and that hot winds actually occur, and at those seasons when the one is most needed and the other most ruinous in their effects.

Let us consider briefly whether the recommendations of the various methods proposed for augmenting the annual precipitation and the conservation of moisture, so often expressed and gratuitously furnished by the residents of the more favored sections of our State, can under existing conditions be put into practical operation in southwestern Kansas. By the term southwestern Kansas is meant all that part of the State lying west of the one hundredth meridian and south of the Arkansas River.

First, there is the current opinion, founded on scientific principles, based on sound reasoning, and not wholly lacking in support of actual experience, that if this vast expanse of level prairie land, reaching out to the horizon in every direction, be broken by the plow of the husbandman and this work supplemented by stirring and pulverizing the deep, rich subsoil underlying the surface, the amount of moisture thus conserved for agricultural purposes would greatly enhance the possibilities of bountiful crops every year.

Now, if $1.50 per acre be taken as the minimum cost of breaking prairie sod, and an equal amount as the cost of subsoil plowing, and if this work is to be supplemented by a thorough pulverization of the soil to the depth mentioned in the report of the experimental station, the aggregate cost of preparing the ground for the first crop would be not less than $5 per acre. But if we admit that the cultivation of one-fourth of the territory, or 1,000,000 acres, would be sufficient to have a desirable and salutary effect upon the annual precipitation and hot winds, and the crops thus produced ample to sustain the population necessary for so great a work, even on this basis the expenditure of labor and money for the first crop would be more than double the assessed valuation of this entire section.

Leaving the question of cost entirely aside, when we inquire into the present facilities for putting this experiment into general practice we find that they are grossly inadequate. Probably not more than 1,000 men who own good strong teams are now actual residents of southwestern Kansas, and with such a meager force as this it requires no argument to warrant the conclusion that successful and profitable farming, or the conservation of moisture by the process described in the report of the agricultural experiment station, is wholly impracticable, and that it is impossible under existing conditions to reclaim the semi arid lands of southwestern Kansas by breaking prairie sod or subsoil plowing.

Referring now to the question of timber-culture, it will not be denied that the planting and cultivation of forest trees has been to a certain degree instrumental in conserving moisture for agricultural purposes, at least in some sections of the State. Our national legislators doubtless had this theory in view when they passed the timber-culture act. But we are informed that not over 20 timber-culture entries have been completed in the Garden City land district, and after examining the condition of trees planted on a large number of timber claims we are clearly of the opinion that very few of the entries made under the provisions of this act will ever be completed, certainly not until there is a second influx of immigration into this section of the State; and even though in the future the climatic conditions should be most favorable to the growth of trees already planted, the influence to be exerted by this means must necessarily be almost infinitesimal as a source of augmenting the annual precipitation.

Then there is another theory, to the effect that if the surplus water which falls during the winter and spring months, also the water produced by the melting of snow, could be in some way impounded and retained till allowed to evaporate under the summer sun, it would greatly increase the humidity of the atmosphere and have a marked influence upon the rain-fall later in the season. This theory presents to our mind a greater semblance of reason than the two preceeding, but as no data have been compiled and no known experiments have been made on which a calculation could be based, and although a general survey of the surface of the country seems to disclose many locations for building dams or dikes, and thus impounding the surplus water, yet the evaporation in this section is so great that unless some means can be devised for replenishing the artificial basins thus constructed the opinion must be that the necessary expenditure of money would hardly be compensated by the benefits accruing therefrom.

Several other theories have been advanced which might be here discussed, but so far as can be learned their demonstration will depend upon conditions almost wholly wanting in southwestern Kansas. Hence it must be concluded that all the theories relative to the subject of increase of the annual precipitation, the conservation of moisture and modification of hot winds, which have heretofore obtained circulation must for the present be discarded, for the reason that their demonstration is impracticable under existing conditions.

There are three elements then which must be combined before we shall discover the key to the solution of the great economic problems mentioned in the first chapter, and which not only the inhabitants of southwestern Kansas but also every person pecuniarly interested in that section of the State are anxiously awaiting a practical demonstration. These elements are:

First. A complete study of the geological formations underlying the surface of the country as described in the State geological survey.

Second. The data compiled with reference to the artesian wells already existing in this section of the State.

Third. A thorough examination of the topography of the territory described.

The first two elements are even now largely matters of public information.*

An artesian well is one in which an artifical vertical shaft is filled to overflowing by water, which enters it at some distance below the surface of the ground. The water may spout up with force and rise higher than the surface or it may barely reach the point at which it flows over. The conditions under which this can occur are the same as those which govern the supply of water to the upper rooms of buildings in cities. The reservoir with which the water-mains are connected must be higher than the place supplied; for the same reason the stand-pipe which takes place of a reservoir in towns located in a level country must be higher than the tops of the highest buildings. This is made necessary by a well-known principle in hydrostatics, that a fluid will not rise in an open tube higher than its source. There are some artesian wells whose flow is due to other than hydrostatic pressure here described, viz, to gas pressure and rock pressure, but these forces need no illustration. In nature the channel through which the water flows is more like a sponge than the orifice of a pipe. It is porous rock, standstone, conglomerate, gravel, sand, or limestone more or less cracked or broken. The walls of the natural pipe must be impermeable and usually beds of clay or clay-shale serve this purpose. To get the head of water the beds of sandstone, shale, etc., must have a dip, *i. e.*, they must be higher at one part than another. The best conditions are when the rock strata take a basin formation, highest on the edge of, circular area, and a well sunk in the middle of the basin. It is to be understood that all the waters of the land are meteoric waters, having their origin in the rains and snows. If, then, the rain falls on porous rock on the upturned edge of a basin, which within the basin is overlaid and underlaid with impervious clays, a well sunk at or near the middle would be artesian.

The basin form is, however, comparatively rare in nature, but continuous dip of rocks in one direction is by no means uncommon, so that the form of a trough is more often found. If the relative position of porous and impervious rocks is the same, artesian wells may be found on the slope or at the lowest point. In southwestern Kansas the general dip of the geological strata is from west to east, as is also the slope of the surface of the country, thus widely distributing the conditions for finding artesian wells.

A brief description of the artesian wells already existing in southwestern Kansas will be useful. Mr. B. F. Cox, who resides on the northeast quarter of section 5, township 31 south, of range 27 west, in Meade County, was the first to find artesian water south of the Arkansas River in Kansas. This discovery was made about two years ago, and since that time nearly one hundred wells have been sunk and are now flowing in Meade County from 10 to 60 gallons each per minute. Nearly every farm in the vicinity of Artesian City has one, and some farms have several. These wells evidently derive their water supply from the Dakota formation, which, as has been before stated, is the stratum from which the deep wells of the high prairies is supplied. The water of the wells is clear as crystal, and is used by the farmers for supplying the troughs in the feed lots and pastures, also for drinking and culinary purposes. Several farmers are preparing to use the water for irrigation next season.

---

* Prof. Robert Hay, geologist of the State board of agriculture, furnishes a report on the first topic.

At Richfield, the county seat of Morton County, are two artesian wells to which the water is supplied from a lower stratum, evidently the miocene grit, the lowest of the Triassic series. These wells are 670 and 710 feet in depth respectively. The drill passed entirely through the red beds, which at that point are over 400 feet in thickness. The flow of the first well is over 25 gallons per minute and of the second about 10 gallons, which may be increased to 25 gallons or more by driving the casing down to the Triassic strata. These wells are located on a ridge one-half mile west of the center of the town. The surface of the ground being as high as any of the surrounding territory, and about 75 feet higher than the site of the Morton County courthouse, situated near the center of the town, the pressure is sufficient to carry the water in a 2-inch pipe to the top of the derrick used in drilling, which is 70 feet in height.

We have, then, two sources of artesian water in southwestern Kansas. There is another group of artesian wells at Coolidge, in Hamilton County, which yields from 30 to 100 gallons per minute each, and one at Larned, Kans., having a flow of salt water of 250 gallons per minute.

Other wells are projected and one is now being put down at Johnson City which on the 20th of December had reached a depth of 260 feet at which the water rose in the tube 54 feet.

From these facts we may conclude that a strong flow of artesian water may be readily obtained any where in southwestern Kansas when the drilling is properly done and the shaft sunk below the Triassic strata.

The special aim of this statement is, however, to supply the third element in the group mentioned, to wit, a careful investigation of the topography of southwest section of Kansas.

A cursory survey of the surface of southwestern Kansas from almost every point of observation presents to the view a vast expanse of level prairie unbroken by any apparent elevation or depression, and reaching to the horizon in every direction. But every person who has traveled extensively over this region has doubtless been attracted by the numerous shallow depressions with which the surface is so thickly interspersed. These depressions may be separated into three classes, and that the classification which we shall give may be more readily understood we will in defining and describing them make use of the terms commonly employed by the inhabitants of southwestern Kansas and denominate them as buffalo wallows, prairie sinks and draws, and will define them as follows:

A buffalo wallow is a shallow depression in the surface of the prairie, usually circular in form and from 1 to 10 rods in diameter.

A prairie sink is a shallow depression in the surface of the prairie, either of circular or irregular form and from one acre to several hundred acres in area.

A draw is a narrow, shallow depression in the surface of the prairie, from a few feet to several rods in width, and often extending several miles in a broken and irregular line and opening into a valley or prairie sink.

Having now defined these shallow depressions, it may be proper to explain or at least give an opinion concerning their origin, and in offering this opinion we adopt the views of Mr. Edward Dudley, who resides near the village of Moscow, in the eastern part of Stevens County. In addition to farming and stock-raising he has acted as agent for the United States Wind-Mill Company and has drilled over one hundred and fifty wells in Stevens and adjoining counties within the last two years. Mr. Dudley now resides on a homestead on which is a prairie sink of 50 acres, by which he camped when buffalo hunting thirty years ago. He says he has often seen buffaloes wallowing in these depressions when partly filled with water, and has also witnessed the initiatory work in the excavation of buffalo wallows, which the buffaloes performed by pawing with their feet and tossing with their horns the loose dirt thrown upon the surface by prairie dogs, gophers, and other burrowing animals, and by breaking dawn the surface undermined by the burrows. These small depressions, afterward filling with water, furnished the buffalo a safe retreat from the attacks of buffalo gnats and other insects. He has seen a herd of buffalo make sad havoc with a colony of prairie dogs in a short time. As to the origin of prairie sinks Mr. Dudley has made numerous experiments to determine the depth of the hard and impervious soil with which they are covered and the strata underlying them. He finds the coating of putty-like clay to be from 4 to 10 feet thick, and underlying this is a stratum of sand 50 to 100 feet thick, and in his opinion these depressions were originally beds of quicksands into which flowed the surplus water from a much larger area, each heavy rain having left a thin coating of silt, consisting of gypsum and clay which in course of time became thick enough to sustain the surplus water for a much longer period or until it evaporated under the summer sun. Some of these prairie sinks now furnish water the entire year. They are usually covered with growth of light colored gramma grass and on a bright day the reflection of the sun gives the prairie the appearance of being thickly interspersed with lakes in which the buildings and wind-mills of the improved farms are clearly reflected.

In endeavoring to account for the presence of the third class of depressions or draws we would assign the same causes that are usually given for the origin of valleys, *i. e.*, the erosion caused by the flow of surplus water from the surrounding territory. It is a noticeable fact that draws are much more numerous where the soil is sandy and the surface covered with blue stem grass which is of recent origin. In fact many men now residing in southwestern Kansas remember when these sections of country were almost entirely devoid of vegetation, and similar to the sand-hills which yet exist south of the Arkansas River. And it is quite probable that in former times these sandy sections were frequently visited by severe rain-storms, cloud-bursts, and water-spouts, caused by the intense heat arising from the arid soil condensing the moisture in the rain clouds which may have caused the erosion to be much more rapid than under ordinary precipitation.

It will require further investigation to determine even the approximate amount of the surface of southwestern Kansas that is included by prairie sinks and draws. Having located and secured approximate measurement of over five hundred prairie sinks, varying from 5 to 200 acres in area, in Seward County in six days' drive; also a large number of draws which might easily be converted into basins for holding water at very little expense, and from observations made while driving over the other counties of southwestern Kansas the opinion has been reached that they contain an equal number. At present it is estimated that at least one-tenth of the surface of southwestern Kansas could be converted into artificial lakes, providing a sufficient amount of water can be obtained with which to fill them.

And with these data before us a theory may now be presented which if practically demonstrated, will reclaim for agricultural purposes all the so-called semi-arid lands of southwestern Kansas.

If by sinking artesian wells in this region a sufficient flow of water can be obtained to fill the prairie sinks and draws, the whole of southwestern Kansas will be thickly interspersed with a vast number of artificial lakes. The evaporation of the water from these lakes will increase the humidity of the atmosphere, augment the annual precipitation, and dispel these disastrous hot winds. The deceptive mirage will be then a reality. Groves of trees will grow upon the borders of the lakes and the whole country will be converted from a semi-arid region into one most delightful to the eye and the finest agricultural and grazing country on the American continent.

The points of merit which may be justly claimed for this theory are numerous and apparent.

It admits of the employment of all those means which have heretofore been recommended for the solution of these problems. If these draws and prairie sinks can be filled with water, the amount of moisture conserved by breaking prairie sod and subsoil plowing will be greatly augmented. As we have before stated, groves of trees can be successfully cultivated on the margins of these artificial lakes, and whatever modifying influence there may be in the growth of forest trees can be readily appropriated. The theory of impounding and conserving the surplus water which falls in rain and snow is combined and brought within comprehension of those whom it is intended to benefit and relieves the serious doubts as to the influence to be exerted by large basins hundreds of miles distant.

It is not claimed that a sufficient flow of water can be secured to irrigate by the usual method, nor is it necessary to affirm or deny such a possibility. The aggregate flow of the wells in Meade County are sufficient to irrigate at least 500 acres during the severest drought, and those at Coolidge will serve 1,000 acres. Mr. Edward Dudley has irrigated about 5 acres of ground during the past summer by the water from two ordinary wells, and raised an abundance of garden vegetables of all kinds; and the growth of various kinds of forest trees in a small nursery which he supplied with water by this means was truly marvelous. A well like that at Richfield would insure a bountiful crop of vegetables and small fruits any ordinary season on at least 10 acres of ground, and by conducting the surplus to a prairie sink which may be found on nearly every quarter section, it would thus be conserved and allowed to evaporate.

Deep wells have been sunk at Meade, Syracuse, Santa Fé, and Liberal, in which the water does not flow over the top of the shaft. Whether these wells were properly cased when being sunk is not determined. But in no instance does the drill record show that the drill passed through the red beds and into the Miocene grit, as at Richfield. While other wells like these might be the result, even when the most careful work in sinking the shaft, yet, owing to the triumphs of inventive genius, even those difficulties may be readily overcome by the use of irrigation pumps, which are available at a much greater depth than the surface of the water in any of the wells in which a sufficient rise has not been secured.

It may be claimed that if a flow of salt water should be obtained, as is the case in the well at Larned, Kans., it would be injurious rather than beneficial. While unprepared to say that salt water would not be detrimental to the growth of vegetation if used for irrigation, yet the rank growth of vegetation noticed along the margin of the great salt plains of the Cimarron in the Indian Territory is at least one point in favor of the opinion that salt water would be in no way injurious if used for irrigating purposes. Certainly no objection could be offered if the salt water be allowed to evaporate from prairie sinks, for the salt thus obtained might be a source of great profit.

In fact it is believed that this theory incorporates all the desirable features of those heretofore advanced, and answers every objection that can be raised in opposition to it.

In conclusion it will be proper to make some inquiries concerning the sources from which to secure the proper financial support for the development of the scheme. While many might be named, three only will be referred to.

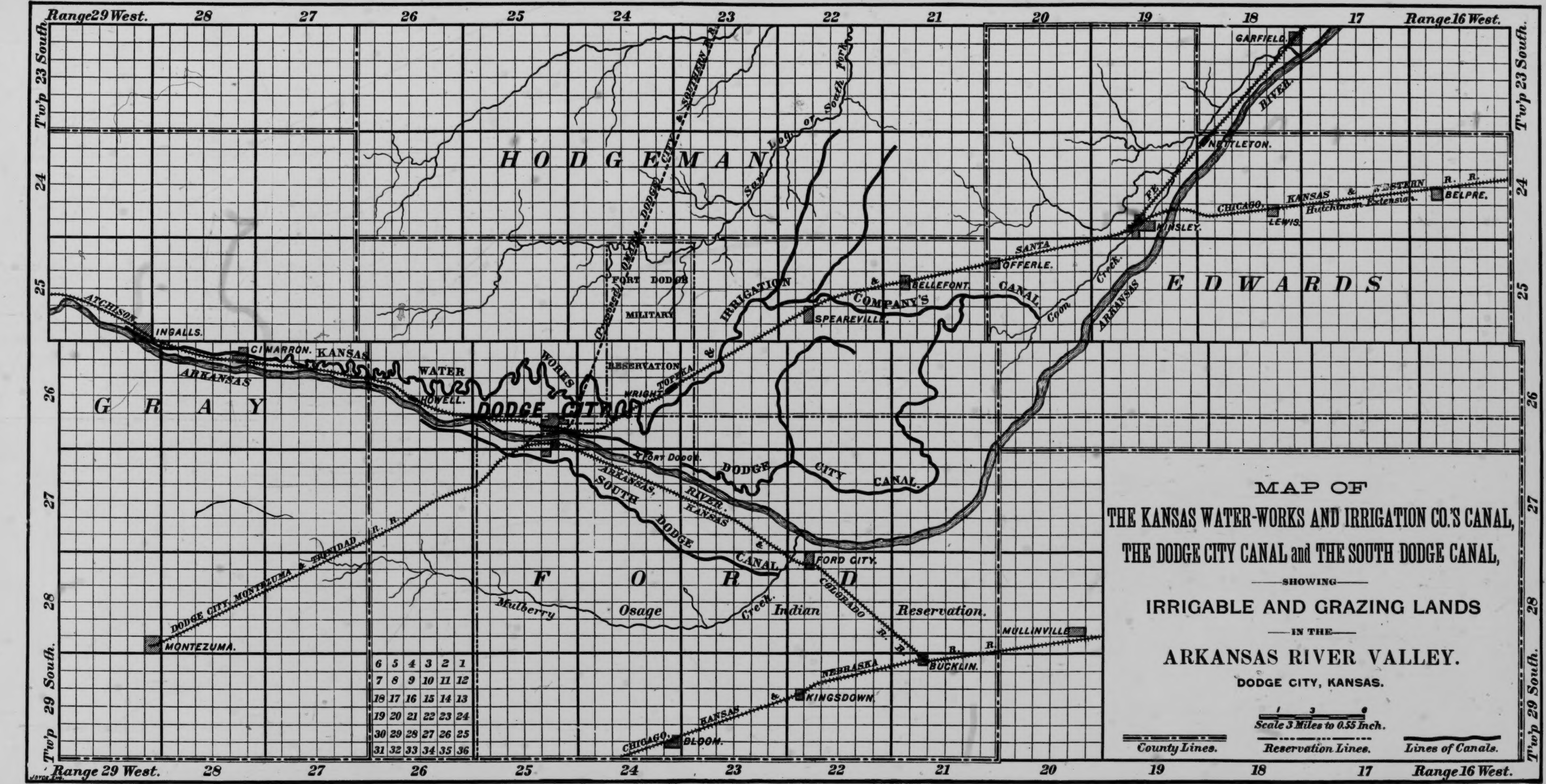
First. By Congressional appropriation. In this connection we will state that although we have confined this discussion to southwestern Kansas, we have done so only for the reason that we have not yet had opportunity to extend our personal investigations over a larger area.

Many arguments might be offered to induce recognition of the claims of southwestern Kansas on Congressional legislation. The United States Government has received from the settlers of southwestern Kansas hundreds of thousands of dollars in payment for lands under pre-emption and homestead entries, of which hundreds have been abandoned for no other reason than that the numerous failures of crops have exhausted the means and blighted the hopes of those who came to this country in good faith and are compelled by force of circumstances to abandon it. It may be said that many of the pre-emption entries were made by single men and others, who had no experience in agricultural pursuits and no intention to improve their farms after completing their entries. While this is true it will be readily admitted that nearly all the farms whose owners were of this class have always been, and are still, for sale at very low prices; and, had this country been blessed with bountiful crops these low-priced unimproved farms would have been eagerly sought after by practical farmers, and the population of the counties of southwestern Kansas, instead of being less than one-third what it was two or three years ago, would be much greater to-day than at any time in their history. Besides, as we have before stated, very few of the entries made under the timber-culture act can ever be completed until there is a marked change in the climatic conditions, and the greater part of southwestern Kansas must sooner or later revert to the use of cattlemen for grazing purposes; and the sugar industry, which promises so much for this country, must be greatly retarded if not eventually abandoned.

Aside from the salt industry which might be developed by sinking deep wells, agriculture and stock-raising are the only resources of southwestern Kansas. No demands will ever be made upon Congress for improvements of rivers or protection of mineral products. Besides, the great West is on general principles certainly deserving of more recognition from our national legislators than it has heretofore received. The second source to which we may look with some confidence is to a union of interests on the part of loan companies and other corporations who have invested largely in real estate and municipal securities in this section of the State. Many of these corporations already realize the necessity of prompt and united action in devising some scheme to prevent a heavy depreciation in the value of their securities and obviate a great loss of money on their own part and that of their patrons. From these two source can scarcely be hoped a sufficient sum to more than carry the scheme over the experimental stage and sink a few wells in each county with a view of determining the feasibility of the plan. Before the plan can be practically demonstrated it must be prosecuted by those directly interested in its success, which is the third source and the one from which all great enterprises are carried out. The practical demonstration of the theory must depend on private enterprise.

Until the plan is carried beyond the experimental stage we would certainly discourage all efforts to secure money for sinking artesian wells at public expense—and by this reference is made to the questionable methods employed for raising money for public benefits which seem to be practiced to an alarming extent in all the recently organized counties in Kansas. This pernicious practice of issuing county, township, and city scrip for purposes plainly unprovided for by statute and immediately converting the obligation thus ostensibly created into a bonded debt under the refunding act of 1879, should be stopped immediately if the municipalities would escape expensive litigation in the future and private and public credit would be maintained. But if proper influences are brought to bear, and experiments made by those who can afford to lose in case of failure and greatly aid in case of success, then the great work of reclaiming the semi-arid lands of southwestern Kansas can be commenced with some assurance of ultimate success.

The cost of a plant for sinking a shaft to the depth of 1,000 feet is about $4,000, and may be used for years with very little expense for repairs. The one at Richfield cost $2,600. And the cost of sinking the well will depend very largely on the management of the enterprise and the experience of those having control of the work. Upwards of $4,000 was expended by the city of Richfield in attempting to educate local


Range 29 West.
28
27
26
25
24
23
22
21
20
19
18
17
Range 16 West.
T'w'p 23 South.
24
25
26
27
28
T'w'p 29 South.
HODGEMAN
EDWARDS
GRAY
FORD
GARFIELD.
NETTLETON.
KINSLEY.
LEWIS.
BELPRE.
OFFERLE.
BELLEFONT.
SPEAREVILLE.
INGALLS.
CIMARRON.
HOWELL.
DODGE CITY
WRIGHT
FORT DODGE
MILITARY
RESERVATION
FORD CITY.
BUCKLIN.
MULLINVILLE
KINGSDOWN.
BLOOM.
MONTEZUMA.
ARKANSAS RIVER.
ARKANSAS
Saw Log or South Fork
Coon Creek.
Mulberry
Osage Creek.
Indian Reservation.
ATCHISON, TOPEKA & SANTA FE
KANSAS WATER WORKS & IRRIGATION COMPANY'S CANAL
DODGE CITY CANAL.
SOUTH DODGE CANAL.
DODGE CITY MONTEZUMA & TRINIDAD R. R.
(Proposed) DODGE CITY, OMAHA & SOUTHERN R.R.
KANSAS & COLORADO R. R.
CHICAGO, KANSAS & NEBRASKA R. R.
CHICAGO, KANSAS & WESTERN R. R. Hutchinson Extension.
Fort Dodge.
6 5 4 3 2 1
7 8 9 10 11 12
18 17 16 15 14 13
19 20 21 22 23 24
30 29 28 27 26 25
31 32 33 34 35 36
1 3 6
Scale 3 Miles to 0.55 Inch.
County Lines.
Reservation Lines.
Lines of Canals.
Joyce Eng.

MAP OF
THE KANSAS WATER-WORKS AND IRRIGATION CO.'S CANAL, THE DODGE CITY CANAL and THE SOUTH DODGE CANAL,

SHOWING

IRRIGABLE AND GRAZING LANDS

IN THE

ARKANSAS RIVER VALLEY.

DODGE CITY, KANSAS.

talent in sinking deep wells, and without benefit. But when the enterprise was put under exclusive control of one man who really had the interests of the city at heart, and the machinery put into control of a man who had had experience in sinking deep wells, not in the oil or coal regions of the east, but in western Kansas, the work was easily and satisfactorily completed at a cost of $1,000, and a contract promptly let for the second well for one-half that amount.

Let it be once demonstrated that artesian water can be found under proper management and at a reasonable cost, and private companies, fully equipped for sinking deep wells and with employés trained to assist in the work, will spring up. The competition which will follow will reduce the price of sinking wells, and eventually, at an aggregate cost much less than at present would seem available, these great economic problems of increasing the annual precipitation, conservation of moisture, and modification of hot winds will be practically demonstrated, and the vision of the future as herein described will become a reality.

FURTHER STATEMENT OF JOHN G. STEFFEE.

THE UPPER ARKANSAS VALLEY "UNDERFLOW."

Within the last ten years over 500 miles of irrigating ditches have been constructed in the Arkansas Valley west of the one hundredth meridian, in Kansas. These ditches are capable of supplying water for the irrigation of more than 100,000 acres of land in Ford, Gray, Finney, Kearney, and Hamilton Counties; but, owing to the failure of the water supply in the Arkansas River for the last two or three years, the ditches have not been used to their full capacity. This failure of water was caused mainly by the paucity of snowfall in the Rocky Mountains in the winters of 1887 and 1888, and the severe droughts which have prevailed between the one hundredth meridian and mountains for the last three seasons. We think the current opinion that the numerous irrigating ditches which have been recently constructed along the Arkansas Valley in Colorado exhaust the water in the river before it reaches the Kansas line is largely erroneous. During the summer of 1889 there was more water in the Arkansas River at Dodge City than at Coolidge, near the State line. There was more at Wichita than at Dodge City, and more flowing water in the channel in the 200 miles in Kansas than in the 200 miles west of the Colorado line.

From records kept at Dodge City during the last eighteen years, and from information gathered from other reliable sources, we believe it is safe to depend on an abundant supply of water for irrigation in the Arkansas Valley in at least seven years out of ten. And we believe that when the snow-fall and rain-fall are sufficient to supply the ditches in Colorado, the residents of the Arkansas Valley in this State have no reason to fear a water famine. If these same climatic conditions are to be looked for in the future, would it not be wise to make some provision for these three years of drought? Manifestly so, if the conditions are present which will render such a provision possible. For several years past articles have appeared in the newspapers of this State discussing various methods of utilizing the underflow of the Arkansas River to supply the irrigating ditches with water which the river failed to furnish during seasons of deficiency in precipitation. That the supply of water is inexhaustible has been frequently demonstrated by pumping water from wells located in the valley. The two most noted experiments were made last year at the wells which supply the water-works at Dodge City and at Garden City. These wells are 22 feet and 19 feet in diameter, respectively, and about 20 feet deep; the water rises to within 4 feet of the surface of the ground. Over 1,000,000 gallons have been pumped out of the Dodge City well in a single day without lowering the water to any appreciable extent. At the Garden City well the water-works pump, with a capacity of 600 gallons per minute, and a Huffer irrigation pump with a capacity of 500 gallons per minute, were both worked to their utmost limit for a period of four hours without lowering the water in the well. Numerous other experiments of a similar nature have been made.

While ditch companies have been repeatedly assured that the underflow of the Arkansas Valley might be utilized for supplying their ditches none of them had sufficient confidence in the recommendations to warrant the necessary expenditure of money to demonstrate its practicability until quite recently.

The South Dodge Canal Company was organized last year with a capital of $250,000. The officers of the company are E. E. Soule, president; G. G. Gilbert, vice-president, and J. W. Gilbert, secretary. This company has secured the right of way for 35 miles of irrigating ditch on the south side of the Arkansas River. Fifteen miles of the ditch have already been completed. It will be known as the South Dodge Canal. Nearly 100,000 acres of valuable lands may be irrigated by this Canal. The ditch extends from Howell Station, 8 miles west of Dodge City, to Ford City, a distance of about 35 miles. The original survey provides for taking water from the Arkansas River at the south bank, opposite Howell Station. It is at the head of the South Dodge Canal that the experiments are being conducted for securing a flow of water in an open channel from a reservoir to which the water is supplied by the underflow of the Arkansas valley.

The reservoir or head of the canal is located about 60 rods from the river bank. At a point one and three-eighths of a mile from the head the ditch was built exactly at grade—*i. e.*, the bottom of the ditch is on a level with the surface of the ground, the bank of the canal being levees about 8 feet high. Commencing at the grade point the excavation of the upper end of the ditch was begun, due allowance being made for the proper fall. At a distance of about half a mile the water-bearing stratum of sand was reached, the bottom of the ditch at that point being about 4 feet below grade. After reaching this sand the soil was then stripped off to the head of the ditch, the work all being done by teams and scrapers. The ditch at a point 2,000 feet from its head is 30 feet wide at the surface of the ground. This increases to 60 feet at the head of the ditch. For this entire distance of 2,000 feet both sides of the ditch are protected by sheet-piling.

The company did not expect to secure a flow of water at this stage of the excavation, but contrary to their expectations the water began to accumulate and run in a strong current down the ditch and in such a quantity that it was necessary to put in a head-gate and cut-off at the grade point 1⅜ miles from the head of the reservoir. The flow extended over 8 miles, and as far as the ditch had been completed at that time. Since the head-gate and cut-off have been put in no water is allowed to pass below it in the ditch, but is turned off at the side of the ditch and runs in a open channel to the river, which at that point is about 100 yards from the ditch. The writer measured the flow of water at the point where it falls over the river bank, and found the stream to be 4½ feet wide and 13 inches deep. It will be remembered that this result has been obtained without any reservoir yet being constructed.

The head of the ditch, as before described will constitute the reservoir, and will be 60 feet wide at the upper end, 30 feet at the lower and 2,000 feet in length. The sand will be excavated by a dredging-machine, which was placed in position on Saturday, February 1.

Owing to the extreme cold weather which has prevailed during a greater part of that month the work of excavating the reservoir progressed very slowly. Over 200 feet was completed by the 7th instant. The excavation was begun at the upper end. Two dredging-machines are in operation, and if the weather is favorable the work will be completed by the 25th of this month. The flow of water has increased largely, and is now fully 2,000 gallons per minute. If the water continues to rise to the same height at which it has been found impossible to reduce it in small wells by pumping, the profile and survey of the ditch provides for a stream of water 5 feet in depth at the grade point before mentioned. The managers feel confident that this supply can be secured.

As an experiment, the work has been a complete success; the water will, and does, flow in an open channel from the underflow of the Arkansas Valley; the channel does not fill with sand, and manifests no disposition to do so.

The Gilbert Bros. have had the general management of the constructing of these ditches. On the 7th the Eureka ditch, 96 miles in length, was full of water, besides over fifty storage reservoirs of from 5 to 40 acres in area. The Dodge City Canal and the Eureka Ditch will both be furnished with reservoirs for supplying water from the underflow of the Arkansas River this season.

*A REPORT ON A PROPOSED PLAN FOR THE IRRIGATION OF WESTERN KANSAS WHEN WATER FOR IRRIGATING CAN BE PROCURED FROM THE UNDERFLOW OF GROUND WATER BY PUMPING FROM WELLS AND DISTRIBUTING BY PIPES.**

PREPARED BY W. TWEEDDALE, C. E., OF TOPEKA.

Observation shows that there are certain districts within the arid subregion where the rain is concentrated in certain months so as to produce a rainy season. When this occurs during the growing period, and the temperature is not too high, less than 20 inches will suffice for "dry farming."

In Texas, with 20 inches of rain-fall, "dry farming" is not profitable; while in Dakota, Minnesota, and Nebraska 16 inches of rain-fall gives good results. The reason for this is that in Texas the temperature is high, and the rain-fall uniformly distributed throughout the year, while in the above-named States the temperature is much lower, and there is a well-defined rainy season giving 72 per cent. of the annual rainfall during the spring and summer, while Texas has but 50 per cent. during the same time; for which reason 15 inches in the above States will be equivalent to 20 inches in Texas, with the further difference in their favor due to much lower temperature.

---

* This paper was forwarded as an "advance copy subject to revision" by the Kansas State board of agriculture.

The relative value of rain-fall for agriculture in the different localities will appear from a comparison of the tables of rain-fall at eight selected stations in Texas, three in western Kansas, and eight in Dakota, Minnesota, and Nebraska. Of the annual rain-fall of these several stations, the amount that falls during the spring and summer is as follows: In Texas, 55 per cent.; western Kansas, 65 per cent.; Dakota, Minnesota, and Nebraska, 72 per cent.; from which it will be seen that the proportional part of rain-fall in western Kansas during the growing season is intermediate between that of Texas and the above-mentioned three States; and while that in western Kansas is but 11 per cent. less than in the above three States, the difference in effectiveness is much greater by reason of difference in temperature.

In a consideration of the subject of rain-fall, it must be borne in mind that in the so-called "subarid" region there is a great liability for many seasons in a long series of years to be without sufficient rain-fall to make agriculture profitable, in which case the whole supply of water for irrigation must be procured artificially. And as it is the certainty of results alone that will justify the investment of capital in new enterprises, it follows that in any scheme for furnishing water for irrigation estimates of cost must be based on being able whenever required to furnish the whole amount of water necessary for the profitable raising of any particular crop. The disregard of ohis rule in the projects for irrigation in western Kansas has been the cause of many failures.

It is claimed that 336 miles of irrigating ditches have been constructed in Kansas, designed to irrigate 300,000 acres of land, with water procured from the Arkansas River. The amount of water, as per estimate of the State engineer of Colorado, required for grain crops for this amount of land, when the rain-fall was 9½ inches, during the growing season would be 3,000 cubic feet per second; while the average discharge of the Arkansas River at Pueblo during the months of May, June, and July, 1888, was but 2,000 feet per second, and the ordinary flow at Hutchinson in 1876 was but 1,500 cubic feet per second, being but from 66 to 50 per cent. of the requirement. From this it will be seen that the solution of the problem of irrigation for western Kansas must be sought for elsewhere.

It is the universal testimony of settlers in the aforesaid region, that the soil in the river bottoms, which is for the most part sand and gravel, is water-bearing, and that the whole of the Arkansas River valley is underlaid with a vast sheet of water, which can furnish unlimited, never-failing supplies of water at depths not to exceed 25 or 30 feet. The prevalent idea is that the source of this supply is the Arkansas River, and that the completion of the immense systems of irrigating works projected and in course of construction in Colorado will materially affect this supply. In pursuance of this idea, Congressional aid is being invoked to protect western Kansas from so dire a calamity. That this alarm is causeless, and that no fears need be entertained of this result, will appear from the following considerations: Water-works of varying extent, ranging from that of the Croton, which supplies the city of New York, to that of a village of a few thousand inhabitants, have been and are continually being constructed on the basis that in any locality, the rain-fall and physical characteristics being known, a given number of acres of water-shed will furnish a determinable quantity of water. This basis is always used (unless the source, being a large river or lake, is largely in excess of the requirement), whether the water be taken from a pond, a running stream, or where in the dryest season of the year there is little or no water. Thus a pond of 100 acres area, with a water-shed of 500 acres, will furnish precisely the same quantity of water in one year as 600 acres of contiguous and equally favorable territory where there is no pond, provided that in the latter case the water falling on the surface can be saved for use by means of a dam in a storage reservoir.

In designing storage reservoirs of limited extent, account must be taken of the minimum annual and minimum periodic rain-fall. It sometimes happens that the annual rain-fall continues to be less than the general mean through cycles of three or four years. Computations based on a number of selected stations of largest observation in the United States, extending throughout the whole country, give the average annual rain-fall of the least three-years cycle, at any one of these points, as 67 per cent. of the mean annual rain-fall at the same point, and the greatest three-years low cycle as 97 per cent. of the mean annual rain-fall at the same point. Taking 16 inches as the mean annual rain-fall at Fort Dodge, the mean annual rain-fall of the low cycle will be 67 per cent. of 16, equals 10 inches. Of this amount, favorably situated gathering-grounds of unbroken prairie will furnish at least 60 per cent. This will give a depth of 6 inches of water over the whole area drained for collection in a reservoir. Taking 16 inches depth of water over the area irrigated as the requirement in addition to the proportional part of 16 inches of rain-fall, and we have 16 divided by 6, equals 2⅔; *i. e.*, the water from 2⅔ acres of drainage area will furnish sufficient water to irrigate one acre of land. Doubling this amount for contingencies (as evaporation and seepage), and 5¼ acres will suffice for one acre. On this basis the owner of a favorably-situated quarter-section of land can collect in a reservoir the required amount of water to irrigate 30 acres, which will allow 15 acres for agriculture, 15 for meadow, and 130 for grazing. The reservoir should be made deep, to prevent loss by evaporation. Should the gathering ground be large, and owned by a number of persons, a reservoir of greater capacity might be constructed, and by purchase or exchange with each other, a unit of forty acres of irrigable land might be secured to each, with diminished cost per acre.

As the prosperity of a community and nation consists in the land being divided into a great number of well-cultivated small holdings rather than in large tracts owned and controlled by organizations of capital, the above plan will especially apply.

When, however, there is no suitable site for a reservoir, the rain-fall from the gathering-ground will run onto and be absorbed by the porous soil of the bottom lands. Pure sand, when saturated with water, will contain from 30 to 40 per cent. of its bulk, while gravel contains 25 per cent. The eminent scientist, Sterry Hunt, estimates that one square mile of sandstone 100 feet thick will contain, when saturated, water sufficient to sustain a flow of one cubic foot per minute for a period of thirteen years. Sandy soil at a certain depth is always saturated with water, which rises, after large accessions from rain, nearly to the surface of the ground, and falls again during periods of drought. In a region of sand and gravel a fall of 6 feet in the ground-water will give a discharge into the streams of from 40,000,000 to 50,000,000 cubic feet per square mile of ground. The water so held constitutes the reserve which goes to maintain the dry-weather flow of streams.

The water in the ground, like that in the streams, is in constant motion, although its rate is by comparison with that of streams very slow. The quantity of water flowing in an open channel 100 feet wide and 6 feet deep, with a fall of 1 foot per mile, is about 1,000,000,000 of gallons per day. The quantity flowing through a channel of the same dimensions and fall, filled with gravel, will not exceed 600 gallons at the same time. This extreme slowness with which the ground-water moves serves as a regulating sluice to the ground reservoir, securing it against rapid exhaustion.

From the above it is evident that the water stored in the porous soil of the bottom lands is the source of the water supply of the Arkansas River valley, rather than the flowage of the river, which in fact for a portion of the year acts as a drain to the valley rather than as a supply to the under-current. The longitudinal fall of the ground-water in the valley in western Kansas is about 7 feet per mile. The writer found by measurement that the fall of the ground-water from the Arkansas River to Cow Creek, a distance of 2 miles, near Hutchinson, was 8¼ feet per mile. Observations made during the construction of water-works for cities show that in ordinary sand and gravelly soil a fall of 7 feet per mile will give a rate of motion of the ground-water of about 1 foot per hour.

The plans proposed for procuring water for irrigation from the under-ground current, that are said to be in course of construction in the sand hills on the south side of the river, near Fort Dodge, of excavating a large reservoir; and that proposed, of digging an intercepting ditch, and to carry the water thus collected in open ditches to the land to be irrigated, will require that the reservoir and intercepting ditch be made large and very deep, for the reason that the water thus obtained must be procured from above the surface of the water in the reservoir or ditch, with a grade of 7 feet per mile of ground-water to have a rate of motion of water into the reservoir or ditch of even so much as 1 foot per hour. The least allowable inclination of the ditch to carry off the water with a depth of 2 feet will be 3 feet per mile, and as the water collected will be free from silt, the loss from seepage will be very large. Add to this the liability of the carrying ditches becoming filled with drifting sand, and it is extremely doubtful whether, in the case of works of any magnitude, the cost of construction and maintenance may not be largely in excess of pumping from wells.

The question of the supply of any desired quantity of water for irrigation from the underflow being assured, we will consider the subject of its procurement, etc., in the following order: First, the quantity of water required for irrigation, generally and specifically; second, the manner of its procurement from the under-ground current; third, the cost of plant for procurement and distribution; fourth, the results of irrigation and a comparison of it with "dry farming" when the rain-fall is deficient, and also when it is ordinarily considered ample for "dry farming," together with a comparison of the methods in general use of distributing the water from open ditches by means of rills opened and closed with shovels or hoes; and of distributing pumped water from pipes by means of hose and hydraulic monitors attached to plugs or hydrants.

First. The quantity of water required for profitable agriculture depends upon the nature of the soil, character of the crops, and the position of the district in relation to the surrounding country. Thus in the case of a permeable soil with considerable declivity the water deposited upon it will pass off rapidly, erhaps even before serving for the germination of the seed or the nutriment of the plant. If, however, the soil be retentive, and the site low as compared with its surroundings, the soil may become so saturated with water that germination and growth may be greatly impeded. The conditions necessary for the germination of seed and the growth of plants are moisture, air, and a certain degree of heat. In a clayey, impervious soil an excess of water will act injuriously by reason of the absence of air and heat. In the case under consideration, the soil being pervious and the ground having sufficient declivity to give surface drainage, the discharge will be large. Add to this an elevated temperature, a clear sky, and dry air—in brief, a normal drought—and we have all the conditions which require frequent and plentiful waterings. In the process of vegetation, water is the medium through which plants obtain nourishment. The water, charged with the organic and mineral substances in a state of solution which constitute the food for plants, is drawn up through the roots; these substances are assimilated, and the water thrown off through the leaves. Many experiments have been made to determine the amount of water transpired by plants. M. E. Risler, a Swiss philosopher, has recently given a good deal of attention to this subject. He operated both in the laboratory and by observing the flow from the drains of a field especially arranged for such observation. He gives the daily consumption of water for different kinds of crops as follows:

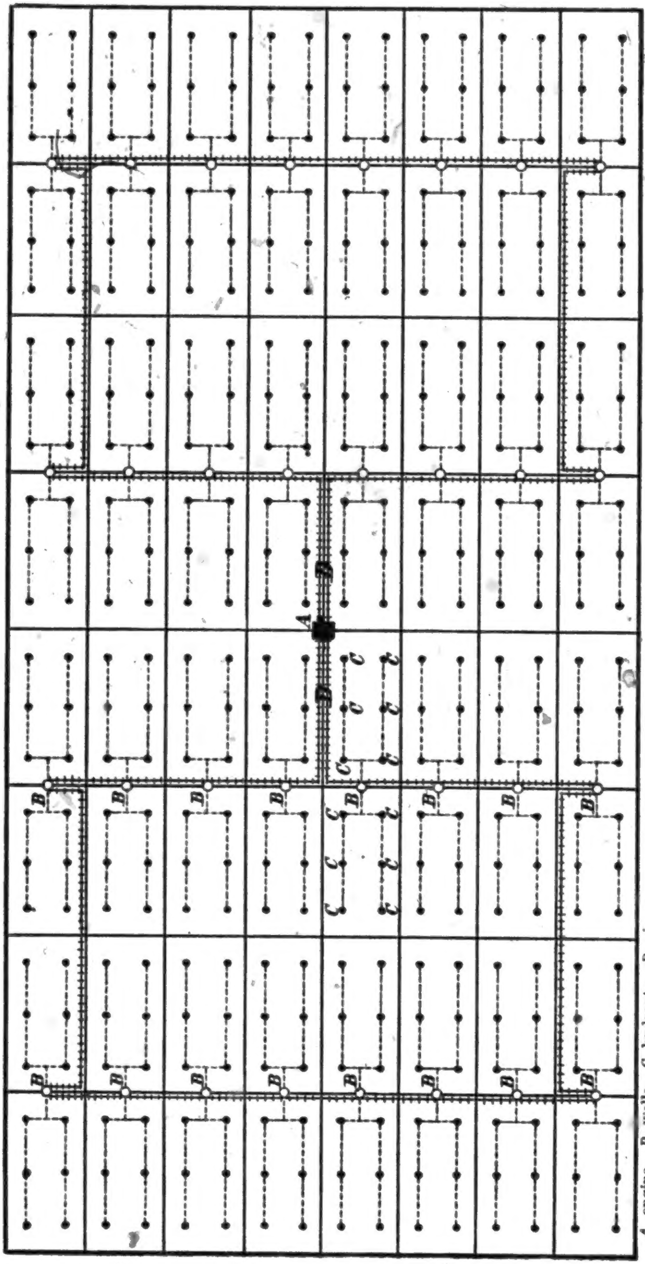
	Inch.		
Lucern grass	0.134	to	0.267
Meadow grass	0.122		0.287
Oats	0.140		0.193
Indian corn	0.110		1.570
Clover	1.140		
Vineyard	0.035		0.031
Wheat	0.106		0.110
Rye	0.091		
Potatoes	0.038		0.055
Oak trees	0.038		0.030
Fir trees	0.020		0.043

Schlieden, at Jena, found for a mixture of clover and oats grown in earth contained in an iron box which was weighed at intervals to determine the evaporation, a consumption of about 0.0984 inch per day from the time of sowing until the time of harvesting, a period of one hundred and twenty-nine days—13 inches nearly. Very careful experiments on this subject have been in progress for several years at the observatory of Mountsouris, in France. The grain is grown in earth contained in metallic boxes, and similar boxes without grain are used to determine the evaporation. In some cases the earth was dried and weighed both before sowing and after harvesting. The results obtained were essentially as above given. It was found that to produce one pound of wheat required the expenditure of from 800 pounds to 2,400 pounds of water, the lesser quantity being when the soil was fertile. In the case of wheat the maximum consumption of water occurred at the period of flowering, after which it diminished to the ripening, and then ceased.

From the above table it appears that a field of grain (as wheat, oats, or rye) may absorb, between seeding and harvesting, 15 inches of water, while grass may absorb 37 inches during a period of growth of one hundred and thirty days. This question of the effect of water on fertility explains the difference observed in the yield of different fields of grain at the same time, and of different yields of the same field in different years. It also serves to explain some points in hydrology, as to the effect of the destruction of forests on the flow of streams. The table shows that the quantity of water transpired by the leaves of cereals is greatly in excess of that by the leaves of forest trees, which proves that the clearing and cultivating of forests do actually diminish the quantity of water in the streams. It also explains how lands rich in the chemical constituents of certain grains produce large crops with a small rain-fall, as in the case of Northern Dakota and Minnesota, where with a rain-fall of but 17 inches, 30 and 35 bushels of wheat to the acre is not an uncommon yield.

To the above quantity of water, viz, 15 inches for cereals and 37 inches for grasses, the amount transpiring through the leaves respectively, there must be added that required for evaporation and percolation. This last in the case under consideration will depend on the condition of the soil and the frequency of waterings; the application of even two inches when the soil was dry would not penetrate to any considerable depth.

As examples of the quantity of water found necessary for profitable agriculture: California, with 15 inches of water, in addition to rain-fall, secures good crops; this is a duty of 206 acres for 1 cubic foot of water per second. A. D. Foot, in his estimate for irrigating works in Idaho, gives 100 acres as the duty of the above quantity of water. India, for wheat, uses four waterings of 2¼ inches each; this is a duty of 267 acres. C. L. Stevenson, civil engineer, gives the duty in Utah formerly as 60 acres,



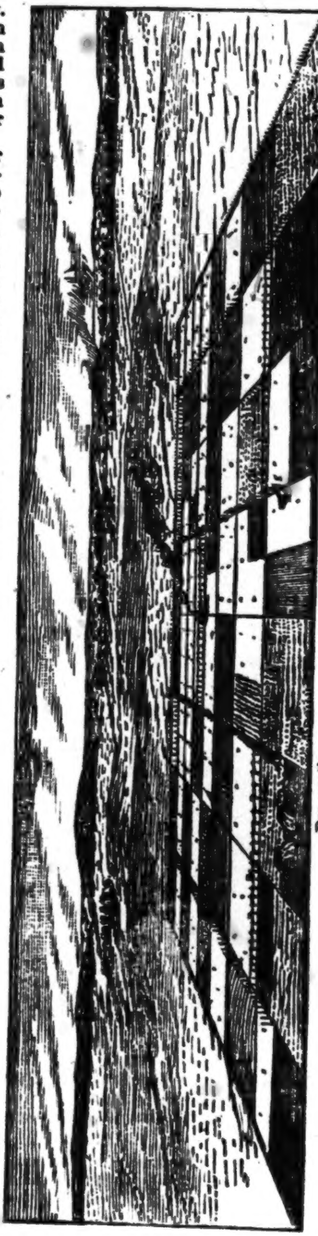
A, engine. *B*, wells. *C*, hydrants. *D*, pipes.

Proposed plan, showing installation for 1,280 acres, consisting of engine, dynamos, poles, wires, motors, pumps, wells, pipes, and hydrants.

and now of 100 acres. Lombardy, Italy, with an annual rain-fall of 38 inches, 22 of which falls in the growing season, finds it necessary to irrigate, especially for rice and meadow. A grass called marcite requires, except when being cut, the continuous passage of a thin film of water. A cubic foot of water per second irrigated 3 acres, thus securing an enormous yield. The meadows near Milan were cut seven times, yielding from 50 to 75 tons per acre per annum.

J. D. Schuyler and G. F. Allardt, in their report upon the water supply for the irrigation of Claus Spreckel's sugar plantation in the Hawaiian Islands, state that the customary allowance for sugar cane in Spain, Italy, Algiers, Egypt, and Japan is from 45 to 60 acres for 1 cubic foot of water per second; and that the manager of the Hawaiian Commercial Company gave as his experience that for water applied every seven days, when the allowance was 1 cubic foot of water per second for 65 acres, the yield of sugar was an average of 5¼ tons and a maximum of 10 tons per acre. The yield of cane sugar in Louisiana is a maximum of 3,200 pounds, and an average of 2,800 pounds per acre, while the yield of sorghum sugar in Kansas is a theoretical maximum of but 1,400 pounds per acre.

The above large range of water used points to the fact that, depending on the crops being raised, the more water the larger the yield; for which reason any scheme for the procurement of water for irrigation from the underflow of the ground in a region of normal drought, the requirements are not only that the supply be ample, but that provision be made to furnish it on call as required. To insure certainty of supply and mimimum of cost will require that the water be obtained from wells. These conditions will be satisfied by the use of steam-power pumps, obtaining their supply from a system of tube wells connected to a horizontal main which constitutes the suction-pipe of the pump. This arrangement, while the first cost is small, admits of extension as required. As an example of the successful operation of this way of procuring water in quantity, is that of the water supply of Brooklyn, N. Y., where, from one hundred well-points driven to a depth of from 50 to 75 feet, 7,000,000 gallons of water were pumped daily. While this method allows of the construction of works for the irrigation of any desired area of land, the larger and more complete the installation the less will be the cost per acre. With two sections of land as the area to be irrigated, divided into units of 20 acres each, place the engine and dynamos at the center of the area; locate each battery of wells at the adjoining ends of two 40-acre tracts, the motors and pumps to be portable, and the power to be transmitted by means of copper wires from the dynamos to the motors; the capacity of engine, dynamo, wires, wells, motors, and pumps to be such as to provide for the covering of the whole area of two sections of land with 1 inch of water per week. This quantity of water will serve for ordinary agriculture. Should circumstances require an additional supply the works can be extended by simply adding to the plant.



Prospective or proposed plan, as seen on preceding page.

As the success of all enterprises requires a sound financial basis, and this system, while adapted to the irrigating of a few acres, is also susceptible of any desired extension, we will consider in what manner it may be put into operation where there is a number of interests concerned, bearing in mind that with the upland range for grazing, 40 acres of irrigated land is a farm.

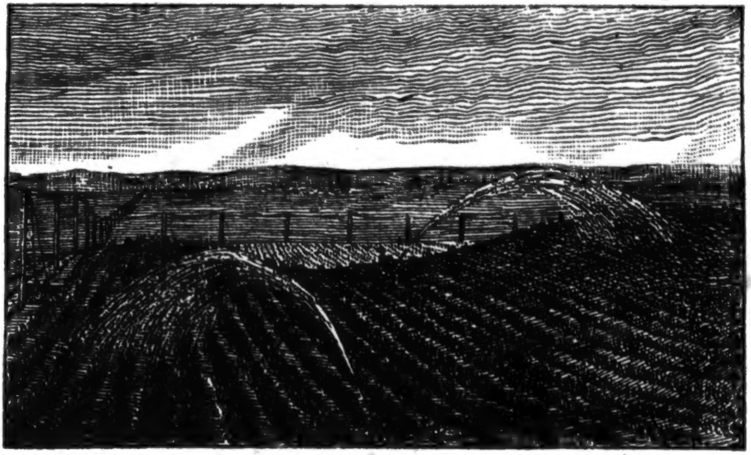
One method might be by the formation of an irrigating district, as is done in cities in the construction of sewers; the whole cost of installation for the delivery of the water at the end of each 20-acre tract to be assessed on the property benefited, and payment extended over a term of years; the works to be paid for in construction bonds. As soon as their nature and value become known, they can be sold readily at a low rate of interest.

Or the works might be put in by a chartered company as contractors, who would be paid a rental as a return for their investment. This rental would entitle all parties within the district to the privilege of obtaining water on payment for the same, which charge would be the cost of pumping and maintenance of plant.

For the installation for an area of 1,280 acres, consisting of a 60-horse power engine, dynamo, poles, wires, insulators, sixteen batteries of wells of fifteen points each, six motors and six pumps, two extra motors and pumps being provided for the purpose of allowing for moving to new stations, thus keeping the pumps running continuously, on the basis of one watering per week of one inch depth of water, each under a head of thirty feet, the cost will be twenty-five dollars per acre. The cost of pumping, consisting of fuel, oil, attendance, and depreciation of plant, will be 12 cents per acre per watering. This delivers the water without waste at the end of each twenty-acre tract.

The distribution of the water may be done, as in the case of that supplied from canals and ditches by hand labor, from lateral ditches; or, preferably, as the water is delivered under a head, by means of a system of pipes, hydrants, hose, and monitors. The cost of distribution will vary with the character of the ground and the nature of the crop, being a minimum for meadow land having a regular declivity, and a maximum in the case of fruit, when, in addition to the regular system of pipes, a line of small perforated pipes is put between the rows of trees.

For two lines of pipes and eight hydrants to each twenty trees, the cost of installation will be about $20 per acre. This, however, allows of the irrigation of land situated 25 feet above the pump, and entirely does away with all labor connected with the construction and maintenance of lateral ditches and the conducting of water over the lands by means of rills. Estimated cost of irrigating by this method will be as follows:



Proposed plan, showing distribution of water from hydrants.

Installation of plant proper for one acre	$25.00
Installation of pipe system	20.00
Total cost of installation	45.00

Interest on above at 8 per cent	$3.60
Sixteen waterings at 12 cents per watering	1.92
Cost of distribution of water, one-twentieth of thirty-two days' labor, at $1.50 per day	2.40
Total	7.92

Contra, for cost of irrigating with supply from canals and ditches:

Cost of water rental per acre	$2.50
Labor, laterals, and distribution, one-fortieth of three men for three months, at $40 per month, per forty acres	9.00
Total cost	11.50

A saving of $3.58 per acre, equal to 45¼ per cent.

The advantages in favor of irrigation are: not only are the crops much larger, but they are entirely unaffected by drought or wet; and being harvested under a clear sky are in good condition, and therefore, being of superior quality, command higher prices. As a rule, persons living on irrigated land, having regular occupation, are more thrifty; their crops are certain, regardless of seasons; having larger and more certain incomes, their earnings are expended in increased comforts—all of which increases the business of railroads. And now that the competition between rival lines has destroyed the profits of through traffic, dependence must be placed on local business, which for that reason must be developed, resulting in the charges for the hauling of coal used for pumping being the least possible. As the effect of an extensive system of irrigation is toward small holdings and a dense population, the result will be increased business. It is estimated that 1 acre of irrigated land produces, directly and indirectly, more than 1 ton of railroad freight annually, or more than two hundred times as much as the same land used for grazing cattle, as the effect of any considerable amount of irrigation would, by increasing the humidity, tend to a reclamation of the unirrigated desert, and in a measure affect the humidity of the whole State; for it is from the desert that the hot winds come that have proved so disastrous to the eastern portion of the State.

Justice would seem to require that some return be made for the benefits rendered, by way of bounty or remission of taxes for a term of years on all irrigating plants and all increased value of irrigated lands. Such aid would greatly promote this industry, and work no injustice to other portions of the State.

While the above proposed plan allows of application on any scale from 1 acre to 100,000 acres, whether by means of storage reservoirs or by pumping, extensions on a scale commensurate with its importance and magnitude may be made by Governmental or State aid with perfect safety, the cost being a lien on the land benefited in a manner similar to that practiced by the British Government in their administration of the affairs of India. In the case of works of improvement that promise to be remunerative the Government takes the initiative, and sends its engineer to make surveys, plans, estimates of cost, and reports as to its character, etc. These reports, with detailed plans and estimates, are sent to the collector of the district, who publishes them and invites objection. If no valid objection is made, the work is done and paid for by the Government, and the cost assessed on the property benefited. If small, it is collected at once; if large, the payment is extended over a period of years. The enhancement of the value of the property by reason of the improvement always precedes the payment of the cost.

The above proposed method of irrigation is but an application of known methods of procuring, pumping, conveying and distributing water; and the mode of transmitting the power, while in one sense new, is of very general application. With an abundant supply of water assured, the merits of this plan are so marked that it would seem that a simple presentation would secure recognition and adoption. The necessity of devising some system of irrigation for the reclamation of so vast an extent of territory of such known fertility, situated in the center of the civilized world, will be seen by a consideration of the methods of developing India by the British Government, in the construction of works of irrigation aggregating millions of dollars of cost, and the resources of Africa awaiting development by them. It was from the then undeveloped Soudan that England obtained the cotton for its factories during the blockade of the Southern ports at the time of the late civil war.

As to the claim that we can not compete in production with the cheaper labor of India and Africa, it must be borne in mind that 40 pounds of coal, costing 10 cents, in a first-class steam-engine will develop 1 horse power for ten hours, which is equivalent to the labor of five stalwart English laborers, and probably seven or more underfed Asiatics or Soudanese, which, at 30 cents a day, will be $2.10, a saving of $2 on 1 horse-power per day. This saving is not only in the procurement, but also in the distribution, which, apart from the cost, is especially applicable to American methods of doing work by machinery and power.

COLORADO DIVISION.

PUEBLO, COLO., *September* 14, 1889.

The committee met pursuant to call of the chairman.

Present, Messrs. Stewart (chairman) and Jones, also Director Powell.

STATEMENT OF VICTOR G. HILLS, OF PUEBLO.

The CHAIRMAN. We are investigating the subject of irrigation with reference to the water supply, the land to be irrigated, and the crops produced. Will you please give the committee such information as you may have touching those subjects, so far, especially, as relates to the State of Colorado or to this county?

Mr. HILLS. Had I known that I should be examined to-day I should have brought with me, as county surveyor, some notes and figures that I have left at my office. I will endeavor, however, to meet your wishes.

The source of our water supply here is, generally speaking, the mountain streams, the main stream of this county being the Arkansas River. There is one thing which occurs to me to mention in that connection; that the flow of the Arkansas is greatest in June and July, which is the time when most water is needed for irrigation. Therefore less storage capacity is required to utilize that water than if the greatest flow were at some other time. That may be said probably of all the streams flowing from the mountains east, across these plains.

The CHAIRMAN. Describe the Arkansas River, its dimensions, etc., and the quantity of water flowing into it, if you have kept any gauge of it. State also whether the water now runs to waste, or whether anything can be done to increase the volume at the time needed for irrigation, both here and in Kansas.

Mr. HILLS. The Arkansas River has its source near Mount Lincoln, north of Leadville. It may be said here that something could be done there toward turning the waters of the western slope into it if that should be thought best. I am well acquainted with that particular locality personally. There is a stream tributary to Grand River, which should probably be turned into the Arkansas at some time, as the water is not needed west on account of its streams going into cañons and not being available.

The CHAIRMAN. Which one of those streams could be turned?

Mr. HILLS. There is a tributary which is called the Ten-Mile Creek or Blue River, which has it source near Breckinridge.

Director POWELL. Do you know as an engineer that that can be done?

Mr. HILLS. Yes.

Director POWELL. The Grand River will always run to waste where it is.

The **CHAIRMAN**. It will unless we can make it tributary to the Colorado.

Mr. **HILLS**. I believe the State of Colorado appropriated something for surveys to determine those questions at the last session of the legislature.

Director **POWELL**. Where could the Ten-Mile River be tapped and be turned into the headwaters of the Arkansas?

Mr. **HILLS**. At that portion which is called McNulty Gulch, where the old placer mines were twenty years ago.

The **CHAIRMAN**. How much of a stream is it there where it can be turned? How much water is there in it?

Mr. **HILLS**. It is very difficult to guess at the capacity of a mountain stream without knowing its fall. I never gave that question any special thought.

The **CHAIRMAN**. You can state whether it is an ordinary mountain stream or a considerable one.

Mr. **HILLS**. It is a good mountain stream.

The **CHAIRMAN**. Has it a good water-shed?

Mr. **HILLS**. It has its head in Mount Lincoln and Mount Bross.

The **CHAIRMAN**. Are there opportunities for the storage of those waters?

Mr. **HILLS**. I think the opportunities for storage are fairly good. I do not know of any special reason for saying that they are better than ordinary opportunities.

The **CHAIRMAN**. How many ditches are taken out of the Arkansas River in the State of Colorado?

Mr. **HILLS**. As to the whole number of small or individual ditches I could hardly make a guess. The State engineer's report would show that fully. Of extensive ditches there are only two that we might call large company ditches now.

The **CHAIRMAN**. How much land is irrigated from the waters of the Arkansas?

Mr. **HILLS**. I could not answer that question so well probably as you can get it from some other source.

Director **POWELL**. I have all those statistics prepared for the committee.

Mr. **HILLS**. I have not the figures in my mind.

The **CHAIRMAN**. You have been engaged in engineering for irrigation here?

Mr. **HILLS**. Yes.

The **CHAIRMAN**. What is the character of the crops produced?

Mr. **HILLS**. We can produce almost everything here that grows in a temperate climate.

The **CHAIRMAN**. You produce, of course, good crops with irrigation?

Mr. **HILLS**. Yes.

The **CHAIRMAN**. What amount of water does it require to irrigate an acre of land here—have you paid attention to that?

Mr. **HILLS**. That is difficult to answer.

The **CHAIRMAN**. It has been discussed among you here, I suppose?

Mr. **HILLS**. Yes, it has been discussed a good deal, but the amount of water used by inexperienced persons is well known to be greatly in excess of that actually needed, as was proven in cases where they could not get the water, and as proven by the amount used in dry seasons, like the present one.

The **CHAIRMAN**. I suppose they waste water here as they always do where they have not had experience.

Mr. **HILLS**. Yes.

The **CHAIRMAN**. Some soils and some climates require more than others?

Mr. **HILLS**. Yes. You will find them to vary here, as we have different soils. We have different soils even in this county.

The **CHAIRMAN**. I should like to ascertain what efforts have been made to economize water. What is the least amount required to irrigate an ordinary crop?

Mr. **HILLS**. I could not state that from personal observation. We have not had enough of it. What I would state in that connection would be simply what I have gathered from reading and experience.

The **CHAIRMAN**. I do not mean to ask you as to the results of your reading and experience elsewhere. Have you had experience of that character here to enable you to state as to this locality?

Mr. **HILLS**. I have not.

The **CHAIRMAN**. There is good soil here, I suppose?

Mr. **HILLS**. The larger part of the soil here east of the foot-hills is excellent soil and capable of cultivation.

The **CHAIRMAN**. What proportion of it is under ditches?

Mr. **HILLS**. A small proportion of it—you may say nothing but the bottom lands in this county.

The **CHAIRMAN**. They have not brought the water to the uplands at all?

Mr. **HILLS**. No. There is now one ditch building—the Bessemer ditch—that will bring some water onto the uplands.

The **CHAIRMAN**. You have no idea, I suppose, of the amount of land here that is irrigated?

Mr. **HILLS**. About three-fourths of the area of the county.

The **CHAIRMAN**. How much would that be?

Mr. **HILLS**. I could not tell the area of the county without referring to notes.

Senator **JONES**. Could water be put on lands in this county with comparative ease?

Mr. **HILLS**. It can when it is once placed on the mesa lands.

Senator **JONES**. That is the question. Can that be done?

Mr. **HILLS**. It can.

Senator **JONES**. What would be your source of supply, the Arkansas River?

Mr. **HILLS**. The Arkansas River mainly, but not altogether. We think other small tributary streams in the Greenhorn range could be made available by storage reservoirs, and Beaver Creek from the Pike's Peak region.

Senator **JONES**. What is the nature of the Arkansas River above here—how far would you have to go to get the necessary fall to take the water out? Would you have to dam the river, and how expensive would the works be, comparatively, to get water enough to irrigate this part of the county which is susceptible of irrigation?

Mr. **HILLS**. I think we should have to go above Cañon City to irrigate most of the county. That means that we would not have to dam the river, but the water could be brought out by a ditch.

Senator **JONES**. How far is Cañon City?

Mr. **HILLS**. Forty-two miles above Pueblo, and just at the place where the river comes out of the mountains.

Senator **JONES**. Where the irrigable lands begin?

Mr. **HILLS**. Yes.

Senator **JONES**. Water could be placed immediately on the land by taking it out up there?

Mr. **HILLS**. Yes.

Senator **JONES**. Are you familiar with other parts of Colorado besides this county—the physical features of the country, the possibility of irrigation and the demand for it?

Mr. **HILLS**. Some parts of it.

Senator **JONES**. Not generally?

Mr. **HILLS**. My observation has extended over the counties south of here. Otherwise I am familiar only with the mining or mountain regions.

Senator **JONES**. Are you familiar with the southwestern part of the State—that portion south of the Arkansas River?

Mr. **HILLS**. I am, through that portion south of the river and east of the San Juan Valley.

Senator **JONES**. What is your southeastern county named?

Mr. **HILLS**. Las Animas County.

Senator **JONES**. Are you sufficiently familiar with Las Animas County and that part of Bent County south of the Arkansas River to say whether or not any large proportion of those counties is susceptible of irrigation, and whether there is sufficient water supply to irrigate them?

Mr. **HILLS**. No. I am not sufficiently acquainted with Las Animas County to make any statement in regard to that matter.

STATEMENT OF HENRY R. HOLBROOK.

The **CHAIRMAN**. What is your occupation?

Mr. **HOLBROOK**. I am a civil engineer.

The **CHAIRMAN**. How long have you been engaged in this section of country?

Mr. **HOLBROOK**. About sixteen or seventeen years.

The **CHAIRMAN**. Then you are quite familiar with this portion of the State?

Mr. **HOLBROOK**. Yes. I have been over it considerably. I have been in railroad engineering mostly since I have been in this country.

The **CHAIRMAN**. You have heard the examination of the previous witness and observed the scope of our inquiries. You may proceed to make any statement which will afford information to the committee with regard to the Arkansas River and to other supplies of water here, the extent of land to be irrigated, and any scheme by which the water supply might be augmented if it is insufficient. Give us a general statement of your information and views on that subject.

Mr. **HOLBROOK**. Our main source of supply of water for irrigation is the Arkansas River. It is the largest river on the eastern slope of the Rocky Mountains in Colorado. The Arkansas River has a good many branches that carry a good deal of water, especially during the flood season. This water might be stored in reservoirs for the purposes of irrigation.

The **CHAIRMAN**. Does a large portion of the water of the Arkansas River run to waste?

Mr. **HOLBROOK**. Yes. The Arkansas River is highest during June and July. That is the flood season. It carries then an enormous quantity of water. That is also the season of irrigation in this country—June and July.

The **CHAIRMAN**. What proportion of water is taken out by the ditches in Colorado during irrigation season?

Mr. HOLBROOK. I do not know how it is as to the whole State. I know only about this vicinity—the Arkansas Valley.

The CHAIRMAN. State the amount of proportion of water taken out by the ditches in the Arkansas Valley in flood times.

Mr. HOLBROOK. Perhaps there is one-tenth of it taken out now during flood time—during June and July—in the Arkansas Valley. I do not know how it is about Denver.

The CHAIRMAN. They do not take the Arkansas out in Denver, do they?

Mr. HOLBROOK. No.

The CHAIRMAN. I am only speaking of the Arkansas River.

Mr. HOLBROOK. About one-tenth, perhaps, of the water of that river is taken out for the purpose of irrigation during flood time. I would not think more than that.

The CHAIRMAN. Is that stored at all, or is it taken out as it is needed and put on the land?

Mr. HOLBROOK. It is taken out in ditches when needed. There is no water stored in this valley now to amount to anything.

The CHAIRMAN. What proportion of the land in Colorado might be irrigated by the waters of the Arkansas that are under ditches?

Mr. HOLBROOK. There is a very small proportion of land in the Arkansas Valley irrigated that might be irrigated. All this land in the Arkansas Valley will produce well if you can get water on it. I never saw an acre of it that would not.

The CHAIRMAN. Is one-tenth of the land under cultivation?

Mr. HOLBROOK. No.

Senator JONES. What do you mean by "the Arkansas Valley;" how wide a tract of country do you include in that term?

Mr. HOLBROOK. The Arkansas Valley extends from the divide, 50 miles north of here, south to the Raton Mountains. That is about 80 miles south.

Senator JONES. About 130 miles wide altogether?

Mr. HOLBROOK. About 130 miles wide. Of course it would not be practicable to irrigate all of that strip.

The CHAIRMAN. What proportion of that could be irrigated if proper ditches were constructed?

Mr. HOLBROOK. Ditches can be taken for, say, 20 miles each side of the valley.

The CHAIRMAN. Could they not be taken out farther than that?

Mr. HOLBROOK. Yes, by going to greater expense; but it would cost so much money to take ditches out farther than that that it would not be practicable.

The CHAIRMAN. Would that strip extend down to Kansas?

Mr. HOLBROOK. Yes; all the way down to Kansas.

The CHAIRMAN. Would it be 40 miles wide all the way down?

Mr. HOLBROOK. Yes; it would not be quite so wide as that at Pueblo. These ditches would diverge from the river.

The CHAIRMAN. But 40 miles wide from the cañon up here?

Mr. HOLBROOK. Suppose you commence at Cañon City, the width there would be nothing. The canals would diverge from the river gradually until they reached, say Pueblo. That would be about 10 miles each side of the river, so that you could irrigate a strip here at Pueblo 20 to 30 miles wide.

The CHAIRMAN. Then it would go on expanding?

Mr. HOLBROOK. Yes; it would go on expanding until you got down to West Las Animas, say, 80 miles east of here you would irrigate a strip of country from 30 to 40 miles each side of the Arkansas River.

The **CHAIRMAN.** It would be 60 or 70 miles wide when you got 80 miles below here?

Mr. **HOLBROOK.** Yes; then these ditches would steadily diverge from the river until you got to the State line. The strip then would be very wide; I do not know exactly how wide.

The **CHAIRMAN.** When you got down to Kansas you could distribute over an almost unlimited space of ground?

Mr. **HOLBROOK.** Yes.

Senator **JONES.** If that system of ditches were already made how would it be about the water supply?

The **CHAIRMAN.** Yes; suppose you had ditches enough to carry it all the way down to Kansas, what would be the water supply for those ditches?

Mr. **HOLBROOK.** The present water supply would not be enough to irrigate all that land, but the supply might be increased very largely by storage reservoirs.

Senator **JONES.** You mean the present water supply—the running streams?

Mr. **HOLBROOK.** Yes.

The **CHAIRMAN.** You mean by saving the water of the running streams to be used at irrigation time?

Mr. **HOLBROOK.** Yes.

The **CHAIRMAN.** Suppose you saved in reservoirs all that was practicable to save in that way, what extent of land would it irrigate; would it irrigate all this land that it would flow over?

Mr. **HOLBROOK.** It would not irrigate all the land that you cover with ditches, but of course the amount that could be irrigated would be largely increased; just how much it would be very difficult for me to say.

The **CHAIRMAN.** If this land were brought under cultivation by reservoirs and other works, would there be any floods in the Arkansas Valley?

Mr. **HOLBROOK.** There would not be such large floods if the waters were stored and kept back.

The **CHAIRMAN.** Do you think it is practicable to keep them back so that there would not be floods below?

Mr. **HOLBROOK.** They could be very much diminished by reservoirs.

The **CHAIRMAN.** Are you not mathematically certain of it?

Mr. **HOLBROOK.** Yes.

Senator **JONES.** You think that if all the water in the water shed of the Arkansas that could be stored in reservoirs should be stored, there would not be enough water to irrigate all the land in the Arkansas Valley which is between here and the Kansas line?

Mr. **HOLBROOK.** No. You have more land than you can irrigate. It is simply a question of water supply. All this land east of here will produce fine crops if it can have water; all the crops incident to this latitude.

Senator **JONES.** But it seems to me there must be a large water-shed in the Arkansas Valley, in these mountains.

Mr. **HOLBROOK.** Yes; it is a very large basin.

Senator **JONES.** Have you made any calculations as to the rain-fall in that basin and the amount of water that could be stored, or is this just an impression without careful examination on your part?

Mr. **HOLBROOK.** I never made any careful calculations in regard to it at all.

The CHAIRMAN. You have been over it somewhat?

Mr. HOLBROOK. I have been over it a good deal. I located the railroad line from here to Leadville, and was over it a good deal during location and construction.

The CHAIRMAN. What occasion have you had for examining the water-shed generally of the Arkansas?

Mr. HOLBROOK. I have made surveys from here to the head of the Arkansas River.

The CHAIRMAN. What kind of surveys?

Mr. HOLBROOK. Railroad surveys. I located the line from Cañon City to Leadville for the Atchison, Topeka and Santa Fé Railroad Company, and was also engaged on the construction of the road. I made surveys through Marshall Pass and down to Gunnison.

The CHAIRMAN. Then you have had rather unusual opportunities for observation?

Mr. HOLBROOK. Yes; although I was not observing the country then for irrigation. I was making railroad surveys and locating railroad lines.

The CHAIRMAN. But you observed how the country was?

Mr. HOLBROOK. Yes, and I observed one point, as I now recollect, up there, where I think a large storage reservoir could be made at small expense.

The CHAIRMAN. Where is that?

Mr. HOLBROOK. At the Twin Lakes. That is the finest natural water storage place I ever saw.

The CHAIRMAN. Is the water-shed large?

Mr. HOLBROOK. Very large. It is on a small branch of the Arkansas River, just above Granite. I was up there several times, though not for the purpose of examining its adaptability for a storage basin, but from my knowledge of it I think it is the finest storage reservoir in the world.

The CHAIRMAN. What proportion of the Arkansas River comes out of there in flood time?

Mr. HOLBROOK. I do not know; I could not say. It was quite a large outlet and a very strong stream of water comes out of there, perhaps 20 feet wide and 1 foot deep in low water.

The CHAIRMAN. How is it in high water?

Mr. HOLBROOK. I never saw it in high water.

Senator JONES. How large are those lakes?

Mr. HOLBROOK. I do not know just how large they are. They are several miles long and 2 or 3 miles wide. One is larger than the other.

Senator JONES. How much could the level of those lakes be raised?

Mr. HOLBROOK. I do not know. I should think 20 feet without trouble.

Mr. STANTON. Mr. Holbrook made a survey for a line of ditch on the north side of the river with storage reservoirs, etc. Perhaps he could give the committee some information as to that.

The CHAIRMAN. Was that below here or above?

Mr. HOLBROOK. It commences below—20 miles east of Pueblo.

The CHAIRMAN. Is that as good a place as it would be to commence above—it will not cover so much land, will it?

Mr. HOLBROOK. Yes. Water can be taken out below cheaper than it can be taken out above. The farther down you go the cheaper you can take out ditches, because the bluffs on either side are not so high.

The CHAIRMAN. How is it as to the bottom of the river; is that sand or rock?

Mr. **Holbrook**. Sand usually.

The **Chairman**. Would you not select a place where there is a rock foundation to bring the water to the surface?

Mr. **Holbrook**. It would be better if you could, but I do not know of any such place in the Arkansas River east of here.

The **Chairman**. Are there not places west coming out of the cañons?

Mr. **Holbrook**. There may be some places west, but the bottom is covered with bowlders for several feet deep, and I do not know that I ever saw a place where the water ran on solid rock.

The **Chairman**. But have you not seen places where the rock was not very deep in the channel?

Mr. **Holbrook**. Yes.

The **Chairman**. Are you not aware that by taking sandy places you are liable to lose a good deal of water by percolation?

Mr. **Holbrook**. Yes.

The **Chairman**. Is it not better to select a rocky spot?

Mr. **Holbrook**. Yes; if you can find the rock.

Mr. **Stanton**. They do not build dams here as a general thing.

The **Chairman**. It is very well to build dams, but it is a good thing to have a rocky bottom.

Mr. **Holbrook**. Undoubtedly, if it can be found. Here, generally, they tap the river at the channel, but it is a little better to tap it 6 inches or a foot below the level of the channel instead of building a dam. Then if there is any water in the river at all you will get it.

The **Chairman**. What kind of a head gate do you make in order to regulate the flow?

Mr. **Holbrook**. They are made here usually of timber, say 4 feet wide and 4 or 5 feet high.

The **Chairman**. Tell us something in regard to the ditch that you surveyed.

Mr. **Holbrook**. The ditch that I surveyed commences at a point on the north side of the Arkansas River, 20 miles east of Pueblo. It diverges gradually from the river, and runs 100 miles to a point about 25 miles north of West Las Animas.

The **Chairman**. How much land does it cover?

Mr. **Holbrook**. In that distance it covers 500,000 acres of land.

The **Chairman**. What size is it?

Mr. **Holbrook**. I do not know the size. There has been no construction work done on it yet. It ought to be, I think, at least 70 feet wide at the bottom. In that distance it covers several large natural basins that can be used for storage reservoirs.

The **Chairman**. It drops down into a basin and it comes out again?

Mr. **Holbrook**. Yes; the basin becomes filled with water, and from there it is taken for irrigation as it is needed. One basin is 50 feet deep and has an area of 600 acres.

Senator **Jones**. Is that shown on your map?

Mr. **Holbrook**. Yes, I think it is.

Senator **Jones**. I see here a place marked that I suppose is a basin.

Mr. **Holbrook**. There is another basin shown there that is 20 feet deep and has an area of 600 acres. Another basin is 35 feet deep and has an area of 3,000 acres. Another basin is 15 feet deep and has an area of 1,500 acres. Another basin is 50 feet deep and has an area of 10,000 acres. Another basin is 55 feet deep and has an area of 4,000 acres.

Senator **Jones**. Are all those basins high enough to carry the water on the land adjacent without raising it by artificial means?

Mr. HOLBROOK. Yes, they might be raised a little, 4 or 5 feet, perhaps, in some places.

The CHAIRMAN. Would it not be more economical to ascertain where the highest ditches could be taken out on both sides, and construct but two ditches, one on each side, and carry all the water in them and discharge it lower down? Would not that be more economical than to have a multiplicity of ditches?

Mr. HOLBROOK. No, I think not.

The CHAIRMAN. I do not mean in the amount of money to be expended, but in the economy of water?

Mr. HOLBROOK. No, I think not. I think it would be more economical to construct a number of ditches, one below the other. If you take out two ditches, say commencing at Cañon City, one on each side of the river, as these ditches are run down the river there is a great deal of water lost by seepage that runs back into the river, and to utilize that water you would have to take out other ditches below. Of the water you take out at Cañon City 75 or 80 per cent. would ultimately get back to the river, and to utilize that again you would have to take out other ditches farther down. Then to take out only two ditches would require very long lateral ditches. Your main ditch might be 20 or 30 miles from the river, and it would take a lateral ditch of many miles to irrigate land down near the river.

Mr. STANTON. Do you know anything about a chance for a reservoir on Beaver Creek, at about Seven Lakes?

Mr. HOLBROOK. No, I have not been up there.

STATEMENT OF O. H. P. BAXTER.

The CHAIRMAN. How long have you resided in Pueblo?

Mr. BAXTER. In this county ever since 1860.

The CHAIRMAN. Are you familiar with the topography of the southern portion of Colorado?

Mr. BAXTER. Somewhat.

The CHAIRMAN. That portion drained by the Arkansas?

Mr. BAXTER. Yes, I know something about it.

The CHAIRMAN. What do you say of the Arkansas River as a source of water supply, from your observation?

Mr. BAXTER. We have an abundant supply of water in that river for irrigation in the early season.

The CHAIRMAN. Have you ever thought how much land you could irrigate by it?

Mr. BAXTER. No, I have never figured that up, but we have a very big supply of water in the early spring in this country.

The CHAIRMAN. What proportion of it runs to waste?

Mr. BAXTER. I think almost all of it. The small ditches do not cut much of a figure in the early season of high water, during May, June, and July.

The CHAIRMAN. Very little of the water then is taken out?

Mr. BAXTER. Very little, comparatively speaking. We have not a great many ditches and they are nearly all small.

The CHAIRMAN. Have you been practically engaged in irrigating?

Mr. BAXTER. Yes, many years ago. I commenced farming in 1860.

The CHAIRMAN. What amount of water do you need for irrigation after you have had the ground saturated?

Mr. **Baxter**. In the way that we used to take out ditches here, which was a small way, a ditch 4 feet wide at top and 2 feet at bottom would irrigate about 360 acres of a crop.

The **Chairman**. You have not arrived at that by actual measurement, I suppose?

Mr. **Baxter**. No; not being an engineer I never measured it accurately.

The **Chairman**. Do you have a water-master here to distribute water?

Mr. **Baxter**. There are water-masters now, but when I was a boy, in the early days, we distributed it ourselves.

The **Chairman**. You have not done anything with it recently?

Mr. **Baxter**. No; I have not farmed for ten or twelve years.

The **Chairman**. How much land is there in the Arkansas valley, in Colorado, under cultivation?

Mr. **Baxter**. I do not know how much there is—not a large portion. A very small part, in fact, of the valley is under cultivation. I do not suppose there is one-twentieth even of the low valley under cultivation.

The **Chairman**. And none of the mesa land?

Mr. **Baxter**. Very little. They are doing a little of it now; but heretofore they have been confined to the low lands along the river.

The **Chairman**. How does the low land compare in productiveness with the mesa land?

Mr. **Baxter**. I do not think it is any better. I think the mesa land is really the better land. It is more easily attended to; the low land is more weedy.

STATEMENT OF W. P. HOBSON.

The **Chairman**. How long have you resided in Pueblo?

Mr. **Hobson**. I have been here the greater part of the time for eleven years.

The **Chairman**. What is your occupation?

Mr. **Hobson**. I am a civil engineer by profession.

The **Chairman**. Are you familiar with the topography of the watershed of the Arkansas River and the flow of water into and on land to be irrigated by it? Have you given that subject any attention?

Mr. **Hobson**. Yes; considerable.

The **Chairman**. Please give the committee the results of your observations and experience in that respect.

Mr. **Hobson**. I should like to have a suggestion from the committee as to the points upon which they wish me to touch.

The **Chairman**. Tell us what you know as to the quantity of water, the means of increasing that quantity, the area of land to be irrigated, the kind of crops to be produced, how much of the water runs to waste, how much of it can be saved, and such other information as you think may serve to give the committee an idea of the situation in this locality.

Mr. **Hobson**. There is a very large quantity of water in the Arkansas River at this point on the surface. Below here a very large proportion of the water sinks into the sand. From this point upward there is a very large body of it. There is less volume in sheet water below because it extends much wider the farther down you go. The water on the surface here would certainly irrigate very large tracts of land on either side of the stream if properly handled and properly stored.

The **Chairman**. Give us your idea on that subject as fully as you please.

Mr. Hobson. This season I have run a ditch line from Cañon City, on the north side of the river, to a point on the divide west of the Fountain (about 85 miles in length) at an elevation of about 500 feet above this point. It crosses the Fountain about 20 miles north of here, and it covers an area of probably 200,000 acres of arable land.

The Chairman. The ditch might be extended farther and cover more land?

Mr. Hobson. Yes, the next 6 miles would probably cover 100,000 acres of land.

The Chairman. Could it be dropped down from time to time to make reservoirs?

Mr. Hobson. Yes, there are some points where we could make reservoirs.

The Chairman. At how much an elevation above the river is the lower end of that ditch line?

Mr. Hobson. It is over 400 feet, and there are basins, of course, over that. There are broad, flat areas, that have basins. I do not have much faith, however, in all large flat areas for basins. There is too much evaporation.

The Chairman. I am not speaking of that, but are there not places where the ground is such as to give opportunities for making deep basins?

Mr. Hobson. Yes, there are certainly some locations of that kind in which a great deal of water might be stored for use.

The Chairman. What is your idea as to whether or not a large portion of the Arkansas could be used?

Mr. Hobson. I think it could be done.

The Chairman. Did you ever figure upon how much land it would irrigate if you could utilize the principal part of the water that flows down every year?

Mr. Hobson. No, I have never rated the Arkansas, nor have I ever seen an approximate rating. I do not think that even an approximate rating has ever been made of the waters of this river.

The Chairman. Or an estimate of the land that could be irrigated?

Mr. Hobson. No.

The Chairman. That is all to be determined by surveys hereafter?

Mr. Hobson. Yes, I think so.

The Chairman. Is it not important, before commencing work and spending a great deal of money, to have that done?

Mr. Hobson. Yes, I think so, to the extent through which the work is to be applied.

The Chairman. Ultimately you intend, I suppose, to irrigate all the land that can be practically irrigated by the river?

Mr. Hobson. We have no intention of doing anything only the matter that is in hand. I think that the water will all be utilized certainly, but that is a question for the future. The land is very fertile and very productive.

The Chairman. Have you been engaged personally in farming?

Mr. Hobson. Yes; I have had some experience in that line.

The Chairman. Give us the benefit of your experience in that respect so far as irrigation is concerned.

Mr. Hobson. My experience has shown me that a great many persons sed too much water. I have had experiments made with recent crops nd find that they did very well with a small amount of water. I know hat many persons frequently use too much.

The **CHAIRMAN**. Do not nearly all people use too much when they have an opportunity?

Mr. **HOBSON**. I think so.

The **CHAIRMAN**. And by that means they injure their land as well as their crop?

Mr. **HOBSON**. Yes. A very serious difficulty in connection with storage reservoirs, especially from the saving of storm waters, is the sediments in the water. That is a very serious question in the solution of the irrigation problem. My opinion is that from 10 to 15 per cent of the water from floods in our streams here is sediment. That would be a great trouble when you come to make reservoirs for the storing of flood waters.

Senator **JONES**. You think the trouble would be that the reservoir would fill up with sediment?

Mr. **HOBSON**. Yes, I think they would. I made a little reservoir up here, and after a rain I found nearly a foot of sediment in the reservoir. I think the sediment would make over 10 per cent.

Mr. **HINTON**. Is there no way of sluicing it?

Mr. **HOBSON**. That might possibly be done, and in that case the sediment would make an excellent fertilizer for the soil.

The **CHAIRMAN**. Sediment in reservoirs is one of the things that people have been contending with for thousands of years. I think we will overcome that in this country by superior skill, and finally get the mud on to the land. That would make it a great deal better land. The people have been doing that for many years.

Mr. **HOBSON**. I have thought of that.

The **CHAIRMAN**. That sediment makes land very rich and perhaps it can be sluiced out. That is one of the problems involved in this great question. High up in the mountains you do not meet with so much difficulty of that kind.

Mr. **HOBSON**. No, but I think that getting the water from those high reservoirs through the mountains would be a very serious obstacle.

The **CHAIRMAN**. Through the mountains! You would let it come down by ditches in the proper season of the year. You would not let it come through the mountains.

Mr. **HOBSON**. The great volume of our high water comes from this slope of the mountain. If you store water up there we will have to get it through the mountains by tunnels.

The **CHAIRMAN**. Does it not come down now by the river?

Mr. **HOBSON**. Yes.

The **CHAIRMAN**. Then what is the difficulty of getting it that way?

Mr. **HOBSON**. That comes down very gradually.

Senator **JONES**. The water out of the reservoir would come just as gradually.

The **CHAIRMAN**. It would not come down to augment the flood. It seems to me there is no difficulty about it.

Senator **JONES**. The water will come down the stream naturally?

Mr. **HOBSON**. Yes, but there are the ditches, and the great volume of water that comes down the Arkansas River comes down in these floods and high tides.

The **CHAIRMAN**. Have you measured the water-bed to know that the larger portion of the water is on this side of the mountain where it could not be stored, or does it not come in ravines?

Mr. **HOBSON**. I never measured it. I do not think any rating has been made of the Arkansas River.

Senator **JONES**. You say that they use too much water on the land. How much water is it usual to make use of on an acre here?

Mr. HOBSON. Various soils and crops require different quantities of water.

Senator JONES. I know that, but is there any limit to the amount per acre on any kind of land or for any kind of crop?

Mr. HOBSON. My opinion is that a cubic foot of water per second will irrigate 80 acres of ordinary crops after a second or third season.

Senator JONES. That is a good deal of water?

Mr. HOBSON. Yes.

The CHAIRMAN. How much is used here on 80 acres?

Mr. HOBSON. They often use three or four times as much as that, and damage their crops.

The CHAIRMAN. Does this land require drainage?

Mr. HOBSON. Very rarely, and but very little of the land.

The CHAIRMAN. You do not let the water evaporate on the land so as to form alkali, do you?

Mr. HOBSON. There is very little evaporation.

The CHAIRMAN. I mean you do not let it lie in puddles on the land. I suppose it soaks in immediately?

Mr. HOBSON. There is very little of our soil but what has a sufficient slope to carry it away.

The CHAIRMAN. What is the character of the soil?

Mr. HOBSON. The character of the soil is such that it absorbs the water at once. There is very little puddling of the surface.

Mr. STANTON. I think Mr. Holbrook made a statement that on reflection he may qualify; that is, that perhaps one-tenth of the water was utilized in flood-time—the water of the Arkansas River. I am sure that he did not intend to say that.

The CHAIRMAN. He may correct his statement if he pleases.

Mr. HOLBROOK. I do not think there is probably so much. I do not know exactly how much.

Senator JONES. I suppose he meant one-tenth of the water that went down the river in the irrigating season—one-tenth of the normal flow.

Mr. HOLBROOK. That would be the flood-tide of the irrigating season—June and July.

Mr. STANTON. There is certainly not one-hundredth part of the water that flows in the river at that time utilized for irrigation at present.

STATEMENT OF IRVING W. STANTON.

The CHAIRMAN. How long have you resided in Pueblo?

Mr. STANTON. Eighteen years.

The CHAIRMAN. Have you observed the Arkansas River from time to time during that period?

Mr. STANTON. I have generally.

The CHAIRMAN. What do you say of that river as to the supply of water running down it?

Mr. STANTON. In the months of June and July and up into August there is an immense quantity of water usually running in the river.

The CHAIRMAN. What proportion of that water is diverted by ditches for irrigation purposes?

Mr. STANTON. About this point I do not believe that there is the two-hundredth part of the water running in the river above this point used for irrigating purposes, and below this point I do not think there is the one-hundredth of the water used for those purposes.

Senator JONES. For what distance do you mean that?

Mr. STANTON. I mean for the whole State of Colorado. Of course, recently more ditches have been constructed, and a greater proportion of the water is taken out of the river; but when you consider the velocity of the water in the river and of that in the ditches, the amount of water taken in ditches, a few ditches make no perceptible difference whether that water runs in the river or not, because it runs with such velocity in the river channel and so slowly in the ditches. That has been my observation.

The CHAIRMAN. Then, from your observation, you conclude that there is a vast amount of land not occupied that might be brought under cultivation?

Mr. STANTON. I am confident that there is a vast extent of land—all the land for 30 miles on each side of the river as you go east from here—that can be irrigated by water from the Arkansas River, if the water can be stored for the purpose.

The CHAIRMAN. Upon that basis would you stop with the line of the Colorado or would you go along down?

Mr. STANTON. I would go along down (if Kansas wants it) through Kansas. It can be taken through the western part of the State of Kansas just as well.

The CHAIRMAN. Do you think that by storing there would be enough for the whole?

Mr. STANTON. I believe that storage reservoirs could be made so that they would hold an immense quantity. I do not know whether there would be enough for the whole, as there would be a vast amount of water required. I do not think my opinion would be worth much as to that.

The CHAIRMAN. You have been up in the mountains and know generally the condition of that country. What is its condition, and what is its capacity for keeping the water stored up there?

Mr. STANTON. I think there are places where immense reservoirs could be made and immense quantities of water stored for use in irrigating the plains. I think the day is coming when the Arkansas valley will be not only the garden spot of Colorado, but of the whole country. I do not think that any such garden spot occurs anywhere else in the country as is to be found in this valley.

The CHAIRMAN. Would a survey and gauging of the streams be of use in informing the people on this subject?

Mr. STANTON. It would be of immense benefit.

Senator JONES. Have you any idea how much land is in cultivation in the Arkansas valley in Colorado by irrigation?

Mr. STANTON. I have not.

Senator JONES. You could not approximate it?

Mr. STANTON. I do not believe I could, or if I did I do not think my approximation would be reliable. You can probably get that at Denver.

The CHAIRMAN. Have you anything else you wish to say to the committee?

Mr. STANTON. I only desire to say that I am a firm believer in the system of storage reservoirs and I think the actual experience and surveys will demonstrate the entire feasibility of the plan.

Adjourned.

COLORADO SPRINGS, COLO., *September* 14, 1889.

The committee met pursuant to call of the chairman.

Present: Messrs. Stewart (chairman) and Jones; also Director Powell.

STATEMENT OF A. Z. SHELDON, OF COLORADO CITY.

The CHAIRMAN. How long have you resided in the State of Colorado?

Mr. SHELDON. About thirty years.

The CHAIRMAN. Are you familiar with the water supply for irrigation in this State, the succes sof that method, the quantity of land that can be covered by water, etc.? Have you given that subject attention?

Mr. SHELDON. Yes.

The CHAIRMAN. You may proceed and make such statement with regard to it as will aid the committee.

Mr. SHELDON. I have been engaged in the business of civil engineering most of the time while here, and much of the time have, as a matter of course, been dealing with water. I am really at a loss to know exactly what information you desire.

The CHAIRMAN. We want to know what water supply you have, whether it needs to be increased; if so, how it can be increased; the land that you think can be covered by it, whether you have water enough for the land, and whether irrigation is a good thing in this country.

Mr. SHELDON. Water is essential to us here. It is out of the question to depend upon cultivating the soil here without an artificial supply of water. In this immediate neighborhood we are dependent on the water of the Fountain River and the Monument River mainly for our supply. There are several tributaries to the Fountain above, but I include those in the term. I suppose we have some 7,000 or 8,000 acres under cultivation, and if we depend on the natural flow of the water during the season of tillage there is not sufficient to supply that amount of land. Very many persons are short of water during the season. There is, however, taking the season together, in my opinion, water enough flowing here to supply three or four times that amount of land by storing it properly. During the winter-time it virtually runs to waste; there is very little use made of it. During the summer we have copious waterfalls, and, as a matter of course, we have no means of retaining it; so that it flows off.

The CHAIRMAN. What are the opportunities for making storage reservoirs in this vicinity?

Mr. SHELDON. There are several localities in the mountains where reservoirs might be made, but my idea has been to make those reservoirs on the plains. That is further off. If we attempt to make a reservoir on the mountain and then carry it a long distance towards the plains, there is a large loss of water before it reaches its destination. Of course that would contribute to the supply of those in the immediate neighborhood, but it would not sufficiently supply outlying lands. My idea of the proper course to be pursued is to locate those reservoirs at suitable places on the plains and have provision made not only for draining the waters of the stream during the winter to those reservoirs, but for intercepting the rain-fall and storing that. I have seen a single rain-fall here that would fill a large reservoir, and the quality of our land is such that places could be selected where there would be absolutely no loss from storage except from evaporation.

Another feature of the country adjacent to us is, east of us are a system of sink-holes. You understand, I suppose, what is meant by that. Those have for their substratum, you might say, beds of sand. I am satisfied, from my experience, that those sand-beds can be made places for the storage of water. Our experience shows that wherever irrigation is employed springs break out where under ordinary circumstances they never flowed, and they frequently flow along into the winter, sometimes throughout the winter; and if these sand-beds were infiltrated with water I am satisfied that it would constitute a constant source of supply to the stream below, because water in those sand-beds finds its way to the stream. They generally overlie a stratum of alluminous shale which is impervious to the water, and it will flow out to the stream and constitutes a continuous flow. Mr. Nettleton, our former State engineer, made a series of experiments on Boulder River and made careful measurements of water where it leaves the mountains. Although there were no additional streams entering it below that, he measured it some 20 miles below. The water was being determined from the stream by the ditches above and he found a larger flow of water below than came from the mountain; which corroborates the theory that I have advanced here. Any one who has had any experience in the matter will confirm me in this statement that the filling of the earth with water is virtually storing it. East of us there are places where very considerable reservoirs could be constructed with comparatively little expense.

The CHAIRMAN. Are you familiar with other streams than the two you have mentioned?

Mr. SHELDON. I am familiar with the Arkansas River and the Platte.

The CHAIRMAN. We have had no one to give us an account of the Platte, but have had considerable testimony with regard to the Arkansas. Are you quite familiar with the Platte?

Mr. SHELDON. Yes.

The CHAIRMAN. That is dry in summer, is it not?

Mr. SHELDON. After you get some distance from the mountains it is apparently dry, but our streams here are peculiar. Their beds are immense sand-beds and nine-tenths of our streams that appear dry are really full of water which is percolating through the sands. If at any point where the Platte River appears to be dry a permanent dam could be constructed on the bed-rock, there would be a large flow of water intercepted by that dam. But as it is, of course it is not available for irrigation. The expense of reaching it is so large that individuals could not undertake it.

The CHAIRMAN. The waters of the Platte are pretty much consumed above, are they not, in irrigation?

Mr. SHELDON. They are at present. That is, those which appear on the surface. During a very dry time, even in the neighborhood of Denver, the waters of the Platte are very low. I have never seen the Platte perfectly dry, though. I take it that it is never dry anywhere. If the waters which are flowing through the sands could be intercepted, there would be a considerable flow.

Senator JONES. Can that be done?

Mr. SHELDON. I think places could be selected where it could be done. Of course, that is a matter for examination. I never made any special examination.

Senator JONES. That is your conjecture?

Mr. SHELDON. That is my conjecture. I do not know how far below the surface the hardpan or firm bottom is, but I know a great many streams of that character which seem to be dry and yet are carrying a very comfortable body of water.

Senator JONES. What crops do you raise here when you have water?

Mr. SHELDON. We raise all the grains common to farming, vegetables, hay, etc.

Senator JONES. Fruits of some kinds?

Mr. SHELDON. Yes, fruit is quite successful here. If we had water facilities we have as good farming country as there is in the world. There is no question about that.

Senator JONES. What do you say as to the supply of water for Colorado—is it sufficient for the lands you have?

Mr. SHELDON. It is my impression that if a proper system of reservoirs were constructed the entire portion, or almost the entire portion, of that which is known as the plains can be cultivated.

Senator JONES. Would there be some water left that could be used in Kansas, beside?

Mr. SHELDON. It is my impression that it would be a source of supply for Kansas—the storage of those waters. It would increase the flow of those streams which are running toward Kansas, and hence Kansas would be benefited.

Senator JONES. Then you think that with a proper system of storage, that is, if the water were saved and utilized, there would be enough to supply all Colorado and what is required for Kansas?

Mr. SHELDON. It is my impression that if a proper system of reservoirs were constructed on the plains sufficient to retain the rain-fall, which every one who has had any experience in the West knows flows off immediately as it falls, the whole of Colorado and Kansas would be relieved in respect to the water supply.

Senator JONES. Would you regard investigation and survey of this country important, with a view of ascertaining what could be done?

Mr. SHELDON. I most certainly would do so. I have been working up the subject for the last twenty years, making a start. Of course my productions have been merely local here in Colorado, but I have made an effort to attract attention to the subject.

Senator JONES. What do you say of the value of irrigated land for homes? Taking a period of ten years, how will the same quantity of land compare for production with the same quantity of land where they rely on rain-fall?

Mr. SHELDON. I think the advantage is in favor of irrigated land.

Senator JONES. In regularity of crops?

Mr. SHELDON. In regularity of crops and in the fact that you have the disposition of the water in your own hands and can apply it to the crops when they need it, and in the fact that flooding the land with water enriches it—an important factor.

Senator JONES. Has that been the experience in Colorado?

Mr. SHELDON. Yes. I have land which I have cultivated for twenty years successively, with irrigation and without manuring, depending, therefore, on irrigation. Last year I did not see any modification in the crop. I raise from 40 to 70 bushels of oats to the acre every year.

Senator JONES. Successively for many years?

Mr. SHELDON. Yes, and that is a test that tries.

Senator JONES. Has a similar test been applied anywhere around here with regard to wheat?

Mr. SHELDON. I do not know. I raised wheat on one plat of ground for ten years until the prices dropped and then I relinquished it. I did not see any abatement of the crop of wheat for ten years.

Senator JONES. But there was an abatement of the price?

Mr. SHELDON. Yes, the price abated and that abated the growth of the wheat.

The CHAIRMAN. Then, in any crop that you have tried, you have not found that it exhausted the soil at all?

Mr. SHELDON. No.

The CHAIRMAN. Irrigation has supplied nutriment for the soil?

Mr. SHELDON. Yes. I have other lands which I have laid down in grasses. I think I was the first man in Colorado who commenced irrigating the land to produce native grass. I cut grass on the land for twenty years and I have an increasing crop all the time.

The CHAIRMAN. The native grass, without manure?

Mr. SHELDON. Yes.

The CHAIRMAN. How much water is necessary to the land here, after it is fairly reclaimed?

Mr. SHELDON. I have not those figures in my mind. I made several calculations and stored them away; but from 1 inch to 2 inches of water to the surface will constitute a good irrigation.

The CHAIRMAN. An inch under a 4-inch pressure?

Mr. SHELDON. No; an inch or two in depth.

The CHAIRMAN. That is probably about one-tenth of a foot in depth?

Mr. SHELDON. Yes.

The CHAIRMAN. Well, if that is the case, you certainly have water enough.

Mr. SHELDON. We have water enough by storing it.

The CHAIRMAN. There are places where they think they must have a foot in depth.

Mr. SHELDON. There is a good deal of water wasted in irrigation. Many people think they must run floods over the land to irrigate it.

Senator JONES. Do you need more than one irrigation here?

Mr. SHELDON. I used to think that in order to make a crop of wheat about three irrigations were necessary; sometimes, if the season was dry, I used to think four irrigations necessary.

Senator JONES. Then you divide that one-tenth of a foot into three irrigations?

Mr. SHELDON. No; apply one-tenth for each irrigation.

Senator JONES. Then you want more nearly half a foot than one-tenth of a foot?

Mr. SHELDON. About that.

The CHAIRMAN. About 6 inches for the year?

Mr. SHELDON. Yes. That was what I meant to say.

The CHAIRMAN. Is there anything further you would like to suggest?

Mr. SHELDON. Nothing that occurs to me now.

The CHAIRMAN. Where are the places for reservoirs? Are they on public or on private land?

Mr. SHELDON. Most of them are on public land, but those I have in mind are on private land.

The CHAIRMAN. Have you a law for condemning sites for reservoirs?

Mr. SHELDON. We have a law condemning right of way for ditches, and that would naturally carry the reservoirs.

The CHAIRMAN. You have a good law in Colorado.

Mr. SHELDON. It took a long time to get to it, but the people are coming to it now. I made an effort to have them begin as early as 1864 to provide specifically for the distribution of the water.

STATEMENT OF EDGAR T. ENSIGN, OF COLORADO SPRINGS.

The CHAIRMAN. What is your occupation?

Mr. ENSIGN. I am State forest commissioner for Colorado. With respect to Mr. Sheldon's testimony in regard to the storage of water in the land serving to keep alive the streams, I will say that I think we have an illustration right here in the matter of Shook's Run. Shook's Run formerly was one only in name; that is to say, it was a dry creek. It is quite a little stream now right back of the town. The storage of the water in the land tends to preserve a uniform and steady flow in the streams.

The CHAIRMAN. You may proceed and make any statements you please.

Mr. ENSIGN. In my own behalf I only wish to make the point in respect to our forests, that according to our belief and according to the belief of most of the people of Colorado, our forests tend largely to conserve the waters. I am aware that I differ quite a good deal from our friend, Major Powell, in that respect, but I can not help it. I think that the forests help to keep alive the streams. I believe that they keep the snows from melting prematurely, and are vastly advantageous. I shall be glad to give the committee copies of my last official report in which I have shown the irrigated land of the State. The forests and streams and the irrigated lands, not the lands strictly that are or may be irrigated, but the lands on the ditch.

The CHAIRMAN. What do the colors on the map signify?

Mr. ENSIGN. The green indicates the forests, the red shows approximately the land on the ditch. The object of this map is to show the intimate connection of forests with the streams and the irrigated land.

The CHAIRMAN. Have you any suggestions to make in relation to necessary regulations of Congress in regard to forests?

Mr. ENSIGN. Yes, I have.

Senator JONES. Do these red places show land under irrigation?

Mr. ENSIGN. Land actually under ditch, but not irrigated. It is only an approximate estimate, you understand. It is taken pretty largely from reports received from the county surveyors and from Mr. T. C. Henry, a man of high character, acquainted with the subject. I get statements from people living in the neighborhood when I can not have personal observation.

I was asked a moment ago by the chairman of the committee in regard to the action of Congress. I think decidedly that Congress ought to provide an efficient forest administration. What it should be as to details I am not prepared to say.

The CHAIRMAN. You have had experience in regard to forests. What is your idea as to what should be done?

Mr. ENSIGN. I should say that instead of making forestry a mere appendage of the Land Office at Washington it ought to be put in a department by itself and have an efficient head, and have representatives and officers in every State where there are public timber lands.

The CHAIRMAN. We have a public timber land law in some or most of the States. Would you sell the timber lands at all? If not, how would you allow people to get timber? When they come into the west they must have timber. What arrangement would you make whereby they could have timber, and at the same time have the forests preserved?

Mr. **Ensign**. Your question is very vital. That is the thing. The point is to preserve the timber and not prevent the legitimate use of it.

The **Chairman**. If they can not have the use of it the country can not be settled. How can it be arranged so that the people may have the timber and at the same time preserve the forests?

Mr. **Ensign**. I think that should be done so long as our pre-emption and homestead laws allow people to take up land of that character that may come on their own claims.

The **Chairman**. But you know that in this great interior there are no legitimate homesteads now on the timber lands.

Mr. **Ensign**. There are no agricultural lands, but they take them up under the homestead law for cattle uses.

The **Chairman**. There are many fraudulent claims.

Mr. **Ensign**. There are many legitimate ones also. The fraudulent claims are for milling purposes, where they skin the timber off and then leave it. That is where the fraudulent claims come in mostly, I think.

The **Chairman**. This has been suggested through Montana and other places where we have been: That all law for the sale of timber lands should be repealed and that the Government retain all timber lands, except where it is seen in good faith to be agricultural. Then let every man have all the timber he requires by paying a small stumpage, which shall meet the expenses of the administration and have local agents that shall have charge of the timbers and prevent forest fires, etc.

Mr. **Ensign**. I think that should be done. People ought to pay enough to keep up the protection of the forests and they would be willing to do so.

The **Chairman**. If there is anything further that you wish to communicate after reflection I hope you will communicate it to us.

Mr. **Ensign**. I shall be glad to do so.

The **Chairman**. There are two things to accomplish; first it is absolutely necessary that people shall have timber.

Mr. **Ensign**. I know that.

The **Chairman**. The next is that the timber shall not be wasted and the forests denuded. Now, how can that be accomplished?

Mr. **Ensign**. I have long known that the people must have timber. The question is how they can so use it as not to destroy it. Let them have the timber crop like any other crop. When it becomes mature let it be reaped. Let it be consumed in some legitimate way without waste, and at the same time prevent the people from destroying all the young timber. That should be preserved.

The **Chairman**. That needs local supervision?

Mr. **Ensign**. Yes.

The **Chairman**. Would not citizens residing in the locality of the forests be apt to exercise more interest and control than strangers sent in to supervise them?

Mr. **Ensign**. That is a very good theory. If you will pardon me I will tell you what our administration here is. We have a State forest commissioner; then we have county commissioners and overseers. The idea is also that we must interest the people locally; that if the people are not interested the forests will not be saved. That is very nice. It has been my duty to correspond with the county commissioners and overseers all over the State, and I find a woeful degree of indifference, perhaps worse than that where the saw-mill interest predominates, where the public interest seems to lie in the destruction of the forest rather than protecting it.

Senator JONES. If the neighborhood wants some timber the local agent is rather inclined to be kind to his neighbor?

Mr. ENSIGN. Yes; in the forests they are nearly all pioneers. They want to build corrals and doors and windows.

Senator JONES. Is this question discussed in your pamphlet?

Mr. ENSIGN. Yes, to some extent.

Senator JONES. Do you desire to discuss it further after reflection?

Mr. ENSIGN. Not now.

Senator JONES. I mean will you communicate with the committee if you think the question needs discussion further?

Mr. ENSIGN. Yes. We will have a bill before Congress, as we have had nearly every session, for a forestry administration that would include all the public timber land in the United States. By "we" I mean the American Forestry Congress, which meets again next October. That body nearly every year has put forward a bill for the preservation of the forests.

The CHAIRMAN. I have seen some of your proceedings, and I find you are taking Germany as a model a good deal. I think you will have to abandon that and take this country as a model, and look at it as it is. You can not control it here exactly as they do in Germany.

Mr. ENSIGN. I suppose from your reading such volumes and reports as have been published by the Department of Agriculture with respect to foreign systems you are led to believe therefrom that the most we are thinking of is to get some foreign system engrafted on our systems here.

The CHAIRMAN. I have seen much of the foreign reports reprinted in our books.

Mr. ENSIGN. We will be quite satisfied here if we can exercise a sort of gentle supervision over the matter.

The CHAIRMAN. I sympathize with that movement. We have seen terrible destruction by forest fires. There has been more timber destroyed this year probably than has been cut for useful purposes since the first settlement of the West. Fires were numerous in Montana, Idaho, and Washington. It was so dark that we could not see the mountains on either side.

Mr. ENSIGN. There is a paragraph in this report published last year in which I stated that Colorado had for several years been quite free from forest fires, but that as soon as we had another dry season the experiences of 1879 would be repeated. That came sooner than I thought it would, for we have had very disastrous fires this year.

STATEMENT OF GEORGE H. PARSONS.

The CHAIRMAN. You understand the class of information of which the committee is in search. Please state anything that may interest the committee in that respect, especially in regard to the preservation of forests.

Mr. PARSONS. It seems to me that the principal thing in the preservation of forests is first to withdraw certain parts of them from sale, so that they can be looked after, then put them under Government supervision. That of course would only apply to certain parts of the forests that are most important, the headwaters of streams, etc. Then, if we should devise some means—I think it would take the wisest heads in the country to do it, however—to keep down the fires. We have tried many means in this State, but they do not seem to be efficient. Fire seems to be the greatest cause of destruction.

The **CHAIRMAN.** Have you any suggestion as the result of your experience to offer to the committee in that respect?

Mr. **PARSONS.** No, I have not.

Senator **JONES.** What have you tried in this State to prevent it?

Mr. **PARSONS.** We have the different county officers, and they have power to get help to put out any fires that they see, and to post notices, etc., and to institute suits for damages.

The **CHAIRMAN.** Has that been no protection?

Mr. **PARSONS.** No; none at all. They will not look after it. If a fire starts it is very hard to stop it, and it gets to going before we know it. We have had one case here where the fire started a quarter of a mile from a gentleman's house, in the mountains. He happened to discover it, and it was the hardest thing in the world for him to get it out, although he discovered it shortly after it was started.

Senator **JONES.** What is the origin of forest fires here?

Mr. **PARSONS.** Camps and parties through the mountains generally. Regarding storage reservoirs I may be mistaken, but I differ from many others. The forests would store the water just in the same way that the reservoirs would. In fact, they act just as reservoirs do, and in preserving the forests we more or less preserve the waters. There are certain parts of the country which can be reserved without injuring anybody—where people are not apt to go for timber. If those could be reserved it would be of great advantage to agriculture.

The **CHAIRMAN.** When the forests are removed the water is let down more suddenly?

Mr. **PARSONS.** Yes, the forests catch it and hold it in the soil. A few years ago the hillsides were all covered with trees; now they are denuded, and when we have rain it is pretty bad.

Senator **JONES.** I never heard a suggestion that anybody doubted that until to-day.

The **CHAIRMAN.** I have never heard it stated that if the forests were denuded it would not increase the rapidity with which the streams would discharge the water.

Mr. **PARSONS.** I have heard people speak of the wisdom of caring for our forests for that purpose.

Mr. **CHAIRMAN.** I think you will get just as much rain-fall without the forests as ever, but if you have means of storing the moisture below, of holding the water, probably the forests would not be so necessary.

Mr. **PARSONS.** I have noticed here that the rain-fall is now better distributed. We are irrigating, and are planting more trees around the town sites here and in the country around.

The **CHAIRMAN.** The rains are less erratic and do not come down so much in spots in this vicinity?

Mr. **PARSONS.** Yes.

The **CHAIRMAN.** The rain-fall is modified so that the showers do not resemble cloud-bursts so much as they used to do?

Mr. **PARSONS.** I do not know about that. I have been here only ten years, but I notice that our showers through the summer come more steadily and I do not think we have had such severe cloud-bursts as we used to have, though of that I have hardly had sufficient experience.

The **CHAIRMAN.** Have you observed whether the cloud-bursts come more where there are few trees?

Mr. **Parsons.** That is a point that I have never observed. They generally come north of us. I do not think though that there is any difference as to that.

The committee ordered filed papers to be forwarded and then adjourned.

2

STATEMENT OF W. N. BYERS, OF COLORADO, AS TO WATER-STORAGE.

[Forwarded by Mr. Ensign.]

There is one plan of water storage which I think has never been publicly discussed. I doubt if it has been much thought of. It has the merit of being cheap and simple whenever the natural conditions will permit of its adoption. In many places it can not be used at all. It could not be applied upon the water of Cherry Creek, Plum Creek, Monument Creek, or many other streams that might be named. It is perfectly feasible upon the head waters of the Arkansas, the Platte, Clear Creek, the Boulders, Cache-a-la Poudre, and all other streams that head high up upon the Snowy Range. The plan is simply to convert the winter flow of water in such streams into ice. It can be made to pile itself up into great masses and extensive fields, many feet in depth, sufficient to withstand the sunshine of the entire summer following. This opinion is based upon an intimate knowledge of high mountain streams and many years' observation of the effect of frost and snow upon them.

Most of the longer streams that flow out from the crest of the Snowy Range rise at, or above, the upper line of timber growth. They descend by a steep grade through the upper belt of timber and a number of them converge toward the center of a basin which is the gathering point for a large stream. This basin is generally a swampy meadow or a thicket of willows filled with beaver dams. Sometimes it is partially covered with spruce trees. In any case it is wet and nearly or quite level. The water flows through it very slowly and a relatively large quantity is always in store there. At the foot of the basin a sharper descent begins and a large, well-defined stream is formed. It may further on pass through other basins and lose itself in successive swamps or beaver ponds.

In ordinary seasons these high regions are early covered with snow. In many places it comes before the ground is frozen at all. It bridges over the channels of the small streams and each succeeding storm covers them deeper. Consequently they flow all winter under the snow. When the small streams have united and formed the large one, it is too wide for the falling snow to bridge over, but the frosty nights soon cover it with ice, leaving plenty of room beneath for the winter flow of water. Snow soon spreads a blanket over the ice and the stream is safely housed from its source at timber line all the way down the mountain slope to the point where changing temperature brings alternate freezing and thawing. Away up at the head, and for many miles down its course, there is no thawing for many months. Ice once formed remains ice until next summer.

Now my plan is to obstruct these small streams at, or just above, where they enter their first Alpine basin. It can be very easily done. When the snow has covered over the little rivulet and the weather has become freezing cold, break through the covering at a favorable point, pack the channel full of snow and compel the water to flow over your snow-dam into the open air. The compact body of water that hitherto flowed in its confined and covered channel, now spreads out like a fan, in a thin sheet; it saturates the snow, the freezing air quickly changes it to ice, and in a little while a hillock is growing up like the dump at the tail of a ground sluice. And this hillock, or thousands of them, may be kept growing all winter. They will require some attention to prevent the water from burrowing a new channel under the snow, but this can hardly happen except during a very heavy storm.

To carry out this plan would require an able, trusty man for each given space. It may be the basin, or a number of basins at the head of a considerable stream. He must make his winter home there. Before winter sets in he will have surveyed the ground and marked out his route. It will be nearly on a level along the mountain side and will resemble a trapper's trail for setting a line of traps. He will mark it well by blazing trees or planting poles. At the crossing of each little stream he will determine the exact place to interrupt its flow and mark it by a high stake or pole. When the proper time comes he will proceed as above explained. During the winter he must keep watch of the work, and especially after each considerable fall of snow he should go over his entire circuit. A man should take care of 15 or 20 miles or from 50 to 100 little streams. The tools required would be a shovel and possibly a wooden maul. As may be readily seen, this same process might be applied lower down the stream where it is larger, and instead of building up a great number of little glaciers, construct a grand one. Success depends upon bringing the water out to the air; distributing it in a thin sheet over a comparatively large surface so it will freeze quickly, and keeping the flow all the time on the surface. To save it all the process must be high enough upon the mountains to have steady freezing weather. Taking the head waters of any one of our important irrigating streams, as the St. Vrain, the Boulders, or Bear Creek, and I believe that one man at $60 per month for six months in the year will store up more water against the next irrigating season than can be stored in a $50,000 reservoir. The plan is so simple and the expense would be so little, that it is certainly worth an experimental trial at any rate.

COLORADO FOREST LEGISLATION AND SUGGESTIONS.

[Forwarded by State Forest Commissioner Ensign.]

By the laws of Colorado the office of State forest commissioner has been instituted, and the county commissioners and road overseers throughout the State are constituted forest officers in their respective localities.

Under the act found at page 299, session laws of 1885, county commissioners and road overseers are made conservators of woodlands in their respective localities, and are required to enforce the laws and regulations made for the protection and preservation of such woodlands.

County commissioners are also enjoined to encourage, to the extent of their power, the planting of trees along water-courses and irrigating ditches, and in other proper places.

It is made the special duty of all forest officers to exercise great care and diligence in the prevention and extinguishment of fires, within the State, likely to endanger or destroy forest growth, and to apprehend any persons who may be guilty of causing such fires; and in the performance of such duties, such officers may call to their aid such person or persons, within the State, as they may deem necessary.

All forest officers and all peace officers, within the State, are empowered and required to arrest any and all persons found trespassing upon the woodlands of the State, or unlawfully cutting or destroying timber thereon, or setting fire in a manner to endanger such woodlands; and shall cause actions to be instituted, in courts of proper jurisdiction, to punish violators of the forestry laws of the State.

Judges of the supreme and district courts and justices of the peace, are by law made conservators of the peace, or "peace officers."

Section 7 of the forestry act also prescribes the mode of compensating county forest officers for services performed under the act.

The session laws of 1885 (page 164) provide for the punishment of persons building camp-fires and failing to extinguish them.

A further act (see page 161, session laws, 1885) makes it the duty of the county commissioners, in each county, to cause to be erected, in conspicuous places, throughout their respective counties, notices in large letters, substantially in the following form, to wit:

"Camp-fires must be totally extinguished before breaking camp, under penalty of not to exceed one month imprisonment, or $100 fine, or both, as provided by law."

Section 3426 of the general statutes of Colorado provides that whenever a line of forest trees, not less than 16 feet apart, shall hereafter be planted, at not more than 8 feet from the outer line of a highway upon which his land may border, or along ditches within his land, and kept in good growing condition for three years, there shall be paid as a premium to such owner of the said land, on the fourth year, and for the next six years following, the sum of $2 for every one hundred trees so planted, provided that said trees be so long kept in good growing condition.

FORESTRY MEASURES PROPOSED.

(1) That a memorial to Congress be adopted, urgently setting forth the immense and increasing destruction of the public forests, in Colorado and adjacent Territories, by fire, railway companies, charcoal-burners, lumbermen, and others, causing great and irreparable injury, and earnestly requesting the enactment of laws to afford necessary relief.

(2) That a liberal annual appropriation be made to the State Horticultural and Forestry Association to aid it in its work.

(3) That arbor day be established by legislative act, and made a holiday in the public schools.

(4) That more substantial encouragement in the way of premiums, etc., be given for the planting of trees. The bounties and exemptions, now provided by law, are inadequate.

(5) That railway and telegraph companies, mill-owners, charcoal manufacturers, and others, who consume, in the prosecution of their business, large amounts of timber or other forest material, be required to make reports, in connection with the use and consumption of such timber or material, to the State forest commissioner, as may be called for by that officer.

(6) That the act found at page 161 of the laws of the fifth general assembly, be so amended as to require the continued maintenance of fire notices; such notices to be posted annually, when necessary.

(7) That a law be enacted prohibiting the wasteful use and destruction of young evergreen trees during the winter holidays, or at other seasons.

IRRIGATION AND TREE-PLANTING.

In nearly all portions of the State where water can be had for irrigation, trees can be made to grow. The method or methods, by which they can be grown in certain portions of the plains region, beyond the reach of irrigation, and without the so-called "rain belt," is yet an unsolved problem. It is, however, quite confidently expected that by the introduction of certain hardy foreign species, by the more careful and extended cultivation of some of the native varieties, and by certain prospective experimental work, much may be done to promote the cultivation of trees in the hitherto treeless sections of the State. That crops have been successfully grown in some parts of the plains region without the aid of irrigation, warrants the belief that trees also may be grown there.

PROPOSED NATIONAL LEGISLATION.

In furtherance of a movement to give the State control of such lands, Congress has been memorialized, and the subject more or less agitated by State organizations and individuals interested in the question. The later, and perhaps the better, opinion is, that, owing to the great difficulty of obtaining legislation of that character in behalf of any particular State or States, some general measure should be proposed applicable to the entire body of public timber-lands, wherever situated, and which would leave them under the control of the General Government. Therefore, a bill in accordance with the last-named plan was prepared, and copies of the same sent to leading citizens in different sections of the country for an expression of their opinion upon its merits. The proposed measure met with general favor, and was also heartily indorsed by the American Forestry Congress, at its 1887 annual meeting.

The bill provided for the withdrawal from sale, or entry, of the public forest lands and their classification. It instituted, in the Department of the Interior, the offices of commissioner of forests, and four assistant commissioners; authorized the appointment of necessary forest inspectors and rangers, and sought to establish an effective and reasonably complete forest administration. By a system of licenses for the cutting of public timber, it provided for the needs of settlers and others. Five hundred thousand dollars was named as the amount required to carry out the provisions of the act.

The bill was duly introduced in both branches of the 1887-'88 Congress, but seems to have made but little, if any, progress beyond the committees to which it was referred. A new bill, differing in some important particulars from the old one, will be prepared and introduced at the next session of Congress.

DENVER, COLO., *September* 16, 1889.

The committee met pursuant to call of the chairman.

Present: Messrs. Stewart (chairman), and Jones; also Director Powell.

STATEMENT OF SUMNER H. BODFISH, OF WASHINGTON, D. C.

The CHAIRMAN. Have you made an examination of the topography, the water supply, and the land to be irrigated in the State of Colorado, with reference to the subject of irrigation?

Mr. BODFISH. As engineer assigned to the drainage basin of the Arkansas River, I have had a little experience in searching for reservoir sites in the Upper Arkansas.

The **CHAIRMAN**. How long were you engaged in that work?

Mr. **BODFISH**. Since the 1st of July of this year.

The **CHAIRMAN**. What district have you examined?

Mr. **BODFISH**. The upper portion, in the vicinity of Leadville.

The **CHAIRMAN**. Commencing at what point below?

Mr. **BODFISH**. Commencing at the village of Granite, on the Denver and Rio Grande Railroad and the Arkansas River.

The **CHAIRMAN**. Have you examined from there up as far as the sources of the Arkansas?

Mr. **BODFISH**. Thoroughly, and from there below have made prospecting trips.

The **CHAIRMAN**. State exactly what you found.

Mr. **BODFISH**. I have found several reservoir sites of the old glacial period of the Upper Arkansas, above the town of Granite, which will store 300,000 acre-feet of water. They are now being surveyed by one of our parties. I have made one trip southward in a wagon as far as Cañon City and across from there to Colorado Springs; and also up and down the Monument and Fountain Rivers, the finding some small sites in the vicinity of Cañon City; also on the Monument and Fountain Rivers.

The **CHAIRMAN**. Describe the principal sites and the probable amount of storage capacity and the probable cost; not having made an accurate survey, of course, it will be only an estimate. When will you have accurate estimates made?

Mr. **BODFISH**. Not until the field season is done and I arrive in Washington. The time we use in the field is entirely for prospecting work.

Senator **JONES**. How late will that be?

Mr. **BODFISH**. The month of January next.

Senator **JONES**. You mean you will be in Washington in January?

Mr. **BODFISH**. I shall be in Washington probably in December, but probably by the last of January I will have those estimates ready.

The **CHAIRMAN**. Can you give a general statement of what you found?

Mr. **BODFISH**. Do you mean the reservoir sites and the localities?

The **CHAIRMAN**. Yes—the principal ones—I do not wish you to go into details.

Mr. **BODFISH**. Some of them will be rough guesses.

The **CHAIRMAN**. You can qualify your language as you choose.

Mr. **BODFISH**. The first site surveyed was that of the Twin Lakes in the vicinity of Granite, in which we find about 108,000 acre-feet, upon the supposition that it was dammed to a height of about 30 feet and drawn off to a depth of 40 feet below the existing surface of the lake.

The Clear Lake reservoir site on the next stream to the south would, at comparatively small cost, store 7,000 acre-feet.

The next area already surveyed is what I called the Hayden reservoir site, on the main Arkansas stream, with a dam, within about 2 miles of Twin Lakes. That has a natural basin out of which the river would cut its way, and it would constitute a storage basin of about 60,000 acre-feet.

The next one, which is now being surveyed, is what I called the Sugar Loaf site, on the lake fork of the Arkansas River west of Leadville and consists of two dead glacial lakes, the water of which had cut its way out. By restoring the natural dam at the lower lake some 50,000 acre-feet can easily be stored.

To the northward of that is found what I call the Tennessee reservoir site, on the Tennessee fork of the Arkansas River, a few miles only from Leadville and about 2 miles from the Sugar Loaf site. Roughly, estimated, I would say that the Tennessee reservoir would hold at least 50,000 acre-feet.

To the northward of that, about 2 miles is another site which would hold about 3,000 to 4,000 acre-feet. It is called Crane's reservoir site.

In the vicinity of Leadville, within about 1½ to 2 miles of it, is a narrow gulch on the east fork of the Arkansas river which, when dammed, I think would hold something like from 10,000 to 15,000 acre-feet.

The CHAIRMAN. Those are the principal sites?

Mr. BODFISH. Those are the principal sites.

The CHAIRMAN. You may state roughly the probable cost of dams and the kind of structures required to improve those sites.

Mr. BODFISH. I have not had time to make estimates of that or to compute the cubical contents of those accurately. Those three that I surveyed were accurately given. The others were simple estimates. I should say that those sites could be improved at a cost of about $7 to $8 per acre-foot.

The CHAIRMAN. State whether those would be more than ordinarily expensive or not in the construction.

Mr. BODFISH. In the Twin Lakes Reservoir site, the stream has cut out through a natural dam, which is composed of small glacial drumlins or hills with slight hollows between. The masonry portion of the dam at Twin Lakes would be 70 feet high, provided the lake was drained 40 feet below its present surface and raised 30 feet above its present surface. The masonry portion of the dam would be not over 100 feet wide, including the overfall and waste-way. The remainder would be small earthen embankments on the tops of these hills, the greatest not over 100 feet long and 10 feet high. The Clear Lake Reservoir site is also a natural embankment or dam, through which the river has cut to the depth of about 50 feet. The copage at the bottom is about 75 feet across, sloping to about 250 feet on the top of the dam.

On the Hayden Reservoir site I assumed that because the situation was so favorable, a dam to the height of 120 feet.

The CHAIRMAN. Is the copage narrow?

Mr. BODFISH. It is about 400 feet wide and is precipitous almost on both sides to a depth of 90 feet. On one end it rises fast, and on the other it slopes off to a piece of land between the river side and the neighboring creek. The waste-way would be over the natural rock bed at an elevation of 95 to 120 feet.

The CHAIRMAN. Can you describe the kind of a waste-way needed in the other?

Mr. BODFISH. No: they are all glacial drifts.

The CHAIRMAN. And you have to have the water go over the dam?

Mr. BODFISH. Yes.

The CHAIRMAN. That is much more expensive in the building of the dam, I suppose, is it not?

Mr. BODFISH. Yes. On the Sugar Loaf Reservoir site, where the water has cut through the natural dam, the masonry and overfall would have to be built, including waste gates of about 100 feet in length. The remainder could be of earth. I estimated the height of that to be 45 feet. In the case of the Hayden Reservoir site, I should have said that there are two railroads to be moved. In the case of the Tennessee Reservoir site, the dam would have to abut against a glacial drift and would be a length of 600 feet over all.

The CHAIRMAN. Would the overflow have to be over the dam?

Mr. BODFISH. Yes.

The CHAIRMAN. There are only two of them in which the overflow would be over the dam?

Mr. BODFISH. There is only one in which the overflow would be over the solid rock.

What I call the Leadville reservoir would be caused by damming a narrow gorge through solid rock where the walls are perpendicular, only about 75 feet apart and about 60 feet high. Above that, the masonry could be carried as high as 90 or 100 feet and then by some embankments 200 or 300 yards.

The CHAIRMAN. What proportion of those reservoir sites would be on private lands?

Mr. BODFISH. They are almost all on private lands. It happens on those sites that the basins are natural basins, the land is irrigable land, and the people are settled on them. They have excellent farms on the Tennessee basin, and raise sufficient hay to give them an income on some of the farms of $3,000 a year for 160 acres.

The CHAIRMAN. Have you, in each case, a general estimate of the amount of property that would have to be condemned?

Mr. BODFISH. In the maps of those reservoir sites that are being made, all culture and improvements are recorded—railroads, fences, ditches, everything in existence that was put there by man. The topography is taken around the immediate outlet of the reservoir site. Two-foot contours, to enable careful estimates of construction on high-water lines, are run around the remainder of them.

The CHAIRMAN. Have you made any exploration of the land to be irrigated by the water that is stored?

Mr. BODFISH. Not yet. The Arkansas Valley is about 200 miles in length, from Cañon City to the Colorado and Kansas line. If you take 1 mile wide of that valley for that distance, you get approximately 128,000 acres. You can see how much land could be covered in that valley by the 300,000 acre-feet of the upper portion. The drainage area to furnish the water for these 300,000 acre-feet is approximately about 360,000 acres.

Senator JONES. You have examined all the sites above Cañon City?

Mr. BODFISH. No, sir. I have only made one prospecting tour in a wagon from the lower end of this glacial area down the river to Cañon City and across to Colorado Springs. I have surveyed the Fountain River and the Monument Creek, near Colorado Springs, for reservoir sites.

Senator JONES. How much is embraced in the drainage basin of the Arkansas above the lowest point to which you have made complete examination?

Mr. BODFISH. About 360,000 acres.

Senator JONES. What proportion of the rain-fall embraced in that basin would be caught in those reservoirs?

Mr. BODFISH. It would all be caught.

Senator JONES. There would be no waste of water of that 360,000 acres at all if the reservoirs were built?

Mr. BODFISH. No, sir; they would be sufficient. The rain-fall in the Arkansas River is now being determined and the streams will be gauged by the hydrographic force. That information has not been furnished to me yet. So I can not state how much water there is.

Senator JONES. I did not ask about the quantity of water, but whether the reservoirs would catch all the rain-fall within that basin?

Mr. BODFISH. Yes; they will catch all the rain-fall within the 360,000 acres, and they furnish about 300,000 acre-feet, of storage room.

Senator **JONES**. As to the water supply, that will be ascertained when you find out the rain-fall?

Mr. **BODFISH**. Yes.

Senator Jones. How much will all those reservoirs irrigate?

Mr. **BODFISH**. About 300,000 acre-feet, 300,000 acres of water 1 foot deep.

Senator **JONES**. I think the rain-fall would be very much more than a foot.

Mr. **BODFISH**. I presume it will, but on the assumption that you can store those full twice a year you can have a good deal of water. The rain-fall, with the melting of the snows, would fill them before spring, and when the farmer wants them, in April, May, and June, they can be emptied, and filled again with the melting of the snows in June and July, which would be used again in the fall, on the supposition that there is rain-fall and snow-fall enough to fill them twice.

Senator **JONES**. About how much land do you think (by refilling) could be irrigated if you got enough to fill them twice?

Mr. **BODFISH**. You would have 600,000 acre feet.

The **CHAIRMAN**. They do not need more than 6 inches of water.

Senator **JONES**. His proposition is to irrigate twice a year.

The **CHAIRMAN**. Six inches of water for a year will be enough when the people are reasonably economical.

Mr. **BODFISH**. I have found three small sites on the Fountain and Monument Rivers. I have found one in the vicinity of Cañon City. From my knowledge of the topography and looking into the country from a distance, I think there are many more in the vicinity of Cañon City and Pike's Peak.

Senator **JONES**. How near will you be able to complete the examination of your whole district this season?

Mr. **BODFISH**. I think I can do it all before the end of the season as far as reservoir sites are concerned.

The **CHAIRMAN**. Do you contemplate sites on the plains?

Mr. **BODFISH**. There are some sites there, I understand, and which I am told are good, and will carry a good deal of water, but I do not know about that until I investigate.

STATEMENT OF H. B. CHAMBERLIN, OF DENVER.

The **CHAIRMAN**. What is your occupation?

Mr. **CHAMBERLIN**. Investment banker and real-estate dealer.

The **CHAIRMAN**. You are president of the Chamber of Commerce?

Mr. **CHAMBERLIN**. Yes.

The **CHAIRMAN**. Have you given the subject of irrigation and water supply for land in this State any attention?

Mr. **CHAMBERLIN**. I have given the matter some practical but not theoretical attention.

The **CHAIRMAN**. Please state in your own way what practical attention you have given the subject, and what conclusions you have arrived at.

Mr. **CHAMBERLIN**. My interest in the reservoir question is in the ownership of land adjoining a reservoir built in 1884. I purchased of the Union Pacific Railway in 1882 the northwest quarter of section 12, township 5, south of range 69 west, for $7 an acre. In 1883, this land was held at $10 an acre without a buyer in the open market. No improvements had been made thereon. In the autumn of 1883, W. C.

Henry, the owner of the southeast quarter of section 4, township 5, south of range 69 west, built a reservoir covering 80 acres on said quarter section, this reservoir being completed by the following spring. Within three months of the time this reservoir was completed this land of which I was the owner was sold by me for $25 an acre, the appreciation in value being wholly due to the fact that the reservoir had been built of sufficient capacity to furnish water for the adjacent lands.

During the whole of my ownership that land was under a ditch known as the "Agricultural Ditch." No water could be had for the land, the entire water right being exhausted, so that the stored water referred to enhanced the value of this land within six months from $10 an acre, with no buyers, to a sale at $25 an acre. During this time no improvements of any kind had been put on the land.

The **CHAIRMAN**. What has been the practical result of that reservoir to you which furnished water for irrigation all that time?

Mr. **CHAMBERLIN**. That land has been under cultivation ever since, and is now worth $100 an acre.

The **CHAIRMAN**. From that reservoir?

Mr. **CHAMBERLIN**. Yes.

The **CHAIRMAN**. Explain what water it gave and how much land it covered. Give an idea of the cost of the reservoir and its practical results.

Mr. **CHAMBERLIN**. From time to time this reservoir has been enlarged by heightening the wall that confined the water in a sink, so that from being able to store water to furnish about 400 acres the reservoir is now able to furnish water for an estimate of 1,200 acres.

The **CHAIRMAN**. How much land is flooded?

Mr. **CHAMBERLIN**. I think now about 120 acres.

The **CHAIRMAN**. What is the height of the dam?

Mr. **CHAMBERLIN**. It must be 14 feet high.

The **CHAIRMAN**. How is the reservoir supplied with water; what is the water-shed that supplies it?

Mr. **CHAMBERLIN**. It is not a natural water-shed. It is water stored during the unused season from the Agricultural Ditch.

The **CHAIRMAN**. The water runs to waste from that ditch and you turn it into a reservoir.

Mr. **CHAMBERLIN**. Yes.

The **CHAIRMAN**. And by making that reservoir you have succeeded in irrigating about 1,200 acres that could not have been supplied.

Mr. **CHAMBERLIN**. We saved water in that to irrigate the 1,200 acres.

Senator **JONES**. Has the owner of that tract of land bought a permanent interest in the water-right or does he get it annually?

Mr. **CHAMBERLIN**. He has bought an interest in the stored water of this reservoir, not in the water-right, not in the ditch; he could not buy a right in the ditch; nobody would give up, but he bought a right to the water stored in the reservoir.

Senator **JONES**. What did the water cost him?

Mr. **CHAMBERLIN**. I do not know. I think that another witness later will know.

The **CHAIRMAN**. What is the character of the soil? Is it different from what it is on the plains generally?

Mr. **CHAMBERLIN**. No, not at all. There is a little more adobe in it.

The **CHAIRMAN**. Is not that good for reservoir sites?

Mr. **CHAMBERLIN**. Yes; the reservoir site is sandy and adobe-like, having a little more adobe than the soil east of Denver.

The **CHAIRMAN**. Have you made record of the evaporation?

Mr. CHAMBERLIN. No. Not having interest in it now I have not done so.

The CHAIRMAN. How long did you have to retain the water before using it?

Mr. CHAMBERLIN. The first season it did not hold; the second season it did.

The CHAIRMAN. After you got it puddled so that it would hold water, how long a time elapsed from the time of filling the ditch before you could use the water?

Mr. CHAMBERLIN. The filling was done during the winter and early spring and every time there would be a little water going to waste the commissioners would allow it to be turned into this lake. The water was not all used that was coming through the ditch. There was water coming constantly through until the dry season commenced, about the middle of June.

STATEMENT OF LOUIS G. CARPENTER, OF FORT COLLINS.

The CHAIRMAN. What is your occupation?

Mr. CARPENTER. I am professor in the State Agricultural College.

The CHAIRMAN. Have you given the subject of water supply for irrigation some consideration?

Mr. CARPENTER. I have traveled a good deal in the summer, investigating irrigation in Colorado. In connection with my duties, I have been over a good many thousand miles. I have traveled probably 800 or 1,000 miles over the ditches themselves.

The CHAIRMAN. Give us briefly the result of your investigation.

Mr. CARPENTER. Some features that I have met with in the eastern part of the State may not have been called to your attention, especially as to the Platte River. It has struck me many times that while the Platte River up here has been nearly dry, with very little water in it for many miles, the lower ditches have not suffered for want of water, although the same ditches have used nearly all the water. I understand that the greatest water supply at any one time in the Platte River has been 600 cubic feet per second.

Senator JONES. Where did those lower ditches get their water supply?

Mr. CARPENTER. From the Platte almost entirely. They have been aided somewhat this year from side streams. As you know, through the plains there are streams that are ordinarily dry, yet the total water supply from them is large in one sense. As a special instance, there is the Bijou, which enters the Platte near Fort Morgan. It has several times this summer come down with a rush and has supplied a good deal of water to the Platte in the region below. It has helped out the Platte and Beaver very much. One special instance was told me by the superintendent of that canal, with whom I went over the canal. He heard the flood coming down the canal and went up to protect the ditch. The water came down that channel a good many feet wide and 3 or 4 feet deep, sufficient to cover all the highlands outside. The water commissioner of that district corroborated that statement and also stated that the water ran for nearly twenty-four hours. He further stated, as showing the effect of the Platte, that the water commissioner of the district below told him that although they ran for twenty-four hours, it did not affect the water supply at Sterling or on the Pony Ditch, which is some miles below. All the water had disappeared in the sands. The disappearance and re-appearance of the water in the sands is rather surprising. I have not verified that, but it shows something of the characteristics of those streams.

The CHAIRMAN. How do you account for the additional supply down below?

Mr. CARPENTER. It must come from the supply from the mountain, I think, indirectly. It can not come from seepage from irrigation in that immediate vicinity, I think. The water from the mountains must outcrop at various places, as we know it does at the head of the Republican River and so on through Kansas. The Republican River rises in the eastern part of the State entirely away from the mountains or any perpetual water-shed or water supply in the sense of rains or snow; yet I believe it is a perpetual stream, and they are irrigating from it.

The CHAIRMAN. Is there any irrigation done in Kansas from the Platte?

Mr. CARPENTER. Not that I know of, until you reach North Platte, although that is beyond my line of experience. I have confined my travels to this State, but the North Platte waters some portion of it. I have been told that there is none on the South Platte in Nebraska. The lowest ditch in this State that is of any size is the Ileff Ditch, taken from the Platte Valley, which heads just below Sterling. There we see a ditch that seems to be abandoned farther east.

The CHAIRMAN. In your travels this summer have you observed many places where they have attempted to store water, in reservoirs or otherwise, to increase the supply?

Mr. CARPENTER. Yes; I have seen some.

The CHAIRMAN. Describe them and their success.

Mr. CARPENTER. As to a part of them I can not describe their success. In the Arkansas Valley there is a reservoir, covering about 200 acres, about 200 miles from Lamard. It was in process of construction when I was there in April. I have here a photograph of the embankment, which is quite long. It is about 110 miles from the headgate of that canal, that being the largest canal in the State. The canal has been a success during the year, and has furnished a good deal of water. In the northern part of the State there are a number of reservoirs. As to the North Poudre the superintendent is here and can give you definite information, and I would prefer that he should give it. In many cases they have helped out wonderfully. The crops would have been a failure without them.

The CHAIRMAN. Have you heard any discussion of the amount of evaporation from the time of the storage of the water until they got ready to use it?

Mr. CARPENTER. We have conducted a series of experiments at the college, and know something approximately of the evaporation. I have a chart here showing the evaporation, if you would like to look at it.

The CHAIRMAN. We should like to see it.

Mr. CARPENTER (producing the chart). Experiments have been conducted at the college in tanks for several years. I do not know the circumstances of those that were made before I came there, but I combined the experiments of last year, September to December, with those of the first half of this year and reduced them to the evaporation day-rate. In January and February the water was frozen, but we melted it and divided the loss by the number of days. The horizontal lines on this chart represent hundredths of an inch. In January the average was .035 of an inch per day. The progress of the curve indicates the general run. In April it ran up to between .13 and .14 of an inch per day. In May we had a very rainy month, and it increased. In July it ran up to between .17 and .18 of an inch, as an average, per day. We have taken those observations twice a day with the book gauge, so that our experiments are correct, because that is the most careful means of measuring. At least our measurements are correct within one one-thousandth of a foot, and generally within one ten-thousandth. That makes the total evaporation, I believe, about 35 inches for one year. This summer we have placed tanks in canals and tanks in reservoirs. The reservoir experiments have not been carried on now for four years, but for the limited time in which they were carried on in one reservoir the evaporation was a little over 50 per cent. more than that shown in this chart. The tanks are in earth, and their temperature is kept cool by the temperature of the surrounding earth. Heat has, of course, great influence on evaporation. We have really only one good result, because of one of the tanks being tampered with. The evaporation in July was 7½ inches in the middle of the lake, probably 80 rods from the nearest shore, while in this tank, the figures of which are shown in the chart, it was a little less than 5½. We placed a tank in the river, so that the water would be of the same temperature as the river. There the evaporation was between 3 and 4 inches less than in either the tank in the earth or the tank in the reservoir. Temperature, of course, has a controlling influence on evaporation.

The **CHAIRMAN**. About what time does the water remain in the reservoir before it is used for irrigation purposes? When is the end of the irrigation period?

Mr. **CARPENTER**. That depends upon the crops. The water is needed most in June, July, and part of August.

The **CHAIRMAN**. Suppose the water is used in June, July, and August. Then, you commence storing at what time?

Mr. **CARPENTER**. It can be stored just as soon as the ice melts so that water can run in the canals or ditches. In the contracts that are made by the various ditch companies it is generally stated that the irrigation shall be from the 1st of May until the 1st of November. But they are beginning to irrigate earlier wherever they can get water.

The **CHAIRMAN**. Then you would not store it more than five or six months probably?

Mr. **CARPENTER**. No.

The **CHAIRMAN**. It would not be kept stored any longer than that as an average?

Mr. **CARPENTER**. I should not think the average amount would be much more than 4 months.

The **CHAIRMAN**. And during those four months, you have part of the time the maximum of evaporation?

Mr. **CARPENTER**. No; the maximum of evaporations in the streams is in July.

Senator **JONES**. And the maximum needed for irrigation would be in June, I suppose?

Mr. **CARPENTER**. Yes; in the latter part of May, June, and perhaps part of July—along in those three months.

The **CHAIRMAN**. There would not be more than 5 or 6 inches of evaporation during the time the water would have to be retained?

Mr. **CARPENTER**. In the month of June and July, the evaporation under reservoir conditions would not be more than 5 inches per month for these two months, judging from my limited observation.

The **CHAIRMAN**. Then, the whole evaporation would not exceed a foot would it?

Mr. **Carpenter.** I should think not.

Senator **Jones.** For what time?

Mr. **Carpenter.** During the irrigation season, for the time the water would be needed.

The **Chairman.** What I want to get at is the loss by evaporation.

Senator **Jones.** For the twelve months.

Mr. **Carpenter.** For the twelve months, the evaporation would vary from 35 to 60 inches. Storage might begin in the fall, in case there is a reservoir. There is no reason why the winter water should not be saved. Of course, that water would be subject to a greater evaporation than in any other case.

Senator **Jones.** But you will have evaporation as soon as there is water in the reservoir. If you have water there for twelve months there will be evaporation for twelve months.

Mr. **Carpenter.** It is not always full, as the water will be used up for irrigation during part of the time.

Senator **Jones.** What is the rain-fall here per year?

Mr. **Carpenter.** The rain-fall for the State at Denver is something over 15 inches. From our observations at Fort Collins the rain-fall for eight years averages 13¾ inches. There is another diagram here that shows the distribution of the rain-fall, which is fully as important as the amount of rain-fall, so far as crops are concerned. A minimum of rain-fall may do a maximum of good, if it comes when it is needed. It is a chart of the average rain-fall per month. On the rain-fall map you will observe that in June the line descends somewhat, and in July it descends somewhat. In the winter the rain-fall is of course slight. A large percentage of it comes during the months of May, June, and July.

Senator **Jones.** State the amount of rain-fall for each month from the chart so that it may get into the record.

Mr. **Carpenter.** In January it is .80 of an inch; in February, .52 of an inch; in March, .70 of an inch; in April, 1.6 inches; in May, 2.9 inches; in June, it is 1.7 inches; in July, 1.8 inches; in August it is a trifle over 1 inch; in September it is about .94 of an inch; in October, .97 of an inch; in November, .4 of an inch; and in December .35 of an inch. I have further data here from the state engineer's report. It is a chart which was made for another purpose, but it illustrates the discharge, in cubic feet per second, of the Caché la Poudre River. The actual discharge varied from day to day, but I have evened them out. On this chart there are lines which represent the actual discharge, according to the records of the state engineer's office, but the curve has been smoothed out to show the change of the stream. The first line is the discharge of 1884. These lines indicate a thousand cubic feet per second. For 1885 you will observe that the discharge was more variable and less in amount than in 1884. In 1886, the lines indicating the discharge show that in the fall and winter it became very small. Fainter lines represent the discharge of 1887, which is still smaller. In 1888 it is still smaller. As to that year Mr. La Grange, the water commissioner, is here and can tell you as to the condition of the stream.

Senator **Jones.** From 1884 to 1888, there was a steady decrease in the volume of the stream?

Mr. **Carpenter.** Yes.

Senator **Jones.** This year, it would seem, there has been a slight increase?

Mr. **Carpenter.** Yes. The black line running across the chart represents the supply which the ditches would carry if they had all the water they could carry. The needs of the ditches vary. If they all want water at the same time, 2,300 feet would supply them. Early in May a less amount would supply them, but how much, I am not able to say. So this line, as a standard, would be more exact if it were a curve, because the excess of water would be greater than this chart would show. All that water [indicating by reference to the chart] is excess, and if it could be stored it would furnish an immense volume of water, which would benefit all the country east of there.

Senator **JONES**. For how long a time is this 2,300 feet required in the ditches?

Mr. **CARPENTER**. I do not know personally.

The **CHAIRMAN**. Is there not a time when this water is not all required in the ditches?

Mr. **CARPENTER**. I do not know how that is. Mr. La Grange knows more of the matter than I do.

Senator **JONES**. Let us see what Mr. La Grange has to say about it.

STATEMENT OF B. S. LA GRANGE.

Senator **JONES**. Mr. Carpenter has just stated that 2,300 cubic feet per second is what is required by the ditches supplied by the stream he refers to (Caché la Poudre). I ask you for how long a period the ditches require that much water?

Mr. **LA GRANGE**. Thirty to forty days.

Senator **JONES**. Within the twelve months?

Mr. **LA GRANGE**. Yes.

Senator **JONES**. Only that much within a year?

Mr. **LA GRANGE**. Yes, for the general irrigation. We have a surplus of about 1,100 cubic feet per second, basing it on the supposition that the intake of all the canals is 2,300 and the discharge, as recorded in the cañon, would give us about 1,100 cubic feet of surplus.

Senator **JONES**. That is to say, the average annual flow of the stream for twelve months would be about 3,400 feet per second, and the canals require 2,300 feet?

Mr. **LA GRANGE**. It is more than that for the whole twelve months. I am speaking with reference to this season. We had about 1,100 feet excess during the past season of irrigation.

The **CHAIRMAN**. You had that much surplus water that was wasted?

Mr. **LA GRANGE**. Yes.

Senator **JONES**. During the season of irrigation, he says.

The **CHAIRMAN**. Not during the whole year, then?

Mr. **LA GRANGE**. No, I do not mean for the whole year.

Senator **JONES**. There were 1,100 feet of excess during the season of irrigation?

Mr. **LA GRANGE**. Yes.

Senator **JONES**. And the whole flow was in excess, during the rest of the year?

Mr. **LA GRANGE**. Yes.

The **CHAIRMAN**. All of which might be stored and cover further land?

Mr. **LA GRANGE**. Certainly.

STATEMENT RESUMED OF LOUIS G. CARPENTER.

Mr. **Carpenter**. The number of square miles in the Caché la Poudre Valley under ditch is 393. The number under actual irrigation I have not the data for. The State engineer has that data, however.

The **Chairman**. Can you figure up how much this excess would add to the land to be irrigated if it were stored?

Mr. **Carpenter**. You will go into that section this evening and you can get the information there.

The **Chairman**. Have you anything further to state?

Mr. **Carpenter**. I have a map here showing the extent of the irrigation of the State, which combines, graphically, the irrigated regions. Mr. Ulrich has here present a map showing the regions themselves, which contains much valuable information.

Senator **Jones**. Is this map for the entire State?

Mr. **Carpenter**. Yes. This shows, approximately, the land under ditch in the Platte Valley, or Water Division No. 1. That shown in Water Division No. 2 (the Arkansas Valley) is about correct. The region of the San Luis Valley is about correct as to the lands under ditch. The regions in the other portions of the State are approximate.

Senator **Jones**. What do the different colors on that map represent?

Mr. **Carpenter**. The yellow represents the land that Professor Hayden denominated "Agricultural land." The dark color represents the region under ditch—I do not mean irrigated, but the region that has water above it, and that, if there were water in those ditches, the land could derive the benefit of it.

Senator **Jones**. The colors, as I understand you, on this map show the location and quantity of land in the State of Colorado that are under ditch?

Mr. **Carpenter**. Approximately, yes. The information is not exact enough to show the western part of the State accurately, but it is approximate.

Senator **Jones**. Can you give us any idea of the amount of land in Colorado that is susceptible of irrigation if the ditches were extended?

Mr. **Carpenter**. All this portion of the State east of the mountains is agricultural land, if it had water. That is in extent about 50,000 square miles.

Senator **Jones**. About how much of it is so situated that water can be carried to it if a water supply were to be found in the mountains?

Mr. **Carpenter**. As to that I am not prepared to state exactly.

Senator **Jones**. Is it a very large proportion?

Mr. **Carpenter**. It is a very large proportion. From this map, and from knowing the location of the ditches from Mr. Ulrich's map and determining the area by the perimenter, I compute the total extent of the lands under ditches to be 4,552 square miles.

Senator **Jones**. That is, the land shown by coloring on this map.

Mr. **Carpenter**. Yes.

Senator **Jones**. Is there water enough in the ditches to irrigate that land?

Mr. **Carpenter**. No.

Senator **Jones**. How much more would be required in the ditches to irrigate that much land?

Mr. **Carpenter**. I could only make an estimate that might be very far from the truth, but I should say three or four times as much.

Senator JONES. There is no more water in the ditches than would be necessary to irrigate one-fourth or one-third of this land.

Mr. CARPENTER. That would be my estimate, though it may be very far from the truth. It is merely an opinion. You have asked me in regard to the tenure of water property. I have brought the forms of a couple of deeds used by the canal companies, that may be entered as exhibits, which you can examine at your leisure.

FORM OF AGREEMENT FOR WATER RIGHT.

The Arkansas River Land, Reservoir, and Canal Company.

This agreement, made this —— day of —— in the year 18—, between the Arkansas River Land, Reservoir, and Canal Company, a corporation existing under the laws of Colorado, party of the first part, and —— ——, of the county of ——, and —— of ——, party of the second part, witnesseth: That in consideration of the stipulations herein contained, and the payments to be made as hereinafter specified, the first party hereby agrees to sell unto the second party —— water right — to the use of water flowing through the canal of said company, each water right representing 1.44 cubic feet of water flowing over a weir per second, subject to the following terms and conditions, to which the said party of the second part or assigns expressly agrees:

First. The said company agrees to furnish the said water to the said second party or assigns continuously during the irrigating season, except as hereinafter provided, and at no other time, unless with consent of company thereto in writing.

Second. Said water shall be used only for irrigation and domestic purposes on the following-described tract of land, to wit, —— ——, and under no circumstances shall said water or any portion thereof be used for mining, milling, or mechanical power, or for any other purpose not directly connected with or incidental to the purposes first herein mentioned, unless with consent of company thereto in writing.

Third. The said company shall deliver said water at such point or points along the line of said canal or ditch, or from any of its reservoirs, or either or all, as it may determine to be the most practicable, and the manner of withdrawing and regulating the supply of said water from said company's canal, ditch, or reservoir shall be prescribed by said company, and shall at all times be under its control as determined and directed by the board of directors of said company. The head-gates, flumes, weirs, or other arrangements through which the water hereby sold shall be drawn off from the said company's canal, ditch, or reservoirs shall be made and placed in position by said company, but at the cost of the said second party, who shall also be liable for the expense of keeping the same in good repair and condition, and the said company may collect and enforce the payment of all sums expended for said purposes in the same manner as prescribed for collecting and enforcing assessments.

Fourth. The said first party agrees to keep and maintain said main canal or ditch and any and all of its reservoirs in good order and condition, and in case of accident to the same to repair the injury thereby occasioned as soon as practicable and expedient; and the company shall have a right to assess for the ordinary expenses of maintaining, repairing, and superintending said canal and any and all reservoirs connected therewith a sum not exceeding $12 per water right sold per annum, payable on April 1 of the year for which said assessment is made.

Fifth. The first party shall have the right of roadway on the banks of its ditch and main laterals, and the same shall never be obstructed by fence or otherwise by second party or assigns, and in case a fence is constructed by second party across said roadway he shall construct and maintain convenient gate or gates across said banks or roadways wherever such fence may be constructed by second party. It shall be the duty of the employés of said first party to close all such gates whenever they open them.

Sixth. It is hereby distinctly understood and agreed by and between the parties hereto, that in case the canal of said company shall be unable to carry and distribute a volume of water equal to its estimated capacity, either from casual or unforseen or unavoidable accident, or if the volume of water prove insufficient from drought, or from any other cause beyond the control of the company, the company shall not be liable in any way for the shortness or deficiency of supply occasioned by any of said causes. If, however, by reason of such causes, the supply of water be insufficient to furnish an amount equal to all the water rights then outstanding the said company shall have the right to distribute such water as may flow through said canal to the holders of such water rights pro rata, and for the purpose of so doing may establish and enforce such rules as it may deem necessary or expedient.

Seventh. It is hereby specifically understood and agreed that the necessary right of way upon which to construct and maintain laterals through which to conduct water from the ditch or reservoirs of first party onto lands situate and lying below or under the lands herein described shall be, and is hereby, granted for said purposes; and the right to enter upon said lands to survey and locate said laterals, and to construct and maintain the same by first party, or the owner or owners of the lower lands, is hereby granted by second party, without other or further consideration than is herein contained; and such right of way is hereby granted where the same may be located on the lands herein described. Provided, however, that such laterals shall only be built when and where it is reasonably impracticable to do otherwise, and to the least harm and injury to said second party.

In consideration whereof the said second party agrees to pay unto said first party the sum of ——— dollars, with interest payable annually, at the rate of ——— per cent. per annum.

Payment has been made and received of ——— dollars, and the remaining principal, with the annually accruing interest, shall be paid at the office of the first party in Denver, Colo., in ——— payments, at the time and in the manner following, that is to say:

	Day.	Month.	Year.	Principal.	Interest.	Amount.	Remarks.
First payment......							
Second payment....							
Third payment.....							
Fourth payment....							
Fifth payment							
Sixth payment							

And the said second party, in consideration of the premises, hereby agrees to make punctual payment of the above sums, as each of the same respectively becomes due and to regularly and seasonably pay all assessments that may hereafter be imposed by said company for the purpose aforesaid ——— ———. And it is hereby agreed and convenanted by the parties hereto, that time and punctuality are material and essential ingredients of this contract.

It is understood and agreed that in the event of a failure to make payment of either principal or interest, when the same by the terms of this contract become due, then all the deferred payments due and to become due, as agreed, shall become then due, and the said first party shall have the right, at the expiration of sixty-days, to foreclose and terminate this contract: Provided it shall first give said second party notice of its intention so to do.

It its further agreed that the irrigating season shall commence April 1 and continue to November 1 of each and every year, and that thereafter water shall be conveyed for domestic purposes whenever reasonably practicable, subject to the right of said first party to repair, enlarge, or extend said canal.

And it is further stipulated that no assignment of the premises shall be valid unless the same shall be indorsed hereon, and that no agreements, or conditions, or relations between the second party and assignee of the second party, or any other person acquiring title or interest from or through the second party, shall preclude the first party from the right to convey the premises to the second party, the assigns of the second party, and the surrender of this agreement and the payment of the unpaid portion of the purchase-money which may be due to the first party.

It is also stipulated and agreed that from and after the execution hereof, the said second party shall enter into the use and enjoyment of the water flowing through said ditch to the extent of the right above contracted to be conveyed as fully as though a final certificate for said right had been issued, but subject, nevertheless, to all the terms and conditions above set forth.

It is further expressly understood and agreed between the parties hereto, that neither this contract nor any of its terms, conditions, or provisions shall be in any manner supplemented, altered, or changed from what has been provided, or any other or further contract be made respecting the subject-matter of this contract, except that it be indorsed hereon in writing, signed by the president, and attested by the secretary, under the corporate seal of said company.

It is agreed and understood that when the owner or holder of a water right has fully paid for the same, he may have the right to relocate the same, wholly or in part, upon any other land under the line of the company's canal, provided the same be done without any detriment, expense, or liability whatever to said canal company.

It is hereby further stipulated and agreed that when said first party shall have sold, and shall have outstanding and in force a number of water rights equal to the estimated capacity of the company's ditch, to furnish water, and two-fifths of the contract price for the same shall have been paid, then the holder or holders of such contracts for water rights shall have a voice and vote in the management of the affairs of said company's canal, proportioned to the interest which said second parties' contract bears to the entire number of contracts outstanding; and when two-thirds of such outstanding rights have been fully paid for, according to the terms of the several contracts entered into, then the title to said canal shall pass to the owners and holders of contracts for such water rights at the time, on the plan following:

Within sixty days thereafter, at such time as may be fixed by the board of directors of first party, said board of directors of first party shall hold a meeting for the purpose, and thereat designate ——— persons, who are at that time owners of water rights under said ditch, to be the incorporators of a new company, to be incorporated under the laws of the State of Colorado, and which said ——— persons shall, within thirty days thereafter, subscribe to articles incorporating a new stock company under a new name, and said ——— persons shall be the directors for the first year; and immediately following the signing and filing of articles of incorporation the directors thereof shall organize, make by-laws, procure a seal, and otherwise proceed as the law directs; and at said time they shall issue to the owners of said water rights, and to each owner of the capital stock of the new company, full paid, the same proportion of the whole of said stock as the water right each owner thereof has will bear to the whole amount of water rights sold as aforesaid, and second party hereby agrees to accept and receive the sock of said new company as aforesaid, and when said water rights shall have been fully paid, as aforesaid, and said ——— persons shall have been named as herein provided by first party, and said ——— persons notified in writing of that fact and that said water rights had been fully paid, as aforesaid, then the obligations of this company, said first party, in respect to said ditch and keeping the same in repair, or supplying water through the same, or any other ditch, canal, or reservoir connected therewith, shall cease, and the said new company and the stockholders thereof shall thereafter be the owners and in control of the said ditch and the water of the same.

It is expressly provided, however, that should first party, in exercising its rights in its articles of incorporation set forth, carry on any business therein named—for instance, stock-raising, farming, milling, etc., and should require water for such purposes, that first party will take the same subject to the same restrictions and rules that govern the use of water for others, and that it will also be entitled to its pro rata representation and stock in the new company.

It is further agreed that if said ——— persons provided to be appointed to incorporate a new company should decline or fail to incorporate said new company as herein contemplated, then first party may, within ——— days, appoint others for said purpose and to so continue to appoint persons until said company is incorporated as herein provided. And it is further agreed that the said first party will deliver said ditch to said water-right owners, as aforesaid, and at the time and manner aforesaid, free of any debts against the same.

In witness whereof the said Arkansas River Land, Reservoir and Canal Company has caused its corporate name to be hereunto subscribed by its president, and its corporate seal to be hereunto affixed by its secretary, as well as to a duplicate hereof, and the said ——— ——— subscribed —— name hereto, as well as to a duplicate hereof, this ——— day of ——— A. D. 188—.

Attest:

——— ———. [SEAL.]
——— ———. [SEAL.]
——— ———. [SEAL.]
——— ———. [SEAL.]
——— ———. [SEAL.]

——— ———,
Secretary.

[Indorsement:] No. —— contract. The Arkansas River Land, Reservoir and Canal Company, with ——— ———.

Received ——— 18 —, of ——— ——— the sum of ——— dollars, interest on the within contract.

Received ——— 18 — of ——— ——— the sum of ——— dollars amount of first payment on the within contract.

Similar receipts for second to sixth payments, inclusive, follow.

ASSIGNMENT.

——— ———, the within-named purchaser, for and in consideration of ——— dollars, do hereby assign and transfer all —— right, title, interest, and claim in said to the within-described right to water, unto ——— ———, of the county of ——— and ——— ———, of ———, heirs and assigns, forever. And —— do hereby authorize and empower —— ——, to receive from the said —— —— all unpaid balances due to said company, in part consideration for said water right, and upon the final payment of all the purchase-money, and a full compliance with all the requirements contained in the within agreement, to execute, or cause to be executed, to the said —— ——, heirs and assigns, a deed for said water right, instead of to ——.

Given under —— hand and seal this —— day of ——, A. D. 18–.

It is expressly understood that in consenting to recognize this assignment the officers of this company do not exempt the original purchaser from any of his liabilities under the contract, but to protect the rights of the assignee, provided he complies with his obligations.

Countersigned:

—— ——. [SEAL.]

—— ——.
—— ——.

—— of ——.
—— *County, ss:*

Before me, —— ——, in and for said county, this day personally came —— ——, known to me to be the identical person described in the within agreement, and who executed the foregoing assignment, and acknowledged that —— signed, sealed, and delivered the same as —— free and voluntary act and deed for the use and purposes herein set forth.

Given under my hand and seal of office this —— day of ——, A. D. 18–.

—— ——.

FORM OF WATER DEED.

Know all men by these presents that the Arkansas River Land, Reservoir, and Canal Company (a corporation existing under the laws of the State of Colorado), of the first part, and —— ——, of the county of ——, and State of Colorado, of the second part, for and in consideration of the sum of —— dollars, paid by said second party, the receipt whereof is hereby acknowledged by said first party, and in consideration of the mutual covenants and agreements in this deed contained, to be performed and kept by both of said parties, and hereafter specially mentioned, the said first party hereby grants, bargains, sells, and conveys to the said second party, —— heirs and assigns —— —— water right; that is to say, the right to the use of water flowing through the canal of said first party, each water right representing 1.44 cubic feet of water flowing under a weir per second, subject, however, to the following reservations and conditions, to which said party of the second part expressly agrees:

First. Said company to furnish the said water to the second party or assigns continuously during the irrigating season, except as hereinafter provided, and at no other time, unless with consent of company thereto in writing.

Second. Said water shall be used only for irrigating and domestic purposes on the following described tracts of land, to wit, —— ——.

Third. Said company expressly reserves to itself the right to distribute the water from its said canal, in accordance with such rights and priorities as are or may hereafter be established or decreed; and this deed is received by the party of the second part subject to such priorities.

Fourth. The said second party, —— heirs or assigns, shall not permit said water or any portion thereof, to be furnished as aforesaid, to run waste, but as soon as a sufficient quantity shall have been used for the purposes herein allowed, the second party, —— heirs or assigns, shall in such a manner as the first party may prescribe, notify the first party that the said water may be shut off, and shall also give the first party timely notice when the same shall be again needed for the purposes aforesaid; but in no case shall the amount of said water taken or received at any time by said second party, —— heirs or assigns, exceed the quantity first herein referred to.

Fifth. The said company shall deliver said water at such point or points along the line of said canal or ditch or from any of its reservoirs, or either or all, as it may determine to be the most practicable, and the manner of withdrawing and regulating the supply of said water from said company's canal, ditch, or reservoir, shall be prescribed by said company, and shall at all times be under its control, as determined and directed by the board of directors of said company. The head-gates, flumes, weirs or other arrangements through which the water hereby sold shall be drawn off from the company's canal, ditch, or reservoirs, shall be made and placed in position by said company, but at the cost of the said second party, who shall also be liable for the expense of keeping the same in good repair and condition, and the said company may collect and enforce the payment of all sums expended for said purpose in the same manner as prescribed for collecting and enforcing assessments.

Sixth. The said first party agrees to keep and maintain said main canal or ditch and any and all of its reservoirs in good order and condition, and in case of accident to the same to repair the injury thereby occasioned as soon as practicable and expedient; and the company shall have a right to assess for the ordinary expenses of maintaining, repairing, and superintending said canal and any and all reservoirs connected therewith, a sum not exceeding $12 per water right sold, per annum, payable on April 1 of the year for which said assessment is made.

Seventh. The said first party to have, and the said second party hereby grants to the said first party, a right of way across said above-described land of the width of ——— ———, of the main canal of said first party as now located, and also the right of roadway on the banks of the canal and main laterals; and in case a fence is constructed by said second party across said roadway, he should construct and maintain a gateway across said bank, when said first party finds it necessary to use said bank as a roadway, in which case said first party shall close said gate when opened by it.

Eighth. It is hereby distinctly understood and agreed by and between the parties hereto, that in case the canal of said company shall be unable to carry and distribute a volume of water equal to its estimated capacity, either from casual or unforeseen or unavoidable accident, or if the volume of water prove insufficient from drought, or from any other cause beyond the control of said company, the company shall not be liable in any way for the shortness or deficiency of supply occasioned by any of said causes. If, however, by reason of such causes, the supply of water be insufficient to furnish an amount equal to all the water rights then outstanding, the said company shall have the right to distribute such water as may flow through said canal to the holders of such water rights pro rata; and for the purpose of so doing may establish and enforce such rules as it may deem necessary or expedient.

Ninth. It is hereby specifically understood and agreed that the necessary right of way upon which to construct and maintain laterals through which to conduct water from the ditch or reservoirs of first party on to lands situate and lying below or under the lands herein described, shall be, and is, hereby, granted for said purposes; and the right to enter upon said lands to survey and locate said laterals, and to construct and maintain the same by first party, or the owner or owners of the lower lands, is hereby granted by second party, without other or further consideration than is herein contained; and such right of way is hereby granted where the same may be located on the lands herein described. Provided, however, that such laterals shall only be built when and where it is reasonably impracticable to do otherwise, and to the least harm and injury to said second party.

Tenth. It is further agreed that the irrigating season shall commence April 1 and continue to November 1 of each and every year, and that thereafter water shall be conveyed for domestic purposes whenever reasonably practicable; subject to the right of said first party to repair, enlarge, or extend said canal.

Eleventh. It is also further agreed and understood that the said party of the second part, as long as said second party shall remain the owner of such water right, and entitled to control its use, shall be entitled to relocate the same upon any other lands (owned or controlled by said second party) under the line of the said company's canal, to which land a water right has not already attached, providing such relocation can be made without detriment, expense, or the incurment of any liability whatever by said company; said location to be made upon a showing by said second party that said second party is still the owner of said water right, and entitled to relocate the same, and upon cancellation of the prior location, such relocation to be made by the company, and a record thereof kept by said company in the records of the company.

It is hereby further stipulated and agreed that when said first party shall have sold and shall have outstanding and in force a number of water rights equal to the estimated capacity of the company's ditch, to furnish water, and two-fiths of the contract price for the same shall have been paid, then the holder or holders of such contracts for water rights shall have a voice and vote in the management of the affairs of said company's canal, proportioned to the interest which said second party's contract bears to the entire number of contracts outstanding; and when two-thirds of all such outstanding rights have been fully paid for, according to the terms of the several contracts entered into, then the title to said canal shall pass to the owners and holders of contracts for such water rights at the time, on the plan following:

Within sixty days thereafter, at such time as may be fixed by the board of directors of first party, said board of directors of first party shall hold a meeting for the purpose, and thereat designate ——— persons, who are at that time owners of water rights under said ditch, to be the incorporators of a new company to be incorporated under the laws of the State of Colorado, and which said ——— persons shall, within thirty days thereafter, subscribe to articles incorporating a new stock company under a new name, and said ——— persons shall be the directors for the first year; and immediately following the signing and filing of articles of incorporation the directors thereof shall organize, make by-laws, procure a seal, and otherwise proceed as the law directs; and at said time they shall issue of the capital stock of the new company, full paid, to the owners of said water rights, such a proportion of the whole of said stock as the water right each owner thereof has will bear to the whole amount of water rights sold as aforesaid, and second party hereby agrees to accept and receive the stock of said new company as aforesaid, and when said water rights shall have been fully paid, as aforesaid, and said —— persons shall have been named as herein provided by first party, and said —— persons notified in writing of that fact and that said water rights had been fully paid, as aforesaid, then the obligations of this company, said first party, in respect to said ditch and keeping the same in repair or supplying water through the same, or any other ditch, canal, or reservoir connected therewith, shall cease, and the said new company, and the stockholders thereof, shall therafter be the owners and in control of the said ditch and the water of the same.

Provided, however, and this grant is specially subject to the conditions following, that is to say: That inasmuch as said parties so holding water rights are forever exempted from any and all assessments that may be made upon the stockholders of the said company as it now exists, for any purpose, except that of keeping said ditch in repairs, as stated in subdivision 6, of this deed, and inasmuch as an increase of the capital stock of the company as it now exists may become necessary or an assessment of the present stockholders, in order to complete the construction of the ditch and reservoir of said company:

Now, therefore, said second party does hereby agree with said first party that this deed, and the right of said second party to vote and have a voice in the management of the company, is subject to the limitation that said second party shall not, by reason of anything in this deed contained or by reason of any relation he may bear to this company arising out of said water right, be entitled to claim, demand, or receive any part or portion of any moneys arising out of the sale of any stock of said company, should the said company find it necessary to increase its capital stock, and the said second party is to be allowed a voice and vote only as relates to the said company's affairs at the time of executing this deed, and necessary to securing to said second party the fullest enjoyment of said second party's water right.

It is expressly provided, however, that should first party, in exercising its rights in its articles of incorporations set forth, carry on any business therein named—for instance, stock raising, farming, milling, etc., and should require water for such purposes, that first party will take the same subject to the same restrictions and rules that govern the use of water for others, and that it will also be entitled to its pro rata representation and stock in the new company.

It is further agreed that if said —— persons provided to be appointed to incorporate a new company should decline or fail to incorporate said new company as herein contemplated, then first party may, within —— days appoint others for said purpose and so continue to appoint persons until said company is incorporated as herein provided. And it is further agreed that the said first party will deliver said ditch to said water-right owners as aforesaid, and at the time and manner aforesaid, free of any debts against the same.

In witness whereof, the said Arkansas River Land, Reservoir, and Canal Company has caused its corporate name to be hereunto subscribed by its —— president, and its corporate seal to be hereunto affixed by its secretary, this —— day of —— A. D. 18—

Attest:

—— —— [SEAL.]
—— —— [SEAL.]
—— —— [SEAL.]
—— ——
Secretary.

INDORSEMENT.] No. —— water deed. The Arkansas River Land, Reservoir, and Canal Company to —— ——.

STATE OF COLORADO,
County of Arapahoe, ss:

I, ——, ——, a notary public in and for the county and State aforesaid, do hereby certify that —— ——, the —— president of the Arkansas River Land, Reservoir, and Canal Company, personally known to me to be the person whose name is subscribed to the annexed deed, and to be the —— president of said company, appeared before me this day in person and acknowledged that he signed, sealed, and delivered the said instrument of writing, and affixed thereto the corporate seal of said company as his free and voluntary act as said —— president, and as the free and voluntary act of said company for the uses and purposes therein set forth.

Witness my hand and official seal this —— day of ——, A. D. 18—.

My commission expires on the —— day of —— A. D. 18—.

—— ——,
Notary Public.

The **CHAIRMAN.** Are those samples of the general contracts?

Mr. **CARPENTER.** Yes, of the stock companies that sell water and make water contracts. The provisions of all are about the same.

The **CHAIRMAN.** Explain generally the relations of the land-owners to the water.

Senator **JONES.** That, I suppose, is what those deeds do.

The **CHAIRMAN.** There are others where the land-owners own the water, I suppose?

Mr. **CARPENTER.** The ditch managers could give more definite information, I suppose, than I could. There are two classes of companies. There is a mutual company class and one class of companies that are formed to sell water. The mutual companies generally divide the ditch into shares—each person taking a number of shares depending upon the extent of his property underneath. The amount of water he gets from the ditch depends in that case upon the number of shares he has in the ditch. They divide it according to the number of shares. In the second, or stock companies, they generally sell the water, or water-rights. "Water-rights," as a term, in this State, is generally taken to mean the supply of water necessary for 80 acres of land. In those companies they agree, if they have water, to give a definite amount of water, not exceeding a certain quantity. There are two general types of contract; first, a contract made by the company with a man to sell him a certain amount of water on certain conditions, provided he keeps up his payments. The second is a water deed, which is given to the man, in exchange for the first, when he has carried out the provisions of the first contract. These contracts represent the provisions of nearly all companies that I have been able to secure deeds of.

Senator **JONES.** Do farmers as a rule, who get water from those ditches, pay for the right to use the water perpetually, or year by year?

Mr. **CARPENTER.** In most cases they have a perpetual water-right. Under a few canals they rent water. The prices for perpetual water rights vary with the different canals. In the San Luis Valley they pay $400—that is $5 an acre for the perpetual right. In the northern part of the State the Larimer and Weld Company have a different price. In the case of the North Poudre it is $15 an acre. The North Poudre also has a charge of $1,200 for a perpetual right. Another prevailing price is $800, and another one is for $1,000. The Arkansas Valley Company charges that much. That is for a perpetual water-right, but all subject to an assessment for maintenance. The farmers are assessed for running expenses.

Very frequently in those deeds, almost always in fact, there is a provision that an assessment for maintenance shall not exceed a certain amount, say $10 for 80 acres, for ordinary assessments. Then they very frequently have a provision that in case of a very extraordinary difficulty in that ditch, or extraordinary repairs, they may be subject to a certain maximum assessment, $20 or so.

Senator **JONES.** Who is the judge of all that?

Mr. **CARPENTER.** The ditch company. But they very rarely charge an extraordinary assessment, even when they have extraordinary difficulties. But for the larger ditches that does not seem to be enough (with the present amount of irrigated land under them) to maintain the ditch. If all the land were under cultivation that would perhaps be enough. In other ditches the assessment is more, depending somewhat upon the local conditions, or the difficulties the company think they may meet.

In the case of the union ditches, they keep the ditches in repair, and the prices are less, because generally the ditches are smaller and the expense of maintenance is less. A small ditch runs itself almost. In the small ones it is perhaps from 5 to 15 cents per acre per year for maintenance.

The CHAIRMAN. Who deals out the water?

Mr. CARPENTER. Each large ditch has a superintendent whose business it is to distribute the water.

Senator JONES. Who appoints him?

Mr. CARPENTER. The stock owners, or in the case of a mutual company, they have a meeting as every company would have, and make their own arrangements.

Senator JONES. The superintendent is an officer of the company?

Mr. CARPENTER. Yes, he is appointed by them, and he distributes the water according to the farmer's holdings in the ditch. In the smaller ditches where they have plenty of water, each man takes all the water he wants?

Mr. CARPENTER. I have some views of the boxes used for measuring water. In the two kinds of ditches there are really two kinds of devices. In the box where they divide the water pro rata they do not care about the amount of water but they want their share of the water in the ditch. Here are two types of boxes [showing photographs]. I will mark them "Division box A" and "Division box B" in the San Luis Valley. Both of those are used in other parts of the State. The second one is the division box of the Lariet Canal for dividing water.

In the case of the Division box A, there is a permanent partition just at the crest of the weir. In case each man is to have half of the water, this division board is in the middle, and the water will split, part of it going one way and part another. This was introduced in the San Luis Valley by Mr. Graves. It is also used in the northern part of the State.

The Lariet ditch has a movable board, so that a farmer may get more or less water, but he could not get more than his share, because the movable board is prevented from going beyond a certain point. If he wants a less quantity of water he can get it.

Senater JONES. He can regulate his own supply so as not to exceed what he is entitled to.

Mr. CARPENTER. It is arranged so that a man can have up to his supply, but can not exceed it. Here is another box for measuring water. It is called "Graves's Spill-box." There are three views of that here. This measures water by the statute inch. It is called a "spill" box probably because it is so arranged as that the water passes into the upper end of a long box, and the excess over 5 inches spills back. These other two views show the thing in operation when the water is running.

The CHAIRMAN. Is that regarded as an accurate measurement?

Mr. CARPENTER. The "inch" is not as a general thing a satisfactory measurement. It is convenient for the users because they can determine approximately the amount of water they are getting without going through a calculation. But the inch is not a very accurate measure, because, if a man is taking 100 inches and another man 10 inches, the first man gets more than ten times what the second man gets. Very few of the people have got to measuring by cubic feet, and when they do they measure over a weir, which is a very reliable way if properly conducted. This is derived, of course, from the miner's inch. In one place in the State they measure by "2 inch". I have been endeavoring to collect data of all kinds regarding this matter, but my survey of the State is incomplete.

The CHAIRMAN. Before you leave this question of measurement, let me inquire if they have invented any other mode of measuring water except by the inch.

Mr. CARPENTER. The contracts generally provide for measuring by cubic feet per second.

The CHAIRMAN. Have they any device for measuring by cubic feet per second?

Mr. CARPENTER. The plan of measuring by the weir is the most accurate of any I know of.

Senator JONES. How is that done?

Mr. CARPENTER. The weir is really a box or small flume. The water is brought to a rest as nearly as may be by a vertical board. This illustration [exhibiting a wood-cut] shows it very well. For accurate measurement by weir the water should come to almost a complete rest. The weir should then contract the area of the stream. Then it should have a free fall. The edge and sides of the weir should be perfectly sharp. The board over which the water falls should come to a sharp edge, and the oblique side should be toward the direction in which the water is falling. The depth of water in front of the weir should be at least twice as great as that on the weir.

The theoretical measurement supposes that the water comes from an infinite reservoir, or one from which, if the water passes over, it will not give any velocity. That has been experimented on very accurately, especially by the Massachusetts experiments of Mr. Francis, who has gone to a great deal of expense to experiment. The weir formula is most accurate when the weir is properly placed, without actually measuring the water into some vessel of a fixed capacity. Under proper conditions the result will be true to within, say, 3 per cent. That is what Professor Francis concludes. With ordinary ditch arrangements most of the weirs I have seen have not been placed under proper conditions for entire accuracy.

Senator JONES. You ascertain the amount that goes over the fall by measuring the fall of the ditch when the weir is open?

Mr. CARPENTER. No; the depth of the water above the weir. The depth of the water should not be measured at the weir itself, because, as the water passes over it, it curves. The water will begin to curve before it gets to the crest of the weir, so that the depth of the water above the crest of the weir should always be measured some distance above the weir. You see in the photograph here a stake made level with the crest of the weir, and the water is measured several feet above that, so as to avoid the curvature of the water.

Senator JONES. In practice, if you were going to take a measurement, as this is here [referring to the photograph] you would stop the water entirely and take the depth first?

Mr. CARPENTER. No.

Senator JONES. How would you measure it?

Mr. CARPENTER. Both from theoretical knowledge and from experiment, the quantity of water, depending on the depth, is known, and a formula is known which, knowing the depth and the length of the orifice, gives the discharge.

Senator JONES. That is based on the knowledge of the rapidity with which water runs under those conditions?

Mr. CARPENTER. Yes, and on experiments on the flow of water from theoretical conditions and the force of gravity. The co-efficient had to be determined by experiment, and that was done by Francis.

The CHAIRMAN. It is not expensive to arrange the weirs that way, is it?

Mr. CARPENTER. No. Of course it requires a fall, which is not always practical. If the country falls slowly, every inch may be worth saving. In such cases a measurement of that kind is somewhat objectionable.

The CHAIRMAN. Have you ever tried to get a formula that will determine, in measuring miners' inches, how much less in proportion you must have the size of the orifice when there is a large number of inches to be discharged, compared with the size when a smaller quantity has to be discharged?

Mr. CARPENTER. That would have to be determined by experiment.

The CHAIRMAN. I think it might be worth some experiment so as to determine that proportion with accuracy.

Mr. CARPENTER. Then it would be as troublesome to use as this one would be. That is the objection to the weir method.

STATEMENT OF J. C. ULRICH, OF FORT COLLINS.

The CHAIRMAN. What is your occupation?

Mr. ULRICH. I am superintendent of the North Poudre Land and Canal Company.

The CHAIRMAN. Will you give the committee any information you may have with regard to water supply and irrigation in your vicinity; what has been done there by you and what has been done by others?

Mr. ULRICH. Our principal work at present is developing some reservoirs which we have on the canal line up on the plains.

The CHAIRMAN. Where is it located?

Mr. ULRICH. Forty miles north of Fort Collins.

The CHAIRMAN. Please explain what you are doing.

Mr. ULRICH. There are natural depressions on the plains, and we make a cut from those natural depressions; we then put a pipe in the cut and build "fills," which will retain the water, which is afterward drawn off to irrigate the land.

Senator JONES. You have water ditches?

Mr. ULRICH. Yes.

Senator JONES. And you are providing those fills in order to store the excess of water in the irrigating ditches, not used during the irrigating season?

Mr. ULRICH. Yes.

The CHAIRMAN. You expect to fill them from the ditches?

Mr. ULRICH. Yes, when the rivers are high and the amount of water used by other ditches is small—where there is a considerable excess.

The CHAIRMAN. To what extent have you gone in that operation?

Mr. ULRICH. At present we have four reservoirs constructed, with an aggregate capacity of 175,000,000 cubic feet.

Senator JONES. Will they store all the excess of water that your ditch carries?

Mr. ULRICH. No, but we intend to make more.

Senator JONES. When you have reservoirs sufficient to store all the excess of water that you have, how much more land will your ditches be able to irrigate than they would be otherwise?

Mr. ULRICH. When our system is completed, we expect to serve probably seven or eight times as much as we can at present irrigate.

The **CHAIRMAN**. Have you a map showing this system?

Mr. **ULRICH**. Yes, this map shows it [exhibiting a map].

The **CHAIRMAN**. What is this map called?

Mr. **ULRICH**. This is a map of the North Poudre Land, Canal and Reservoir System. At present it is called the North Poudre Land and Canal Company's Canal.

Senator **JONES**. How long is the canal?

Mr. **ULRICH**. Twenty-five miles.

Senator **JONES**. What is its size?

Mr. **ULRICH**. Sixteen feet wide on the bottom, with an average depth of about 4 feet. It has a grade of about 2½ feet to the mile on the first 7 miles, and 4 feet on the rest of it, on the lower division. We estimate that it will carry about 300 cubic feet per second. The first 7 miles are in the mountains or foot-hills, and after getting out on the plains we strike the land which we expect to irrigate.

The reservoir on section 21 [illustrating] has an area of about 100 acres and a depth of 14 feet. The next reservoir brings two "fills" together, containing each about 35 acres, about 9 feet deep. The third contains 160 acres 26 feet deep. That is as far as we have completed the system at present. Then, below the last one I have mentioned, (south of it), is a chain of proposed reservoirs, aggregating something like 2,500 acres.

Senator **JONES**. When those are completed they will store all your excess of water, will they?

Mr. **ULRICH**. They will store more than we have any use for.

Senator **JONES**. What was the total cost of this ditch?

Mr. **ULRICH**. About $175,000.

Senator **JONES**. What will be the total cost of the reservoirs as you contemplate completing them?

Mr. **ULRICH**. It will take about $50,000 yet to complete them.

Senator **JONES**. So by an expenditure of $50,000 you increase seven or eight fold the capacity of a ditch that cost $175,000?

Mr. **ULRICH**. Yes.

Senator **JONES**. And therefore very much cheapens the cost of the water?

Mr. **ULRICH**. We would consider the ditch absolutely worthless without that, because we do not get water long enough in the season to irrigate a crop. Without the reservoirs the crop would be an absolute failure and our ditch a failure.

The **CHAIRMAN**. Have you experimented to ascertain or determine the seepage and evaporation in that vicinity?

Mr. **ULRICH**. No, we have not been able to ascertain the seepage. I have not been able to make any experiments on evaporation except in the winter time. Then I have been able to examine them, because we were not running any water there, either in or out, at that time. I found last year that No. 3 reservoir, containing 160 acres, only lowered about 9 inches during the six months of winter. I think there was no seepage at all, because the bottom of the reservoir is rock. The first reservoir lost about 1 foot. That would indicate that there was some seepage there, or at least more than in the other case. Whether there was any seepage in the third we could not determine.

The **CHAIRMAN**. What is the altitude of the country?

Mr. **ULRICH**. About 5,000 feet.

Senator **JONES**. How are those reservoirs constructed?

Mr. **ULRICH**. By dams. They are natural depressions, with a rim all around them. We usually make a cut on the side and take the water from the reservoir, but make no excavation of the reservoir itself. We generally make a cut from the top of that rim, and in addition to that we raise and fill to a height depending on the contour of the country.

Senator **JONES**. These reservoirs are north of Fort Collins?

Mr. **ULRICH**. Yes.

The **CHAIRMAN**. Can you let us have this map?

Mr. **ULRICH**. Yes, you may have that.

The **CHAIRMAN**. What does the map now presented by you show?

Mr. **ULRICH**. This map shows all the irrigating ditches in the State that we can get any description of.

The **CHAIRMAN**. How is it marked?

Mr. **ULRICH**. It is marked "map of the State of Colorado, showing irrigating ditches." [Explaining it.] The first location represents the North Platte and its tributaries. The red lines indicate the irrigating ditches. The blue lines represent the streams from which taken. The second location represents the South Platte and its tributaries.

Senator **JONES**. The water-shed is not marked?

Mr. **ULRICH**. No, it is not marked. At present I can not give you this map, as it was prepared for the State Commissioner of Immigration, but I will have a copy sent to you.

The **CHAIRMAN**. I wish you would explain this map a little further.

Mr. **ULRICH**. The number of miles of irrigating ditch shown on this map is 5,500; that is for the whole State of Colorado.

Senator **JONES**. Can you state how many of those are in the valley of the South Platte or the Arkansas?

Mr. **ULRICH**. No.

Senator **JONES**. Can you ascertain that?

Mr. **ULRICH**. Yes, I can.

Senator **JONES**. When you send us the copy of the map, please indicate that.

Mr. **ULRICH**. Yes, I will do so.

Senator **JONES**. The water-shed of the Arkansas, the Platte, and the Colorado?

Mr. **ULRICH**. Yes.

Senator **JONES**. How many ditches are represented on that?

Mr. **ULRICH**. The total number of ditches represented here is 1,120. I have every reason to believe that there are a great number of small ditches that we have not been able to get any record of at all. I believe there must be 2,000 ditches in the State. Those that we have not got, however, are, I think, very small and insignificant. Those that I have shown here are from personal knowledge of the ditches, or from maps that I got from persons in the different localities.

STATEMENT OF J. R. BURTON, OF ABILENE, KANS.

The **CHAIRMAN**. What is your occupation?

Mr. **BURTON**. I am a lawyer. I am interested also in irrigation in Colorado.

The **CHAIRMAN**. State your interest.

Mr. **BURTON**. I am president of the Arkansas River Land, Reservoir, and Canal Company.

The **CHAIRMAN**. You may make such statement as you please with regard to irrigation.

Mr. **BURTON**. The canal of that company is 113.2 miles long. I have a map here which shows its course. [Produces map.]

The **CHAIRMAN**. What is the map you present?

Mr. **BURTON**. It is a map showing the territory covered by our canal.

The **CHAIRMAN**. How is the map marked?

Mr. **BURTON**. It is marked "map of canal and reservoirs of the A. R. L., R., and C. Company, Colorado."

The upper tracing shows the meanderings of the canal from where we take the water out of the Arkansas River, 2 miles above La Junta, to where it enters into Sand Creek, or to a point about 10 miles east of Lamar. The canal, for the first 17 miles, is 35 feet wide on the bottom. For the next 40 miles it is 42 feet, and for the balance 12 feet. It is 6 feet deep. At the end of the 99th mile we strike a natural reservoir.

Senator **JONES**. What is the grade of this canal?

Mr. **BURTON**. It averages 24 inches to the mile. As I say, we strike a natural reservoir at the 99th mile, covering 240 acres of ground. We banked a little on the west and south, and made the water in some places about 17 or 18 feet deep, or an average of 12 feet deep. We placed a head-gate on part of that, and extended our canal on to Sand Creek. This reservoir we have been using this summer and it holds water without any trouble whatever. It will irrigate fully 2,000 acres of ground.

The **CHAIRMAN**. Have you observed the evaporation and seepage of it this year?

Mr. **BURTON**. Generally, the seepage, so far as we could tell, has been practically nothing. It will hold water just like a basin. It will be observed that the reservoir is high up on the divide, far away from the river. Having run our canal so far we strike these natural reservoirs. Then, just west, or within 2 or 3 miles before we reach the canal (off the line of the ditch), there is a reservoir that we call the "King," covering about 1,040 acres, in which the water, without any embankments at all, can be made 42 feet deep, or an average of about 23 feet, and can easily irrigate 20,000 acres.

The **CHAIRMAN**. You have to make or cut a tunnel to get the water out?

Mr. **BURTON**. Yes. Our engineer has made the survey. We can cut under the ditch and also cover this territory here. There are about 200,000 acres of ground under this canal, and our present capacity is only about 65,000 acres. We have contemplated widening it. The cuts and fills and flumes now are all 60 feet wide. I mean by that that the grade in the flume is so sharp and the sides so high that it will float 60 feet of water with a fall of only 24 inches.

The **CHAIRMAN**. What amount of land do you intend to irrigate with those reservoirs when completed?

Senator **JONES**. Before you come to that, let me ask one question. Will these reservoirs that you speak of constructing store all the excess of water which your ditch carries?

Mr. **BURTON**. No.

Senator **JONES**. You have land enough to take all the water out of your ditches in the irrigating season, I understand?

Mr. **BURTON**. Yes; much more.

Senator **JONES**. You design increasing the capital of your ditch company to meet that demand?

Mr. **BURTON**. Yes.

Senator **JONES**. You propose in addition to that, to provide reservoirs to store water to be used during the irrigating season?

Mr. **BURTON**. Yes.

Senator JONES. Will you be able to store all that excess — can you find reservoirs enough for that?

Mr. BURTON. I should think not.

Senator JONES. Do you contemplate making any other reservoirs besides those two?

Mr. BURTON. Yes. About 2½ miles southwest of the reservoir that we are now using——

Senator JONES. That is the first-mentioned reservoir?

Mr. BURTON. Yes; below that there is a natural depression, where we could easily make a reservoir. We do not need it now, but we have secured the title to that land, and if we need it we can make use of it.

The CHAIRMAN. And if you have a surplus of water you can use it along down?

Mr. BURTON. Yes.

Senator JONES. What has been the total cost of your ditch, exclusive of reservoirs?

Mr. BURTON. About $300,000.

Senator JONES. What has been the cost of your reservoir?

Mr. BURTON. That cost very little because it is a part of the canal I spoke of; but as to the cost of the other reservoir, I have not yet received the estimate from the engineer.

Senator JONES. Can you not estimate it?

Mr. BURTON. No; but it will be trifling compared with the territory it will irrigate.

Senator JONES. From the amount of water that can be stored in the reservoir the cost will be trifling compared with the amount of water carried in the ditch?

Mr. BURTON. Yes. Wherever you go to a great depth, if the reservoir will hold water well, then the cost of the reservoir is trifling compared with the land it will irrigate.

The CHAIRMAN. How much land will you irrigate when you get this complete?

Mr. BURTON. Two hundred thousand acres; but of course that will take some years to develop.

Senator JONES. The present supply of water in the irrigating season will irrigate how much?

Mr. BURTON, About 65,000 acres; that is the present capacity of the ditch.

The CHAIRMAN. You say you reside in Kansas?

Mr. BURTON. Yes.

The CHAIRMAN. In the arid portion of the State?

Mr. BURTON. No; I live 100 miles west of Topeka, on the line of the Union Pacific Railroad.

The CHAIRMAN. What is the character of your company?

Mr. BURTON. Ours is a stock company. Many farmers imagined that they were in the rain belt and went down there and pre-empted ground and afterward discovered that they were not in the rain belt. We went there and sold water rights and began the construction of our canal. We derived a good deal of money from that before we began to build. The gentleman who furnished the brains of the enterprise is Mr. T. C. Henry, who is now abroad. We sell a perpetual water-right contract. The present price is $12.50. We agree in the contract to furnish water perpetually; enough to irrigate the land. We also have in that contract a provision for the assessment of not more than 15 cents an acre, and for that to keep up the expenses of the canal. When we shall have sold all the water and the enterprise is fully developed it will then belong to the farmers.

Senator JONES. Have you a prospectus of it in writing?

Mr. BURTON. It is in the contract, and you have a copy of that contract. Mr. Carpenter gave it to you. I might say that so far we have collected, in the two years that we have been running, 15 cents per acre, and it was paid without any trouble at all. We had a break in our canal this year. A portion of one of our flumes "went up," and it cost us about $5,000 to repair it. We have only 550 feet of fluming, however, in the 113 miles.

With regard to the homestead law, I believe a man should not be allowed to pre-empt more than 40 acres of land in the arid region. I believe the homestead law ought to be amended so that one person could not acquire more than 40 acres of land under its provisions in the arid region. My reasons for this position are, first, the average farmer could make more money farming 40 acres of land by irrigation, than he can a larger amount. The homesteader is a poor man, generally. He must borrow the money, at a very high rate of interest, with which to improve his land and live upon it, to provide himself with the necessary farming implements. He must go in debt for water, and wait for the harvest season for any returns from his toil and expenses. If he has 160 acres, his great desire to improve it all causes him to buy too much water, too much farming machinery—in short, it causes him to shoulder too much debt. His taxes and expenses are greater, and he is not capacitated to farm so much land, and farm it well, and the result is his harvest is no greater than it would have been had he carefully cultivated a smaller tract. Instead of getting out of debt and saving a little spare money to invest in live stock, or to help develop some other industry in his immediate locality, at the end of ten years he is above the average farmer if his quarter section is not mortgaged and a large share of his earnings does not annually go to the money-loaner.

Then, again, it is far better for the ditch company for the farmers to have small holdings of land. They are enabled to pay out on their water-rights, or to keep up the water-rentals. But a still greater reason is that if the homesteader could not secure but 40 acres of land, the opportunity for speculators to secure the land in the arid region by engaging professional homesteaders to prove up and obtain title would be greatly lessened. There are localities where ditches or reservoirs could and would be built but for the fact that speculators have obtained the land in this way. The interest of the ditch company and the land owner ought to be mutual. Where the land is held by farmers for homes, and especially where the land is cultivated, it is so, and there is but little or no friction between the owners of water and the owners of land.

I also think the law ought to be changed so as to make the cultivation of the land for a given time requisite to obtain title, rather than occupancy. Land that is cultivated in the arid region must have water. If the farm is once put into a state of cultivation, and has a water-right attachment, there is no danger but that it will be occupied, and, for ever after, be a home for somebody. But under the law as it now is, a homesteader may put upon the land a trifling building, ever so small and worthless, sleep there occasionally, but in reality live elsewhere, and in a short time have title from the Government, called a homestead, which, in reality, remains wild land. The spirit of the homestead law is violated, there is no home upon the land; it is used entirely for speculative purposes. I am not stating an exceptional case. In many localities it has been and is now the rule to obtain what is miscalled a homestead in this way.

Senator **Jones**. I would like you to state as to a man's ability to make a living on a 40-acre tract—a man with a family.

Mr. **Burton**. A man, with an ordinary family, that will cultivate 40 acres of ground and have no more than that to cultivate (and he can cultivate practically all of that) will not only make enough to supply his family with the necessaries of life, but he will be like the Maine farmer, who will have a little surplus each year to put into the construction of a mill or manufactory, right beside his farm. In other words, he will have a little surplus left instead of a debt.

Senator **Jones**. He may have a surplus after making a living, but will a man on such a 40-acre farm make a living as easily and with as much certainty as a man now does on a 160-acre farm where he depends on rain-fall?

Mr. **Burton**. Yes. He will make more money. I have 160 acres of land which cost me $8,000, near Abilene, Kans. I can go on any 40-acre farm, under my ditch, and make more clear money than I can on that land. That is my judgment, after having farmed my land for four years.

Senator **Jones**. Do you think the means of acquiring land under the present law ought to be repealed and nothing left standing except the homestead law?

Mr. **Burton**. You might reduce the timber claim to 40 acres.

Senator **Jones**. How about the desert-land act?

Mr. **Burton**. That ought to be repealed by all means. It is entirely on the wrong principle. Instead of making it a section, it ought to be the other way—it ought to be reduced. My idea is that, in the arid region, you ought to have a thickly-settled population, and every acre of land should be utilized.

Senator **Jones**. Is there much good, practically, resulting from the timber culture law?

Mr. **Burton**. No.

The **Chairman**. Would you repeal all those laws except the homestead law?

Mr. **Burton**. I think that is a good suggestion. I hesitated to be overradical, but I think it is a good suggestion to repeal them all.

The **Chairman**. What would you do with timber land?

Mr. **Burton**. I have not given that much attention and am not prepared to suggest.

STATEMENT OF J. P. MAXWELL, STATE ENGINEER OF COLORADO.

The **Chairman**. You have, of course, given this subject of irrigation and water supply full consideration?

Mr. **Maxwell**. Yes.

The **Chairman**. Please give the committee such information as you have with regard to those subjects.

Mr. **Maxwell**. I have tabulated from the records in the State engineer's office certain matters upon which questions have been sent to the office, and I can give you the result of those tabulations, if you wish. That is, with reference to the mileage of ditches, the area of land under cultivation, and the area of land under ditches, and other points in connection therewith. This paper is a tabulated statement of the eastern slope, and for the distribution, under the irrigation laws of this State, of the water from the natural streams, irrigating canals, ditches, and reservoirs.

The State is divided by law into six irrigation divisions and sixty-eight water districts. In a general way, the first division comprises that portion of the State which is drained by the North and South Platte Rivers. The second division is that portion drained by the Arkansas, and the third that portion drained by the Rio Grande. These three divisions compose the eastern slope, or all that part of the State which drains into the Gulf of Mexico. I make that statement for the purpose of explaining more clearly the tabulated statement I have. The tabulation is simply confined to the eastern slope, because that is the only place I have the data for, to any great extent.

I have here the water districts comprised in the South Platte division, which is division No. 1, the names of the streams, the number of miles of ditches, the number of acres under ditch, and the number of acres actually irrigated.

In division No. 1—the Platte division—there are 2,067.36 miles of ditch; there are 1,126,800 acres under ditch; there are 631,036 acres actually irrigated.

In the Arkansas division, which is division No. 2, there are 943.30 miles of ditches; 440,240 acres under ditch; 116,047 acres actually irrigated.

The Rio Grande division is not complete, but I will give the totals as I have them. Miles of ditch, 1,033.68; acres under ditch, 596,097; acres actually irrigated, 250,263. The records of the office are not complete with regard to that. There are two districts that we have no records of at all, to amount to anything.

As a recapitulation of the eastern slope, I will state that in those three divisions we have, in the aggregate, 4,044 miles of ditch, 2,163,137 acres of land under ditch, and 997,346 acres actually irrigated.

The total area of the arid lands on the eastern slope is about 30,000,000 acres in this State. That is all agricultural land, practically. If it could be watered, it is magnificent land; and it can be watered if we have the facilities for doing so.

Senator JONES. There is no statement in this summary about the capacity of these ditches to water lands. You state that there are 2,000 miles of ditch in the first district that irrigate actually 631,036 acres of land, and that there are 1,126,800 acres under ditch; but there is no statement of the capacity of the ditches to water lands.

Mr. BURTON. I have a statement as to capacity; that is, with regard to division No. 1, or the South Platte division. This is for the year 1888.

The average discharge from the streams for four months in 1888, per second of time, was 1,624 cubic feet, and there were decreed to the ditches in that division 24,787 cubic feet per second of time.

The CHAIRMAN. Explain what you mean by "decreed."

Mr. MAXWELL. As a district, they have decrees made by the court, for that amount of water, under their several "appropriations." The total area cultivated is something over 631,000 acres, and I have estimated that about 68,000 acres of that was irrigated by reservoirs, and about 563,000 irrigated by ditches. The duty of water—1,624 feet—on that basis, would be 346 acres to the cubic foot per second.

The CHAIRMAN. What is about the duty of water, in that connection?

Mr. MAXWELL. That is very hard to determine. It is estimated all the way from 50 to 100 acres to the cubic foot per second. I think it overruns 100 acres in this division.

The CHAIRMAN. You think a cubic foot irrigates more than 100 acres?

Mr. MAXWELL. I think it does, on the average.

The **CHAIRMAN.** Will water perform a greater duty in older districts than in the new?

Mr. **MAXWELL.** Yes. In the older districts we use it over and over again in some cases, and as land is irrigated it requires a less amount of water. As an illustration, I will state that we have a gauging station at the base of the mountains at the Platte, so that we know the amount of water that comes out of the mountains. We have also a gauging station at Denver, and from the reports of those stations we determine the amount of water that passes Denver and the amount that is carried into the ditches between this point and the base of the mountain, where the other gauging station is, and we determine, to a certain extent, the amount of seepage we have the benefit of here. We have as much water in our gauging station here as we have at the base of the mountains, while a good portion is also taken out in the ditches between the two stations.

The **CHAIRMAN.** After the ground is filled with water it discharges itself into the river again?

Mr. **MAXWELL.** Yes.

The following is the table prepared by Mr. Maxwell:

COLORADO.

For the distribution, under the irrigation laws of this State, of the water from the natural streams to the irrigating canals, ditches, and reservoirs, the State is divided into six irrigation divisions and sixty-eight water districts.

In a general way, the first division comprises that portion of the State which is drained by the North and South Platte Rivers, the second division of that portion drained by the Arkansas River, and the third division of that portion drained by the Rio Grande.

These three divisions compose the "Eastern Slope," or all that part of the State which drains into the Gulf of Mexico.

EASTERN SLOPE.

Tabulated statement showing the number of miles of irrigating canals and ditches, the number of acres of land under such canals and ditches, and the number of acres of land actually irrigated by such canals and ditches.

[Compiled from data in the State engineer's office.]

SOUTH PLATTE DIVISION, No. 1.

No. of water district.	Name of principal stream in district.	Ditches.	Under ditches.	Actually irrigated.
		Miles.	*Acres.*	*Acres.*
1 6	South Platte	238.00	150,000	39,719
2	......do	150.00	174,000	46,233
3	Cache le Poudre	340.75	207,360	103,895
4	Big Thompson	236.66	80,690	69,908
5	St. Vrain	225.50	92,460	86,655
6	Bowlder Creek	125.00	89,580	72,895
7	Clear Creek	240.00	98,558	66,405
8	South Platte	206.50	131,537	53,110
9	Bear Creek	50.00	6,915	3,742
23	South Platte	61.50	23,270	20,920
47	North Platte	124.00	46,980	41,080
46	......do	61.45	24,330	21,470
48	......do	8.00	800	4
	Total	2,067.36	1,126,800	631,036

Tabulated statement showing number of miles of irrigating canals and ditches, etc.—Cont'd.

ARKANSAS DIVISION, No. 2.

No. of water district.	Name of principal stream in district.	Ditches.	Under ditches.	Actually irrigated.
		Miles.	*Acres.*	*Acres.*
10	Fountaine que Bouille	53.00	32,680	18,000
11	Arkansas	46.10	39,820	34,780
12	do	34.00	33,760	25,520
13	Grape Creek	3.00	600	540
14	Arkansas	92.50	13,694	7,265
15	St. Charles	91.50	7,314	4,543
16	Huerfano	340.00	32,129	12,547
17	Arkansas	167.50	224,640	38,700
18	Apishapa	24.00	6,700	6,000
19	Purgatoire	58.10	33,380	25,600
49 66 67	Various	29.70	5,490	2,492
	Total	943.30	440,240	116,047

RIO GRANDE DIVISION, No. 3 (SAN LUIS VALLEY).*

No. of water district.	Name of principal stream in district.	Ditches.	Under ditches.	Actually irrigated.
20	Rio Grande	300.00	398,140	98,515
21	Alamosa	175.00	57,711	45,093
22	Conejos	160.00	45,711	33,340
24	Culebra and Costilla	(†)	(†)	(†)
25	San Luis Creek	227.78	42,425	31,315
26	Saguache	143.80	33,380	28,000
27	La Garita	5.60	570	500
35	Trinchera	21.50	18,160	13,500
	Total	1,033.68	596,097	250,263

RECAPITULATION.

	Ditches.	Under ditches.	Actually irrigated.
Division No. 1	2,067.36	1,126,800	631,036
Division No. 2	943.30	440,240	116,047
Division No. 3	1,033.63	596,097	250,263
Aggregate	4,044.29	2,163,137	997,346

Total area of arid land .... acres 30,000,000

* The records relating to this division are not complete. † No data.

Division No. 1.

Average discharge of streams for four months in 1888, per second, 1,624 cubic feet, and decreed, 24,787.81 cubic feet.

	Acres.
Total area irrigated	631,000
Irrigated by reservoirs	68,000
Irrigated by ditches	563,000

Duty of water, as per above, 346 acres per second foot.

One thousand six hundred and twenty-four cubic feet per second will cover 563,000 acres with water .69 foot, or 8.28 inches deep in one hundred and twenty days.

Measurement of local flood storms.

August 1, 1888. Clear Creek discharged for two hours 8,700 cubic feet; Clear Creek decrees, 1,131 cubic feet; surplus, 6,569 cubic feet; 47,296,800 cubic feet in two hours, which would cover 1,086 acres 12 inches deep.

Coal Creek (a practically dry stream) August 10, 1889, discharged for three hours 968.40 cubic feet per second, making 10,458,720 cubic feet, which would cover 240 acres 12 inches deep. Same creek, September, 1887, discharged for two hours 6,076 cubic feet per second, making 43,747,200 cubic feet, which would cover 1,004 acres 12 inches deep.

Senator **Jones**. Let me ask you some questions concerning this statement. You say "duty of water, as per above, 346 acres per second foot." By that statement do you mean that 631,000 acres of land are actually irrigated, and that 346 acres are actually irrigated per second?

Mr. **Maxwell**. I mean that 631,000 acres are actually irrigated and that we have 346 cubic feet per second.

Senator **Jones**. Can the water capacity of the first district be materially increased with that sort of showing?

Mr. **Maxwell**. Yes, I think it can be increased.

Senator **Jones**. From the conversation of the local floods?

Mr. **Maxwell**. Yes.

The **Chairman**. By means of their storage?

Mr. **Maxwell**. From such storage.

Senator **Jones**. So far as the running capacity of the streams is concerned, I should think that that was exhausted by this showing, and that to increase the capacity you would have to resort to storage.

Mr. **Maxwell**. Yes; unless we have better facilities for spreading the water on the land and saving it.

Senator **Jones**. It seems to me to indicate that the facilities for spreading the water are pretty good when a foot per second irrigates 346 acres.

Mr. **Maxwell**. It also indicates that we use it over and over again.

Senator **Jones**, Yes; I should say it was pretty well managed.

The **Chairman**. That is a great economy of water.

Mr. **Maxwell**. It gives about 8 inches of water over the ground.

The **Chairman**. This takes the water during the irrigating season alone?

Mr. **Maxwell**. Yes.

The **Chairman**. Then, what runs outside the irrigating season practically goes to waste, and if that were conserved the irrigating area could be increased in the proportion that that bears to the volume of water used in the irrigating season?

Mr. **Maxwell**. Yes.

The **Chairman**. Then, what runs out the irrigating season practically goes to waste, and if that were conserved the irrigating area could be increased in the proportion that that bears to the volume of water used in the irrigating season?

Mr.**Maxwell**. Yes.

The **Chairman**. Can you give any estimate of that?

Mr. **Maxwell**. No. At our gauging stations we make observations during the irrigating months. In the winter time we can not do it because it freezes up, and we can not take observations or measurements.

Senator **Jones**. The amount of water going down these streams must be larger for the other eight months of the year than for these four months.

Mr. **Maxwell**. I think there is less water during the other eight months.

Senator **Jones**. In the aggregate?

Mr. **Maxwell**. Yes; the water gets very low in the winter time. Much of the water also becomes ice, and that we get the benefit of in the spring.

Senator **Jones**. What four months are those?

Mr. **Maxwell**. May, June, July, and August.

The **Chairman**. You will file this statement, will you?

Mr. **Maxwell**. Yes, but there is something else I wish to read first. I have some figures of local floods. On August 1, 1888, Clear Creek discharged in two hours 8,700 cubic feet per second of time, while the ditch will only take 1,131, thus leaving a surplus of 6,569 cubic feet per second of time. There was then 47,296,800 cubic feet of water that was in excess of the demand and which could have been stored had we had the facilities for doing it.

Senator **JONES**. Three times as much went to waste there at that time as was used?

Mr. **MAXWELL**. Yes; that amount would cover 1,086 acres 12 inches deep. At Coal Creek, August 10, 1889, there was discharged for three hours, 963.4 cubic feet per second of time. That was a local flood. That makes 10,453,720 cubic feet, which would cover 240 acres, 12 inches deep. The discharge was much greater than that, but that was the maximum for two hours. In September, 1887, on the same creek, there was a discharge of 6,076 feet per second; making 43,747,200 cubic feet, which would cover 1,004 acres 12 inches deep. We have in this country a great many local water-spouts in the small cañons near the base of the mountains. They are peculiarly subject to them and we do not get the measurement of them. They do not come into the stream above our gauging stations and, of course, we have no estimate of them at all.

The **CHAIRMAN**. Could such water be stored and utilized?

Mr. **MAXWELL**. Yes, if we had the proper facilities.

Senator **JONES**. As to this average discharge of streams for four months in 1888 which you say is 1,624 cubic feet per second, the water was not I suppose all used in irrigation, but a considerable part of it was lost?

Mr. **MAXWELL**. I presume most of it was used in irrigation. In the excessive floods, however, probably some of it passed down.

Senator **JONES**. In the case of those two streams you have mentioned a large proportion of that water was lost?

Mr. **MAXWELL**. Yes, it was lost. Those are on the dry gulches.

Senator **JONES**. Yes; but that suggested the idea to me that there was a considerable loss of water during the irrigating season in such streams.

Mr. **MAXWELL**. Yes, there is during high floods a considerable loss of water.

I also have here a statement of the reservoirs on the eastern slope, giving the divisions and the acreage where I have been able to get it from the records and the capacity of the reservoir.

In division number one there are nine districts. I will simply give the totals of those. There are seventy-five reservoirs on record with a capacity of 3,168,780,082 cubic feet of water. That would furnish water 1 foot in depth for 72,746 acres.

In division number two, there are seventy-seven reservoirs, with a total capacity of 2,069,000,706 cubic feet. That amount would water 47,495 acres of land 1 foot in depth.

In division number three there are ten reservoirs, with a capacity of 82,159,000 cubic feet, which would furnish water 1 foot in depth for 1,885 acres. Those are reservoirs actually constructed, being one hundred and sixty-two in all, with a total capacity of 5,319,939,788 cubic feet, which would furnish water 1 foot in depth for 122,129 acres.

The **CHAIRMAN**. Have you visited those reservoirs personally?

Mr. **MAXWELL**. No, not all of them; only a small proportion of them in fact.

The **CHAIRMAN**. What is your information as to seepage and evaporation? Do the people effect much saving of water here or do they have a good deal of difficulty?

Mr. **MAXWELL**. I think as a general thing they save water pretty well.

The CHAIRMAN. Are they generally able to fill the ditches that are constructed?

Mr. MAXWELL. In some cases they have been able to fill them, and in some cases they have not. It depends on the water supply and the surplus.

The CHAIRMAN. They usually fill the reservoirs from the ditches.

Mr. MAXWELL. Yes.

The CHAIRMAN. They have commenced constructing reservoirs for the purpose of storing the storm water?

Mr. MAXWELL. Not to any great extent. There are a few reservoirs constructed for that purpose, but they are small.

The CHAIRMAN. Is that practical or have you not given sufficient attention to it to know?

Mr. MAXWELL. I have not given sufficient attention to it to determine the question thoroughly, but I think it is practical.

The CHAIRMAN. What observation have you made in regard to it that makes you think it is practical?

Mr. MAXWELL. My observations are principally in connection with the office, where I have been called upon to examine localities in regard to the construction of reservoirs. The State made an appropriation for the purpose of constructing a reservoir at Cold Creek to hold the flood storms.

The CHAIRMAN. Is there anything further you wish to say?

Mr. MAXWELL. I believe not.

The following is the table of reservoirs submitted by Mr. Maxwell:

Colorado (eastern slope).—Tabulated statement of reservoirs so far as the same are of record in the office of the State engineer.

DIVISION NO. 1.

Name of reservoir.	Name of stream from which water is diverted.	Area.	Capacity.
First district:		*Acres.*	*Cubic feet.*
Dry Creek	Dry Creek	10.00	2,000,000
Byers' No. 1	West Bijou	20.30	4,275,000
Byers' No. 2	do	3.80	670,556
Byers' No. 3	do	5.00	875,700
Byers' No. 4	do	13.50	2,870,000
Byers' No. 5	do	22.50	3,932,280
Byers' No. 6	do	20.00	6,996,000
Box Elder	do		
Snow	do		800,000
Brewer	do		5,000,000
Total capacity			27,419,536
Second district:			
Harris	Dry Creek		60,000,000
German No. 1	do		1,045,000
German No. 2	do		54,450,000
German No. 3	do		700,000
Smith	First, Second, and Third Creeks and South Platte		20,000,000
Oasis	do		400,000,000
Hudson	South Platte		1,800,000
Hudson No. 2	do		792,000
Total capacity			538,787,000
Third district:			
Mitchell	North Pine		14,754,930
North Poudre Co	North Poudre		174,240,000
Total capacity			188,994,930
Fourth district:			
Mariano	Big Thompson	373.80	180,000,000

Colorado (eastern slope).—Tabulated statement of reservoirs, etc.—Continued.

DIVISION NO. 1—Continued.

Name of reservoir.	Name of stream from which water is diverted.	Area.	Capacity.
		Acres.	*Cubic feet.*
Fifth district:			
Highland No. 2		140.00	118,119,280
Oligarchy No. 1		75.00	47,044,800
Total capacity			165,164,080
Seventh district:			
David Peabody No. 1			80,000
David Peabody No. 2			100,000
David Peadody No. 3			100,000
David Peabody No. 4			100,000
Webster	Clear Creek		7,588,900
Kox & Reser No. 1	do		2,900,000
Kox & Reser No. 2	do		609,150
Kox & Reser No. 3	do		1,761,230
Lake Erie	do		13,077,000
Ohio Lake	do		3,900,500
Cole No. 1	Clear Creek and Seepage		1,440,000
Cole No. 2	do		1,675,000
Lake No. 1	Clear Creek		2,400,000
Lake No. 2	do		16,300,000
Lake No. 3	do		1,000,000
Swan	do		6,000,000
Cart	do		100,000
Ward No. 5	do		9,429,800
Neal	do		1,258,850
A. W. Chamberlain	do		36,950,000
Church	do		7,229,017
Total capacity			114,089,456
Eighth district:			
John Thomas	Cottonwood		290,000
Linhart	Marcy Gulch		1,000,000
Lambert	Indian Creek	30.00	36,000,000
Enlargement of Frank Mannis'	Deer Creek		2,025,000
Melvin	Cherry Creek		1,000,000
Reservoir No. 1	South Platte and Bear		960,062,942
Reservoir No. 2	Bear Creek		371,944,970
Reservoir No. 3	do		85,550,957
Reservoir No. 4	Turkey Creek		12,949,081
Reservoir No. 5	Dutch Creek		223,872,560
Interlaken No. 1	Bear Creek		2,189,280
Interlaken No. 2	do		789,525
Interlaken No. 3	do		616,502
Windsons	Dry Creek	.72	92,000
Total capacity			1,688,381,817
Nineth district:			
Ward No. 1	Clear and Beaver Creek		42,364,000
Ward No. 2	do		2,272,800
Ward No. 3	do		230,000
Ward No. 4	do		320,000
H. W. Lake A	Beaver and Turkey Creek		13,939,200
H. W. Lake B	do		3,920,400
H. W. Lake C	do		653,400
H. W. Lake D	do		1,306,800
Frederick	Bear Creek		14,472,340
W. C. Henry's	Bear and Turkey Creek		9,900,000
Bowles No. 1	do		165,000,000
Bowles No. 2*	do		†9,400,000
Bowles No. 3*	do		
Total capacity			263,778,940
Twenty-third district:			
Anterors	South Platte		2,214,323

---

* About 12 feet deep or about 25 acres.

† Estimated.

Colorado (eastern slope).—Tabulated statement of reservoirs, etc.—Continued.

RECAPITULATION, DIVISION NO. 1.

District.	No. of Reservation.	Area.	Capacity.
		Acres.	*Cubic feet.*
First	10		27,419,536
Second	8		538,787,000
Third	5		188,994,950
Fourth	1		180,000,000
Fifth	2		165,164,080
Seventh	21		1,114,089,456
Eighth	14		1,688,381,817
Nineth	13		263,778,910
Twenty-third	1		2,214,323
Total	75		3,168,780,082

NOTE—The above number of cubic feet of water would furnish 1 foot in depth for 72,746 acres.

DIVISION No. 2.

Name of reservoir.	Name of stream from which water is diverted.	Area.	Capacity.
Tenth district:		*Acres.*	*Cubic feet.*
Banning & Matthews	Cheyenne Creek		3,500
Overland Heights Improvement Company			208,360
Johnson No. 1	Springs		330,000
Johnson No. 2			207,000
Johnson No. 3			207,000
Johnson No. 4			334,000
Johnson No. 5			334,000
Johnson No. 6			12,500
Johnson No. 7			12,500
Johnson No. 8			12,500
Johnson No. 9			12,500
Johnson No. 10			12,500
Johnson No. 11			660,000
Lake Moraine	Ruxton Creek		22,580,000
East Colorado Springs	Sand Creek		23,905,210
The Broadmoor	Cheyenne Creek		8,933,333
Haynes	Little Fountain and Rock Creek		8,702,600
Bear Lake	Bear Creek		1,205,280
Roberts	Bierstadt		230,000
Cheyenne Mountain	Fountain		21,500,000
Wolfe			160,635
Corbin	Fountain		106,667
Phelps	W. Monument		26,000
Mt. Baldy	Springs		21,500,000
Broadmoor No. 1	Broadmoor		1,880,000
Broadmoor No. 2	Spring		2,000,000
Broadmoor No. 3	Run		200,000
Broadmoor No. 4	do		475,000
Fursman	Bierstadt		186,667
Total capacity			115,937,752
Eleventh district:			
Cottonwood Lake	Cottonwood		6,294,048
Donnell No. 1	Lake Fork		9,614,880
Donnell No. 2	do		4,704,480
Total capacity			20,613,408
Fourteenth district:			
Hobson No. 1	Fountain		4,626,551
Hobson No. 2	do		1,076,301
Hobson No. 3	do		1,136,132
Hobson No. 4	do		1,637,159
Bessemer No. 1	Arkansas		189,000,000
Bessemer No. 2	do		240,000,000
Bessemer No. 3	do		120,000,000
Bessemer No. 4	do		47,600,000
Bessemer No. 5	do		51,840,000
Bessemer No. 6	do		15,840,000
Bessemer No. 7	do		28,800,000

Colorado (eastern slope).—Tabulated statement of reservoirs, etc.—Continued.

DIVISION NO. 2—Continued.

Name of reservoir.	Name of stream from which water is diverted.	Area.	Capacity.
Fourteenth district—Cont'd.		*Acres.*	*Cubic feet.*
Bessemer No. 8	do		31, 280, 000
Bessemer No. 9	do		34, 500, 000
Bessemer No. 10	do		43, 200, 000
Bessemer No. 11	do		34, 560, 000
Bessemer No. 12	do		54, 000, 000
Bessemer No. 13	do		112, 000, 000
Total capacity			1, 011, 596, 143
Sixteenth district:			
Huerfano Valley	Huerfano		87, 855, 000
K and M	Apache Creek		1, 667, 283
La Joya	Cucharas		7, 741. 400
Hayden A	Cheyenne Creek		56, 810
Hayden B	do		19, 700
Hayden C	do		50, 000
Hayden D	do		78, 605
Place	South Veta		860, 000
Total capacity			98, 329, 398
Seventeenth district:			
Woodworth A	Caddoa Creek		720, 000
Woodworth B	do		540, 000
Maryland No. 1	Springs		24, 349
Maryland No. 2	do		407, 109
Maryland No. 3	do		451, 592
Maryland No. 4	do		86, 352
Maryland No. 5	do		30, 817
Maryland No. 6	do		245, 568
Thurston A	Steele's Fork		360, 000
Thurston B	do		390, 000
Thurston C	do		350, 000
Thurston D	do		5, 425, 000
Thurston E	do		2, 760, 720
Thurston F	do		585, 000
Thurston G	do		585, 000
Thurston H	do		262, 500
Thurston O	do		210, 000
Thurston P	do		90, 000
King	Arkansas		748, 000, 000
Prince	do		61, 000, 000
Total capacity			822, 524, 005

RECAPITULATION, DIVISION No. 2.

Districts.	No. reservoirs.	Area.	Capacity.
		Acres.	*Cubic feet.*
Tenth	29		115, 937, 752
Eleventh	3		20, 613, 408
Fourteenth	17		1, 011, 596, 143
Sixteenth	8		98, 329, 398
Seventeenth	20		823, 524, 005
Total	77		2, 069, 000, 706

NOTE.—The above amount would furnish 1 foot in depth of water for 47, 495 acres.

Colorado (eastern slope).—Tabulated statement of reservoirs, etc.—Continued.

DIVISION No. 3.

Name of reservoir.	Name of stream from which water is diverted.	Area.	Capacity.
		Acres.	*Cubic feet.*
Twenty-second district:			
Poncha No. 1	San Antonio	60.00	6,000,000
Poncha No. 2	do	40.00	4,000,000
Poncha No. 3	do		4,000,000
Poncha No. 4	do		2,000,000
Total capacity			16,000,000
Twenty-fifth district:			
High Line	Black Cañon Creek		2,000,000
Richard Cooper			64,000,000
Total capacity			66,000,000
Twenty-sixth district:			
John O'Neil's	Jones's Spring		50,000
Twenty-seventh district:			
San Juan Gulch No. 1	San Juan Gulch Creek		13,000
San Juan Gulch No. 2	do		76,000
San Juan Gulch No. 3	do		20,000
Total capacity			109,000

RECAPITULATION. DIVISION No. 3.

Districts.	No. reservoirs.	Area.	Capacity.
		Acres.	*Cubic feet.*
Twenty-second	4		16,000,000
Twenty-fifth	2		66,000,000
Twenty-sixth	1		50,000
Twenty-seventh	3		109,000
Total	10		82,159,000

NOTE.—The above amount would furnish 1 foot in depth for 1,885 acres.

GENERAL RECAPITULATION.

Division.	No. of reservoirs.	Area.	Capacity.
		Acres.	*Cubic feet.*
First	75		3,168,780,082
Second	77		2,069,000,706
Third	10		82,159,000
Grand aggregate	162		5,319,939,788

NOTE.—This total amount of water would furnish 1 foot in depth of water for 122,120 acres.

STATEMENT OF JOS. C. HELM, ASSOCIATE JUSTICE, SUPREME COURT OF COLORADO.

The **CHAIRMAN.** Will you please state anything that may interest the committee in regard to the irrigation laws of this State?

Mr. **HELM.** There are several lawyers present who undoubtedly could give the committee a better idea than I can of the statutes. I simply consented to answer any questions the committee might have to ask me with regard to our decisions. I could not go into a discussion of the statutes or express any views concerning them unless I had written an opinion on the subject. There are lawyers here who will give you all the evidence you desire on that subject.

The **CHAIRMAN.** We do not ask any extended evidence because it is mostly in your reports I suppose. I have been a student of your reports for many years and I must say that your court is considered the most enlightened on this subject by those who are familiar with irrigation matters.

Mr. **HELM.** That is a compliment that we appreciate.

The **CHAIRMAN.** You are governed by the principle of prior appropriation?

Mr. **HELM.** Yes, we adopted that doctrine. I think the supreme court of the State announced that doctrine before it was incorporated into the statutes. It was in the case of Younker against Nichols, reported in the First Colorado. The court at that time decided that it was the best common-law doctrine for this country. The decisions since, I believe, have been in harmony with that. Of course a multitude of questions have come up and I think there are a dozen decisions at least in which this subject was before the court in one way or another.

The **CHAIRMAN.** There is a question now with regard to appropriation which is interesting the people all over the country very much; and that is what is meant by the word "appropriation," whether you mean taking the water out of the stream or whether you mean something else?

Senator **JONES.** I imagine the judge might object to construing the statutes.

Mr. **HELM.** I would not object to that so far as to state the opinion of the court about it.

The **CHAIRMAN.** Have you considered the question of what is prior appropriation?

Mr. **HELM.** I think that in a number of decisions we have announced that to constitute a valid appropriation within the meaning of the constitution (and our constitution is in accord with our common law) there must unite two acts, the diversion and the use.

The **CHAIRMAN.** Use for a beneficial purpose?

Mr. **HELM.** Use for some beneficial purpose.

The **CHAIRMAN.** It has been stated here that under the court decisions a certain amount of water is "decreed" to a district. What is meant by that?

Mr. **HELM.** Our statutes divide the State into irrigation districts, as you know, and under the statutes the district courts, which are the highest courts of record, next to the supreme court, adjudicate what we call the priorities of right. These districts are generally arranged with reference to the natural streams, and if from the principal natural stream in a district one hundred ditches have been taken, the court proceeds in the method pointed out by statute to determine the dates at which each of these appropriations were made when the ditches were constructed; the size of the ditches; their capacity; the degree of fall of the water. Then a decree is entered which declares these dates, declares these facts, and assigns the priorities to these ditches in accordance with the dates of the diversion.

Senator JONES. The diversion and use go together?

Mr. HELM. The diversion and use. And I might say here that under our views the use must follow the diversion within a reasonable time. These decrees assign to these ditches priorities in accordance as I have stated with the dates of the diversion, and, as I have said, the use, of course, is connected with that diversion.

Senator JONES. It must be within a reasonable time?

Mr. HELM. Within a reasonable time. The question of reasonable time goes according, of course, to circumstances. But the proposition is that if the ditch is dug with due diligence and the water is applied reasonably soon, the priority relates back to the date of the commencement of the ditch.

Senator JONES. And that is a question for the court?

Mr. HELM. That is a question, I take it, to be determined in each particular case in the absence of statute. Possibly a statute might be framed which would declare how soon use must follow diversion, but so far we have no such general statute, and the court has not laid down the proposition. It would remain a question of fact to be determined at each particular case. This decree that I spoke of also determines the quantity going to each ditch. I suppose in answer to your question, that the decree of a given district must be considered and the quantity of water assigned to each particular ditch or to all the ditches taken together in the aggregate, would constitute the quantity in use or the quantity assigned.

The CHAIRMAN. If there is not water enough, those having priority under the decree would get it first?

Mr. HELM. That is the decision.

The CHAIRMAN. Have you any officer to deal it out?

Mr. HELM. We have.

The CHAIRMAN. How do you arrive at that? To get at priority, do you let them regulate it themselves?

Mr. HELM. Mr. Nettleton can answer that question better than I can, but I think in each district there is an irrigation commissioner whose duty it is to superintend the distribution of water according to the decrees of the court.

Senator JONES. Is he an officer of the court or of the State or county?

Mr. HELM. He is not an officer of the court; I think he is appointed by the governor. The governor appoints a commissioner for each water district.

The CHAIRMAN. Have you, in your decisions, classified the different uses of water, with a view of giving a preference to one use above another?

Mr. HELM. We have not, but our constitution has. First, to domestic use; second, to irrigation; third, to mining, and then to manufacturing. I believe that is the order. Domestic use is certainly first and irrigation second.

The CHAIRMAN. You have not yet by any judicial decision determined what you understand by domestic use?

Mr. HELM. We have not; I think the question has never been fairly presented.

The CHAIRMAN. That is a very important question.

Mr. HELM. We have a decision which touches upon it slightly but not sufficiently for me to dwell upon.

The CHAIRMAN. It ought to be limited in some way. Of course, if a man were to insist on having a river run down for the purpose of getting a drink of water it would interfere with irrigation.

STATEMENT OF WALTER H. GRAVES.

The CHAIRMAN. Will you please state anything which may interest the committee.

Mr. GRAVES. In the first place, I desire to state that I represent a company that has invested considerable money in building canals in Colorado.

Senator JONES. What is the name of the company?

Mr. GRAVES. There are various enterprises backed by Eastern capital, they are one interest but under different names. We have altogether something over 1,000 miles of canals and we have spent nearly $4,000,000 in building them. I have promised Major Powell to send him a tabulated statement, embodying some points in connection with our maps. These maps [indicating the maps] are all that I have at present. We have canals, as I say, in different parts of the State; two large canals in the western part of the State, two large ones in the San Luis Valley on the Rio Grande River, and one in the northeastern part of the State.

There are many questions that have arisen in connection with our enterprises and schemes that are of interest. Professor Carpenter has already presented some of the questions. Many of the questions you are investigating we have had occasion to deal with. In the San Luis Valley we have 468 miles of ditch. One of our canals, known as the Rio Grande Canal, is, I think, the largest canal in operation at present in the West. We have 312 miles of ditch system. The canal at the head is 80 feet wide on the bottom, and it is contemplated that it will supply water to about 240,000 acres of land. The conditions and character of the soil of the San Luis Valley, on the Rio Grande River, in the southern part of the State, are different from other sections of Colorado. That valley has an area of 5,000 square miles, and with probably 3,000,000 acres there that could be redeemed if we had the water to do it with. We have altogether in the San Luis Valley, not embodying our canals entirely, but other canals also, probably 1,150 or 1,200 miles of canal. There are supplied by these canals about 1,500,000 acres of land.

The CHAIRMAN. That is the number of acres under the canal?

Mr. GRAVES. Yes. Our water supply is not sufficient to irrigate those lands at all times. The present year has been one of low water, and we have not been able to irrigate more than 50,000 or 60,000 acres. There is a splendid opportunity for conserving the water and increasing the area of cultivated land.

The CHAIRMAN. How?

Mr. GRAVES. The Rio Grande River carries a large amount of flood water during the summer months, but of course we are unable at that time to utilize it all, and will be unable to do so even if our canal system be extended. There are probably six weeks during the average year when there will be sufficient water to irrigate the entire valley if we could rely on it, but we can not do that. There are fine sites within the mountains adjacent to the valley for building reservoirs.

In order to redeem that entire area it is necessary to conserve the water. We are all interested in the reservoir system, because that is the only way that the entire valley can ultimately be settled. With that area we can probably support 150,000 or 200,000 people there, but with our present irrigating facilities and water supply we will not be able to support more than 50,000 people. The soil is good.

The **CHAIRMAN.** What is its general altitude?

Mr. **GRAVES.** About 7,500 feet, but the latitude is such that it gives us a good locality for irrigation. The San Luis Valley, which, by the way, is the largest valley in the Rocky Mountain region, has a soil somewhat peculiar and different from the soil on the eastern slope of the mountains. Our soil is underlaid by a heavy stratum of drift.

We find artesian water in the San Luis Valley at a depth of 800 feet, a very full flow of water that will cut a figure sometime in the progress of irrigation; but even with this artesian water and all the water we have we will be unable to redeem the valley without storing the water.

The **CHAIRMAN.** Have you explored the mountains with a view to finding reservoirs?

Mr. **GRAVES.** Yes, and a number of them have been picked out and located by the owners of the various ditches in the locality.

The **CHAIRMAN.** Has the Government made any surveys there yet?

Mr. **GRAVES.** I think Major Powell's men have been on the east slope this summer and surveyed some.

The **CHAIRMAN.** Are those sites on public or private lands generally?

Mr. **GRAVES.** Public lands mostly up in the mountains. In some cases, however, there are ranch claims that would have to be condemned to avail of the site.

The **CHAIRMAN.** But they are generally on public lands, you say?

Mr. **GRAVES.** Yes; most of the land in the San Luis Valley is public land, but the State has some 200,000 or 250,000 acres therein. In order to induce capital to invest in this enterprise the State passed a law providing for the sale of the State land in alternate quarter sections at $1.25 per acre to any company that would build a canal large enough to supply the entire area. They require the canal company to make a contract and give a bond and supply that land. There is one feature about those large enterprises which is this: Capital is loath to go in and investigate and make the expensive examination necessary to ascertain whether these canals are feasible. There are a number of canal and other irrigating projects in the State, especially in the western and southwestern portions, that would undoubtedly be undertaken if it could be demonstrated they were feasible, but in order to demonstrate that it would require the expenditure of considerable money.

The **CHAIRMAN.** Then you think the Government surveys would be useful?

Mr. **GRAVES.** By all means, yes. It seems to me that if the information could be got and promulgated, so showing that these schemes are feasible, capital might be induced to go in and construct them. That is especially true in Grand Valley. This valley, extending from Grand Junction over to the valley of the Green, in Utah, embraces a fine section of land, but to build a canal that would reclaim the whole of the land that is irrigable therein would require much money. We have made some reconnaissances to ascertain that, and it was ascertained that the canal would cost probably $2,500,000. It is hardly probable that capital would go in and build such a canal as that without some benefit that would be commensurate with the investment. I do not believe that capital will ever go in there to build a canal unless there is some inducement—some bonus or franchise to induce them to go in.

The **CHAIRMAN**. They could estimate that better if the surveys were made.

Mr. **GRAVES**. Yes, but it is highly important that these surveys should be made by the Government.

As to the question of the duty of water, you have ascertained from the State engineer's remarks here what has been done in this vicinity. I think that, in a measure, that is misleading. In the first place it is a difficult matter to ascertain absolutely the duty of water. It varies very largely with the locality, the nature of the soil, and the nature of the crop. By the most careful experiments we have been able to make in the San Luis Valley, the duty of water will run from 80 to 100 cubic feet per second. We have there offered as a premium on the minimum use of water a plan similar to this: We sell water by the quantity. In certain cases, we sell at so much a cubic foot to a certain number of individuals and deliver it to them at a certain point. They can distribute that water as suits them, but it is to their interest to make it go as far as possible. We sell water generally by the statutory inch. It is easily measured to the consumer in that way. We advise a farmer to buy so many statutory inches less than he would probably ultimately need. If, by careful and economic distribution, he can make that water cover a certain amount of land, it is to his interest to do it. That is a much better plan than to allot a certain amount of water to a certain amount of land, because in that case the farmer will surely use it, even if thereby it is wasted. In the same fields sometimes there are places that require different amounts of water, but the question of distribution in that sense is a matter for careful observation and economy.

The **CHAIRMAN**. Do you sell water rights?

Mr. **GRAVES**. We rent it per annum and we also sell it in perpetuity. We allow a man to buy as many inches as he wants to buy. If we sell him 20 or 30 inches this year, when he has paid for them we will sell him an additional amount. Each perpetual right is followed by an assessment to keep up the canal.

The **CHAIRMAN**. Is there any limitation on the assessment?

Mr. **GRAVES**. Yes; it is limited and it is sometimes graduated, running so much for a certain number of years and so much for the years following that, and so on. The idea is this: The ditch is built by the company——

Senator **JONES**. When you sell a number of inches do you obligate yourself to furnish that number of inches?

Mr. **GRAVES**. Yes.

Senator **JONES**. Suppose you have not got them?

Mr. **GRAVES**. It is provided that if the water is in the river we shall supply it. It is contemplated that if a man buys a certain right he buys a corresponding interest in the ditch, and at a certain time stock will be given to him, so that in time the consumers will own the ditch, and by electing their own officers they will have the management. By the time that is done we expect to have the ditch in perfect operation, so that the cost of maintenance would be comparatively small. This plan [referring to a map] gives a skeleton outline of our canal system.

The country lies very level, and it is such that we carry our water east and north. We carry our laterals in section lines and quarter-section lines. In some cases our laterals follow the ridges. The canal referred to has cost about $800,000.

Senator **JONES**. How long is it?

Mr. **GRAVES**. Our total mileage under that is 212 miles.

Senator **JONES**. How much land is covered by that ditch?

Mr. **Graves**. Two hundred and forty thousand acres.

Senator **Jones**. Is there water enough in it to irrigate that amount of land?

Mr. **Graves**. There is, in the river, at times.

Senator **Jones**. Is the capacity of the ditch sufficient to carry it?

Mr. **Graves**. It has a theoretical capacity sufficient; yes. It was built on that basis.

The **Chairman**. Have you adopted the plan of having storage reservoirs along the line of the ditch?

Mr. **Graves**. No, only the little one you see there [indicating by reference to the map]. Of course, for the present, we have an ample supply in the river, but since our ditch system was built quite a number of other ditches have also been built, and some must go short unless the water is supplied by means of storage.

The **Chairman**. What are the opportunities of storing water in this valley?

Mr. **Graves**. Practically none in the valley.

The **Chairman**. It is very level there?

Mr. **Graves**. Yes. It must all be done in the adjoining mountains. In Grand Valley we have an ample supply of water. Grand River is sufficient, but the difficulty there is the very great cost of maintaining the ditch. The peculiarity of the soil is such that it has been very difficult to maintain the ditch as against the floods and water-spouts during the summer.

The **Chairman**. We have heard a good deal of that in Utah. How much land area is there in the Grand Valley?

Mr. **Graves**. There is a very large country there that could be redeemed. We cover, by our canal, about 40,000 acres, but there must be some 250,000 to 500,000 acres that could be redeemed.

The **Chairman**. In that estimate do you include any portion of Utah?

Mr. **Graves**. Yes; in that estimate I include a portion of Utah. I have here two maps that I present to the committee. One is the map of the north side of the river in the San Luis Valley, and the other is a map of the south side. The first map is entitled "Map of the Del Norte Canal and laterals." This second map is entitled "Map of the Citizens' Ditch," now called the "Monte Vista Ditch."

In addition to our canal, there are probably fifteen large ditches in the valley. Many of those are comparatively new, and some of them are not noted yet in the State engineer's office. Consequently, these estimates are designed to include them.

The **Chairman**. If these schemes are carried out and the water used in the valley, what effect would it have on the Rio Grande Valley?

Mr. **Graves**. It would practically exhaust it; indeed, it is doing it already. We have found that it is true that after water is distributed over a country for a number of years, nearly all the swales and dry gulches become running streams.

The **Chairman**. Are you aware that the citizens of Mexico feel aggrieved over your use of the water?

Mr. **Graves**. Yes, we are aware of that fact, but inasmuch as we take the water here in this country, we think we have a prior right to it.

Senator **Jones**. You do not think that the Mexicans have a prior right?

Mr. **Graves**. That is an international question that we have not considered.

The **CHAIRMAN**. They say they have had it for two hundred years and have some right in the matter.

Mr. **GRAVES**. After we have used it for some years in all probability it will be returned to the river. We look at it as we do at an artesian well. When a man puts an artesian well on his place, we think he has a right to it, because in one sense it is a creation of his own, and when the snow falls on our mountains and the rain falls here, we think it is our water.

Senator **JONES**. You have not increased the snow-fall?

Mr. **GRAVES**. No, sir.

The **CHAIRMAN**. Is there anything further that you wish to say?

Mr. **GRAVES**. We have spent a large amount of money in the State and we are covering a much larger area of land than there is water at all times to cover. If there is any possible way in which the water could be increased or information about it could be had, it would be a material advantage or benefit to the people who have invested the money.

Senator **JONES**. Is all the water in the ditches practically taken in the irrigating season?

Mr. **GRAVES**. No, excepting in the low-water season. Our canals have only been built a few years, and the present settlement of the country is comparatively small in proportion to the amount that will ultimately be settled. It will take a great many years to fully develop this country. We have, therefore, a surplus of water except in extreme low seasons of water.

Senator **JONES**. What proportion of that water is taken now?

Mr. **GRAVES**. Possibly from 5 to 10 per cent. is utilized—may be more; I can not say exactly.

Senator **JONES**. Not more than from 5 to 10 per cent.?

Mr. **GRAVES**. No, that is the capacity of our canals.

The **CHAIRMAN**. You mean the water actually taken out?

Mr. **GRAVES**. Yes.

Senator **JONES**. During the irrigating season?

Mr. **GRAVES**. Yes, but in low-water season this year we have hardly had enough to supply our customers. We have had to economize and utilize it in the best way possible. Any information or system promulgated by the Geological Survey, or any action taken by the Government, will be highly important to us, to the capital invested, and the people who are to use the water.

Senator **JONES**. About what do people pay per acre for perpetual water rights to your company?

Mr. **GRAVES**. We do not sell or measure it in that way. We sell it by the inch to them.

Senator **JONES**. Yes, but you know how much it takes to irrigate an acre.

Mr. **GRAVES**. It varies. I might approximate it on an average.

Senator **JONES**. That is what I mean.

Mr. **GRAVES**. They are probably paying us from $5 to $8 an acre. But there is all the difference in the world in men. One man on this piece of land—his water would cost him perhaps $10 an acre. His neighbor, by more intelligent and economic use of it, might get along for $5 on the method we have adopted. A parallel case would be the consumption of gas and coal. One man will consume more than another to supply the same house.

Senator **JONES**. What I wanted was the average.

Mr. **GRAVES**. I should say an average of $5 to $10 an acre.

Senator JONES. And the expense of keeping it up is $5 to $15 per acre, did you say?

Mr. GRAVES. No, I did not say that. We charge by the inch. In the San Luis Valley the ordinary assessment runs from 15 to 30 cents an inch. In Grand River it is $1 an inch, and that is insufficient to maintain the ditch there. The expense of keeping up the ditch varies with the capacity of the canal.

Senator JONES. What is the selling price per inch?

Mr. GRAVES. We are selling it at $8 an inch in the San Luis Valley for the first 5 miles. A man 24 miles down would pay about $12 an inch for it. We charge so much an inch and agree to carry it to a certain point. For instance, if we sell to a colony, we agree to give them so many cubic feet at a certain place, and they do what they think proper with it.

Senator JONES. But in case of a failure of the water you are discharged of your obligation to furnish it?

Mr. GRAVES. If it can be had in the river we must furnish it. If it is not in the river we are relieved of our obligation.

Form of water contract in use in Colorado—submitted by Mr. Graves to the committee:

WATER CONTRACT.

Know all men by these presents, that the —— —— Canal Company, a corporation existing under the laws of the State of Colorado, of the first part, and —— ——, of the county of —— and State of Colorado, of the second part, for and in consideration of the sum of $ —— to be paid as hereinafter specified, and in consideration of the mutual covenants and agreements in this contract contained, to be performed and kept, the said company hereby agrees to carry and convey for the use of the second part—, —— statutory inches of water in and through the canal of said company, subject to the following terms and conditions, to which the said part— of the second part, —— heirs and assigns, hereby expressly agree:

I. The said company agrees to carry and convey the said water in its said canal for the use and benefit of the said second part—, ——, heirs or assigns, continuously during the irrigating season, except as hereinafter provided, and at no other time, unless with the consent of said company thereto in writing.

II. Said water shall be used only for irrigating and domestic purposes on the following described tract of land, and none other, to wit: —— —— and under no circumstances shall said water, or any portion thereof, be used for mining, milling, or mechanical power, or for any other purpose not directly connected or incident to the purposes herein specified.

III. Said company expressly reserves to itself the right to distribute the water from its said canal in accordance with such rights and priorities as are or may hereafter be established or decreed; and this contract is received by the part— of the second part subject to such priorities.

IV. The said second part—, —— heirs or assigns, shall not permit said water, nor any portion thereof carried as aforesaid, to run to waste, but as soon as a sufficient the quantity shall have been used for the purposes herein allowed and contracted for, said second part—, —— heirs or assigns, shall shut off said water and keep the same shut and turned off until the same shall be again needed for the purposes aforesaid. But in no case shall the amount of water taken or received by said second part—, —— heirs or assigns, exceed the quantity first herein referred to, and said company hereby reserves the right at any time to shut off the water herein mentioned whenever it shall find that the said part—of the second part —— wasting it or not using it in accordance with the agreements herein contained on the land above mentioned.

V. The said company shall deliver said water at such point or points along the line of said canal or ditch, or from any of its reservoirs, laterals, either or all, as it may determine to be the most practicable, and the manner of withdrawing and regulating the supply of said water from said company's ditch and reservoirs shall be prescribed by said company, and shall at all times be under its control, as determined and directed by the said company. The head-gates, flumes, weirs, or other arrangements or devices, and all measuring boxes and devices through which the water hereby contracted to be carried shall be drawn and measured from said company's ditch or reservoirs, shall be made and placed in position by the said company, but at the cost of said second part—, who shall also be liable for the expense of keeping the same in good repair and condition; and the said company may collect and enforce the payment of all sums expended for said purposes in the same manner as prescribed for collecting and enforcing assessments.

VI. The said first party agrees to keep and maintain said main canal or ditch and any and all of its reservoirs and laterals in good order and condition, and in case of accident to the same, to repair the injury thereby occasioned, as soon as practicable and expedient; and the company shall have a right to assess the said second part— for its expenses of maintaining, repairing and operating said canal, and any and all reservoirs and laterals connected therewith, including taxes and legal assessments on said canal, a sum not exceeding —— per statutory inch hereby contracted to be carried, per annum; and in addition thereto may, when necessary by reason of accident, assess all owners or holders of water rights, pro rata, such sums as may be necessary to repair the injuries so occasioned, —— the amount of all assessments herein provided for shall be determined and levied by said company by resolution of its board of directors, and the company also reserves to itself the right by like resolution to establish and enforce such rules and regulations, and to provide and declare such penalties as it may deem necessary and expedient for the purpose of enforcing and collecting said assessments or any part thereof. Said assessments shall be due and payable at such time as may be fixed by the board of directors of the first party, and the second part— hereby agree— to duly pay the same, and further agree— that the failure to pay the same or any part therof within sixty days after notice of the levy of any assessment (which notice may be either personal or by registered letter addressed to the second part— at ——, Colorado) shall, at the option of the board of directors of the first party, constitute a forfeiture of all the rights of second part— as provided in paragraph XIII of this agreement.

VII. The said first party shall have, and the said second part— hereby grant — to the said first party, a right of way across said above described land of the width of —— feet for the main canal as now located and a right of way for the laterals of said first party as now located, of the width of —— feet, and also the right of roadway on the banks of the canal and main laterals; and in case a fence is constructed by said second part —across said roadway —— shall construct and maintain a gateway across said bank, when said first party requests, in which case said first party shall close said gate when opened by it.

VIII. It is hereby distinctly understood and agreed by and between the parties hereto, that in case the first party shall be unable to carry and distribute a volume of water equal to the estimated capacity of its canal, either from casual, unforeseen, or unavoidable accidents, or from any cause beyond the control of said first party, or if the volume of water prove insufficient from drought or from any other cause beyond the control of said company, the company shall not be liable in any way for the shortness or deficiency of supply so occasioned, or any loss or damage resulting therefrom by reason of any of said causes. If, however, by reason of such causes, or any of them, the supply of water be insufficient to furnish an amount equal to all the water rights then outstanding, the said company shall have the power and the right to distribute such water as may flow through said canal to the holders of such water rights pro rata, or may alternate the same; and for the purpose of so doing may establish and enforce such rules as it may deem necessary or expedient. And the second part— for —— and —— heirs and assigns, agree— in consideration aforesaid, to waive, and hereby do— waive, any claim for loss or damage by reason of any leakage, overflow, or breaking of said company's canals, or any of its reservoirs, lakes, or laterals, either upon the land aforesaid or any other tract belonging to the part— of the second part, provided the same is not caused by the negligence of said company.

IX. The said company agrees that when it shall have sold and have outstanding and in force a number of water rights equal to the estimated capacity of the company's canal, or sooner, at its option, it will then transfer to the holder of each water right, who shall have complied with the terms and conditions of this contract, without further consideration, such a proportion of the number of shares of the capital stock of the said —— company as the number of water rights held by —— bears to the whole number of water rights held or outstanding in the canal of the company, or as near thereto as may be possible without making fractions of shares, and which said shares the second part— agree— to accept: *Provided, however*, that such transfer is to be made only on the express condition that the first party shall thereupon and thereafter be absolutely released from any and all obligations or liabilities arising out of the ownership, operation, management, or control of said canal, or out of any contract (including this) pertaining to the distribution of water therefrom, which said obligations shall be assumed by said holders of water rights, who shall pay all expenses incident to such transfer; which said condition the said second part—, in consideration thereof and of these presents, for —— and —— heirs and assigns do— hereby accept. Such transfer shall only be made when the canal is in good order and unencumbered.

X. It is further agreed that the irrigating season shall commence April 15th and continue to November 1st of each and every year, and that thereafter water shall be conveyed for domestic purposes whenever reasonably practicable; subject to the right of said first party to shut off the water in order to repair or enlarge or extend said canal.

XI. The payment of the consideration heretofore specified herein shall be as follows: —— dollars upon the ensealing and delivery of this contract, payment of which is hereby acknowledged, and the balance in —— payments at the times and in the manner following, that is to say:

	Day.	Month.	Year.	Principal.	Interest.	Amount.	Remarks.
First deferred payment							
Second deferred payment							
Third deferred payment							
Fourth deferred payment							
Fifth deferred payment							
Sixth deferred payment							
Seventh deferred payment							
Eighth deferred payment							

Said deferred payments shall bear interest at the rate of —— per cent. per annum, payable annually, and shall bear interest after maturity at the rate of —— per cent. per annum, and the second part— in consideration of the premises hereby agree— that —— will make punctual payment of the above sums, and each of the same, together with the interest thereon as the same respectively become due; and that —— will regularly and seasonably pay all assessments that may be imposed by said company for the purposes aforesaid as above agreed.

XII. In case the second part ——, legal representatives, heirs or assigns, shall pay the several sums of money punctually, and at the times above limited, and shall strictly and literally perform all and singular the agreements and stipulations aforesaid after their true tenor and intent, then this contract shall be and operate as a contract entitling said second part— in perpetuity to the enjoyment of the right hereby granted, subject, however, to the same assessments and forfeitures for non-payment as herein provided.

XIII. And it is hereby agreed and covenanted by the parties hereto that time and punctuality are essential elements of this contract. And in case the second part— shall fail to make the payments aforesaid, and each of them, or shall fail to pay any assessment which may be levied as provided in paragraphs V and VI hereof, punctually and upon the strict terms and times above limited for the payments and assessments herein provided for, or likewise to observe, perform, and complete, all and each of said agreements and stipulations aforesaid strictly and literally, without any failure or default, then this contract, so far as it may bind the first party, shall become null and void, the water may be immediately shut off, and all rights and interests hereby created or then existing in favor of the second part,—, —— heirs or assigns, or derived from this contract shall utterly cease and determine, and all equitable and legal interest in the right hereby contracted for shall revert to and revest in said first party, without any declaration of forfeiture or any other act of said first party to be performed, and without any right of said second part—of reclamation or compensation for moneys paid or services performed, as absolutely, fully, and perfectly as if this contract had never been made: *Provided*, That said first party shall give to said second part— heirs or assigns, sixty days' notice, either personal or by mail, of the said second part—, —— heirs or assigns, being in arrears upon said payments, or any of them, or the interest thereon, which notice, if by mail, shall be sufficient, if by registered letter addressed to said second part— at —— Colorado.

XIV. It is also stipulated and agreed that no assignment of the rights of the second part— under this contract, whether by conveyance or lease of all or part of said lands, or by operation of law, or otherwise, shall be binding on the first party, so as to require it to carry for or deliver to such assignee any of the amount of water herein contracted to be carried and delivered unless the first party shall consent thereto in writing; and provided, that no assignment whatever shall be binding as to the first party herein until the same is endorsed upon these presents and consented to in writing upon these presents by the said company: *And provided further*, That nothing herein contained shall be taken to bind the party of the first part herein to release the second part— in case of such assignment, from any liabilities to said first party under this contract. The endorsement upon these presents of the company's consent to the assignment by the party— of the second part of this contract and of —— rights hereunder will be made by said company upon request of the part— of the second part, provided all payments, assessments, and charges herein provided for which may have become due at or prior to the time of such request shall have been fully paid.

XV. It is further stipulated and agreed that nothing in the foregoing provisions as to relocation and assignment shall be taken to bind the first party to convey or deliver water in less amount than 5 statutory inches for any one tract of land.

XVI. It is also stipulated and agreed that from and after the execution hereof, the said second part— may enter into the use and enjoyment of water flowing through said canal, its reservoirs or laterals, to the extent of the rights above contracted for as fully as though fully paid for, but subject, however, to all the terms, limitations, and conditions above set forth.

In witness whereof, the —— —— Canal Company, party of the first part, has hereunto caused its corporate name to be subscribed by its president, and attested by its secretary, and its corporate seal to be affixed hereto as well as to a duplicate hereof, and the part— of the second part— hereunto subscribed — name— and affixed — seal— hereto, as well as to a duplicate hereof, this the — day of —— A. D. 18—

—— —— COMPANY.
By —— —— *President.*

Attested by:
—— —— *Secretary*

—— —— [SEAL.]
Address, —— ——
—— —— [SEAL.]
Address, —— ——

ASSIGNMENT.

—— ——, the within-named purchaser, for and in consideration of —— dollars, do hereby assign and transfer all — right, title, interest, and claim in and to the within-described rights to water unto —— ——, of ——, county of —— and State of ——, heirs and assigns, forever; and — do hereby authorize and empower the —— —— Company to receive from the said —— —— all unpaid balances due to said company, in part consideration for said water rights.

Given under — hand and seal this — day of ——, A. D. 18—.

It is expressly understood that in consenting to recognize this assignment the officers of this company do not exempt the original purchaser from any of his liabilities under the contract, but will protect the rights of the assignee, provided he complies with its obligations.

—— ——. [SEAL.]

Countersigned.

—— ——,
President.
—— ——,
Secretary.

STATE OF COLORADO,
County of ——, *ss:*

Before me, —— —— in and for said county, this day personally came —— ——, known to me to be the identical person described in the within agreement, and who executed the foregoing assignment, and acknowledged that — signed, sealed, and delivered the same as — free and voluntary act and deed, for the uses and purposes therein set forth.

Given under my hand and — seal of office this — day of ——, A. D. 18—.

—— ——.

My commission expires ——, 18—.

Received ——, 189—, of —— —— the sum of —— dollars, amount of first deferred payment, on the within contract.

—— ——.

[Receipts similar to the above for the second to the eighth payments, inclusive, follow.]

(Indorsement:) No.—. Agreement to carry — inches of water. The —— —— with —— ——.

The following is another form of contract in use:

WATER CONTRACT.

Know all men by these presents, that the —— —— Canal Company, a corporation existing under the laws of the State of Colorado, of the first part, and —— ——, of the county of —— and State of Colorado, of the second part, for and in consideration of the sum of $—— to be paid as hereinafter specified, and in consideration of the mutual covenants and agreements in this contract contained, to be performed and kept, the said company hereby agrees to sell unto the second party a water right for —— statutory inches of water flowing through the canal of said company, subject to the following terms and conditions, to which the said party of the second part, —— heirs and assigns, hereby expressly agree:

I. The said company agrees to furnish the said water to the said second party, —— heirs or assigns, continuously during the irrigating season, except as hereinafter provided, and at no other time, unless with the consent of said company thereto in writing.

II. Said water shall be used only for irrigating and domestic purposes on the following described tract of land, and none other, to wit: —— —— and under no circumstances shall said water, or any portion thereof, be used for mining, milling, or mechanical power, or for any other purpose not directly connected or incident to the purposes hereinafter specified.

III. Said company expressly reserves to itself the right to distribute the water from its said canal in accordance with such rights and priorities as are or may hereafter be established or decreed; and this deed is received by the party of the second part subject to such priorities.

IV. The said second party, —— heirs or assigns, shall not permit said water, nor any portion thereof furnished as aforesaid, to run to waste, but as soon as a sufficient quantity shall have been used for the purposes herein allowed and contracted for, the said second party, —— heirs or assigns, shall shut off said water and keep the same shut and turned off until the same shall be again needed for the purposes aforesaid. But in no case shall the amount of water taken or received by said second party, —— heirs or assigns, exceed the quantity first herein referred to, and said company hereby reserves the right at any time to shut off the water herein mentioned whenever it shall find that the said part— of the second part —— wasting it or not using it on the land above-mentioned.

V. The said company shall deliver said water at such point or points along the line of said canal or ditch, or from any of its reservoirs, laterals, either or all, as it may determine to be the most practicable, and the manner of withdrawing and regulating the supply of said water from said company's ditch and reservoirs shall be prescribed by said company, and shall at all times be under its control, as determined and directed by the said company. The head-gates, flumes, weirs, or other arrangements or devices through which the water hereby sold shall be drawn from said company's ditch or reservoirs, shall be made and placed in position by the said company, but at the cost of said second part— who shall also be liable for the expense of keeping the same in good repair and condition; and the said company may collect and enforce the payment of all sums expended for said purposes in the same manner as prescribed for collecting and enforcing assessments.

VI. The said first party agrees to keep and maintain said main canal or ditch and any and all of its reservoirs and laterals in good order and condition, and in case of accident to the same, to repair the injury thereby occasioned, as soon as practicable and expedient; and the company shall have a right to assess the said second part— for its expenses of maintaining, repairing, and operating said canal and any and all reservoirs and laterals connected therewith, including taxes and legal assessments on said canal, a sum not exceeding —— per statutory inch hereby contracted to be supplied per annum; and in addition thereto may, when necessary by reason of accident, assess all owners or holders of water rights, pro rata, such sums as may be necessary to repair the injuries so occasioned. The amount of all assessments herein provided for shall be determined and levied by said company by resolution of its board of directors, and the company also reserves to itself the right by like resolution to establish and enforce such rules and regulations, and to provide and declare such penalties as it may deem necessary and expedient for the purpose of enforcing and collecting said assessments, or any part thereof. Said assessments shall be due and payable at such time as may be fixed by the board of directors of the first party, and the second part— hereby agree— to duly pay the same, and further agree— that the failure to pay the same or any part thereof within sixty days after notice of the levy of any assessment (which notice may be either personal or by registered letter addressed to the second party at ——, Colorado) shall, at the option of the board of directors of the first party, constitute a forfeiture of all the rights of the second part— as provided in paragraph XIV of this agreement.

VII. The said first party shall have, and the said second part— hereby grant— to the said first party, a right of way across said above described land of the width of —— for the main canal or laterals of said first party as now located, and also the right of roadway on the banks of the canal and main laterals; and in case a fence is constructed by said second part— across said roadway —— shall construct and maintain a gateway across said bank, when said first party requests, in which case said first party shall close said gate when opened by it.

VIII. It is hereby distinctly understood and agreed by and between the parties hereto, that in case the first party shall be unable to carry and distribute a volume of water equal to the estimated capacity of its canal, either from casual, unforeseen, or unavoidable accidents, or from any cause beyond the control of said first party, or if the volume of water prove insufficient from drouth or from any other cause beyond the control of said company, the company shall not be liable in any way for the shortness or deficiency of supply so occasioned, or any loss or damage resulting therefrom, by reason of any of said causes. If, however, by reason of such causes, or any of them, the supply of water be insufficient to furnish an amount equal to all the water rights then outstanding, the said company shall have the power and the right to distribute such water as may flow through said canal to the holders of such water rights pro rata, or may alternate the same; and for the purpose of so doing may establish and enforce such rules as it may deem necessary or expedient. And the second part— for ——— and —— heirs and assigns, agree—, in consideration aforesaid, to waive, and hereby do waive, any claim for loss or damage by reason of any leakage, overflow, or breaking of said company's canals, or any of its reservoirs, lakes, or laterals, either upon the land aforesaid or any other tract belonging to the part— of the second part.

IX. The said company agrees that when it shall have sold and have outstanding and in force a number of water rights equal to the estimated capacity of the company's canal, or sooner at its option, it will then transfer to the holder of each water right, who shall have complied with the terms and conditions of this contract without further consideration, such a proportion of the number of the shares of the capital stock of the said ——— ——— company as the number of water rights held by —— bears to the whole number of water rights held or outstanding in the canal of the company, or as near thereto as may be possible without making fractions of shares, and which said shares the second part — agree— to accept: *Provided however*, That such transfer is to be made only on the express condition that the first party shall thereupon and thereafter be absolutely released from any and all obligations or liabilities arising out of the ownership, operation, management, or control of said canal, or out of any contract (including this) pertaining to the distribution of water therefrom, which said obligations shall be assumed by said holders of water rights, who shall pay all expenses incident to such transfer; which said condition the said second part— in consideration thereof and of these presents, for ——— and —— heirs and assigns do— hereby accept. Such transfer shall only be made when the canal is in good order and unencumbered.

X. It is further agreed that the irrigating season shall commence April 15 and continue to November 1 of each and every year, and that thereafter water shall be conveyed for domestic purposes whenever reasonably practicable; subject to the right of said first party to shut off the water in order to repair or enlarge or extend said canal.

XI. The payment of the consideration heretofore specified herein shall be as follows: —— dollars upon the ensealing and delivery of this contract, payment of which is hereby acknowleged, and the balance in —— payments at the times and in the manner following, that is to say:

	Day.	Month.	Year.	Principal.	Interest.	Amount.	Remarks.
First deferred payment....							
Second deferred payment..							
Third deferred payment...							
Fourth deferred payment..							
Fifth deferred payment....							
Sixth deferred payment....							
Seventh deferred payment.							
Eighth deferred payment..							

Said deferred payments shall bear interest at the rate of —— per cent. per annum, payable annually, and shall bear interest after maturity at the rate of —— per cent. per annum, and the second part—, in consideration of the premises, hereby agree— that —— will make punctual payment of the above sums, and each of the same, together with the interest thereon, as the same respectively become due; and that —— will regularly and seasonably pay all assessments that may be imposed by said company, for the purposes aforesaid, as above agreed.

XII. In case the second part —— legal representatives, heirs or assigns, shall pay the several sums of money punctually, and at the times above limited, and shall strictly and literally perform all and singular —— agreements and stipulations aforesaid after their true tenor and intent, then the first party shall cause to be made and executed unto the second part —— heirs or assigns, a deed conveying the water-right above described in fee-simple; subject, however, to the same assessments and forfeitures for non-payment as herein provided.

XIII. The first party claims and reserves a strip of land of the width necessary and sufficient for the right of way of the canals of the first party, and for enlarging and repairing and superintending the same where any such canal is located upon or contiguous to the premises, hereby claiming and reserving the right of way across said lands for lateral canals where the same are or may become necessary and expedient for the purpose of conveying water from the main canals of first party to the lands below, whether such laterals are constructed by the first party, or by persons owning such lower lands; provided that the laterals aforesaid shall be constructed under the supervision of and upon such lands only as are selected by the first party.

XIV. And it is hereby agreed and covenanted by the parties hereto that time and punctuality are essential elements of this contract. And in case the second part— shall fail to make the payments aforesaid, and each of them, or shall fail to pay any assessment which may be levied, as provided in paragraphs V and VI hereof, punctually and upon the strict terms and times above limited for the payments and assessments herein provided for, or likewise to observe, perform, and complete all and each of said agreements and stipulations aforesaid strictly and literally without any failure or default, then this contract, so far as it may bind the first party, shall become null and void, the water may be immediately shut off, and all rights and interests hereby created or then existing in favor of the second part —— heirs or assigns, or derived from —— —— shall utterly cease and determine, and all equitable and legal interest in the water-right —— —— hereby contracted to be conveyed shall revert to and revest in said first party, without any declaration of forfeiture or any other act of said first party to be performed, and without any right of said second part— of reclamation or compensation for moneys paid or services performed, as absolutely, fully, and perfectly as if this contract had never been made: *Provided*, That said first party shall give to said second part—, —— heirs or assigns, sixty days' notice, either personally or by mail, of the said second part —— heirs or assigns, being in arrears upon said payments, or any of them, or the interest thereon, which notice, if by mail, shall be sufficient, if by registered letter addressed to said second part— at ——, Colorado.

And it is further stipulated that no assignment of the premises shall be valid unless the same shall be indorsed hereon, and no agreements, or conditions or relations between the said second part— and —— assigns, or any other person acquiring title or interest from or through ——, shall preclude the first party from the right to convey the premises to the second part— or —— assigns, on the surrender of this agreement and the payment of the unpaid portion of the purchase money which may be due to the first party.

XV. It is also stipulated and agreed that from and after the execution hereof, the said second part — may enter into the use and enjoyment of water flowing through said canal, its reservoirs or laterals to the extent of the right, above contracted to be conveyed, as fully as though fully paid for, but subject, however, to all the terms, limitations and conditions above set forth.

In witness whereof, the —— —— Company, party of the first part, has hereunto caused its corporate name to be subscribed by its president, and attested by its secretary and its corporate seal to be affixed hereto as well as to a duplicate hereof, and the part— of the second part —— —— subscribed —— —— name— and affixed —— seal— hereto, as well as to a duplicate hereof, this the —— day —— A. D. 18—.

—— —— COMPANY,
By —— —— *President.*

Attested by—

—— —— *Secretary.*

—— —— [SEAL.]
Address: —— ——

—— —— [SEAL.]
Address: —— ——

—— —— [SEAL.]
Address: —— ——

ASSIGNMENT.

—— ——, the within-named purchaser, for and in consideration of —— dollars, do — hereby assign and transfer all —— right, title, interest and claim in and to the within-described rights to water unto —— —— of ——, county of ——, and State of ——, heirs and assigns, forever. And —— do — hereby authorize and empower the —— —— Company, to receive from the said —— —— all unpaid balances due to said Company, in part consideration for said water rights and upon the final payment of all the purchase money and a full compliance of all the requirements contained in the within agreement, to execute, or cause to be executed, to the said ——— ——— heirs and assigns, a deed of said water rights, instead of to ———.

Given under —— hand and seal, this —— day of ———, A. D., 18—.

It is expressly understood that in consenting to recognize this assignment, the officers of this Company do not exempt the original purchaser from any of his liabilities under the contract, but will protect the rights of the assignee, provided he complies with its obligations.

——— ———, [SEAL.]

Countersigned:

——— ———,
President.

——— ———,
Secretary.

STATE OF COLORADO,
County of ———, *ss.*

Before me ——— ———, in and for said county, this day personally came ——— ———, known to me to be the identical person— described in the within agreement, and who executed the foregoing assignment, and acknowledged that —— signed, sealed, and delivered the same as —— free and voluntary act and deed, for the uses and purposes herein set forth.

Given under my hand and —— seal of office, this —— day of ———, A. D. 18—.

My commission expires ———, 18—.

——— ———.

Received ———, 189—, of ——— ——— the sum of —— dollars, amount of first deferred payment on the within contract.

——— ———.

[Receipts similar to the above for the second to the eighth payments, inclusive, follow.]

(Indorsement.) No. ——. Agreement for sale of water right. The ——— ——— with ——— ——— for —— statutory inches.

The following is another form of contract in use:

WATER CONTRACT.

THE FORT MORGAN LAND AND CANAL COMPANY.

This agreement, made this —— day of ———, in the year 18—, between the Fort Morgan Land and Canal Company, a corporation existing under the laws of the State of Colorado, as the first party, and ——— ———, of the county of Weld, and State of Colorado, as the second party, witnesseth:

I. That in consideration of and subject to the stipulations herein contained, and the payments to be made as hereinafter specified, the first party hereby agrees to sell unto the second party —— heirs or assigns, —— water right —— to the use of water, flowing through the canal of said first party; each water right to be sufficient to irrigate 80 acres of land, but not to exceed 1.40 cubic feet of water per second of time, which the first party agrees to furnish to the second party —— heirs or assigns, during the irrigating season, except as hereinafter provided, and at no other time, for domestic purposes and for irrigating the following-described land, situate in the county of Weld, and State of Colorado, viz: ——— ———.

II. Said second party ——— heirs or assigns, shall not permit said water or any portion thereof, furnished as aforesaid, to run to waste, provided, however, that owners of water rights from the said canal may temporarily, for mutual convenience for irrigating purposes only, use their water in combination upon their several lands, but never upon lands for which the first party has not sold its full quota of water, on a basis of one water right to 80 acres of land.

III. Said first party shall deliver said water at such point or points along the line of said canal, or from any of its reservoirs, either or all, as it may determine from time to time to be most practicable; and the location of all headgates, and the manner of withdrawing and regulating the supply of water from said company's canals and reservoirs, shall be prescribed by said company, and shall at all times be under its control.

IV. Said first party agrees to keep and maintain said canal and any and all of its reservoirs in good order and condition, and in case of accident to the same to repair the injury thereby occasioned as soon as practicable and expedient; and the company shall have a right to assess said second party, for the expense of maintaining, repairing and superintending said canal and any and all reservoirs connected therewith, a sum not exceeding $10 per water right sold, per annum, and in addition thereto may, when necessary by reason of accident, assess all owners or holders of water rights pro rata such sums, not exceeding $10 in any one year for each water right, as may be necessary to repair the damages so occasioned. The amount, manner of collection, and time of payment of all assessments herein provided for shall be determined by said company; and the company also reserves to itself the right to establish and enforce such rules and regulations, and to provide and declare such penalties as are necessary and expedient for the purpose of enforcing and collecting said assessments, or any part thereof.

V. It is further expressly understood and agreed that when the first party shall have sold and have outstanding and in force water rights, fully paid up, equal to the full capacity of its canal (or sooner at its option), it will distribute pro rata the stock of said company among the holders of water rights so sold and the first party as owners of unsold water rights (if any), and the second party agrees to merge —— water right —— in this contract, and the first party, in the exercise of said option, to merge all its water rights then remaining unsold, if any, severally, into the capital stock of said company, in equitable proportions to the water right— so merged.

VI. It is hereby distinctly understood and agreed by and between the parties hereto, that in case the canal of said first party shall be unable to convey and distribute a volume of water equal to the estimated capacity, either from any accident, or from lack of supply in the South Platte River, or from any other cause beyond the control of said first party, then the first party shall not be liable for the shortness or deficiency of supply so occasioned, or any losses or damages resulting therefrom. It is further agreed that during a deficiency in the water supply of such canal, from any of the causes aforesaid, the first party shall have the right to divide the diminished supply pro rata, among the holders of water rights under said canal, and for the purpose of so doing may establish and enforce such rules and regulations as are necessary and expedient. And the second party, for —— and —— heirs and assigns agree— in consideration aforesaid to waive, and do hereby waive, any claim for loss or damage by reason of any leakage or overflow of said canal, or any of its reservoirs, lakes, or laterals, not resulting from the negligence of the first party, either upon the land aforesaid or any other tract belonging to said second party.

VII. In consideration of foregoing promises, covenants, and agreements of the said party of the first part, the second party agrees to pay unto the said first party the sum of —— dollars with interest, payable annually, at the rate of 10 per cent. per annum. Payment has been made and received of —— dollars, and the remaining principal, with the annually accruing interest, shall be paid at the office of the first party in Denver, Colo., in —— payments, at the times and in the manner following, that is to say:

	Day.	Month.	Year.	Principal.	Interest.	Amount.	Remarks.
First deferred payment....	......	....	....	....	....	....	....
Second deferred payment..	......	....	....	....	....	....	....
Third deferred payment...	......	....	....	....	....	....	....
Fourth deferred payment..	......	....	....	....	....	....	....
Fifth deferred payment ...	......	....	....	....	....	....	....
Sixth deferred payment....	......	....	....	....	....	....	....

And the second party, in consideration of the premises, hereby agrees that —— will make punctual payments of the above sums, as each of the same respectively becomes due, and that —— will regularly and seasonably pay all assessments that may hereafter be imposed by said company for the purposes aforesaid. And when the said party of the second part or —— assigns, shall have fully paid the consideration for the water rights herein conveyed, with interest thereon according to the terms of this contract, the absolute title to said water rights, free and clear of all incumbrances, shall be thereby vested in the said party of the second part, and his assigns without any further or other deed of conveyance whatsoever.

VIII. The second party for —— heirs and assigns further agree— to pay to the first party or its assigns, on such terms and regulations as its board of trustees may from time to time prescribe and determine —— proportional part of the expenses of maintaining and repairing the general fence, constructed to inclose a large tract of land lying under said canal; and said second party for —— heirs and assigns further expressly agrees, in consideration of these presents, that —— will not permit any live stock in —— possession or under —— control to run at large within such general fence; and any violation of this agreement shall render the second party —— personal representatives or assigns, liable in damages to the first party, as trustee for the benefit of any persons and their privies in interest, who may be injured by reason of depredations of live stock so allowed to run at large in violation hereof.

IX. And it is hereby covenanted and agreed by the parties hereto, that time and punctuality are material and essential elements of this contract, and that in case said party of the second part shall fail or neglect to make the payments aforesaid, and each of them, at the time and times herein stipulated, then all rights, privileges, and benefits accrued or accruing under the terms of this contract in favor of said party of the second part or —— heirs or assigns, shall utterly cease and determine after thirty days' notice of such default being given by deposit thereof in the post-office at Denver, addressed to said party of the second part at his last known post-office address, or by personal service of such notice, at the option of said party of the first part, and without any right of said party of the second part of reclamation or compensation for moneys paid or services performed, as absolutely, fully, and perfectly as if this contract had never been made; and all moneys theretofore paid by said party of the second part to said party of the first part under the provisions of this contract shall belong to, and be retained by, said party of the first part as liquidated damages for the breach hereof.

It is further expressly and distinctly agreed and understood that this contract shall not be construed or operate to convey or vest any interest whatever in the water right hereinbefore mentioned until said party of the second part shall have fully performed each and every of the covenants and agreements herein contained, for the payment of the aforesaid consideration and purchase price, and shall not be assigned until fully paid up, without the consent of the first party indorsed hereon.

In witness whereof, The Fort Morgan Land and Canal Company has hereunto caused its corporate name to be subscribed by its president and attested by its secretary and its corporate seal to be affixed, and the second party —— subscribed —— name and affixed —— seal hereto, the day and year first above written.

THE FORT MORGAN LAND AND CANAL COMPANY,
By —— ——,
President.

Attested by:

—— ——,
Secretary.

—— —— [SEAL.]
—— —— [SEAL.]
—— —— [SEAL.]

ASSIGNMENT.

—— ——, the within named purchaser, for and in consideration of —— dollars, do— hereby assign and transfer all —— right, title, interest, and claim in and to the within described rights to water unto —— ——, of ——, county of —— and State of ——, heirs and assigns forever. And —— do— hereby authorize and empower The Fort Morgan Land and Canal Company to receive from the said —— —— all unpaid balances due to said company, in part consideration for said water rights, and upon the final payment of all the purchase money, and a full compliance with all the requirements contained in the within agreement, to execute, or cause to be executed, to the said —— ——, heirs and assigns, a deed of said water rights, instead of to —— ——.

Given under —— hand— and seal— this —— day of ——, A. D. 18—.

It is expressly understood that in consenting to recognize this assignment, the officers of this company do not intend to exempt the original purchaser from any of his liabilities under the contract, but to protect the rights of the assignee, provided he complies with its obligations.

—— ——. [SEAL.]

Countersigned:

—— ——,
President.
—— ——,
Secretary.

STATE OF COLORADO,
County of ——, *ss:*

Before me, —— ——, in and for said county, this day personally came —— ——, known to me to be the identical person— described in the within agreement, and who executed the foregoing assignment, and acknowledged that —— signed, sealed, and delivered the same as —— free and voluntary act and deed for the use and purposes herein set forth.

Given under my hand and —— seal of office this —— day of ——, A. D. 18—.

—— ——.

Received —— 18 —, of —— ——, the sum of —— dollars, amount of first deferred payment on the within contract.

—— ——.

[Receipts similar to the above for the second to the sixth, inclusive, follow.]

(Indorsement:) No. —— Agreement for sale of water right. The Fort Morgan Land and Canal Company with —— ——,

STATEMENT OF THOMAS P. DUNBAR.

The **CHAIRMAN.** I understand you have given some attention to rating lands with a view of making loans—irrigated lands and non-irrigated lands.

Mr. **DUNBAR.** Yes; I have been loaning money for twelve years here.

The **CHAIRMAN.** State your observation and experience and the rules you have been guided by in the matter of security.

Mr. **DUNBAR.** As a rule, I do very little in non-irrigated lands because we think them of very little value. Very few crops can be grown on them with any certainty on what we call dry lands. I confine my loans almost exclusively to lands under ditches and with ditch rights attached.

The **CHAIRMAN.** What are irrigated lands generally worth that are under cultivation—what would be their average value?

Mr. **DUNBAR.** Pure agricultural lands?

The **CHAIRMAN.** That is what I mean.

Mr. **DUNBAR.** In the best counties, Larimer and Weld, land that is well improved and well down in grasses, under a ditch that is reliable and with perpetual water-right attached to the land, go as high as from $50 to $75 an acre, the very choicest; the second class from $25 to $50.

The **CHAIRMAN.** That is for loaning purposes?

Mr. **DUNBAR.** I value them at that. They could be sold and they do sell for that. Taking the new places, like the San Luis Valley, with perpetual water-right attached to the land, the advances on loans on mortgage average from $3 to $5 per acre. The highest advances made in the State will probably range at $25 per acre. The medium advances, about $10.

The **CHAIRMAN.** What is the difference in the San Luis Valley between irrigated and non-irrigated lands?

Mr. **DUNBAR.** The lands that can not be irrigated in the San Luis Valley are only good for grazing and are not worth over $1.25 an acre. Lands under one of those ditches without a perpetual water-right to enable the acquiring owner to get water would be worth from $5 to $6 an acre.

The **CHAIRMAN.** If it is under cultivation, what is it worth then?

Mr. **DUNBAR.** That depends upon the cultivation. The trouble is with a man living on 160 acres of land, carrying a mortgage on the whole and only cultivating 25 or 50 acres. The holdings are too large. We want smaller holdings of land and better use of what we have. There should be close tillage, so as to make every gallon of water tell on every square yard of ground. They can not do it now. A man could well support and bring up his family on 40 acres if thoroughly well tilled, where he could do the work himself. He attempts to grab 320. The consequence is he has only got 10 per cent. of his land producing anything, or, if he does attempt to cultivate it, he has to do so by expensive and inefficient labor. He goes to an expense for machinery and gets no result. Instead of plowing 10 inches deep, he plows 3 inches deep and goes over a large area.

The **CHAIRMAN.** You think 40 acres enough for a man?

Mr. **DUNBAR.** Forty acres is enough for a man to live on with his family. Of course, he can not do that by raising wheat and oats.

The **CHAIRMAN.** He must have a variety.

Mr. Dunbar. Yes, and a better class of crops. He should have fruit, vegetables, hops, and so on. There is a large demand for hops. I know a man making $300 or $400 an acre on hops, and a man can easily make $100 an acre on alfalfa. To get the best results a man must have a small area and cultivate closely and have a supply of farm-yard manure. Our soil here is very heavily charged with mineral matter and is very deficient in manure material. He must grow a variety of crops. We do not want men to raise a large surplus, but we want large communities and to have the land more closely cultivated, so as to bring our population nearer together, and have them produce everything that men can and need to live upon. That is what brings wealth into any State. All our immigration comes from non-irrigated districts. Everything here is new to such immigrants. The conviction is forced on my mind that a man is better off with 40 acres thoroughly cultivated than 160 acres half cultivated. You can not convince the immigrant of it, however.

The Chairman. Experience does it after awhile?

Mr. Dunbar. Yes; but it takes a good while to convince a man sometimes.

The Chairman. As to supporting a family, which is the better situated, the man with 40 acres in the arid belt or a man with 160 acres where he has to depend upon rain-fall?

Mr. Dunbar. If I had to bring up my family that way, I should take the 40 acres in the arid belt with irrigation.

The Chairman. You would be better off, you think?

Mr. Dunbar. I should consider myself so,

The Chairman. What is your observation and experience?

Mr. Dunbar. My observation is that a man is better off with 40 acres in the arid belt with every foot of it well cultivated, and his crop thoroughly attended to, than he is to have 160 acres skimped over. The man with 40 acres in the arid belt, well cultivated, will make more clear money in the end. I will lend him 25 per cent. more money on 40 acres of well cultivated land than on 160 acres half cultivated. The men that have a section of land have to have machinery and all that. Then a man's water-right will go farther on a small farm. His supply of water would have to be all put on at the same time. One great thing is to protect the land from the rays of the sun to prevent baking. You can not do that with a very large farm. I have often gone into an alfalfa field where the alfalfa grows half an inch a day in the warm weather, and within two or three weeks after it had been irrigated the crop was up 6 inches, which would prevent the land from being dried up. I have picked up there as damp a piece of soil as was wanted. On the other hand, I have been in a wet field that had been irrigated a few days before, when there was nothing to protect it from the rays of the sun and the soil was baked hard.

STATEMENT OF J. S. STANGER, OF DENVER.

The Chairman. How long have you resided in Colorado?

Mr. Stanger. Fifteen years.

The Chairman. Have you had any experience in the matter of irrigation?

Mr. Stanger. Yes; I have had theoretical experience for about twelve years. I was the editor and proprietor of the Colorado Farmer, and had some little theoretical experience in formulating the laws relating to irrigation and in passing them. For the last few years I have also had practical experience as an irrigator myself. I have been farming my own land and using and distributing water on it myself many times, not only with hired help but personally.

The **CHAIRMAN.** State anything that will enlighten the committee in regard to it. Give us your idea of the practical work, how to distribute the water and the crops you can produce, the size of the farm you can cultivate, what crops you can produce and how.

Mr. **STANGER.** For gardening purposes a man wants but a small quantity of land, and he needs that close to a large city or some good market. Ten or 20 acres is sufficient for any gardener to have. To make a success in grain-raising a man must have a greater quantity of land. On 40 acres a general farmer will not make much of a success. He would raise sufficient undoubtedly to support his own family and probably pay the taxes, and maybe pay Mr. Dunbar the interest on the money he would loan him. He might succeed in doing that, but it would be very doubtful when cabbages are selling at 35 cents a hundred here in Denver. Alfalfa is not worth $5 a ton 10 miles from Denver. The wheat is a good crop, and is worth something like 75 cents a bushel or $1.25 a hundred, as you would understand it.

In regard to the distribution of water, the duty of water is the great question that interests us in Colorado.

Senator **JONES.** I would like you to run along a little further on the line you were talking of now. I infer from what you say that you do not think a man ought to be confined to 40 acres in the arid belt.

Mr. **STANGER.** No.

Senator **JONES.** What size do you think he ought to have?

Mr. **STANGER.** Eighty acres. Forty acres would not be sufficient in Colorado, unless it be near Denver.

Senator **JONES.** Where it could be used for truck farming?

Mr. **STANGER.** Yes. If a practical farmer be away from such a market he can do very little on less than 80 acres. Of course he can support a family.

Senator **JONES.** That is what I wanted to ask. Now you can continue on the other line.

Mr. **STANGER.** You do not care to hear anything from me about how to distribute the water.

But in regard to the water that we have been using in Colorado I wish to say this: Twelve years ago we had an idea that we were using all the water in Colorado. We knew nothing then about the San Luis Valley. The Platte Valley we knew a good bit about, and I suppose ten years ago we had utilized about all the water that was possible, but we have kept on increasing our farms and putting in cultivation new lands, and we find that we have a gradually-increasing water supply—more than we thought we had then. Experience has developed the fact that we can get along with half the water we used to. The old theory was that a cubic foot of water per second would irrigate about 55 acres of land. That was put as nearly the maximum of the duty of water. Our experience is that we can nearly double that—we can irrigate nearly twice as much land.

Getting down to practical operations I will say this: I have a 320-acre farm. We used on that farm eight years ago 125 inches of water. That is a very indefinite proposition, as the engineers have told you, but it was all the water that would run through our box, and was called 125 inches. That was the water for 160 acres of land, and a great deal of it was a natural meadow, some of it in crops (perhaps 40 or 50 acres), fields, and in orchards. I added to it 160 acres more and dropped down to 100 inches of water. Nearly 100 acres of it were put in alfalfa and some of it into other crops. I went on a few years longer and used 8 inches on 320 acres of land—240 of it in actual crops. I find that a service of 80 inches of water in this very dry year gives better results than when we wasted the water. It is very much therefore the fault of the individual, a lack of industry and carelessness on his part in the distribution of the water.

Of course crops have to be somewhat arranged so that we can utilize this water on different crops at different times. Alfalfa is a crop that takes about three or four times the quantity of water that wheat would. This year we have irrigated our alfalfa, but I have only cut two crops on account of the lack of water in our ditch. The third crop I shall not cut. I shall not bother with it. I have irrigated for the two crops four times. My wheat and oats were irrigated but once. I had 40 or 50 acres of wheat and had a good yield. We were favored with rain at the proper time.

The main point I want to impress upon the committee is that we have plenty of water in the State of Colorado to utilize all the land now under ditch; but, in my estimation, we have approached the limit of lands that it would be possible to irrigate with the water or moisture that falls in the State of Colorado. To be more definite, there are enough ditches already constructed, or partially constructed, to consume not only the water we could have, but all that we could save. I am speaking now of the Platte. The Arkansas Valley has not utilized the water it has. It is utilizing it on paper, but it is to be determined whether the water can be got down. There is very much sand on that river, and whether they can get the water down on the mesa I do not know.

Senator **Jones**. You think there are ditches enough in the water-shed of the Platte to use all the water that could be saved?

Mr. **Stanger**. That could possibly be saved, either in the mountains or on the plains.

The **Chairman**. What proportion of the land covered by those ditches is actually cultivated now?

Mr. **Stanger**. About one-fourth or one-fifth of it.

Mr. **Chairman**. It would be four or five times as great an area of cultivation if the water was saved then?

Mr. **Stanger**. Yes. Our State engineer instructed the water commissioners to give him data in regard to the quantity of land under the ditch, the quantity under cultivation, the quantity in alfalfa and other grasses, and the quantity in other crops. I think it amounts to but one-third or one-fourth of the land that is actually under cultivation at the present time, yet it is covered by ditches.

Senator **Jones**. That information is already in, I believe.

Mr. **Stanger**. Yes, I believe it is.

The **Chairman**. Outside of the Platte, and outside of the Arkansas, there is a large area of country here. Have you ever taken into consideration the question whether any portion of it might be reclaimed by reservoirs to accumulate the storm-waters.

Mr. **Stanger**. Yes, I have given that a great deal of attention, and it is possible to do that out on the plains, in our dry streams—those that are dry the greater portion of the year. At certain seasons immense floods come down and if at proper places reservoirs could be constructed that will hold the water, large quantities of water could be stored. Some years ago we had great floods in the streams east of our town, so great that a locomotive going over a bridge could never be found, although the railroad company expended a great deal of money to find it. If it were possible to save those great floods that come down from the divide and hold them, there would be great quantities of water saved and some very fertile tracts of land taken care of.

The **CHAIRMAN**. You think it important to investigate that question.

Mr. **STANGER**. Yes, very.

STATEMENT OF JAMES B. GRANT, OF LEADVILLE.

The **CHAIRMAN**. Where do you reside?

Mr. **GRANT**. In Colorado.

The **CHAIRMAN**. Are you engaged in the smelting business?

Mr. **GRANT**. Yes.

The **CHAIRMAN**. Have you given any attention to the matter of irrigation or the storage of water in reservoirs?

Mr. **GRANT**. Yes.

The **CHAIRMAN**. Please give the committee the benefit of such information as you may have on that subject.

Mr. **GRANT**. I own about 1,000 or 1,200 acres of land about 10 miles from Denver, between Littleton and the mountains, in the triangle between the Bear Creek and the Platte. We have no water practically in the irrigating season, for the ditches absorb it all. Sometimes we get one irrigation in the spring from the natural flow, but for the second and third irrigation we have to rely on reservoirs entirely. A number of us there have spent a great deal of money in building reservoirs.

The **CHAIRMAN**. State what success you have had in storing water?

Mr. **GRANT**. It is an absolute success as far as storing is concerned, and the only trouble about it is the expense. Of course, where you have a natural reservoir there is no expense except the outlet—cutting under the lowest point, putting in pipes, and having valves to let the water out as you want it; but on this land of mine we have something of a natural site, though not very much. We have to dam on one side entirely. My experience is that it costs $20 per acre for 160 acres of land to build the reservoirs for holding the water for irrigation.

The **CHAIRMAN**. That is in your locality?

Mr. **GRANT**. Yes. I have about 1,200 acres of land there, and I expect in time to have plenty of water for it. I have estimates already made on it and have about 300 acres in cultivation.

The **CHAIRMAN**. It costs $20 per acre to build the reservoir for irrigation?

Mr. **GRANT**. Yes. Being near the city, I think good land there is worth $75 per acre.

Senator **JONES**. Where do you get the water for your reservoirs?

Mr. **GRANT**. From Bear Creek.

Senator **JONES**. You take it out of the creek in the flood times?

Mr. **GRANT**. Yes.

Senator **JONES**. Is that practically a dry stream in summer?

Mr. **GRANT**. No. It is not entirely dry, but there is not much water during summer in it. We cannot use the water much in winter because the ditches freeze solid, and it costs so much to clean it out that it does not pay to run the water.

The **CHAIRMAN**. Are you familiar with the topography of the plain between the Platte and Arkansas?

Mr. **GRANT**. Only in a general way. I have no knowledge in regard to reservoir sites.

STATEMENT OF LEVI BOOTH.

The **CHAIRMAN**. Where do you reside?

Mr. **BOOTH**. I reside 5 miles from Denver, on Cherry Creek.

The **CHAIRMAN**. How long have you resided in Colorado?

Mr. **BOOTH**. Since 1860.

The **CHAIRMAN**. Have you given attention to the subject of irrigation and water supply?

Mr. **BOOTH**. I have had practical experience in irrigating.

The **CHAIRMAN**. State your practical experience.

Mr. **BOOTH**. Cherry Creek is a dry creek. I located on a dry creek first. Cherry Creek rises at a point where the bed-rock runs up, and by taking the water from that point and getting it onto the ground you save it from wasting in the sand-bed of the creek. I did that and had reclaimed quite a portion of land until the water was taken away from me by the city company. The question with me, and with farmers generally, is how to save more of the water that is running to waste.

The **CHAIRMAN**. What is your observation as to the amount of water wasted—is it large or small?

Mr. **BOOTH**. There is a great deal of water wasted. In the spring, during the irrigating months, probably more than one-half the water runs to waste; the ditches will not hold it. The Platte runs full very often and sometimes runs over its banks. That water is generally running to waste at least a month and a half. It could all be conserved, saved, and used upon our arid plains.

The **CHAIRMAN**. How?

Mr. **BOOTH**. By reservoirs.

The **CHAIRMAN**. Have you had any experience in constructing reservoirs?

Mr **BOOTH**. No, I have not. All I know is from what I have seen. My idea about it is that we should go in the mountains, not in the deep cañons, however, but take it in the parks where there is a large area of flat lands, dam up the streams and let the water freeze up. It will freeze up in the winter. Then in the spring there is a reservoir for you that will last for a month or two. The ice will melt, the water will run down, and we will get the benefit of it below. That is one way.

Then there are places where large reservoirs can be constructed, and the valley reservoirs here must be constructed on the highest point. My way would be to take the water out onto the divide in a ditch along the apex of the summit, running toward the Arkansas and toward the Platte. There are many such chances to make reservoirs. There I would construct the reservoirs. Then the ditches would run from those reservoirs over the arid plains. I think a great portion of the country that is now worthless between here and western Kansas can be brought under cultivation, and homes made for the millions that are now starving to death in our cities. That is what you want these surveys for, to make small homes for the people, not for speculation. The farmer wants it understood emphatically that he does not want the land to go into the hands of speculators.

The **CHAIRMAN**. What quantity of land is enough for a man?

Mr. **BOOTH**. When a man is engaged in general farming, nothing less than 80 acres. If he is gardening, 5 or 10 acres will do. If he is near Denver or some other point where there is a good market, he would not want as many acres.

Senator **Jones**. Who do you think ought to own the canals or control them?

Mr. **Booth**. I think the State or the National Government should control the canals; at least, they should in such a way that large corporations could not get hold of them, for the man that owns the water owns the land or controls it. Hence the State or the General Government ought to own the land or it should be given into the control of the men who take up homesteads. It is then a question whether the control of the water would not finally get into the hands of the capitalists. My idea would be to have the State control the water. Of course, so far as the construction of reservoirs is concerned, if it is done by the Government, the Government should control them or give them to the State to control, but by no means let them get into the hands of corporations. The reservoir sites must be owned for public use—for the people.

STATEMENT OF BYRON S. WHEELER, OF DENVER.

The **Chairman**. How long have you resided in this State?

Mr. **Wheeler**. Nearly nineteen years.

The **Chairman**. Have you had any experience in the matter of irrigation or water supply?

Mr. **Wheeler**. I have.

The **Chairman**. The committee will be glad to hear what you have to say on that subject.

Mr. **Wheeler**. In regard to irrigation on the dry creeks; I have a ranch east of the town, about 9½ miles, through which runs the bed of one of the dry streams of the plains. Before a ditch was built scarcely ever was there water to be seen on the surface of the creek bed, while at other times the creek would be in a tremendous flood, tearing fences and land away in great quantities. Since the ditch has been built there has been a continual increase of water in the creek—so much so that it is possible to irrigate a good many acres of land from the seepage coming out all along the banks. This comes apparently from lands that had been irrigated miles away—discharging into the creeks—so that it has been possible to again take that same water that had once been used on the higher lands and reirrigate lands lying still lower. That one increase of irrigation by reusing the water is one of the great sources of supply that we will have as we continue our irrigating system. But I suppose Mr. Nettleton wished that I should present my views more on the question of the control that this water shall be put under while we are using it.

For some years I have been associated with the farmers, particularly in regard to that. There is for them a nether millstone, consisting of the intractable things of nature, like the drought, the arid country, the inability of the farmer to always calculate upon a steady flow of water, and an upper millstone in the fact that the water they need so urgently is controlled by men whose only motive can be the money they get out of it. My experience with the farmers is that they are being ground to powder; that they are not getting their crops so that they are able to pay the interest on the money they have borrowed on their 40 or 160 or 320 acres; that the interest of the ditch company is simply as a company to get all the money there is in the water that they furnish. So they charge for the water in advance. The farmer must raise that money for the water before he has raised anything.

Then he alone takes the chances of getting what he has paid for it. The result of it is that in more than half the cases the man is at a loss five years out of every ten. For the last twelve years there is scarcely a question that the average farmer—not the exceptional farmer, but the average farmer—has been going down hill financially from such causes as these. The water supply is sure to be decreased, not alone from natural causes, but from the cupidity of the company controlling the ditch, in continually extending its area and selling water that it can not deliver, even though there should be a flood in the stream. So that 20,000, or 40,000, or 100,000 acres are added to the area which a given ditch is supposed to irrigate at first and the others then must prorate. The result is that every man under the ditch is put to his trumps to get what he pays for. The farmer you see has to pay in advance; the ditch company sells what it can not deliver. But in any event it gets the money. The result of that is there is a great deal of so-called stealing of water. The farmer's family is dependent on the crop he raises. He must have his crop or else his family will have to go naked or in rags. Yet the water is scarce. The company has prorated it along the line and the cupidity of every farmer is roused to obtain a support for his wife and his children. That is the history of all the old settled portions and largely so already in the newly settled parts of the state.

That conflict rises higher and higher as time goes on. It is the farmer as against the man who has put his money into the ditch. It is not the farmer attempting to defeat the just result of capital. The question for him is as to the livelihood of his family. He needs to curtail the ability of the corporation to do him harm, as it does when it contracts to sell water it can not deliver. The quarrel has grown each succeeding year. So that the great question with us in Colorado is the way these ditches shall be managed. If it be left as at present, it goes against the farmer, because he must devote his whole time digging in the soil and distributing the water he gets in order that he may be able to obtain a crop. His entire time and attention is absorbed in that so that the political aspects and the more general features of the matter, such as the manipulation of legislatures, has gone by the board. The ditch companies have their agents, plenty of them, all round the legislature. There is not on the statute books of Colorado to-day more than one law that fixes a penalty for the ditch company if it oppresses an individual who is using water. To get that law passed, the farmers of the State turned out and labored all winter long, going hungry and scantily clothed during that session of the legislature in order to get it through. They finally succeeded on the last day of the session. While the penalties have been fixed higher and higher by each succeeding legislature against the men who violate any of the rights of the ditch company, the ditch company is making his necessity the pretext for having that water. Still the penalty is increased and his necessity increases. The companies have got the penalties all upon him. He has no recourse upon the company when they fail to perform their part of the contract.

So the farmers pretty generally—I am associated with them in three or four organizations—have come to the conclusion that there must be a radical change in the control and management of the water. Most of them approve of State ownership. They take the model of the United States Government in controlling the delivery of the mails, which is the best possible service at the least possible expense. The Government in some form, whether the United States Government, or the State government, should control the water. Whether any given territory should be segregated into water districts, or be controlled as a whole, is a matter of detail. The point is that the water, as far as it goes, shall be justly distributed by men who have no financial interest at stake; men who are simply there for the sake of the service they are to perform. That would be the consensus of opinion in this State as to the delivery of the water to the farmers.

Senator JONES. Have you not got State officers already to do that?

Mr. BOOTH. Yes; but they have no control of the delivery of the water to the individual farmer. They only control the head-gates of the ditches. The individual farmer is dependent upon the head-gates of his ditch.

Senator JONES. It seems to me that your difficulty is not so much with the distribution of the water as with the prior management, or mismanagement, of the company.

Mr. BOOTH. The difficulty is that the companies are endeavoring to get all the money they can out of it. Somebody should see that each ditch is supplied with its proper proportion of the water. Somebody should go down and see that each head-gate and lateral is properly raised and lowered. It can never be properly done as long as there is a financial interest in it, because, like other business matters, heart never enters into the distribution of water. These companies are not governed by the desire to do right; they are only governed by that which pays best. This is accomplished by delivering the least water for the most money that is possible. Hence the quarrel. It has been proposed here in Colorado that the State should own every ditch and all the laterals; should control every outlet in every ditch from beginning to end, and see to it that the water be distributed according to the land that is under cultivation. It has been heretofore, and is to-day, attempted to hold so-called water rights as independent and separate things from the use of the water on the land. The ditch owners assume to say, "We will sell you a water right and give you a piece of paper"—an alleged deed showing that that is your right. Yet a man may sell out the land to another who is ignorant of the water laws, and the second purchaser is thereby left without water. In fact, it has been so arranged that a man has had to pay twice for those so-called water rights, in first buying outright and in after buying over again from the same company. But worse than that, the buying of any water right at all is paying a company that has really done nothing.

The constitution of Colorado declares that the water is dedicated to the use of the people. The doctrine, as I conceive it, should be that when a piece of land is once cultivated with water, the State is interested in seeing that it should never be deprived thereof. Of course, everything should be done to compel the economy of water. While a man's selfishness impels him to get all the water he can, there is but one way to prevent a large waste. If the water were measured accurately to each man as he uses it, and at the end of the season it were ascertained what quantity he had actually used, then he would pay for the actual amount used. In that case the question for him to decide is, "How much does my crop actually need?" He would at once cease to waste the water. In other words, the duty of water would probably be increased to at least twice the amount at present. If the State had the matter under control so that the consumer would pay for what he actually used at the time he paid his taxes, there would soon be universal satisfaction with the system of water distribution.

The CHAIRMAN. How would you get control of those private rights—buy them up?

Mr. **Booth.** Even if the State bought them, it would simply give the private company a proper return for their money. But that should not include watered stock. The first dividends of one ditch built here brought in the first year 60 per cent. of the actual cost of the ditch. One of the stockholders said, "The farmers can never stand 60 per cent." So they went to work and increased the stock, and the next year it was but 30 per cent. profit. They then said, "The farmers never can stand 30 per cent.," so they increased the stock again. That time they got it down to 12½ per cent. profit and next year it increased again. Then I believe they got it down to 8 per cent.

Mr. **Stanger.** Did they not build additional laterals?

Mr. **Booth.** They now say that under that ditch "our stock is only paying 8 per cent. now." But the stock is eight times as great as it was and is eight times what the stock would be if the State had it. If the State took control, it should not pay that ditch company eight times what its works actually cost and give it all of these profits for all those past years. There should be a just estimate put on what it would cost to build that ditch to-day. Pay them their full value for all they have, let the past robbery go, and prevent their future robbery. That's my proposition.

Mr. **Stanger.** Do you know personally of any ditch company that has got rich?

Mr. **Booth.** No, I do not know of any ditch companies that have got rich, but I know a good many individuals in ditch companies who have got rich. The crying need of this country is State control of the water, rather than any increase in the number of ditches. If reservoirs are to be built to improve the supply of water in the ditches, it becomes necessary to see that the persons using the water have the advantage of it instead of making it another means of increasing the wealth of the few. A man who has 40 acres of land should not be confined to that quantity of water that will just enable him to pay interest to the money loaner. The fact is, that the prosperity of the country depends more on the number of men who are prosperous in it than on the few that are prosperous in it.

Senator **Jones.** What is your idea of the changes that ought to be made in the homestead law?

Mr. **Booth.** In this section of the country if the Government will guaranty the water to a man, I would say that 80 acres is of more value to him than 160 acres in a country where they depend on rainfall.

Senator **Jones.** Suppose the Government would not undertake anything about the water?

Mr. **Booth.** Then I think the homestead law should be left as it is. But if the Government would provide means by which water would be put on the land, it might be desirable to reduce the number of acres a man may have. It has been suggested, and I think it will be nothing but fair, that the Government give to the States lying in the arid region the unreclaimed lands that now belong to the nation, binding the State to use all that land for actual settlement as it is made fertile. Then if the General Government wishes compensation, the State can pay back to it a certain amount.

Senator **Jones.** Why would it not be just as well for the Government to give the land to the settlers instead of to the States for that purpose?

Mr. **Booth.** The only difference would be that the State administration would be nearer home and would plan the further development of the irrigating system more rapidly than the Government would.

The **CHAIRMAN.** Will you name an instance where any State having public lands donated to it for any purpose has administered them well?

Mr. BOOTH. No, I am sorry to say I can not; from the swamp lands of Wisconsin all the way through.

Senator JONES. I see no advantage to the State in giving it the desert lands unless it be allowed to dispose of them as it pleases. It is one thing to give the lands to the State and let the State give them to people under mortgage. It is another thing to give the lands, the State being bound to give them to some one else under condition.

Mr. BOOTH. The population would thereby be guarantied.

Senator JONES. The Government is guarantying as it is. It is ready to give lands to the people, and the State can not do it any faster.

Mr. BOOTH. Yes; the State would use the increased value of the land in order to put under cultivation more land and to build those reservoirs and ditches.

Senator JONES. You mean tax it with a debt?

Mr. BOOTH. No; that would not make a debt. For instance, if the lands were sold in a certain district to actual users of water the proceeds of those sales would then be turned over to another district.

Senator JONES. You are in favor, then, of the States selling the lands?

Mr. BOOTH. Yes.

Senator JONES. Not giving them away?

Mr. BOOTH. Not giving them away, unless it be for the purpose of development.

Senator JONES. That is another question; whether it is better to sell the public lands or give them away?

Mr. BOOTH. As it is now the State gives 160 acres to the individual, and he turns around and gives the ditch company the very money that we want the State to have in order to develop the ditch.

The **CHAIRMAN.** In other words, you want the State to become the grand ditch company?

Mr. BOOTH. Either the whole State or its subdivisions. I think the farmers, as a whole, favor the whole State controlling it.

There is another feature I would like to mention. There are new ditches being taken out without any prospect of water during the time it is needed for irrigation, but in which there is plenty of water flowing when it is not used for irrigation. A man comes along to take up a homestead, and they say here is a ditch to supply you with water. He does not wait until it is dry. He goes on and invests the last dollar he has in that homestead, and gets absolutely no show whatever for water. It should be within the power of the State to say, when the waters of a given stream are exhausted, and prevent the further building of ditches under such circumstances, because there will be thousands of men deceived by the over-building of ditches where there is no constant water supply.

Mr. STANGER. Are those extensions of ditches that you speak of theoretical or actual?

Mr. BOOTH. They are actual.

Mr. STANGER. Will you give instances?

Mr. BOOTH. I would prefer not to do so, as there are persons in the room here that would be pretty sure to be hurt. There are many cases I know of in which extensions of the ditches have been made on the lower end where they have compelled those above who have invested their all to go scant of water and let the others below have a still scantier supply.

STATEMENT OF ROYAL A. SOUTHWORTH.

The **CHAIRMAN.** Where do you reside?

Mr. **SOUTHWORTH.** In Colorado, 12 or 14 miles from Denver, down the river.

The **CHAIRMAN.** Have you been engaged in the business of irrigating land?

Mr. **SOUTHWORTH.** Yes.

The **CHAIRMAN.** State anything new in this inquiry that you know of.

Mr. **SOUTHWORTH.** I suppose the object of your committee is to learn facts?

The **CHAIRMAN.** Yes; give us any facts that you may have.

Mr. **SOUTHWORTH.** The question is whether the Government could make profitable use of some outlay here in conserving the water. I am a practical farmer, having been farming for fourteen years. In that time I have been connected with various farmers' organizations, and I have been pretty nearly all over this State. I am familiar with the practical use of water. Unless the waters that are annually going to waste now are conserved in some way, fully 25 per cent. of the people now engaged in farming over the divide here, north as far as the Wyoming line, will have to leave. They have already paid for their alleged water rights, but the water does not come with the paper water-right.

Speaking of the prosperity of the farmers I know that many farms are trust-deeded, and not altogether for farm machinery either. Of course the agricultural implement man has a strong hold on the farmers, but the ditch monopolist of Colorado have a much stronger hold. The ditch companies are drawing good interest. I know one ditch in which twenty-seven farmers have been closed down because of trust deeds for water rights.

Senator **JONES.** They were unable to pay for the rights?

Mr. **SOUTHWORTH.** They were unable to pay the interest on the trust deeds that paid for the rights. The rights had been paid for. I know other instances where people had to leave their farms where they had even paid for the water rights and could not get the water.

Senator **JONES.** Why?

Mr. **SOUTHWORTH.** The companies change hands from one to another. They bond a ditch, for instance, and the ditch is sold to another company, and the new company is not going to put out the money necessary to run the ditch, claiming that they will only put out the money necessary to repair the ditch. This is done when the farmers have in their contracts the clause that they will only pay a certain figure per year, and no more. Then they say "if you do not permit assessments to be raised we will not permit you to have any more water." I believe this land is going to be used some day and that it will not be allowed to lie idle, but we want it put in such shape that whatever expense the Government is at, the people will get the benefit, and that the men who till the farms may not have to pay interest to somebody else for handling it.

With regard to the watering of stock I have a word to say. I am under a ditch that I helped to build. That ditch is watered at a great deal more than has been stated here. That ditch cost only $30 a share and is selling at $300 a share. They profess to give a certain number of inches, but they do not do it. Men have lived near me who have worked for years and years and struggled hard, and have finally had to give up. This thing has gone far enough in this State. The farmers are willing to pay a reasonable price. The ditches have been built at an average cost of $2 or $2.50 an acre and the farmers under the water-right system have to pay $10 an acre and then do not get the water. We can grow crops here and the crops that we do grow are of a better quality than those of any State I have lived in in the East, as Michigan and Illinois, in both of which States I have farmed. While we can raise better wheat, oats, and barley, it costs us considerable to grow it. Many of our farmers sell their crops for less than it costs to grow them. The farmers therefore are going constantly down hill. The price of water has been going up while the prices of the crops have been going down. So if you now find a farmer that is prosperous he is making his money on something other than his farm. Besides they think that if there is to be any speculation in land they ought to be allowed to speculate in lands as well as the companies that own 40,000 or 50,000 acres.

The **Chairman.** Would you make any change in the homestead law?

Mr. **Southworth.** I have arrived at this conclusion after farming for many years. I have several times 40 acres myself and it is near this city, but it is a drag to me. The question is, why should not a farmer be able to pay his help as well as any other man? Still, they can not do it.

The **Chairman.** Are you familiar with the region of country between the Platte and the Arkansas—those plains that have no running streams in the dry season?

Mr. **Southworth.** Yes, I have been all over that country considerably.

The **Chairman.** What are the opportunities there for the storage of the storm-waters?

Mr. **Southworth.** There are many opportunities for the storage of water. On the question of storage my opinion is that the proper place to commence would be at the heads of the streams, and to store there all that could be stored where you can find a place. If you find a place in the mountains, that is the place to begin with, because in storing there you help all the people below.

The **Chairman.** And there is less evaporation there?

Mr. **Southworth.** Yes; and the higher up you get the reservoir the more people it will help.

The **Chairman.** Do you think the area of the farming lands can be extended on the Platte beyond the lands now under ditches?

Mr. **Southworth.** In time it can be; only, however, under State and not under corporation control. If you will let the State do it, when a farmer comes in in the fall and pays his taxes for the county government he pays also for the water, not for the quantity he thought he might want to use, but for what he actually used. As it is, he has to pay in the spring in advance oftentimes for what he will not use at all.

Senator **Jones.** You think, then, it would be better for farmers to get their water year by year?

Mr. **Southworth.** Yes. There is nothing in this water-right business except robbery. We can bring plenty of facts to prove it.

The **Chairman.** How would it do for the farmers to build their own ditches?

Mr. **Southworth.** The place where that plan is adopted here is the only place in Colorado where the farmers are prosperous.

Senator **Jones.** Why can you not all do that?

Mr. **Southworth.** The corporations have got ahead of us and have bought up all the places.

Senator **JONES**. There is a law-making power in every State.

Mr. **SOUTHWORTH**. The farmers tried to get something last winter whereby they might bring the corporations to time or punish a corporation for selling water away from them. But they can not do it. Corporations steal our water. They have burnt up thousands of trees and thousands of acres of alfalfa.

Senator **JONES**. It seems to me that the people of Colorado ought to be able to elect people to represent them.

Mr. **SOUTHWORTH**. We do not have time to pull wires.

Senator **JONES**. There are as many farmers as there are ditch owners, at least.

Mr. **SOUTHWORTH**. Yes; but when you put the ditch owners and railroaders together they can outwind us.

The **CHAIRMAN**. You think where communities own the water and manage it themselves they have prospered?

Mr. **SOUTHWORTH**. Yes; they may have occasional hard times when the water is not to be had at all, but they are the only farmers that have prospered within the arid section.

STATEMENT OF W. E. ALEXANDER, OF DENVER.

The **CHAIRMAN**. What is your occupation?

Mr. **ALEXANDER**. I am in the real estate business.

The **CHAIRMAN**. Have you given attention to the storage of water?

Mr. **ALEXANDER**. I represent a company that is about to begin operations next week. It is in Cherry Creek Cañon, about 30 miles south of Denver.

The **CHAIRMAN**. What kind of stream is Cherry Creek?

Mr. **ALEXANDER**. It is usually a dry creek, and it is for the purpose of saving the flood waters that this enterprise is undertaken.

The **CHAIRMAN**. What is the name of the map you present?

Mr. **ALEXANDER**. It is called the "map of the Denver Reservoir and Canal Company; reservoir site, Douglas County, Colo."

The **CHAIRMAN**. What is your proposition?

Mr. **ALEXANDER**. To dam up this Cherry Creek Cañon, take them off through a ditch and save the waters. We have our surveys made.

The **CHAIRMAN**. Is Cherry Creek used for irrigating purposes?

Mr. **ALEXANDER**. There are some ditches from it.

The **CHAIRMAN**. You propose to take the flood-waters?

Mr. **ALEXANDER**. Yes.

The **CHAIRMAN**. How much do you expect to get?

Mr. **ALEXANDER**. Probably 250,000,000 cubic feet.

The **CHAIRMAN**. Is there flood-water enough for that purpose?

Mr. **ALEXANDER**. The reservoir will hold that much.

The **CHAIRMAN**. Is there probably flood-water enough to fill it?

Mr. **ALEXANDER**. There is probably enough to fill it four times a year.

The **CHAIRMAN**. How much will you be likely to irrigate?

Mr. **ALEXANDER**. Thirty thousand acres.

The **CHAIRMAN**. At what cost?

Mr. **ALEXANDER**. The reservoir and ditch will probably cost $150,000 to $200,000.

The **CHAIRMAN**. That is $3 or $4 an acre?

Mr. **ALEXANDER**. Yes; of course that is only an estimate. Before we can get through it will probably cost more than that.

The **CHAIRMAN**. Do you think you can do it for $5 an acre?

Mr. **ALEXANDER**. Yes. I have here a map of the land to be irrigated by the reservoir. Here are the plans of the dam which we intend to build so that it will not wash away.

The **CHAIRMAN**. Are you going to build it of masonry?

Mr. **ALEXANDER**. Yes; all solid masonry and concrete.

Senator **JONES**. How much land is it intended to be irrigated by this?

Mr. **ALEXANDER**. Probably from 30,000 to 35,000 acres. I can furnish you a full set of those maps and plans. We are going to cut that land up into 40-acre tracts. We own about 60,000 acres.

Senator **JONES**. Are you going to sell the water-right with it, so that the people are going to have the dam when it is done?

Mr. **ALEXANDER**. Yes.

Senator **JONES**. You are not going to continue a water company, but will let the people have it?

Mr. **ALEXANDER**. Yes. But it will be, of course, a benefit to the ditch company. The State was offered the chance to build this but it would not do it. The legislature would not pass the bill that gave them the chance. So we took it up and propose to do it ourselves. That is the only chance for this country to have the water properly utilized.

The **CHAIRMAN**. Are you familiar with the topography of the country?

Mr. **ALEXANDER**. Yes.

Senator **JONES**. Do you think that the opportunities for reservoirs are extensive?

Mr. **ALEXANDER**. Yes; there are many that I know of. We have an immense water-shed there; probably 200 square miles.

STATEMENT OF ROBERT G. DILL.

The **CHAIRMAN**. Have you given any attention to the subject of irrigation?

Mr. **DILL**. I have.

The **CHAIRMAN**. Are you a farmer?

Mr. **DILL**. No.

The **CHAIRMAN**. What is your occupation?

Mr. **DILL**. I am now a printer, but have been in the Government surveys, and have been all over the Arkansas Valley from one end to the other.

The **CHAIRMAN**. What do you think of the Arkansas Valley in reference to opportunities for storage? We have a description of the upper Arkansas from Leadville here, but we would like to have a description of the lower Arkansas Valley.

Mr. **DILL**. My occupation at the time I was in the service of the Interior Department took me from Pueblo to the State line and down into Kansas very frequently. My belief is that in that section of country, with a proper system of canals and storage reservoirs, almost the entire basin on the north side of Arkansas River can be irrigated.

The **CHAIRMAN**. How far down?

Mr. **DILL**. As far as the State line.

The **CHAIRMAN**. How is it beyond the State line? Is there no water left for Kansas?

Mr. **DILL**. My observation as a newspaper man has led me to believe, at any rate, that the water finds its way back to the river. I was here when Greeley had only one canal and it now has four. The one canal exhausted the Cache la Poudre, and that stream now supplies four.

The CHAIRMAN. You think there will be a supply for Kansas after enough is taken out for Colorado?

Mr. DILL. Yes.

The CHAIRMAN. In laying out their ditches some of the schemes presented to us contemplate the construction of reservoirs along the line. Have you been on the divide between the Platte and Arkansas?

Mr. DILL. Yes; all through it.

The CHAIRMAN. What are the opportunities for storm-water reservoirs?

Mr. DILL. They are frequent. The only ones I can testify to are those that occurred to me in surveying Government land. Of course, we frequently came to depressions and had to make calculations. I have not surveyed much above Pueblo but have been over the ground, and from the mouth of the Cañon to the State line there are many natural depressions that can be inclosed at the lower end with very little labor, but it needs a canal the entire length.

The CHAIRMAN. A canal to take water from the Arkansas River?

Mr. DILL. Yes, and along the divide.

The CHAIRMAN. They might be supplied by storm-water?

Mr. DILL. Yes; there are frequent storms there, on the south side of the river particularly, but the opportunities are fewer there because the ground on the south side of the Arkansas River, from Trinidad to the State line, is broken up into cañons from 150 to 350 feet down to prairie. There is one place where you could inclose 500 acres but there is no land to irrigate.

The CHAIRMAN. Have you ever been a practical farmer?

Mr. DILL. To some extent, in Pennsylvania.

The CHAIRMAN. I mean have you farmed here?

Mr. DILL. No.

The CHAIRMAN. Is there anything further you would like to suggest?

Mr. DILL. The only general idea that I got when I was engaged in surveying in that country was, that a canal from the mouth of the Arkansas down to the State line would irrigate, with proper storage reservoirs, the entire country down to the Arkansas River without materially interfering with the Arkansas itself. On the south side of the river there would be frequent opportunities. They are not so frequent until you get down to the Kansas line, and then there would be about equal opportunities.

STATEMENT OF PLATT ROGERS.

The CHAIRMAN. You have given considerable attention to the laws regulating the use of water?

Mr. ROGERS. Somewhat.

The CHAIRMAN. And to irrigation?

Mr. ROGERS. Yes.

The CHAIRMAN. Speak to the committee of these subjects in any direction in which you may feel interested.

Mr. ROGERS. There is hardly much that I could add in a legal way to enlighten the committee, but it has occurred to me that there are some rules of law in this State that might have influence in carrying out this scheme of reservoirs. The statutes of Colorado and the decisions of the courts take the position that a ditch owner is nothing more or less than a common carrier, and that he is simply entitled to make a charge for the carriage of the water. In other words, it is declared by the constitution and enforced by repeated decisions that the water is the common property of the people of the State, and that therefore it is incapable of private appropriation; that it must be put on the land for the purpose of use, and that the owners of the ditch perform no function except to carry it from the stream to the place where it is used. For that they are entitled to pay, and for nothing else. That being so, the county commissioners are vested with authority to fix the charges in case there is a difference between the user and supplier of water. In other words, the rule already applied to railroads is made to apply to ditches. I think that in actual operation this is an obstruction to the building of ditches for the revenue to be derived from the ditches simply as such. My experience is that the large ditch companies in this State have expected to get their revenue, and in fact have got revenue, from the fact that they are the owners of large bodies of land lying under the ditch, and that, save for the ownership in that land, the ditches would have not been constructed. So that if the question were presented now in respect to the use of large sums of money for the building of ditches, the right and power being in the people or in the county commissioners, that right and power would act as an obstruction, because the companies have not the right of making such rates as they think will compensate them for the construction of a ditch.

The **Chairman**. What obstruction would it be if it were organized with the view of disposing of the water right and of the whole property?

Mr. **Rogers**. That is the very question, whether the courts would allow that to be done. The supreme court has practically said that any person that needs water may have it at rates to be fixed by the county commissioners, and that he need not take the contract. The ditches being nevertheless constructed the consumer of the water will not apply for a contract when he can apply for a delivery at the rate per annum that the commissioners will fix.

The **Chairman**. That will not prevent people combining and supplying the water themselves.

Mr. **Rogers**. No. The difficulty is that after all there have been those who have not taken water under the terms, and who, when the ditch is constructed for the first time, say that they will take it for the rates fixed by the county commissioners.

The **Chairman**. Is it clear that the county commissioners will fix rates that will not be sufficient to pay for the construction of the ditch?

Mr. **Rogers**. It is said that they have fixed rates here that will not pay for the construction of the ditch.

The **Chairman**. Then how do you reconcile your statement with those of several persons here that the ditch companies are charging too much and have a monopoly?

Mr. **Rogers**. I do not attempt to reconcile the differing statements of some people. I would have to reconcile many things that do not seem to conform to nature if I had to do that.

The **Chairman**. Is there any instance of the supervisors fixing the rate?

Mr. **Rogers**. I am told that the rate fixed by the county commissioners in this county on the High Line ditch is not sufficient. This ditch company, and it is true of all others, have been able to recoup themselves fully and amply by reason of the increased value of the land that lay under the ditch because they always had the foresight to acquire a large body of land under the ditch. I am not stating this as being actually true but it is a matter that is current.

The CHAIRMAN. Suppose the ditch company here should take out a ditch and should make contracts with land-owners sufficient to use the water of the ditch, would the supervisors have any authority to take it away from the parties who had contracted?

Mr. ROGERS. No.

The CHAIRMAN. It will be only when there was a surplus?

Mr. ROGERS. Yes, it must be shown that there is water to be had.

The CHAIRMAN. That would only treat with the surplus that had not been contracted for?

Mr. ROGERS. That is all.

The CHAIRMAN. Practically that is not likely to become a very serious question?

Mr. ROGERS. I do not know that it is; because instances of the building of ditches by speculative companies, purely as such, has really not occurred in this State.

The CHARMAN. Is it desirable that it should?

Mr. ROGERS. As land is taken up now it must be done because there is not land to be had otherwise.

The CHAIRMAN. The people have the land, have they not?

Mr. ROGERS. Yes, but these lands were obtained by taking the land of railroad companies.

The CHAIRMAN. What is to prevent the people from combining to make ditches?

Mr. ROGERS. That is another scheme entirely. If you should start by building a ditch without making some arrangement beforehand, the returns on the investment would not be assured.

The CHAIRMAN. In other words, if a person should attempt to dig a ditch and charge arbitrary rates, the board of supervisors could regulate him and prevent a monopoly rate?

Mr. ROGERS. Yes.

The CHAIRMAN. Is not that wise?

Mr. ROGERS. Yes.

The CHAIRMAN. I see nothing wrong about that.

Mr. ROGERS. I am simply showing that this it is that stares in the face a purely speculative company.

The CHAIRMAN. But it does not affect the others?

Mr. ROGERS. I do not know that the purely speculative kind of companies are coming in. This question leads to this view in my mind. The difficulty which I see about Government aid in the matter of these reservoirs is, that you are dealing with a commodity that is common to the entire body of the people, and to which different legal rules attach from anything else with which we have to deal. There is no other property in this country to which private proprietorship may not be affixed, except this single element of water for irrigation, unless you take the public streams in the State. You are, therefore, dealing with something that all the people have an interest in and concerning which you can not acquire a title. You have to supply this water at minimum rates. That being true, the question is whether you can get a company to take the risk of putting in the ditches upon a bare return of their money with a low rate of interest.

The CHAIRMAN. I hope there will not be a company in Colorado that will put in water depending on speculative rates. What difficulty does that put in the way of the Government in surveying this land for the purpose of determining what land could be irrigated and what not; taking the gauge of your rivers, determining the amount of rain-fall by experiment; estimating the quantity of water you will get, and then giving out all this information, any more than there would be in surveying it for geological or topographical purposes?

Mr. **Rogers**. There is nothing whatever in the way, but I have not shown you the end to which I was coming. It is this: that on account of the small return coming from ditches and reservoirs, it is doubtful whether companies will take hold of these investments. All these things hamper capital. I am not speaking for capital, at all because I believe in the declaration of our State constitution; but is not the Government as much interested in providing the means by which the water is stored as in getting at the data by which it may be stored?

The **Chairman**. We have not that question before us yet. The Government has not determined to do it.

Senator **Jones**. You think there is no speculative element in the companies? A gentleman testified here to-day who seems to be intelligent and who said he had dcontrol of ditches. He said that his company was get $800,000 for what cost them $300,000. It would seem to an outsider that that was somewhat speculative.

Mr. **Rogers**. But he had not sold the water.

Senator **Jones**. There certainly seems to be an opportunity for speculation in that?

Mr. **Rogers**. If carried out.

Senator **Jones**. He is carrying that out, is he not?

Mr. **Rogers**. I doubt if there is very much land there brought under cultivation at this time.

Senator **Jones**. He seemed to be pretty well satisfied with it.

Mr. **Rogers**. There is no question that he should be satisfied with it, if his scheme carries.

Senator **Jones**. There was another gentleman testified here that the rates paid for water were from $5 to $10 an acre. I asked the cost of a number of the ditches and the cost appeared to run from 50 cents to $2.50 an acre, and it seems to me that there is some opportunity for speculation in that?

Mr. **Rogers**. Yes; but this remains a fact, that they are subject to legislative control in respect to their charges, absolutely, through the county commissioners. I am not saying anything pro or con about it, but these are the laws.

Senator **Jones**. I am very glad they are.

Mr. **Rogers**. There is no objection to them. The constitution was very wise in saying that the water belonged to the body of the people, and that it can only be taken for beneficial purposes. It seems to me wise in regulating the charges for the transfer of water. But I am discussing the point whether men who are looking for the return of their money will invest in ditches. I am not speaking against the justice of the matter because I think it is right, but I do not see that capital will come in to invest in business of that kind.

The **Chairman**. I think it will come in while a man can build a ditch that is going to cost $2 an acre, of which he can sell the rights to the land-owners at the rate of $6 to $10 an acre.

Mr. **Rogers**. Now you are speaking of profits and ditches. According to the statement of Mr. Southworth, and the other gentlemen who testified on his side, they would reduce the profits to a minimum. They organized a farmers' protective union to induce the legislature to give them practically the water for nothing.

The **CHAIRMAN.** There have been cases where they went on and dug their ditch and sold the water to the land-owners as they went along. In that case the people will own the land and the ditch. What have the legislature to do with that?

Mr. **ROGERS.** Nothing.

The **CHAIRMAN.** Is not that a pretty good scheme?

Mr. **ROGERS.** Yes, if you can always develop that scheme; but I think there was only one scheme in which that was developed.

The **CHAIRMAN.** The legislature ought to interfere when the land and water are divorced and an exorbitant charge is made for water.

Mr. **ROGERS.** But you must remember that the capital that goes into ditches is not capital invested from here. It is capital that comes from outside. I am not a capitalist, but I have heard some who were speak of this. It is only within a few hours that I have heard gentlemen discussing this very matter, and that was one of the schemes that stood in the way. The county commissioners' authority led him to reject the security, except so far as the land lying under the ditch was concerned. The ditch as a ditch he entirely rejected. There are some other legal questions. You suggested the situation of New Mexico and Kansas. To my mind that is simply a temporary disarrangement. The water has not yet found its natural channel of seepage, but when the Rio Grande is taken over the San Luis valley and makes, as it will, the reservoir for New Mexico, then they will get their quantity of water, because it will be divided through the proper irrigating seasons.

Senator **JONES.** Have you any facts to show that?

Mr. **ROGERS.** I think Mr. Nettleton has facts to show that at a certain point in the Rio Grande River, where the bed-rock comes up, the volume of water is materially increased.

Senator **JONES.** It might be that it might increase without becoming a full volume.

Mr. **ROGERS.** There is a certain amount of water that is used up in plant life and the rest of it must follow the ordinary law of nature.

Senator **JONES.** And if the plant life exhausted all the water, that would leave nothing for the Mexicans?

Mr. **ROGERS.** The State engineers have shown that 300 acres were served by 1 cubic foot of water, because the water gets back to the river.

Senator **JONES.** That might be accounted for in the way you suggest, and might be accounted for in half a dozen other ways.

Mr. **ROGERS.** There is this other suggestion, that if these reservoirs are to be built and the Government is to give its aid, even to the extent of making the surveys, I think it might be a wise provision (and I think the engineers would agree with me) to arrange that most of the water should be used in the ditches up the stream, not only during the irrigating season, but when the water can be run with safety, that is, when it does not freeze, etc. We get an enormous amount of water from seepage, from the effect of building ditches on the high land.

Senator **JONES.** You would not increase the water supply?

Mr. **ROGERS.** You would increase it at the needed time. Of course you would not increase the amount of rain-fall, but if you get the water on the upper lands, so that they become thoroughly soaked, then there is not so much excessive moisture at other times.

The **CHAIRMAN.** That is a good suggestion, that if they would, in the non-irrigating season, soak the land pretty well it would be better for the land.

Senator JONES. You must not do that so much as to injure the lands.

Mr. ROGERS. Of course it must be done with due respect to other interests. In respect to the legal phases of the matter, I am giving you my experience in talking with the people.

Senator JONES. What is your proposed remedy for that?

Mr. ROGERS. I am not proposing any remedy except for you to consider whether the Government should take any further interest in these reservoirs after you have surveyed the sites, etc., whether you should leave them to the control of the State or otherwise. It is rather anomalous to say that common property shall be for any time whatever subject to the control of corporations.

The CHAIRMAN. I think your laws are very good. If they were adopted throughout the whole arid region, capital would be much more safe in its investment than if it came in here with the object of monopolizing. If a company constructs a ditch and sells the water rights to the people as it goes along, and lets them have the ditch when it is constructed, that will give margin enough to give capital its full profits. The only difficulty is ihat people will be willing to give at the rate of $10 or $15 for what will only cost perhaps $2. You can go anywhere and sell the water rights as fast as you construct the ditches and the ditch will be sold at a good profit, and the people will have it when it is done. That ought to satisfy capital, and it appears it is already satisfying capital in your State, because we have had three or four instances brought before us this morning where companies started to get contracts before they got the ditch. They got them and put in the money to build the ditch and are making 200 or 300 per cent. on their investment. I do not see anything in that in the way of discouraging capital, but I dislike to make it possible for speculators to come into this State and sell it out and thereby create here a race of peons.

Mr. ROGERS. That leads to what I was coming to. That is, whether the State or General Government should be the owner.

The CHAIRMAN. What is the objection to the people themselves owning it?

Mr. ROGERS. That is another name for it. That is a different question from capital coming in to invest.

Senator JONES. It is for you people to say whether the State will own these ditches or not. The Federal Government has nothing to do with it.

The CHAIRMAN. The best thing is for the people to own it themselves.

Mr. ROGERS. The question is whether the Federal Government has nothing to do with this. The Federal Government purchased this land and it might make it available.

Senator JONES. What do you say about the statement made here this morning about the stock of the ditches being watered 300 or 400 per cent.?

Mr. ROGERS. I do do not know anything about that. I do not know whether it is true or not.

Senator JONES. You do not know any instance of that kind?

Mr. ROGERS. I do not. I think it quite true that there have been instances where there have been extortionate amounts charged for water. That may be true, but I do not know of any such instance as is spoken of. The largest value that I know of was where there was a combination ditch on the left hand of a creek where a water right is deemed worth $1,200 for 80 acres. It is an enormous price, but it is purely a private affair. There is no company taking this money. It goes back to the farmers living along the line of the ditch. It is one of the oldest ditches in the State.

Senator **JONES**. Still owned by the farmers?

Mr. **ROGERS**. Yes; the highest value that I know of is on these mutual ditches, that is, ditches built by combinations of farmers, but usually taking a corporate name, with officers, by-laws, etc., and where each share that is issued to represent capital stock also represents interest in the water. The certificate is a contract for water and at the same time it is a share of stock in the company. It performs a dual function.

Mr. **SOUTHWORTH**. Would not those farmers in selling their water rights virtually sell their farms?

Mr. **ROGERS**. What farms do you mean?

Mr. **SOUTHWORTH**. The farms along mutual farmers' ditches—the left hand or any other like it. Would not the sale of the land leave the farm valueless; that is, without water?

Mr. **ROGERS**. There are some grounds for saying that; I should say yes.

Mr. **SOUTHWORTH**. No farmer could sell his water without selling the value of his farm.

Senator **JONES**. Unless he can replace his farm.

Mr. **SOUTHWORTH**. But he could not do that.

Mr. **ROGRS**. Perhaps not, on that ditch.

Mr. **BOOTH**. How is it about paying $30 an acre for the right to use water without getting any stock in the ditch at all? What worth is it to those who pay? They merely pay that for the right to use the water, and they get nothing only the right to buy the water and afterwards pay for it yearly.

Mr. **ROGERS**. Mr. Booth is referring to the ditch built by an English company here at a very heavy expense. They had to take the water out of the cañon and had much rock work about it. As I understand from the statements made by the officers of that company, that ditch, as a ditch, has not, at any time since its construction, paid. That is one instance I had in view of the failure of the ditch, as a ditch, to pay.

Senator **JONES**. Is the statement correct that has been made just now that there have been $30 an acre paid here by the people under the ditch, for the privilege of buying the water?

Mr. **SOUTHWORTH**. More than that in many instances.

Senator **JONES**. And then the purchaser has had to pay $30 an acre annually for the privilege of getting the water?

Mr. **BOOTH**. No; from $1.75 to $4.50 per acre.

Senator **JONES**. In addition to the original price?

Mr. **BOOTH**. The $30 an acre gave you a perpetual right to buy the water—you are not buying the water itself. The buyers get nothing, only the right to buy the water, and pay for it yearly afterwards.

The **CHAIRMAN**. Witnesses who were here this morning spoke of getting a right in the ditch.

Mr. **ROGERS**. There are different systems about that.

Senator **JONES**. After a man pays $30 an acre who regulates the price he shall pay for the water?

Mr. **ROGERS**. The ditch companies.

Mr. **TAYLOR**. They are not allowed to do that now under the present statutes, are they?

Mr. **SOUTHWORTH**. They are if they stick to the contract on both sides.

Mr. **TAYLOR**. That is, if the party chooses to do it; but he can demand water although he may not have paid the $30.

Mr. **SOUTHWORTH**. He can demand water, but it has broken up every man who has tried it in the court.

Mr. **Rogers**. As I understand it, our courts have held that the companies can not exist on the $30 an acre?

Mr. **Southworth**. Yes.

Senator **Jones**. And they are regulated by the commissioners?

Mr. **Rogers**. Yes.

STATEMENT OF E. S. NETTLETON, OF THE U. S. IRRIGATION SURVEY.

The **Chairman**. What is your occupation?

Mr. **Nettleton**. I am a civil engineer.

The **Chairman**. Are you connected with the Government Irrigation Survey?

Mr. **Nettleton**. I am the supervising engineer for the eastern division of the arid region.

The **Chairman**. You are quite familiar in a general way with the arid regions of Colorado, are you not?

Mr. **Nettleton**. I am.

The **Chairman**. Have you prepared some facts for the committee in writing in regard to it which you will furnish the committee?

Mr. **Nettleton**. I have some facts that I think have not been put in; some statistics with regard to what is called seepage—the return of water to the stream after it is once used.

The **Chairman**. You have that information tabulated?

Mr. **Nettleton**. Yes; I made an experiment on the Cache la Poudre four years ago and I am going to make another one next October, that is, four years later on the same stream, to see whether there is any increase or decrease.

The **Chairman**. Will the facts drawn out there be instructive as to what may be expected lower down the river, as in Nebraska and Kansas?

Mr. **Nettleton**. It may be, providing the land adjoining it is irrigated. I suppose seepage comes from the irrigation of land.

The **Chairman**. Then your observations lead to the conclusion that the irrigation of land in Colorado would not necessarily deprive the people of Kansas and Nebraska of water?

Mr. **Nettleton**. It might at certain seasons of the year, but I think the effect will be that they will have a more uniform flow. They will have a less flow during our flood time here and a greater flow during our low water here.

The **Chairman**. Will the same be true as to Kansas; that is, down the Arkansas?

Mr. **Nettleton**. Yes, providing that valley is irrigated to the same extent that the Platte Valley is.

The **Chairman**. You have traveled considerably over the State of Colorado and Western Kansas and Nebraska?

Mr. **Nettleton**. Yes.

The **Chairman**. What is the result of your observation with regard to the storing of storm waters, independent of the rivers, that have been testified to?

Mr. **Nettleton**. I believe that that is practicable in a great many cases.

The **Chairman**. What is the character of the places where it is practicable?

Mr. **Nettleton**. It will be generally done in the ravines that bring this storm water in from the prairie country or the highland country.

The **CHAIRMAN**. You have been here a long time?

Mr. **NETTLETON**. Twenty years.

The **CHAIRMAN**. What do you say of the quantity of this storm water that falls?

Mr. **NETTLETON**. Our heavy storms occur in the summer; generally during the latter part of June and July. It is the storm water that falls at that period of the year that will have to be stored.

The **CHAIRMAN**. What is the difficulty about distributing the water on the land, or is there any difficulty by reason of the storms being sudden and rapid? Do you get a natural and fair distributing, or does it come in violent storms?

Mr. **NETTLETON**. These storms last for a few minutes only and are very violent, and a canal could hardly carry the water more than a mile or two; but if held in a reservoir, that water could be used afterwards.

The **CHAIRMAN**. Does it come so rapidly as not to be useful in fructifying the soil?

Mr. **NETTLETON**. Not only is it not useful, but many times it is destructive.

The **CHAIRMAN**. It passes off rapidly and does not penetrate much into the soil?

Mr. **NETTLETON**. That is the case.

The **CHAIRMAN**. If this rain-fall came at the right season and was properly distributed and soaked into the ground, it would be much more useful?

Mr. **NETTLETON**. Yes. I think the amount of rain and snow we have in a year if properly distributed would very nearly grow a crop without irrigation.

The **CHAIRMAN**. And you think this can be remedied to a considerable extent by reservoirs in the heads of ravines, that will detain the water, and from which it can be distributed through the ditches over the land?

Mr. **NETTLETON**. Yes.

The **CHAIRMAN**. We have information in writing, I believe, as to reservoirs along the streams. I do not care to ask you about that matter. Have you anything to add orally to what you will probably present in writing?

Mr. **NETTLETON**. I think not.

Senator **JONES**. Have you any idea of the proportion of water that escapes by seepage—the proportion of water that is used in irrigation that would ultimately find its way back to the streams? Have you formed any conclusion as to the amount that would be used up in plant growth?

Mr. **NETTLETON**. Much water escapes through ditches; more in the new ditches than in the old. Much water is wasted in irrigation. To-morrow I can show you how the country is being flooded by over-irrigation. Instead of finding its way to a natural channel, that water makes bogs and swamps. Those places are filled up by percolation through the soil, by the over-irrigation of the country surrounding them.

The **CHAIRMAN**. Has any attention been paid in such places to drainage?

Mr. **NETTLETON**. Yes; in many places we have spent almost as much money in drainage as in irrigation. That will be especially true, I think, of the San Luis Valley.

The **CHAIRMAN**. What is the effect of too much irrigation, allowing the water to remain on the land to form pools?

Mr. NETTLETON. Too much irrigation washes the land; washes out the fertilizers and makes the land cold and unproductive.

The CHAIRMAN. Has it gone to the extent that it effects the health of the people in any part of the Territory?

Mr. NETTLETON. I think it would do so in any country than an arid country or a country like this. I think there would be more or less malaria in any other country, though I have not heard of any countries of this altitude being affected that way.

The CHAIRMAN. They find in California that drainage is necessary, and that with irrigation and drainage they have not only prevented any deleterious effects so far as earth is concerned, but that it has improved the health of the country. That is very marked in Kern County, Cal., where they could not live at all until it was irrigated. By irrigation and drainage it has become one of the healthiest parts of the State.

STATEMENT OF JOHN CHURCHES.

The CHAIRMAN. What is your occupation?

Mr. CHURCHES. I am a farmer.

The CHAIRMAN. Have you had experience in constructing reservoirs?

Mr. CHURCHES. Yes.

The CHAIRMAN. State your experience.

Mr. CHURCHES. I got a lease from what was known as the Mineral Land Company about ten years ago, and laid out $3,000 in constructing a reservoir. But the freshets and storms in June and July cut it out again and caused a great expense in repairing; in fact, they cut it out so many times that I could not stand it any longer. It is a large reservoir, about three-quarters of a mile long and half a mile wide or a little over, and will hold about 85 feet in depth of water in that basin.

The CHAIRMAN. How high is that dam?

Mr. CHURCHES. It is a natural dam, a natural depression between the two mountains. It is in Jefferson County and situated on Ralston Creek.

The CHAIRMAN. How did you make the outlet?

Mr. CHURCHES. By a cut. I intended to make a tunnel underneath, but my money would not hold out and I did what I could with that cut.

The CHAIRMAN. If a proper tunnel were secured by an iron pipe cemented in and constructed securely, I suppose you could make it useful?

Mr. CHURCHES. Yes.

The CHAIRMAN. You did not have money enough to construct it properly?

Mr. CHURCHES. That was the trouble.

The CHAIRMAN. It is about 85 feet deep, you say?

Mr. CHURCHES. About 85 feet, the surveyor says it is.

The CHAIRMAN. How many acres are there in it?

Mr. CHURCHES. It is about three quarters of a mile long and half a mile wide.

The CHAIRMAN. That would irrigate a large quantity of land?

Mr. CHURCHES. Yes.

The CHAIRMAN. The Ralston would not furnish much water for irrigation in the dry season?

Mr. CHURCHES. No; this reservoir is above all other ditches. My own property is 640 acres. There are several thousand other acres that are lying there that can be watered from it. All I should ask would be my share like the rest. I would gladly give my share to some parties to put it in running order.

The **CHAIRMAN**. Could you not get the land owners there to join with you in constructing a proper reservoir?

Mr. **CHURCHES**. They are too much like myself. They are too poor.

The **CHAIRMAN**. How much would it irrigate?

Mr. **CHURCHES**. I should think it would irrigate 4,000 or 5,000 acres.

The **CHAIRMAN**. It is all private land, is it?

Mr. **CHURCHES**. The biggest part of it is.

The **CHAIRMAN**. Suppose there are 4,000 acres; what would the land be worth if irrigated?

Mr. **CHURCHES**. They are selling lands as high as $50 an acre down under the ditches and this would be just as good land if irrigated.

The **CHAIRMAN**. That would be a very good water right, would it not, if this were made all right?

Mr. **CHURCHES**. Yes.

The **CHAIRMAN**. Suppose you should give away half your land (all you people that have the land) and make all the land worth $50 an acre, you would have enough left to get rich on?

Mr. **CHURCHES**. Yes; but it would be bad policy to give it away to those that had no money.

The **CHAIRMAN**. I should think that with that amount of good land and something to irrigate it, you would be able to make terms with somebody that would complete the reservoir.

Mr. **CHURCHES**. I think if we could make terms with Uncle Sam, he would be the best person.

STATEMENT OF P. H. VAN DIEST.

The **CHAIRMAN**. You have given some attention, I understand, to the subject of artesian wells in this State?

Mr. **VAN DIEST**. Yes.

The **CHAIRMAN**. Will you please state to the committee such facts and views as you may have on that subject.

Mr. **VAN DIEST**. I have given some thought to the flow of water. I have had something to do in India with artesian borings and gathered some statistics about the amount of water which percolates the lower strata. We found, for instance, that in the Paris and London basins, by careful observation it was ascertained that a third of the water-fall on a certain extent of land gives a certain flow; that another one-third evaporates and is taken off by the plants, and that the last third percolates to the lower strata. How far that is the case here is difficult to know because there are no observations taken.

Senator **JONES**. That is, one-third is taken up by the plants, one-third goes off in evaporation, and one-third percolates below?

Mr. **VAN DIEST**. Yes; that is the experience in London, England, and Paris, France, where considerable artesian water has been got. Similar observations have been made in India. Batavia is now supplied with artesian waters after surveys made by me. No observations are made here, and it is difficult to say what the case is. From the very sandy condition of a great deal of the outcropping rocks in the arable regions of Colorado, a good deal must percolate to great depths. That is proven to be the case in Denver, the Denver basin having observations made in it to some extent by Mr. Cross, of the Geological Survey. We came to the conclusion that there was considerable water running down to the lower strata. By borings that have been made since (about two hundred flowing wells having been bored) we have observed that there are three different flows. Speaking of those flows, I would say that the upper flows, to which many wells have been bored, are very limited. The lower flows take water from a greater extent of country. Much trouble has occurred in the artesian diggings by the bad construction of the tubing. There are a great many of such basins here all along the foot-hills, and it has been proven that there is much loss, as, for instance, in the San Luis Valley, where they have had flows of water to a great amount. I do not know exactly the figures, but very much more than is necessary for domestic use. There would be a chance to apply water for irrigation. The same is the case in the San Bernardino Valley, in California, where over two thousand artesian wells are aiding in irrigation. They are under regulations, so that during the night they must be closed off with stop-cocks. Thus, there is no unnecessary water flowing off. Similar arrangements can be made here.

I will call the attention of the committee to the great amount of water which flows away without our seeing it. There are many streams that run east of us here, such as the Bijo, the Badger, and other creeks, which at their best are all running streams and have considerable water. Over distances of 20 to 30 miles they are entirely sunk and lost. The Platte Valley is increased farther down in its flow. Without seeing it directly here, the volume of water in the Platte is increasing. It must be that the water from some of the mountains flows invisibly away, probably not at a very great depth. Perhaps at 15 or 20 feet deep there may be an impermeable layer and that it flows under the surface away. I think that that water could be made useful by pipes from a distance out, carrying the pipes to a place where the water is needed. Certainly a great deal of land could be redeemed by the percolation of water which is now lost.

The CHAIRMAN. Have there been any deep wells bored here?

Mr. VAN DIEST. The first flow in this neighborhood was got by boring to about 150 feet. The second flow to about 400 feet, and the deepest 700 feet. There may have been some wells bored deeper than that. One well, for example, has been bored to nearly 900 feet. That is the well that contains the iron water.

The CHAIRMAN. No deeper than 900 feet?

Mr. VAN DIEST. No; there is no doubt, according to the outcrop and the water from the mountain side, that there must be an overflow of water from the sandstone layers which are between the other strata under ground.

The CHAIRMAN. Have you observed the formation in the hills here, whether the strata is tilted up?

Mr. VAN DIEST. Yes; certainly. Near Golden the strata are nearly perpendicular. Where Cold Creek comes out the upper part of the formation crops out again as we see it at Golden. If there was not a great deal of friction in the sandstone layers which carry the water we would not get so much at the surface.

The CHAIRMAN. You think there must be a deep vein of water, probably?

Mr. VAN DIEST. I think so because the borings here have not reached the coal formation yet.

STATEMENT OF J. S. GREENE.

The **CHAIRMAN.** You have been State engineer here, have you?

Mr. **GREENE.** I was State engineer in 1887 and 1888.

The **CHAIRMAN.** You have heard the statements made here to-day, have you?

Mr. **GREENE.** Some of them.

The **CHAIRMAN.** Can you add anything to them or make any further statement with regard to your observations?

Mr. **GREENE.** I want to give a little note of warning to the committee. It may be overcautiousness, but I think I detect a tendency to place certain matters before the committee in a flattering light which I think will be to the disadvantage of the State later on. That is more especially in connection with the duty of water.

In speaking of the duty of water, it is often mentioned carelessly, and a distinction should be drawn between water measured at the cañons of streams used for irrigation below them. Sometimes we speak of the duty of water at the entrance of the ditch. At other times the duty of water is spoken of where it is carried and is immediately distributed to the land. There are people looking toward the conclusions of this committee who will base their actions upon what this committee probably shall report or in some way intimate as the duty of water. Already there has been published in our papers a statement to the effect that an acre foot of water was sufficient to irrigate 1 acre of land. That was stated to have come from the Director of the Geological Survey. I have no doubt that when that statement was made it was qualified. Possibly it was said that an acre foot of water could irrigate 1 acre of land, if there was rain-fall of say 8 or 9 inches during April, May, or June. Possibly it meant that it would be an acre foot of water just distributed on the land.

If the impression gets out, however, that an acre foot of water stored in reservoirs in the fall and winter months, to be taken out and put on the ground in the dry season is sufficient to irrigate an acre, the result will be that the people will undertake to build reservoirs and construct ditches and they will be failures. It will do more harm to the State than a more conservative position. I dread expensive failures in connection with irrigation works, and I think I see them coming and resulting from an overestimate of the duty of water. The duty of water that was given to you this morning of 346 acres per cubic foot per second is, as I say, an extremely high one. That water was measured at the cañons or outflow points of the streams. It was used over, many times, portions of it, and all of that land was not satisfactorily irrigated land.

Senator **JONES.** I think all that has come out in evidence.

Mr. **GREENE.** Statistics were taken from my report of last year and I know that very much of that land was not satisfactorily irrigated.

Senator **JONES.** State what you think the duty of water is here, measured when it goes on the land.

Mr. **GREENE.** I have in my report attempted to make an estimate of what it is within Colorado. It differs with the character of the land and the character of the soil and subsoil. It may run to 90 or 100 acres.

The **CHAIRMAN.** That is, 1 cubic foot per second?

Mr. **GREENE.** But that is some years ahead, I think. As a rule, we do not do that now. There is this to be taken into consideration:

Since this measurement of water at the cañons indicates that the water is used over and over again (because we know that water applied directly to the land will not irrigate any 346 acres or any 246 acres—none of us expect to go over 100; and, where the water is taken right on the land, I do not expect it to go over 80 or 90 acres), that indicates that the higher up on the streams these canals are taken out, the better it is for the State; that is, more land will be irrigated. So that with regard to the question as to whether the waters of the Colorado should be turned down into Kansas, I should think that if the benefit of the community was considered, it would appeal to the committee as desirable that this water should be used first near the cañons; then afterward, portions of the same water again and again, so that a greater good can be effected by using the entire water of the streams in Colorado than could be effected if portions of it were turned down.

Senator **JONES**. Than if portions of it were turned down to be used first in Kansas?

Mr. **GREENE**. Yes; to be used there first.

The **CHAIRMAN**. In taking the water on the land, has no method been adopted beside ordinary ditches? Do they use pipes?

Mr. **GREENE**. We have not irrigated much with pipes. We have done very little subirrigation.

The **CHAIRMAN**. I do not mean subirrigation, but to carry the water to the place to be used.

Mr. **GREENE**. We have done some of that.

The **CHAIRMAN**. Have they cemented the bottoms of the ditches?

Mr. **GREENE**. A cement is used in some cases.

The **CHAIRMAN**. That saves considerable of the seepage if you get the water to the land?

Mr. **GREENE**. The objection to pipes is that the friction is increased more, and it requires a greater hill than when the water is brought directly on the land. I am using a pipe now of long-leaved Texas pine, bound with long bands. It is used under the St. Charles River.

The **CHAIRMAN**. How do they irrigate here—by flooding the ground between the rows close together and running the water along in ditches?

Mr. **GREENE**. They have little ditches and frequently flood the ground.

The **CHAIRMAN**. Then, do they check it?

Mr. **GREENE**. It is checked—some of it—and prepared for flooding.

The **CHAIRMAN**. Which is regarded as the most economical way?

Mr. **GREENE**. To carry it in ditches in rows is considered the most economical. I believe the committee has had my report presented to them of statistics gathered during two years, and it contains the maps of Colorado. I do not know whether you have looked into our drainage system or not. My report also contains the figures of the capacity of our streams, so that we know how much water we have to distribute.

As to the matter of the segregation of land I do not know whether the committee is considering that subject or not. But I think it is highly proper that the land suitable for reservoirs should be segregated. The land that lies under the sites of proposed ditches should not be segregated, but it should soon be put upon the market again and be made open to homestead settlement, because otherwise it will delay irrigation development in Colorado.

Senator **TELLER**. It is not segregated now, under any fair construction of the statute, until the reservoir is first made, and then survey made to see what land will be irrigated from it. The statute provides that then that land shall be segregated.

Senator **JONES**. Is that with regard to the National Government?

Senator **TELLER**. Yes.

Senator **JONES**. I understood that the Commissioner of the General Land Office, on request of the Director of the Geological Survey, has the right to reserve for a limited time to give an opportunity for examination. If the Director of the Geological Survey has reason to believe that a certain locality would make a favorable reservoir site he requests the Commissioner of the General Land Office to reserve it.

Senator **TELLER**. He can do that without any statute.

Senator **JONES**. I thought that was provided for by statute.

The **CHAIRMAN**. That is a matter of administration.

Senator **TELLER**. And it is very proper.

Senator **JONES**. Certainly.

The **CHAIRMAN**. You regard it as important, Mr. Greene, that these surveys should be pushed rapidly?

Mr. **GREENE**. I do, indeed. I think these surveys are a great thing; more especially the determination of the precipitation both on the plains and in the mountains. It is from that we must eventually determine what lands can be irrigated. We know pretty well what amount of precipitation in the mountains is carried off through the cañons of the streams, but what proportion of that on the plains runs off we do not know.

Senator **JONES**. What amount of rain-fall do you think passes down through the cañons?

Mr. **GREENE**. My impression is that 40 per cent. of the aggregate rain-fall of the mountains passes down through the cañons.

Senator **JONES**. That is very much smaller than I supposed.

The following papers were received by the committee and ordered filed.

The committee then adjourned.

STATEMENT OF E. T. WILCOX, FIRST LIEUTENANT SIXTH CAVALRY, U. S. ARMY, FORT LEWIS.

I have seen the results of irrigation in certain portions of the West, and in different soils. My experience has been that all that is required on prairie, sage brush, or desert is water, to make the lands of the West productive of any cereal, vegetable, or fruit that the climate will admit of. In and around the town of Phœnix, Ariz., all grains and fruits, even tropical ones, flourish in great richness, the land before reclamation being simply an arid, rocky, and sandy cactus desert. The water is brought from the Salt River by two large canals, and thence distributed over the land by means of ditches, of greater or less size. Veritably, this desert is "blooming like the rose." This section has long been under irrigation. Long before the white man entered it the Pima and Maricopa Indians had made much of the land fertile and productive by irrigation, of which they have an excellent idea. All the country along the Verdi and Salt Rivers is now under cultivation, with rich results, due to irrigation. This much for purely desert lands. Upon the prairie and sage brush country let us take Salt Lake as an example: Not many years ago it was a parched, sage brush wilderness; now it is a garden and a mine of agricultural wealth, all due to irrigation from the waters of the Jordan, and the fresh-water lake 50 miles away. These two examples cover the two kinds of country in the West.

My experience has always been that the soil is ever abundantly productive, and all that is required is water, and if water is at hand, little science is required to carry it over the arid land. In many of the arid valleys of our western country underground rivers run, the waters of which may be brought to the surface by means of wind-mills, hot-air engines, or sunken pipes. As an example of the latter, I note "Soldiers' Holes," or Sanderson's ranch, in the valley of the Sulphur Spring, Arizona, a large arid prairie valley. When I first saw it, in 1878, a miserable little well gave water to a small cow-boy bar-room at "Soldiers' Holes;" when I again chanced there, in 1883, I found a flourishing ranch, two large lakes of water below the houses, hundreds of cattle, horses, etc.; Sanderson, a rich and prosperous man. He told me that he had ust been offered $150,000 for his place. All this was simply produced by sinking

5-inch iron pipes in the ground, striking, as I believe, the underground current of the lost Santa Cruz River, from 30 to 45 feet below, the water bubbling out of the pipes 6 inches above the surface, and then running off and forming its own reservoir—"the twin lakes." Sanderson was induced to sink these pipes by the offer of the Arizona legislature of $10,000 for the first artesian water found in the Territory.

A plan, once proposed by General J. C. Fremont, I believe, seems to me worthy of consideration by Congress for the benefit of our extreme southwestern country, Arizona, etc.; that is, to form of the great Colorado desert, which is in most part below the level of the sea, a great inland sea or lake, by one of two methods, *i. e.*, either by letting the water of the Gulf of California into it, by canals, or by flowing the waters of the Colorado and Gila rivers into the desert, letting them find their own outlet to the Gulf. The desert is now a useless, intensely hot, arid alkali waste and will never be anything else. By making it a sea or lake the whole climate of that section would be changed; rains would come, and the land would produce and grow in fruitfulness for the benefit of our ever-growing and great people. All our Western soil is rich, water on its bosom will make it fruitful.

STATEMENT OF N. S. JARVIS, FIRST LIEUTENANT AND ASSISTANT SURGEON, U. S. ARMY, OF FORT LEWIS.

My limited service has carried me over a portion of Arizona, in which irrigation on an extensive scale will accomplish wonders. An instance coming under my observation proves this: At a point 60 miles to the southwest of the confluence of the Great and Little Colorado Rivers is a small Mormon town, called "Tuba City." This lies on the edge of an arid region, known as the "Great Painted Desert." By collecting the water of several small springs into reservoirs and thence distributing over a few dozen acres the most remarkable success has repaid the efforts of the inhabitants. They raise corn, wheat, a variety of vegetables and fruits and even cane sugar.

This indicates to a certain extent the bearing capacity of this now desert and weird region. The Indians in this country raise millions of sheep. General Greely, in his recent interesting report to the Senate on the rain-fall of certain portions of the West, states that land in the San Joaquin Valley capable of raising grass sufficient to support one sheep, under the influence of moisture permitting the growth of alfalfa will nourish 20 sheep to the acre.

Thus can be imagined the enormous number of these animals, outside of farm products, that could be raised in the country of which I speak if the soil were allowed the benefit of abundant moisture.

STATEMENT OF S. BAKER, CAPTAIN, SIXTH INFANTRY, U. S. ARMY, OF FORT LEWIS.

During the last eighteen years I have observed wherever irrigation was practiced in western Kansas, western Dakota, Montana, Idaho, Wyoming, Utah, and Colorado large yields and sure crops were the result. Every acre of soil in that region, if cultivated by irrigation, will produce any crop in abundance that the climate will permit. Without irrigation farming is practically out of the question in the whole territory mentioned. These remarks apply to Nevada, Arizona, and New Mexico also. The question is, how shall all available arid land be irrigated and reclaimed?

The land on each side of an ordinary stream can be irrigated from the stream to the extent of its water capacity. In the valleys of the larger rivers water can be taken out at any season of the year sufficient to cultivate a large portion if not the whole valley while the river is in the mountain district. I am speaking of such rivers as the Yellowstone, Madison, Gallatin, and Jefferson in Montana; the Snake and Bear in Idaho; the Green, Grand, Arkansas, and other large rivers in Wyoming and Colorado.

The tributaries of these streams run comparatively short distances through extensive valleys and have rapid currents, which, in the season of rains and melting snows in early spring, increase to torrents, in which water is carried off that is absolutely necessary later in the season for the production of crops. Speaking in a general way, it would seem that all that can be done is to save as much of this annually wasted water as possible, and the only way of doing this that presents itself is by means of dams, making lakes at such points as the conformation of the adjacent country will permit with the least damage.

Of course these lakes or reservoirs must be near the heads of streams, and, as all the large rivers have numbers of tributaries, and as each tributary would have its system of reservoir lakes, the storage capacity in the mountains would seem to be quite enough to supply sufficient water for irrigation at pleasure, not only along the whole course of the tributaries, but also in the main stream, if some directing authority like, for instance, the Interior Department, had supreme control over the whole system.

Wherever water is scarce during the growing season a supply must be stored during the previous abundance and kept until it is needed. That it can be stored near the sources of streams and rivers by artificial lakes there can be no doubt. Take, for instance, Snake River, in Idaho. At the head of North Fork there is a basin that was formerly a lake, covering an area of several hundred square miles, the outlet of which runs through a narrow gorge that could easily be dammed at many places, which would create an inland sea where there is now nothing but an enlargement of the river, called Henry's Lake, at the foot of Tahgee, Raynolds, and Red Rock Passes.

Again, at the head of Pierre's River, a branch of the Snake, having its source in the Teton, there is a basin of from 12 to 15 miles square, whose outlet runs through a narrow gorge made in the porphyry rim of the basin, which could be easily dammed, producing a lake of magnificent proportions considered as a reservoir. South fork of Snake runs through another basin east of the Teton, and then gorges, but this eastern basin has a number of quite large lakes already, which supply the main Snake with plenty of water.

I give this as an illustration of the system proposed, not that it is necessary in this case, as I believe there is water enough in Snake River to irrigate its whole valley. Of course such a system involves great expense, but the question of supplying water for irrigation is as important to the country west of the Mississippi Valley as the improvement of river navigation is to the rest of the country.

STATEMENT OF O. B. WARWICK, FIRST LIEUTENANT, EIGHTEENTH INFANTRY, U. S. ARMY, OF FORT LYON.

In reference to the subject of irrigation I can only testify to the satisfactory results obtained from land that has been irrigated. The only land that I have observed was irrigated from ditches taken out of streams. From the general slope of country I have no doubt that many thousand acres of land, now worthless, could be made productive by means of large storage-reservoirs. Irrigation has certainly proved a great benefit to this State and in Montana, where I was previously stationed. Many thousand acres of arid land in Colorado and New Mexico, I think, could be made productive by means of storage-reservoirs, that would be of incalculable value. To accomplish this the cost would be great, but the results obtained would more than compensate for the outlay of money. Cereals and vegetables are now grown near this post on land that two years ago was not productive. The subject is one that I consider of great importance, though I lack the experience to be able to give as satisfactory data as I would like.

STATEMENT OF JOHN S. GRISWOLD, SECOND LIEUTENANT, THIRTEENTH INFANTRY, U. S. ARMY, OF FORT LYON.

The soil of eastern Colorado will produce nothing without irrigation; but where irrigation has been resorted to the results have been entirely satisfactory. This was well demonstrated by the products exhibited at the Colorado State fair, held at Pueblo last October. The inhabitants are unanimously of the opinion that were Colorado well watered it would rival in its products those of Indiana, Illinois, or any other Central or Eastern State. The slope of the country from the mountains in the west and center toward the east would greatly facilitate irrigation. Canals and ditches could be dug, thus opening up thousands of acres to cultivation, the canals being fed by the Arkansas and the mountain streams. It would also be possible to build large central basins. The construction of canals, facilitated by the lay of the country, would be accomplished at comparatively small expense and would be of inestimable value to Colorado.

STATEMENT OF F. E. LACEY, CAPTAIN, TENTH, INFANTRY, U. S. ARMY, OF FORT CRAWFORD.

The system of irrigation in use in this valley does not differ from any I have seen in other parts of the country, and seems to be fairly well adapted to present wants. There seems to me to be an unnecessary waste of water, owing to the fact that there is no proper means of regulating the flow of surplus water when the river is high; consequently in the months of July and August there is a great scarcity of water and late crops suffer. Storage-reservoirs could, with small expense compared with the results, be constructed in the foot-hills on both sides of the Uncompahgre River. There are many natural depressions admirably suited to that purpose and much valuable land now almost barren would become good farming land. I believe a system of reservoirs in the Arkansas Valley will soon be an absolute necessity.

STATEMENT OF WALTER D. McCAW, FIRST LIEUTENANT AND ASSISTANT SURGEON, OF FORT CRAWFORD.

My experience on the subject of irrigation is limited to the most casual observation of the method pursued in this valley, gained from a year's stay at this post. The land here can hardly be called "arid," as the soil seems to contain everything necessary to the growth of nearly all grains, fruits, and vegetables, which will grow in a temperate climate. There is, however, a deficiency of rain-fall usually from May to August or September, and irrigation is practiced to make up for the small amount of rain. The method used is the simplest known. The water is taken directly from natural water-courses, no reservoirs being known, and is conducted to the highest level of the land to be cultivated; there it is caused to overflow the ditch, by the action of small wooden sluice-gates placed at convenient intervals. If the land is planted with vegetables, in hills, the water overflows in a series of small channels perpendicular to the conducting ditch and running between the hills; fields of grass, alfalfa, or grain are simply flooded. The water not taken up by the ground is collected in a ditch placed at the lowest level of the ground, and thus conducted away. Irrigation is practiced from April to the maturing of the crop. No manuring effect is expected of the water, but simply the moisture is needed in the absence of rain. The ditch company in this valley sell the right to water from their ditch for $10 an acre.

That land perfectly arid, without vegetation, may by the constant use of water be rendered fertile, is, I believe, undoubted. In such cases the manuring effect of water, and not moisture alone, is needed, and a long time might be required in effecting the change. The circumstances would be very different from those in this valley. The quality and amount of suspended matter of the water, the climate and soil of the land to be irrigated, would all have to be carefully considered. I am not prepared either by experience or acquirements to offer any views of practical value on the subject of "irrigation of arid lands."

STATEMENT OF THOMAS McCUNNIFF, INDIAN AGENT, OF SOUTHERN UTE AGENCY, IGNACIO.

All facts and data bearing upon the previous customs of irrigation practiced by the Indians under my charge are very meager and unsatisfactory. In fact, in former years, the Utes seem to have relied but little upon the products of the soil. Their efforts were confined to the raising of small patches of corn and melons, which were always planted at the mouth of some vega, where the water from above filtered through the soil and moistened the roots of the plants. From this practice, we may infer, we have the present system of subirrigation. But, owing to the increased numbers desiring to engage in the raising of crops on such small patches and the limited amount of available land under that primitive system of irrigation, it became necessary to devise some means by which a larger area could be utilized. This probably caused the Utes to resort to the system of irrigating ditches, with flumes and headgates, which is now practiced here and in the main throughout Colorado and New Mexico.

STATEMENT OF WILLIAM ASHTON, ENGINEER, COLORADO DIVISION, UNION PACIFIC RAILWAY COMPANY, DENVER.

Along the Kansas Pacific Division of the Union Pacific Railway, which passes through the central eastern portion of the State, water for the various uses of the railway company is obtained from wells; these wells are in most cases sunk at a point near a small water course, and although the water seldom appears as a stream in these water-courses, a fair supply as to quantity is usually obtained by sinking wells through the sand and gravel beneath the bed of these apparently dry streams

At one point on this line of railway an artesian well has been put down which I understand is furnishing a large amount of very good water; of this you probably have record in your office. This well is about 15 miles west of the east boundary line of the State and nearly midway between the north and south boundaries.

The Julesburg branch, owned and operated by this company, lies along the South Platte River from the point where it enters the northeast corner of the State to its junction with the Denver Pacific district at La Salle. Plenty of water for our purposes can be obtained at almost any point along this line by sinking a well from 20 to 40 feet deep; quicksand is often struck in these wells and the water contains some alkali.

Wells along this line are located as below and of dimensions shown.

Station.	Depth.	Diameter.	Quantity.	Quality.
	Feet.	*Feet.*		
Sedgwick	21	11	Plenty	Some alkali.
Crook	20	11	do	Do.
Iliff	21	11	do	Do.
Sterling	22	12	do	Do.
Merino	21	11	do	Do.
Snyder	20	11	do	Do.
Deuel	22	11	do	Do.
Orchard	20	11	do	Do.
Hardin	20	11	do	Do.

On the Denver Pacific district water was more difficult to find. At Pierce a well 34 feet deep supplies all water needed for locomotives and station purposes, while 10 miles farther north, at Dover, a hole was put down 175 feet and no water found.

At Athol, on the divide between Lone Tree and Crow Creeks, a well was sunk 162 feet, but no water found. Athol Station is very near the north boundary line of the State.

On the mountain districts plenty of water for railway purposes can usually be taken from streams along the line or from adjacent springs. Most of the water-tanks on these districts are supplied by gravity pipe lines and the quality of water is usually good.

Dug wells in eastern Colorado cost us from $10 to $15 per foot of depth for wells 10 to 15 feet in diameter and less than 80 feet deep. This price covers the well complete, well lined with a good dry stone wall for its entire depth. Quicksand is usually overcome by walling the well as fast as it is sunk and by cementing the wall where unusually bad strata of quick sand are found.

On the Denver Pacific district, between Denver and Cheyenne, we have for the supply of locomotives five wells, including one at Denver, and, in addition to this, one tank at Carr, supplied from a spring.

These wells are as follows:

Station.	Depth.	Diameter.	Quantity.	Quality.
	Feet.	*Feet.*		
Denver	25	20	Abundant	Alkali.
Brighton	32	6	Plenty	Fair for locomotive use.
Platteville	31	12		Alkali.
La Salle				
Pierce	31	12¼		Fair for locomotive use.
Carr	11	9		Do.

On the line of the Colorado Central we obtained all water from the water-works of the towns we pass through; this water is usually from a mountain stream by a gravity pipe line; the quality of water is good.

On the Denver and Boulder Valley from Brighton to Boulder we have no water stations; water could be obtained at almost any station along this road by sinking a shallow well, except where road crosses the divide between South Platte River and Coal Creek.

The water in this section of the country contains a large amount of alkali if taken from near the surface.

On the Greeley, Salt Lake and Pacific district the only water station is at Fort Collins; this supply is from the city water-works.

At Stout a pipe line is laid from a spring in the side of a steep hog-back from which water of good quality is obtained, but the amount is so limited that it is seldom used for other than domestic purposes.

The Denver, South Park and Pacific district as well as the other mountain lines, is well supplied with water; most of it of good quality, from mountain streams.

No water-storage system used by this company in Colorado.

The headquarters of the engineering department for Colorado being at Denver, the location of a United States observation and weather reporting station, no accurate record of temperatures, precipitations, etc., has been kept.

The use of artesian wells in and about Denver has greatly increased within the past three or four years, and this method of obtaining water for domestic use has been largely adopted both in the city and country. The section about Denver in which these wells flow is described about as follows: From Golden north to the south line of township 1 south; thence northwest to Brighton; thence east to near the divide between the South Platte River and Box Elder Creek; thence southerly along said divide to the south line of township 4 south; thence southwest to Acequia and Platte Cañon; thence north along base of mountain to Golden. There are points outside and adjacent to this district where flowing wells are struck, but as near as I can determine at present the district as described is practically correct.

Artesian wells seem to be a success over the entire eastern portion of Colorado, a good supply of good water usually being found, but at some points it is so far below the surface that the expense necessary for pumping machinery decreases the value of the well. These wells, so far as I know, are used for domestic purposes except in a few cases where the overflow is retained in a small reservoir for irrigating purposes, but these cases are so rare and the reservoirs so small that they practically have no bearing upon the irrigation problem.

Water that rises to the surface is found in the vicinity of Denver at a depth of about 325 feet and 600 feet; the best wells are from the 600-foot flow.

From the 600-foot flow a pressure of 20 pounds per square inch at the surface is often obtained, while it is claimed by many that some wells have a much higher pressure.

That portion of Colorado east of the base of the mountains could be almost entirely utilized as farming land and for agricultural purposes if water for irrigating could be obtained. The soil is light, and in many cases contains a considerable amount of sand, but when properly irrigated the crops grown in this soil are seldom surpassed. Farming has been attempted in the extreme eastern portion of the State at several points without irrigation, but although partial crops have been raised—and some of the farmers by this method are very confident of success—the future will probably prove that even in the most eastern portions of the State this method will prove very uncertain and unsatisfactory.

BLANKS AND FORMS USED IN DITCH MANAGEMENT.

[Furnished the committee through S. J. Gilmore by the Northern Colorado Irrigation Company, office, Denver, Colo.]

RULES FOR EMPLOYÉS ON THE PLATTE CANAL.

D. W. Payne, division superintendent.

Division No. 1.

This division of the canal commences at ——— ——— and ends at ——— ———.

You are specially under the orders and directions of the engineer, and you are to carry out faithfully and promptly all his instructions. You will frequently and closely examine every part of the canal in your division, and enter in your weekly report any remarks that you may think necessary regarding the general condition of the works. Should there be a necessity for immediate attention to any part of the canal, report immediately on the telephone to the office, or if before 9 o'clock a. m. or after 4 o'clock p. m. ring the number on the telephone for the engineer. Failing to get an answer from the engineer ring the manager's number.

Should a serious leak, or break, or overflow occur, you will immediately make every effort to stop it, and to accomplish this you may hire such assistance as may be necessary and close at hand. Open the nearest waste gates above the leak, or break, or overflow, and if necessary to have all the water shut out of the canal, telephone to Denver to any of the three calls there. Should the accident be one that you can overcome without great difficulty, do not lose time by leaving it and trying to telephone, but get such assistance as may be nearest. If necessary, send or go to the nearest telephone and give notice to the engineer.

All employés on the canal are required to promptly render assistance to each other whenever there is any necessity for so doing. Each division superintendent shall keep a daily record of the depth of water on the gauge or gauges in his division, and will report the same to the engineer by telephone daily.

Each division superintendent shall provide himself with a suitable horse and cart, if such conveyance be required, and shall at all times carry with him a shovel, hammer, nails, screw-driver, wrench, measuring rule, and telephone tools, all of which, except the horse and cart, and feed for horse, will be provided by the company. In addition to these tools, there should be on each division oakum and sacks, and division superintendents will promptly notify the engineer when additional supplies are needed.

Expenses.—Except in cases of emergency, such as leaks, breaks, or overflows, or danger of any of these, no materials or tools shall be purchased or obtained on the credit of the company, except by the engineer or on his order, and no labor shall be employed except in emergencies as above stated, without first having the authority of the engineer. In all cases where laborers or mechanics are employed, the person in charge of the division where the work is being done shall keep a full and complete record of the time each person is employed and the wages to be paid, unless the engineer shall place some other person in charge of the work.

All payments for wages or hire of any kind and for material, shall be made at the office of the company in Denver, and then only upon properly stated and certified accounts first approved by the president or manager.

Care of property.—All property of the company must be carefully watched and protected on each division by the division superintendent, and he shall be responsible for locks, keys, gate-pins, tools, bolts, bars, or other effects. He shall report promptly to the engineer or manager all cases where the property of the company has in any way been tampered with or damaged, such as the cutting or breaking of gates or weirs, or interference in any way with the banks of the canal or flumes. He shall also report all cases where any damage has resulted to the property of others by reason of overflow or breaks, or in any other way.

Distribution of water.—Such water as may from time to time be in the canal shall be divided pro rata to all persons entitled thereto by reason of their ownership of water rights, and each person in charge of a division shall in the most impartial and careful manner turn water out of their respective gates in strict accordance with the directions given from time to time by the engineer or from the manager's office, and under no circumstances is any person to be allowed to open a gate or in any way to obtain more water than the quantity stated in the directions. The gate on every outlet must at all times be kept locked and the division superintendent must at all times carry the keys with him. He shall carefully inspect all gates, weirs, and outlets every day to see if all be in good order, also to discover if the gates are being tampered with, and he shall measure and record every day the depth of water flowing over each weir, and enter the same in the reports prepared for such purpose. Look sharply for persons having duplicate keys.

All outlets are to be kept free and clear of drift-wood and all other floating matter, and the gates should be frequently examined to see if there be a free flow under them; also that no wedges have been driven under them by persons trying to get more water.

Do not accept the statement of any person about water; all instructions pertaining thereto will be given on the telephone, or in writing, from the proper authority.

Report promptly the name of any person who offers any bribe or any inducement to get more water than is then being allowed under the directions given you.

Whenever there is a rise in the water in the canal, not caused by floods from the prairie, the quantity running over the weirs in the lateral ditches should not be allowed to increase by reason of the greater pressure on the outlets. The gates in the outlets should be partly closed down so as to give just the same depth of water over the weirs as was running before the rise, unless orders contrary to this have been given from proper authority. In almost every instance when more water is taken into the canal from the river, the extra quantity is intended for the divisions at the end of the canal. When a suddenly great rise occurs in the canal by reason of flood water from the prairies, caused by a storm, make haste to the waste-gates and open them, also let out at all the outlets in the canal as much water as the lateral ditches will fairly carry without overflowing or doing any damage.

Whenever there are indications of a storm and a flood, the waste-gates should be opened before the flood comes. Good judgment and prompt action in emergencies of this kind will determine the efficiency and earnestness of the employé in the duties assigned to him.

Whenever you see that water is being allowed to run to waste by any irrigator, reduce the quantity running over the weir to the extent of such waste. If you see that a lateral ditch is broken, and the water is running to waste, shut off the water and notify the superintendent of the lateral or some person who is using water from it. Make a record of your action in every case of the two above kinds, and state the particulars in your weekly report.

NOTE.—There must not be any absence from duty unless permission first be obtained from the engineer or manager.

There must not be any scolding with, or rough language applied to, farmers or users of water. You can perform your duty better without this. If any one assaults you without just provocation the company will assist you in a prosecution.

Any case of intoxication or any neglect of duty, or apparent indolence or indifference on the part of an employé will be met with prompt dismissal.

All reports must be carefully and accurately made, so that, if necessary, they can be sworn to.

S. J. GILMORE, *Manager*.
GEORGE G. ANDERSON, *Engineer*.

THE NORTHERN COLORADO IRRIGATION COMPANY.

Record of depths of Water at the weir, at the city limits of Denver, for the week ending Saturday, ——, 188—, at 6 o'clock p. m.

Day.	7 a. m., depth in inches.	6 p. m., depth in inches.	Average depth per day.	Discharge in cubic feet.	Total quantity in gallons.	
Sunday						
Monday						
Tuesday						
Wednesday						
Thursday						
Friday						
Saturday						

I certify that the depths of water entered above in the first two columns are true and correct.

—— ——.

I certify that the depths given above in the first two columns and the average depths given in the third column show a total delivery of water for the week ending as above, of —— cubic feet, or the equivalent of —— gallons.

—— ——,

—— ——.

Record of depth of water on weirs in third division for the week ending Saturday, September 16, 1888.

Outlet number.	Sunday.	Monday.	Tuesday.	Wednesday.	Thursday.	Friday.	Saturday.
47	No water in the ditch.	Do.	Do.	Do.	Do.	Do.	Do.
48							
49							
50							
51							
52							
53							
54							
55							
56							
57							
58							
59							
60							
61							
62							
63							
64							
65							
66							
67							
68							
69							
70							
71							
72							
73							
74							
75							
76							
77							
78							

I certify that the depths of water entered above are true and correct.

THOS. EVANS,
Division Superintendent.

Record of depths of water in flumes, etc., for the week ending Saturday, —— 18—.

Location.	Sunday.	Monday.	Tuesday.	Wednesday.	Thursday.	Friday.	Saturday.
Dam........							
Cañon Flume......							
Plum Creek.....							
Bennett Gulch....							
Little Dry.......							
Cherry Creek....							
Section 1 Check .							
Dryer's Check...							

I certify that the depths of water entered above are as telephoned to me daily by the respective division men.

—— ——,
—— ——.

Report of services performed during week ending Saturday evening, ——, 18—, by —— ——.

Sunday,

Monday,

Tuesday,

Wednesday,

Thursday,

Friday,

Saturday,

The Northern Colorado Irrigation Company. Report of services performed by —— ——, for week ending Saturday evening, ——, 18—.

[Fill in every evening, and not wait to end of week, when you may have forgotten particulars.]

NOTE.—This report may be made in pencil. It need not include all the little details of work, but should be sufficiently full to clearly indicate what was done each day. It should be sent by mail, or otherwise, at the first opportunity, to—

S. J. GILMORE,
Manager, Denver, Colo.

STATEMENT OF A. J. McCUNE, CIVIL ENGINEER, GRAND JUNCTION.

[The statements from western Colorado were received after adjournment and ordered inserted in report.]

I am a civil engineer, and have resided here since 1883. I was engineer on the Grand River Ditch during its construction and for two years past have surveyed several sites for small reservoirs for the farmers. As to the extent of our system: The Grand Valley Canal is in width 35 feet in the bottom, to run 5 feet depth of water. It covers 40,000 acres; cost about $250,000. There are about seventy-five small irrigating ditches, covering, perhaps, 60,000 acres. The Grand Valley Canal is taken from the Grand River; the smaller ditches are taken from the tributaries of the Grand River.

The supply of water from the Grand River appears to be sufficient for all land that it is practicable to water from that river. The supply from the smaller streams is limited, except for a period of two months, or perhaps seventy days, while the snow is melting from the mountains.

There is need of storage reservoirs on the southern and western slopes of the Grand Mesa. In the valley of Kannah Creek and Whitewater streams there is a large body of valuable fruit and farming land, perhaps 40,000 acres, that could be successfully watered from reservoirs upon the Grand Mesa.

There are some old lake beds on Grand Mesa that could be successfully converted into reservoirs.

A full survey for irrigating purposes would be helpful in promotingthe co-operation of capital and in constructing storage works.

The farmers have already done something in a very small way, but their means are too limited.

If a survey were made pointing out the location of reservoirs and the feasibility of making by the building of reservoirs thousands of acres of land now worthless to be worth from $25 to $50 per acre, capital could surely be induced to construct such works. There are other portions of this country where the small streams have been overtaxed, in other words, where more land has been entered than could be watered, through ignorance on the part of the farmers, as to the capacity of the streams. At the head of these streams are good reservoir sites where water could be stored, not only to relieve the farms that are already located, but also to supply new ones. Altogether in Mesa County alone about 100,000 acres could be reclaimed.

STATEMENT OF R. W. SHROPHIRE, OF WHITE WATER.

I have been farming in Mesa County, Colo., since 1882. I live about 8 miles from Grand Junction. The results, financially and otherwise, have been beyond my expectations in every respect, both in farming and fruit raising. The chief products are timothy, alfalfa, and fruit. Irrigation does pay; I would not farm in a country where irrigation is not possible. My land, before cultivation under irrigation, was worth nothing. I have since been offered $6,000 cash for my 130 acres. This was days since. I have a house on it worth $1,500, but $8,000 cash is my price. I am cultivating 120 acres. My net profit last year was $2,000 on 80 acres. I had 40 acres rented. My water for irrigation comes from Kannah Creek and I have a plentiful supply, because the private ditch in which I have an interest has the priority of right to the water in the creek. There are 5,000 acres of land taken up and only half farmed, because of the fact that their rights are second to ours. Our ditch covers 1,000 acres.

There is a good location for a storage reservoir on that creek, and its establishment would be of benefit to the farmers now located in that section. It could be built on the Grand Mesa at a cost of $10,000. That would benefit the farmers now located on Whitewater, Kannah Creek, and the country between the two, to the extent of fully $10,000 in one year, besides enabling 10,000 acres more of land equally as good as that now farmed to be settled upon and worked with profit. We are short of water for two months, from July 15 to September 15, just the time when it is most needed. Our irrigating season is, for grain, five months; for fruit, eight months.

STATEMENT OF C. W. STEELE, OF GRAND JUNCTION.

I have been farming in Mesa County, Colo., since 1881. The results have been satisfactory in every respect. Our chief products are vegetables and small fruits. Irrigation pays and I would not farm, unless so situated that I could irrigate the land at will. My land before cultivation under irrigation was practically worth nothing. Its market value is for 35 acres, in cultivated fields, $50 per acre; for 35 acres an orchard, $200 per acre. I am cultivating 70 acres. My net profit per acre last year was for vegetables grown between trees in orchard, $50; alfalfa, $30 per acre. I own a water-right in perpetuity, paying an annual assessment of 20 cents per inch, equal to 12½ cents per acre, and have had plentiful supply at all seasons for eight years past. The water is taken from Grand River.

The possibilities for fruit raising in this section are great. I have lived in southwestern Missouri, and I find Grand Valley, Colorado, far superior. The fruit grows to greater perfection. It is not troubled with insect pests, such as codling moths, curculio, and the borer. Grand Valley is also adapted to a wider range of varieties. Grapes and gooseberries, which often scald or mildew in southwestern Missouri, succeed admirably here, as also do currants. My pears have begun fruiting, and in size and quality they compare favorably with California productions; trees show no symptoms of the dreaded pear blight. All peach trees of sufficient age were loaded with fruit the past season. The length of our irrigating season is nine months. The climate is hot and dry; the thermometer seldom reaches zero. The rain-fall is very little; not enough to be of any practical benefit, and there is scarcely any snow.

STATEMENT OF CYRUS L. HUGHES, OF DENVER.

I am a nurseryman, and my interests consist of an 80-acre peach orchard, three years old, 9 miles from Grand Junction. There are fourteen thousand trees in it, all in healthy condition. They will be in bearing next year. Have every reason to expect a yield of $15,000 worth of peaches from the crop of 1890. In this enterprise I have invested $11,000. The value of my land if I had no water would be practically nothing. I consider my 80-acre farm to be worth to-day at least $25,000.

STATEMENT OF J. CLAYTON NICHOLS, OF GRAND JUNCTION.

I devote my entire attention to alfalfa and stock raising and have 325 acres planted to alfalfa, 6 miles from Grand Junction. The yield of alfalfa thereon is 3 tons to the acre. It is worth this year $9 per ton on the ground. The land would not grow grass before irrigation, and was quite worthless. It is now worth $50 per acre. I get water from the Grand River Ditch. I have a quarter-section of land on "The Big Salt Wash," but prior rights take all of the water from me. Were a reservoir constructed at the head of this mountain stream, 5,000 acres would at once be available for farming purposes. My neighbors raise the finest peaches grown in this valley.

STATEMENT OF A. D. MAHANY, OF FRUITA.

I have farmed by irrigation 12 miles from Grand Junction for the past five years. I would not farm where irrigation was not possible. My principal crops are oats, wheat, corn, alfalfa, and fruit. I cultivate about 100 acres. There is plenty of water, except a little short in July. The water is obtained from the Grand River Ditch. Reservoirs could be built that would benefit the land. Above the line of the present ditch there is a fine country, which comprises about 5,000 acres, that could be economically watered were reservoirs built in what are known as the "Little Salt Wash" and "the Big Salt Wash," which have ravines carrying a large amount of water in the spring.

FORT COLLINS, COLO., *September* 17, 1889.

The committee met pursuant to call of the chairman.

Present, Mr. Stewart (chairman) and Mr. Jones, of Arkansas; also Director Powell.

STATEMENT OF N. C. ALFORD, OF FORT COLLINS.

The CHAIRMAN. What is your occupation?

Mr. ALFORD. Farming, mostly.

The CHAIRMAN. Where are you farming?

Mr. ALFORD. North of the town of Fort Collins; on the north side of the Poudre River.

The CHAIRMAN. I am told that you have had some experience as to the duty of water in this vicinity. Please state as to that.

Mr. ALFORD. As to the amount of water?

The CHAIRMAN. As to the amount of water necessary to produce crops, and the kind of crops that can be produced here.

Mr. ALFORD. For the first irrigation, we think it requires about 15 inches of water, covering the ground. The second time about 12 inches is required to raise a crop.

Senator JONES. Do you mean 15 inches the first year?

Mr. ALFORD. Yes.

Senator JONES. And 12 inches the second year?

Mr. ALFORD. Yes. Thereafter about 8 inches of water will raise a grain crop in ordinary seasons.

The **Chairman**. What amount is required to raise all-around crops, vegetables, etc.?

Mr. **Alford**. They require more. I never had any experience with vegetables.

Senator **Jones**. You mean 8 inches in addition to the rain-fall?

Mr. **Alford**. Yes.

The **Chairman**. Do you know how much rain-fall you have here?

Mr. **Alford**. I think about 15 inches, year after year, in a term of seven or ten years.

Senator **Jones**. How much in the irrigating season?

Mr. **Alford**. Our rain falls largely in the spring. If we have rain it is generally at that season.

The **Chairman**. In the irrigating season?

Mr. **Alford**. Yes, and prior to that time—in May, perhaps.

The **Chairman**. I see in passing through this country that people seem to have given some attention to storing water in reservoirs. Have you given any attention to that subject?

Mr. **Alford**. Yes.

The **Chairman**. With what success?

Mr. **Alford**. With very good success.

The **Chairman**. What is the method of doing it?

Mr. **Alford**. A ditch company of which I was president built one reservoir on the mountains that covered about 200 acres.

The **Chairman**. How deep was it, what did it cost, and what purpose did it subserve?

Mr. **Alford**. We now hold 20 feet of water in it, and we use it after the flood-time, if we do not have water sufficient for the ditch. The ditch it is connected with is one of the State appropriations and it was necessary to have water to carry out the irrigation system, because the prior rights took the water away from us on the river. We built that dam and reservoir on the mountains to supply the ditch at the times when the other ditches required all the water in the river.

The **Chairman**. And when they did not require it, you took the surplus and filled your reservoir?

Mr. **Alford**. Yes, we were allowed to take that when there was a surplus.

The **Chairman**. Is the surplus of this stream, the Caché La Poudre, all saved now, or does it go down stream?

Mr. **Alford**. There is a large surplus yet remaining.

The **Chairman**. A large surplus to supply other reservoirs?

Mr. **Alford**. Yes.

Senator **Jones**. How much did that reservoir cost?

Mr. **Alford**. About $15,000.

Senator **Jones**. It is 200 acres in extent?

Mr. **Alford**. Yes.

Senator **Jones**. And 20 feet deep?

Mr. **Alford**. We hold 20 feet of water in it now.

Senator **Jones**. Is that its capacity?

Mr. **Alford**. Yes.

Senator **Jones**. How far away is that from your line of ditch?

Mr. **Alford**. Seventy miles.

Senator **Jones**. You get it to your ditch by another ditch?

Mr. **Alford**. No; the law gives us a right to use the channel of the river to conduct water in.

Senator **Jones**. And you take the water from your reservoir by the channel of the river to that ditch?

Mr. **ALFORD.** Yes.

Senator **JONES.** So you were not at any great expense in constructing a ditch to carry the water from your ditch?

Mr. **ALFORD.** No, sir.

Senator **JONES.** You only use that to supplement your other ditch at such time when you do not get your ditch supplied from the river?

Mr. **ALFORD.** That is all.

The **CHAIRMAN.** You stated that there was a large amount of water still running to waste that might be stored in reservoirs. Is there land cultivated upon which to use that water?

Mr. **ALFORD.** Plenty.

The **CHAIRMAN.** Are you familiar with the country below here with reference to the opportunities to make reservoirs?

Mr. **ALFORD.** Yes; all the way to the Missouri River.

The **CHAIRMAN.** What do you say of the opportunity to store water?

Mr. **ALFORD.** There is an amount sufficient for more water than I think can ever be stored.

The **CHAIRMAN.** I know that, but what is the opportunity for storing water. They are not storing water away below here, are they?

Mr. **ALFORD.** I am not able to say; I do not think they are.

The **CHAIRMAN.** We have had some testimony all along the State with reference to water accumulating in the streams below after you have taken out all you wanted. Is that true of the Caché la Poudre? Do you find the water again in the streams from seepage or underground channels or anything of that kind?

Mr. **ALFORD.** It appears so in this river.

The **CHAIRMAN.** How far down is the lowest ditch taken?

Mr. **ALFORD.** In this stream, it runs into the Platte at Greeley. If I recollect correctly, Mr. Nettleton says there are 80 feet of seepage there.

The **CHAIRMAN.** Have you ever paid any attention to storing the storm water on ravines where there is considerable water shed, and without any running stream in dry weather?

Mr. **ALFORD.** I have had no occasion to look at that.

The **CHAIRMAN.** The water of the stream has answered your purpose so far?

Mr. **ALFORD.** We sometimes take it out into a depression or lake and store it and then take it out lower in another ditch.

The **CHAIRMAN.** That is, the water of the river.

Mr. **ALFORD.** Yes.

The **CHAIRMAN.** Can you estimate the amount that goes to waste in this river?

Mr. **ALFORD.** I can not say exactly. I have no way of knowing; some years we use quite a large proportion of it, and in other years I do not think that we use a tenth part of it.

Senator **JONES.** During the irrigating season, do you take it all out of the river?

Mr. **ALFORD.** Some years we do; other years we do not.

The **CHAIRMAN.** Do you mean during the irrigating season?

Mr. **ALFORD.** I do not think we use a tenth part, taking it in the whole irrigating season.

Senator **JONES.** What proportion of the entire volume of the river runs during the irrigating season?

Mr. **ALFORD.** That season is about from the 15th of May until the 10th or 15th of August.

Senator JONES. Three months. How much water does this river afford in the other nine months, compared with these three months?

Mr. ALFORD. Very little. I can not tell exactly. At this season the river is very low and will keep so until next May.

Senator JONES. And there is no water taken out of it?

Mr. ALFORD. Only for domestic use.

STATEMENT OF F. J. AMIES, OF FORT COLLINS.

The CHAIRMAN. You have heard the statements of Mr. Alford. Do you agree with him as to the duty of water in this vicinity?

Mr. AMIES. Yes.

The CHAIRMAN. He said he had had no experience in regard to the duty of water in raising vegetables. Have you made any observations in that respect?

Mr. AMIES. None myself. I only know those that have been taken at the college here—at the experiment station.

The CHAIRMAN. What would be the duty of water in raising vegetables?

Mr. AMIES. The duty of water would be at least 1 foot.

The CHAIRMAN. And you could irrigate so as to raise the different kinds of vegetables during the whole season with a foot of water?

Mr. AMIES. Yes; it is more distributed with vegetables than with grain crops. Grain crops require generally two irrigations.

Senator JONES. How about alfalfa?

Mr. AMIES. That requires one irrigation in the spring and sometimes two.

The CHAIRMAN. How much water does it take?

Mr. AMIES. I do not know.

The CHAIRMAN. Is it the practice here to flood alfalfa fields after cutting?

Mr. AMIES. It is customary.

The CHAIRMAN. What would be the amount of water necessary to irrigate alfalfa with that practice?

Mr. AMIES. It would take about two-thirds of what it would take for ordinary crops.

The CHAIRMAN. It would take less than for ordinary crops?

Mr. AMIES. Yes. At each irrigation it would take two-thirds of what it would take with an ordinary crop of grain.

Mr. CHAIRMAN. How much for the season?

Mr. AMIES. About twice as much.

The CHAIRMAN. Is that a reason why you have to use more water with vegetables—that you have to irrigate more frequently?

Mr. AMIES. Yes.

STATEMENT OF A. L. EMIGH, OF FORT COLLINS.

The CHAIRMAN. You are deputy water commissioner of this district?

Mr. EMIGH. Yes.

The CHAIRMAN. Have you taken pains to ascertain as nearly as possible the amount of surplus water that runs away here in the average year?

Mr. EMIGH. I have taken a number of years, so as to get an average. I know pretty well what ran to waste this year, and it was under the average.

The **CHAIRMAN**. This has been a very dry year?

Mr. **EMIGH**. Yes.

The **CHAIRMAN**. What proportion of the whole ran away this year?

Mr. **EMIGH**. For about ten days there was a surplus. There were 2,000 cubic feet per second for several days. For the balance of the time, say a week, there were as much as 400 or 500 feet that ran to waste.

The **CHAIRMAN**. What proportion of the whole amount ran to waste probably during the season?

Mr. **EMIGH**. I can not say; I have not figured that up.

The **CHAIRMAN**. It would cover considerably more land?

Mr. **EMIGH**. Yes. There was enough ran to waste this year to irrigate (if you saved every inch of it) every square foot of arable land in the valley.

The **CHAIRMAN**. More than you have under cultivation?

Mr. **EMIGH**. Yes.

The **CHAIRMAN**. Have the crops suffered by reason of not having the water properly distributed?

Mr. **ALFORD**. The potatoes and corn have. The early crops have not.

Senator **JONES**. What is the discharge of this river by the month?

Mr. **EMIGH**. We have a record of it, but it varies very much. We have nearly 4,000 cubic feet per second as the highest, this year, in one day.

The **CHAIRMAN**. What I want to get at is the flow of the river outside of the irrigation season; what is the usual or normal flow in September say; has it been gauged?

Mr. **EMIGH**. Yes. I have not the record, however. About 225 feet is the usual flow per second in August when it gets down.

The **CHAIRMAN**. That would be about the usual flow outside of the irrigating season?

Mr. **EMIGH**. Yes.

The **CHAIRMAN**. For eight months?

Mr. **EMIGH**. Yes.

The **CHAIRMAN**. That would make a total of about 2,000 feet a second, for one month's time?

Mr. **EMIGH**. Yes. To fill all the ditches, if they are all running full, would take about 2,000 cubic feet per second. The decrees of the court are for a good deal more, but it actually takes that.

Adjourned.

GREELEY, COLO., *September* 17, 1889.

The committee met pursuant to call of the chairman.

Present, Mr. Stewart (chairman), and Mr. Jones, of Arkansas; also Director Powell.

STATEMENT OF JOHN L. ROUTT, OF DENVER.

The **CHAIRMAN**. How long have you resided in Colorado?

Mr. **ROUTT**. Fourteen and a half years.

The **CHAIRMAN**. You have been governor of the Territory and of the State?

Mr. **ROUTT**. I was the last territorial governor and the first State governor.

The **CHAIRMAN**. What is your occupation now?

Mr. ROUTT. I am cattle raising and farming. I have mined some.

The CHAIRMAN. Have you paid attention to the production of crops by irrigation? If so, state the character of the crops and the quantity produced of the various cereals and vegetables.

Mr. ROUTT. I have been engaged in farming for the last five years. I have two ditches on my land; have experimented somewhat with farming products and have succeeded pretty well in some things. I have raised three full crops of alfalfa every year but this. The third crop this year was a little short for want of water. My ground will yield about 5½ tons to the acre this year, counting the three cuttings. I have raised corn, from 25 to 50 bushels to the acre, without irrigation.

The CHAIRMAN. Was that in the low lands, where there was seepage?

Mr. ROUTT. It was in made land, the wash from the foot-hills. It was a level piece of ground with a good deal of sand and lime in it. The erosion of the rocks made a sediment so that I am able to plow pretty deep, and I raise corn in that way. I have to irrigate the oats and the alfalfa.

The CHAIRMAN. What is the average and what is the best crop of oats?

Mr. ROUTT. The best I have been able to raise is 25 bushels to the acre; the oats weighed 43 pounds to the measured bushel.

The CHAIRMAN. What is the average crop for the State?

Mr. ROUTT. About 40 bushels by weight.

The CHAIRMAN. How about wheat?

Mr. ROUTT. I am not familiar with the wheat, but I should think the crop of the State would average 25 to 28 bushels to the acre or somewhere along there, although some extra crops yield over 50 bushels.

The CHAIRMAN. Do you raise vegetables of all kinds here?

Mr. ROUTT. All kinds except the tropical vegetables. We can not raise tropical vegetables here, but this is a great potato country. It is also a great country for cabbages, beets, and all the ordinary varieties of vegetables.

The CHAIRMAN. Have there been experiments made in regard to fruits in different parts of the State?

Mr. ROUTT. Yes.

The CHAIRMAN. What do you say of the capacity of this country to grow fruit?

Mr. ROUTT. We are growing very good fruit in Colorado. We raise excellent apples. This part of the country is not well adapted for peaches, but almost all other sorts of ordinary fruits grow well here.

The CHAIRMAN. Have you made any experiments to ascertain the duty of water?

Mr. ROUTT. Yes; but that is pretty hard to explain.

The CHAIRMAN. I mean the amount of water necessary to water crops?

Mr. ROUTT. That depends upon the quality of the land. It will take double the quantity of water on some kinds of land that it will on others. A sandy loam that is not so sandy but what it will raise a good wild grass will take less water than a clay land. I think it will produce good crops with one-third less water than clay land. On the clay land it takes a long time to flow before you get all the land wet.

The CHAIRMAN. How much does it take any kind of land to get wet?

Mr. ROUTT. They estimate that 1.45 cubic feet flowing past a given point per second every day will irrigate 80 acres of land. I do not use anything near that much water, however, on my land.

The **CHAIRMAN**. Has the irrigation made the land too wet in any place?

Mr. **ROUTT**. You can kill land by too much water just as well as you can kill it by want of water.

The **CHAIRMAN**. Are there any places in this section of the country that have been injured by too much water?

Mr. **ROUTT**. Yes; you passed through much land of that kind near Fort Collins. They have to ditch the land out now so as to drain it and take off the surplus water.

The **CHAIRMAN**. Can it be drained so as to restore it to its original good quality?

Mr. **ROUTT**. That I can not tell.

The **CHAIRMAN**. At the experiment station did you observe where they had drained the land?

Mr. **ROUTT**. Yes, I noticed that; but they have not had a full opportunity to determine the fact of full restoration. I see no reason, however, why the land should not be restored, though I can not speak from actual experience.

STATEMENT OF J. MAX CLARK, OF GREELEY.

The **CHAIRMAN**. What is your occupation?

Mr. **CLARK**. I am a farmer.

The **CHAIRMAN**. Have you been farming in this vicinity by irrigation?

Mr. **CLARK**. Yes.

The **CHAIRMAN**. Have you given considerable attention to the subject of irrigation and the use of water?

Mr. **CLARK**. I have.

The **CHAIRMAN**. Can you state what results have been secured here as to the duty of water?

Mr. **CLARK**. We average, I suppose, something like a cubic foot per second for 60 acres for the season. It varies a little, but I think that is about the average. It varies with the different soils.

The **CHAIRMAN**. You reckon that, that cubic foot will do for how many days?

Mr. **CLARK**. For the season through.

The **CHAIRMAN**. What do you call the season?

Mr. **CLARK**. About one hundred days.

The **CHAIRMAN**. Do you require that for all kinds of crops?

Mr. **CLARK**. There are some kinds of crops that would require more and some that would not need so much. The average of our farmers grow some alfalfa, wheat, and potatoes. For such crops as we grow we want water all the time for about one hundred days.

The **CHAIRMAN**. Do you irrigate every day?

Mr. **CLARK**. Pretty nearly every day.

The **CHAIRMAN**. Not the same land?

Mr. **CLARK**. No.

The **CHAIRMAN**. You change around?

Mr. **CLARK**. Yes.

The **CHAIRMAN**. How often do you irrigate the same land during a season?

Mr. **CLARK**. As to alfalfa, I would rather water it three or four times a season. We can not do that, however; we have not enough water. But we would rather water it after cutting it in the spring and after the last cutting in the fall. When I say we use the water continuously, I do not mean that we are applying the water every day to the same spot.

The **Chairman**. Have you any means of economizining the water by running it in pipes or putting some coping on your ditch?

Mr. **Clark**. Not here.

The **Chairman**. How do you flood the land?

Mr. **Clark**. We flood the entire surface. For potatoes and corn we run the water down between the rows. We water every row when we can; when we can not we do less and get a less crop.

The **Chairman**. Has any of your land been injured by having seepage water settle upon it?

Mr. **Clark**. I do not think the land has been injured.

The **Chairman**. Injured for immediate use, I mean.

Mr. **Clark**. Yes; we have considerable bodies of land in low places where the soil is of such quality that it will get wet and will not dry itself.

The **Chairman**. Do you reclaim that?

Mr. **Clark**. Yes.

The **Chairman**. How?

Mr. **Clark**. We drain it by ditches.

The **Chairman**. Does that restore it?

Mr. **Clark**. Yes.

The **Chairman**. Is there a deficiency of water here sometimes?

Mr. **Clark**. Yes.

The **Chairman**. Does some water go to waste in the flood time?

Mr. **Clark**. Yes.

The **Chairman**. What means, if any, do you take to save the flood water to use for irrigation?

Mr. **Clark**. We have a few natural depressions in the foot-hills and in the mountains where we store some of this water in the high stage, and use it afterwards, but those places which we can make use of with the expense which we can afford are not numerous.

The **Chairman**. Where you store the water in such places is the seepage great, or do the places hold the water pretty well?

Mr. **Clark**. The seepage is great, but the water gets back into the main stream again and there is very little loss, only by evaporation, which, of course, we might not perceive, because it may be carried off into Nebraska or Kansas, but all seepage generally returns to the river. I believe it is estimated that there is not over 15 per cent. of the water that actually dries up in the atmosphere.

The **Chairman**. Are there opportunities for saving the flood water?

Mr. **Clark**. Yes, there is no trouble about that, but all we want is money. It is too expensive for private enterprise. It is more expensive than we have been able to accomplish.

Senator **Jones**. How expensive would it be?

Mr. **Clark**. I will make a statement to show you what I think about it. We have up on the river here a natural depression called Boyd's Lake. We wanted very much to make use of that as a reservoir to help us out. We had no doubt but that we would receive great benefit if we could use it, but we find on making careful estimates that the attempt to make proper ditches to that reservoir would cost more money than the entire capital stock invested in the two ditches that we were proposing to invest in. We have been here nineteen years and this one reservoir would cost more money than we ever put into our ditches.

The **Chairman**. How much is that?

Mr. **Clark**. One hundred and fifty thousand dollars.

Senator JONES. It would cost that much?

Mr. CLARK. It would cost just that to do what we were trying to do. There ought to be two good ditches—one from the Thompson and one from the Poudre, so that we could take from one or the other as the water might be found most in either.

The CHAIRMAN. How much water would that reservoir hold that you wanted to make?

Mr. CLARK. I believe it was calculated to be three-quarters of a mile wide and 3 miles long, and would hold about 30 feet of water.

The CHAIRMAN. How much land would that irrigate?

Mr. CLARK. There were different opinions about that, but there is no doubt that it would be a very great benefit to this whole valley. We have completely exhausted the stream, except in the high-flood time, early in the spring. There is not a year that we have enough water for the proper growth of crops to get the yield that we ought to get, and that we know we can have when we have proper water.

The CHAIRMAN. Does it make any difference in the quantity of water required, whether the amount is properly distributed or not?

Mr. CLARK. Yes.

The CHAIRMAN. What effect has cultivation on the amount of water required to produce crops?

Mr. CLARK. Just the difference in quantity required, I can not say; but we all know that with potatoes and hoed crops, if we stir the ground up immediately after watering, it is improved.

The CHAIRMAN. How is it with wheat? Did you try summer fallowing here?

Mr. CLARK. Yes.

The CHAIRMAN. How does that result?

Mr. CLARK. The wheat will burn a great deal quicker the next year, but if it was watered and plowed two or three times the year before, you will get a large crop. If you put a piece of ground in wheat that you had in corn the year before and were not able to water it thoroughly, you can trace every spot just where the water was before.

The CHAIRMAN. Have you tried summer-fallowing the ground and not irrigating it to see what the result would be?

Mr. CLARK. I have, yes. I do not say that is not beneficial to summer-fallow, but if you let it go a whole season without water, you can not get a good crop here next year.

Senator JONES. What is an average crop of potatoes here to the acre?

Mr. CLARK. I suppose about 100 bushels to the acre on an average. That is not anything like the crop we could obtain, however.

The CHAIRMAN. What is a maximum crop?

Mr. CLARK. About 400 to 600 bushels.

The CHAIRMAN. You cannot raise potatoes without irrigation?

Mr. CLARK. Not successfully.

The CHAIRMAN. How much wheat do you get to the acre on an average?

Mr. CLARK. I have averaged as much as 25 bushels per acre for nineteen years. I do not remember to have ever raised less than 20 bushels to the acre in a single season.

The CHAIRMAN. What is the largest crop you ever got, taking the entire crop?

Mr. CLARK. I have averaged 37½ bushels. I have raised 30 bushels, 35 bushels, 32 bushels, and 33 bushels, according to the year.

The CHAIRMAN. Do you raise corn to any great extent?

Mr. CLARK. No.

The CHAIRMAN. Your principal market crops are wheat and potatoes?

Mr. CLARK. Yes, and alfalfa.

The CHAIRMAN. How much alfalfa do you get to the acre?

Mr. CLARK. From 4 to 5 tons. I have raised 5 tons repeatedly. I suppose 4 tons would be an average crop.

STATEMENT OF BENJAMIN H. EATON, OF GREELEY.

The CHAIRMAN. You have been governor of this State?

Mr. EATON. Yes.

The CHAIRMAN. We would like to have you give us something of the history of the colony of Greeley and your experience with it.

Mr. EATON. In 1869 I saw an article in the New York Tribune, inviting people to meet Mr. M. C. Meeker, to form a colony to come to the frontier country, cut loose from the evils of eastern civilization and locate on the arid plains or in a new country and start a pure and holy colony, so to speak. I was rafting on the river, the Caché la Poudre, and I immediately wrote to Mr. Meeker that here was the place. I saw him at Evans, four months afterwards and he said, "You have helped to get us here and we want you to join us and our colony." I did so. So I am one of the original colonists.

The colony was located here on a barren plain or cactus bed in a very dry spring of 1870. There was not then a house or a building or anything of that kind here. The first season was a very unpromising one. At that time no one in this section of country thought that there was any good land here except the land along the river, watered by capillary attraction. People had great hesitancy about farming here because they had no faith in the soil. In fact, as just stated, it was a new thing. There was no upland farmed.

This Greeley colony was the first pioneer to take a hold of the uplands or cactus-bed. Hundreds and perhaps thousands of people came here, but very few remained. They came from all over the United States, especially from the town portion, of different trades and different professions. There was not very much to be seen in the prospects of the soil.

I, myself, had not faith enough in it to take a claim, but as I lived up the river, I took interest in it and watched it. The second year there was a little plant food put in the soil. It was all absorbed and they were able to raise nothing, but they did better the third year. If a friend came to the house and asked me how much faith I had in these uplands, I would turn the question a little and would not like to tell him. Next year, the land was all taken up. Enough people remained that had faith in it, and altogether it made a colony. At that time there was but very little water in the river late in the season. This Greeley canal irrigated, I think, some 4,500 acres the first year.

Senator JONES. Did they begin irrigation at once when they came here?

Mr. EATON. Yes.

Senator JONES. You have not made any statement about that yet. State what was done.

Mr. EATON. They laid off a ditch and commenced to construct it, and as fast as it was constructed they turned the water in.

Senator JONES. These were irrigated lands that you said made poor crops the first year and did better the next year?

Mr. EATON. Yes. When I speak of high lands, I mean lands that showed no signs of vegitation except the cactus or something of that kind. At that time there was about 4,500 acres irrigated, I believe, under this colony ditch, what we now call the "Caché la Poudre canal, number two." They made that 4 feet deep and 2 feet wide, I think, at the head. It ran out to the railroad, some 24 miles. There it was a little ditch, but next year they enlarged it, and now it is 25 feet wide and 6 feet deep, owing to the natural wear of the ditch and the crooked places having been made straight. It flows now, perhaps, ten or fifteen times the water it did the first year. That ditch has been extended every year. That land has become wet by soakage. The land is now being drained.

The extent to which we can irrigate here is not determined, and will not be in our time. The water is flowing out all the time. By the reservoirs in the mountains, we are able to save a large amount of this water that in former times ran down stream. Some ditches take it all, and others are imperfect and do not take it all, but it does not go very far before it gets back into the river again. There are many depressions in the valley, like Boyd's Lake, that was mentioned, that could be made into good reservoirs. But that is expensive, and the people are not rich. Many of them would not have staid here if they could have got away. It was a matter of necessity for them to stay, though they do not talk that way now. They are now willing to stay. Much more water could be got if we had help. The snow-fall has not been so heavy as usual this last year. There were fourteen or fifteen days last year in which, if we had the water stored that went to waste, we would have saved several hundred thousand dollars.

The CHAIRMAN. In a single year?

Mr. EATON. In that single year. But at other times the stream would flow the amount of water that it has flowed this year.

The CHAIRMAN. And ten times the amount of water that was used?

Mr. EATON. Yes. This river has been flowing so full sometimes that you could not tell where the channel was because of the overflow. It has 16 feet of a fall from here to Fort Collins, and 25 from there to the mountains. Water that falls like that does not pay much attention to a channel.

The CHAIRMAN. Has the country been surveyed to see what could be done?

Mr. EATON. No, I think not; only by slight individual enterprise.

The CHAIRMAN. Would a survey be of benefit to you?

Mr. EATON. It does not require much to know that an immense amount of good can be done if we have reservoirs or ditches. Every man can see the depressions.

The CHAIRMAN. How many people are there, do you suppose, in the east, that believe anything in it at all?

Mr. EATON. Seeing is believing; all believe it who see it.

The CHAIRMAN. The committee desires to ascertain facts and report to Congress. We have not expressed any opinion as to what will be done, and it is improper for us to do so. There will not be much done until all the people understand it as the people of the West do. We are trying to get at the facts, as to what kind of country you have, and as to what can be produced, and what people can do if they come here. To what extent then could the farming land be increased if water were properly used from this river?

Mr. EATON. You would have to limit the time in order that I might answer that question properly. It will depend on the winters and the depth of snow. Large ditches could be constructed to use when water is high; and they would make water available for the other seasons. It is impossible to say how much exactly could be done. Everything depends on moisture. There are large ditches on the flat that are caused by seepage and overflow.

The CHAIRMAN. Can you say generally that it is possible to largely increase the irrigation by reservoir?

Mr. EATON. Yes, that could be undoubtedly done.

The CHAIRMAN. Then, the opportunities for making new homes, even in this vicinity, where you had early irrigation, are not exhausted at all?

Mr. EATON. By no means. New homes are being made all the time, and ditches are being constructed, but for the last two years ditches have been constructed and preparations made to receive the water more rapidly than the water has been available.

The CHAIRMAN. More rapidly than water has been increased by storage or other development.

Mr. EATON. Yes. There is an excellent opportunity for making a reservoir on Chamber's Lake, up in the mountains, and many others are available. You can not tell how much can be done, because past seasons are not fair samples.

The CHAIRMAN. What do you say of this as a good country to live in, with irrigation?

Mr. EATON. It is the best country I know of.

The CHAIRMAN. Why is it best?

Mr. EATON. We have a great deal of sunshine. Many people do not think that that is much of an advantage, but it is an advantage in harvesting crops. We harvested our crops this year without losing a pound, I might say, by "must." In many years, east of here, the crops are destroyed in the harvest season.

The CHAIRMAN. How is it as to the certainty of crops if you have irrigation?

Mr. EATON. With irrigation crops are certain.

The CHAIRMAN. Do you repeat the same crops on the same land?

Mr. EATON. We have done so, but it has not been good. We are rotating now.

The CHAIRMAN. Does land grow better or poorer each year?

Mr. EATON. It grows a little poorer. The lands have been farmed here for twenty years and we raised very good crops last year. I have heard people say that they had 40 bushels of wheat to the acre, but it was on new land.

The CHAIRMAN. As to alfalfa, does the crop increase or decrease year by year?

Mr. EATON. There is one place that has been cut forty-four times, that is, three times a year for fifteen years. This year it is as good as in any former year.

The CHAIRMAN. You say that alfalfa is a great fertilizer?

Mr. EATON. Yes.

The CHAIRMAN. What crops do best immediately after alfalfa?

Mr. EATON. Wheat and potatoes. Some people put in potatoes and some put in wheat. Alfalfa roots are very hard to plow up, but some find it best to plow them up and put in wheat. That saves them from contending with the roots, with the stubs that have not been thoroughly cut off.

Senator JONES. Is there any trouble in destroying alfalfa?

Mr. EATON. It is very hard to plow.

Senator **JONES**. But after the first plowing is there any trouble?

Mr. **EATON**. No; it decays at once.

The **CHAIRMAN**. Did you ever try destroying it by flooding it?

Mr. **EATON**. No; I have heard of people flooding it late in the fall, at a time when we do not have much water. Hard freezing will kill it, but I have never tried it. We are not trying very hard to kill alfalfa.

The **CHAIRMAN**. What use do you make of it?

Mr. **EATON**. It is a good forage plant and is fed to cattle and sheep for fattening purposes.

The **CHAIRMAN**. Do you feed it to hogs?

Mr. **EATON**. I have heard of hogs getting fat lying around about it, but I have never seen them do it. It is a good feed for hogs, but does not make them very fat. I ought to say, perhaps, that irrigation is a wonderful success in this country and community.

The **CHAIRMAN**. You have a fine country out here?

Mr. **EATON**. Yes; the people are doing pretty well and are putting more paint on their houses.

The **CHAIRMAN**. They are getting into a little better financial condition each year?

Mr. **EATON**. Yes, I think so.

STATEMENT OF DAVID BOYD, OF GREELEY.

The **CHAIRMAN**. What is your occupation?

Mr. **BOYD**. I am a farmer.

The **CHAIRMAN**. Where do you reside?

Mr. **BOYD**. In Greeley, sometimes, and sometimes on my farm between here and Eaton. My family live in Greeley and I live there sometimes.

The **CHAIRMAN**. You are farming here by means of irrigation?

Mr. **BOYD**. Yes.

The **CHAIRMAN**. You have given some attention to the subject?

Mr. **BOYD**. Yes; I have been here since 1870 and had control of this canal when it was first built.

The **CHAIRMAN**. You are one of the original Greeley party?

Mr. **BOYD**. Yes.

The **CHAIRMAN**. Give us some of your experience as one member of that colony.

Mr. **BOYD**. I would say, as one differing in view from Governor Eaton, that I did not quite burn my ships when I came here. Neither did I put all my cargo in one ship. I am Scotch-Irish, and proceed cautiously. I did not put all my money in here. I was trying an experiment. I have been informing myself recently in regard to the statistics of irrigation in this irrigation division, and also in the Poudre. I would say that when we came here first, which was in 1870, a corporation was formed according to the laws of Colorado on the 15th of April of that year. The officers of the colony issued a circular stating that they proposed building four canals, which were to cost, according to estimate, $20,000 for the four. This was information for the colonists at large. Only the second and third canals were ever taken out by the colony. No. 3 was built first, in the spring of 1870, and it cost, on first construction, $6,000. We found that it was utterly insignificant and utterly useless for our purposes. We put in 200 acres. I know exactly what was put in because I managed, or rather mismanaged, the canal for the first year. An enlargement had to be made. All the land was put in town lots and everything. It was a scarce year for water. The ditch was poorly constructed. In points it would carry much water, and in points it would not carry any. It was made zigzag. The engineer who did it was one who had run ditches in mountains, and of course he must follow every acute angle. We enlarged that the next year at a cost of $5,000 more. This ditch has cost us $25,000 and irrigates about 4,000 acres of land.

In regard to ditch No. 2, which is across the river; that cost on first construction $27,000. Two thousand acres were put under that canal. A large part of that went under for want of water, because the canal was poorly constructed. My friend Max Clark put in 80 acres and lost it all. Then we had to make another enlargement. We made altogether three enlargements, costing us $60,000. This was done by the colony. It was turned over to the farmers in 1887. They have spent since that time $25,000, making the total cost of canal No. 2 $112,000. I am sure of the figures because I have been over the colony books. They never constructed ditch No. 1. A portion of the land which was to be covered by it had a ditch built by the Larimer & Weld Company.

Senator **Jones**. How much land is irrigated by canal No. 2?

Mr. **Boyd**. About 25,000 acres. There are one hundred and twenty 80-acre water-rights (or the equivalent thereto) in it. The actual cost is $350 per 80-acre water-right, while in the Larimer & Weld, above it, each water-right costs $1,200. We found that a cubic foot of water per second would irrigate about 65 acres.

Canal No. 4, which used to come out at Big Thompson, and covered the land south and west of town, was not constructed by the colony, but by Captain MacKenzie, and is now owned by an English company. It cost $50,000. So that those four canals, which the colonists expected to build for $20,000, actually cost $400,000.

Senator **Jones**. How much land is irrigated by canal No. 4, which, you say, cost $50,000?

Mr. **Boyd**. I have not looked over the statistics. I can not give the figures.

Senator **Jones**. What was the total cost of canal No. 1?

Mr. **Boyd**. The total cost of that, or of the two canals covering the same land, would be about $200,000.

Senator **Jones**. How much land is irrigated by that?

Mr. **Boyd**. Twenty-seven thousand acres are now irrigated by the Larimer & Weld, which is part of the land that would be covered by No. 1. It covers, say, one-half, and we may safely assume that the Larimer County ditch, still above, and covering land that would have been covered by No. 1, will irrigate the same area.

Senator **Jones**. Twenty-seven thousand more?

Mr. **Boyd**. Yes.

Senator **Jones**. That makes 54,000 acres, then, that you say are covered by a ditch that cost $50,000.

Mr. **Boyd**. Yes.

Senator **Jones**. This is what is embraced in what was the original colony ditch No. 1?

Mr. **Boyd**. Yes.

The **Chairman**. Have you enumerated all the ditches?

Mr. **Boyd**. These are the four ditches that were proposed.

The **Chairman**. Are there others?

Mr. **Boyd**. There are some 50 ditches from the Caché la Poudre.

The **Chairman**. Do you know the expense of constructing all those?

Mr. **Boyd**. No; I can say, however, that the two canals, the Union colony, and the Larimer & Weld, covers about as much land as all the rest; they being all small ditches.

The **CHAIRMAN**. How much do they irrigate?

Mr. **BOYD**. Fifty-two thousand acres (that is, 27,000 and 25,000). Of course these figures are approximate. The whole area, as estimated by the commissioner, of all the canals taken out of the Poudre (which is district No. 3) is 108,000 acres.

The **CHAIRMAN**. Has there been any estimate of the entire cost of these?

Mr. **BOYD**. No; I have made no estimate. I could only do it approximately.

The **CHAIRMAN**. How much did the irrigation cost for the 52,000 acres that you irrigate; did it cost $400,000?

Mr. **BOYD**. No; these 52,000 are included in our No. 2, and the Larimer & Weld. The cost of those would be $100,000 for the Larimer & Weld, and $112,000 for our No. 2.

The **CHAIRMAN**, That is $212,000 for the 52,000 acres?

Mr. **BOYD**. Yes.

The **CHAIRMAN**. That would be a little over $4 an acre?

Mr. **BOYD**. Yes.

The **CHAIRMAN**. Is $4 an acre about the cost of irrigation here?

Mr. **BOYD**. That depends on whether you build, yourself, or whether you buy the water.

The **CHAIRMAN**. I mean the actual cost of the construction of the ditches.

Mr. **BOYD**. It varies very much.

The **CHAIRMAN**. I know that, but I mean the average?

Mr. **BOYD**. Take No. 3, which supplies the town; that is to say, 4,000 acres. That cost $25,000.

Senator **JONES**. That is a little over $6 an acre.

Senator **TELLER**. You must remember that those ditches were exceptionally cheap ditches, this valley being an easy valley to irrigate.

The **CHAIRMAN**. I want to know the cost of construction of ditches in this valley.

Mr. **BOYD**. No. 3 cost $25,000 and irrigates 4,000 acres. No. 2 cost $112,000 and irrigates 25,000 acres. The Larimer & Weld cost $100,000 and irrigates 27,000 acres. No. 4 cost $50,000, and I do not know how much that irrigates.

The **CHAIRMAN**. That is pretty cheap irrigating.

Senator **TELLER**. I would not like the committee to have an idea that that is the average cost of irrigating here. This is a peculiarly happy valley in regard to the cost of irrigation.

The **CHAIRMAN**. What do you say, Mr. Boyd, as to the feasibility of increasing the acreage of irrigated land here?

Mr. **BOYD**. In my opinion, what we need irrigation for is to finish crops that are under the ditch. For instance, we lose our potato crop nearly every year because of the shortage of water at the proper time. In regard to the amount of water that comes over this weir, I think the greatest amount of water that ever came over the weir at the cañon was 7,000 cubic feet per second. In 1888 the greatest quantity that came over it was 1,700 feet per second. That seemed to be sufficient for the amount of land, the 108,000 acres irrigated, and if you divide the 108,000 by 1,700 you will get somewhere about 60 acres as the "duty" of water, as it is called. If that had continued for any length of time we would have been all right, and would have saved our crops, but it soon fell. There was only one week when the ditches were dry.

The **CHAIRMAN.** You think if the water were stored and economically used you could prevent all failure of crops?

Mr. **BOYD.** Yes. We are especially devoted to the cultivation of potatoes. Last year we lost a large part of the crop because we had no late water. Late water is important because we can not raise an early crop of potatoes here. If we supply water early to them it makes them "set" and goes to producing tubers at a time when the soil is hot and dry. So we must have late water for potatoes. In 1877 we shipped 2,000 car loads of potatoes from Greeley. We had late water that year. Last year we shipped less than 1,500 car loads, because of the shortage of water. This year we will ship less.

The **CHAIRMAN.** How much would it enhance the average value of the irrigated land (supposing there are 108,000 acres of such land in the whole valley) to have a sufficient supply of water each year to mature the crops.

Mr. **BOYD.** I can best answer that by telling you what people are doing in order to get this late supply. There is a party here who has put in a pump to pump water for irrigating purposes. It costs him $14 a day to run that pump and he pumps a water right and a half. The question arises, does it pay him? It is said that he will have 100 sacks to the acre on 120 acres. That will be 12,000 sacks of potatoes, where he probably would not otherwise have had 12 sacks to the acre. So it pays him to have a pump at a cost of $14 a day, besides $3 a day for coal, and a man night and day to run it.

Senator **TELLER.** How much does it cost him a day for the water which he gets through pumping?

Mr. **BOYD.** He irrigates about 10 acres from his pump. If that be considered in comparison with what our water costs us, it would be cheap.

Senator **JONES.** Did I understand you awhile ago to say that if reservoirs were provided, so as to save the water from going to waste in this river, there would be only about water enough to make a certainty of the crops now under cultivation?

Mr. **BOYD.** That would depend greatly on the year and on the size of the reservoir.

Senator **JONES.** Take the average year and suppose there were reservoirs enough to hold the excess of water.

Mr. **BOYD.** There have been two years when there was very little to spare.

Senator **JONES.** They are exceptional perhaps.

Mr. **BOYD.** Yes.

Senator **JONES.** I was speaking of the average year and the ordinary flow of water.

Mr. **BOYD.** Take this year, which may be considered an average year, there might be a surplus of 1,000 feet per second.

Senator **JONES.** Did I understand you to say that that would be about the utmost that could be expected from storage of water on river?

Mr. **BOYD.** Yes; I really think it would be very unsafe for parties to build reservoirs.

Senator **JONES.** This seems to be very vague and indefinite information; one man stated here that there was not more than one-tenth of the water used.

Senator **TELLER.** That was in some years.

Mr. **BOYD.** I think 7,000 feet per second is the maximum that went down since Mr. Nettleton put in his gauge, and by decree of the court we have appropriated 4,632 cubic feet per second.

Senator Teller. But not every year.

Senator Jones. He meant that it was in the exceptional year that they used only one-tenth of the water.

Senator Teller. He meant that some years there would be ten times as much water running in the streams as compared with other years.

Mr. Boyd. Governor Eaton, I suppose, was thinking of a year when there was not any such large area or ditch capacity as we have now.

The Chairman. Does the land require more irrigation after it has been irrigated a few years?

Mr. Boyd. It requires much less; depending, however, largely, on the character of the subsoil. If gravel is near, and the water is scarce, there seems to be no particular difference—one year is as good as another.

The Chairman. Could you not increase the water very much by seepage from lands that have received too much water?

Mr. Boyd. Yes, we have improved the situation by drainage. There are pipes being arranged for that now.

The Chairman. What are the names of those now using the pump?

Mr. Boyd. Hurdle & Wilson.

STATEMENT OF GEORGE H. WEST, OF GREELEY.

The Chairman. Are you the manager of the concern here which has a new invention—that of a pump for irrigation?

Mr. West. Yes.

The Chairman. What are the general characteristics of the pump?

Mr. West. It is what is called a steam vacuum pump. It lifts the water on a short lift up to say 24 feet.

The Chairman. Being governed by what?

Mr. West. By the weight of the atmosphere producing a vacuum.

The Chairman. Will 24 feet operate in this altitude as much as that?

Mr. West. About as much as that.

The Chairman. By actual experiment here you can operate the suction about 24 feet?

Mr. West. About 22 to the discharge and 24 to the top of the cylinders.

The Chairman. What are the virtues of the pump in the way of cheapness, etc.

Mr. West. It is operated very economically. The ordinary pump lifts the water against the weight of the atmosphere, while this is operated by the weight of the atmosphere.

The Chairman. Have you put it in actual operation anywhere?

Mr. West. Yes, we have quite a number of them in use on ranches in northern Colorado.

The Chairman. How much does it cost to elevate to a height of, say, 22 feet a cubic foot per second? What is the expense of the pump and what does it cost to operate it?

Mr. West. The entire plant—pump, boiler, and steam pipes, complete—cost, set up on the ranch, is $700.

The Chairman. That is, to elevate a cubic foot per second to a height of 22 feet?

Mr. West. Yes. The expense of fuel would be 1 ton of slack coal in three days' continuous pumping of twelve hours a day.

The Chairman. And for one hundred days (which would be the irrigating season) it will therefore be 33 tons of coal?

Mr. WEST. Yes.

The CHAIRMAN. What is the price of coal here?

Mr. WEST. Slack coal costs here, laid down, about $1.50 a ton.

The CHAIRMAN. Would hard coal give better service?

Mr. WEST. Yes, but not with the same economy in results of water.

The CHAIRMAN. So that about $40 or $50 worth of coal would last a season. Then what would it cost for attendance?

Mr. WEST. The same man can attend to the boiler who attends to the irrigation. That depends however on the size of the plant and the kind of boiler used.

The CHAIRMAN. I want to get it down to the cubic foot per second for 60 acres?

Mr. WEST. I think it would be fair to count $1 a day perhaps for attendance.

The CHAIRMAN. That would be $100 for the irrigating season?

Mr. WEST. For one hundred days, yes.

The CHAIRMAN. Then about $150 would be the expense for the season?

Mr. WEST. Yes.

The CHAIRMAN. That would be about $3 an acre?

Mr. WEST. It is about $2 an acre as I have figured it out.

The CHAIRMAN. That is, if you have to elevate it only 22 feet. You could not operate it except to the extent of the weight of the atmosphere?

Mr. WEST. We have another pump on the same principle, which elevates the water above the pump, by steam pressure—a combined lift and force pump. We can lift the water above the pump in that case 170 feet.

The CHAIRMAN. What would be the expense of raising it 170 feet?

Mr. WEST. We have not made any practical tests this year on that.

The CHAIRMAN. Have the farmers resorted to this method of procuring water to any considerable extent in Colorado?

Mr. WEST. It was introduced late this season. I think there are about thirty-five plants in operation, enough to test the water supply and also the question of economy.

The CHAIRMAN. Can you collect the facts as to the actual operation of the different plants and forward them to the committee?

Mr. WEST. I will do so.

Senator TELLER. You might state where you get this water.

Mr. WEST. We have under Greeley 46 feet of gravel stratum filled with water. We have first 4 to 6 feet of surface drift or soil, and below that comes this gravel filled with water, which extends down 46 feet farther to bed rock. On the Platte River, east of here, we have 84 feet of that gravel stratum filled with water.

The CHAIRMAN. What depth is there to it?

Mr. WEST. About the same depth, but the top soil may be a little lighter.

The CHAIRMAN. Are you familiar with the country below here, in Nebraska, and do you know how deep the water is below the surface there?

Mr. WEST. That varies according to the distance back from the streams. We find that in many of these dry creeks or arroyos there is water at a slight depth and also in the flats. At Crow Creek, 40 to 45 miles northeast of here, where there is only a little water in places coming to the surface, they find large quantities of water there at from 4 to 15 feet below the surface over a large area.

The **CHAIRMAN**. Have you any information as to how it is in Nebraska, on the Platte?

Mr. **WEST**. It is the same all along the Republican Valley. As you get on the divide or high land the condition seems to be that you get usually into water, although it is not so in all cases.

Senator **JONES**. You say that a $700 pump discharges about a cubic foot a second?

Mr. **WEST**. Yes.

Senator **JONES**. What is the size of the discharge-pipe?

Mr. **WEST**. The pump I speak of discharges right at the box.

Senator **JONES**. Have you measured the discharge capacity of the pumps?

Mr. **WEST**. Yes.

Senator **TELLER**. You mean to say, I suppose, that these people using the pumps are getting this subterranean water?

Mr. **WEST**. This gravel is very coarse, in places as large as your fist. That lies together irregularly, and there are great spaces or cavities between the pieces. As we pump the tendency is to throw this stuff out and open up great channels, and then there is a rush in of water. On the Albert Howard well, which is 70 feet deep and gives 22 feet of water for irrigation, there are two pumps for the 200 acres, and the water is lowered about 11 feet in pumping twelve hours per day. That leaves 11 feet to draw on. The amount of water underneath in these gravel beds seems to be enormous. Where we have found 12 feet of water in that stratum we have not put in any pumps yet that have pumped it dry. At Platteville, about 20 miles south of here, they have 60 feet of that gravel stratum, and nearer to Denver they have 50 or 55 feet in different locations.

The **CHAIRMAN**. If you will in condensed form give the results of your operations, the cost, and the amount of land irrigated, and also any information you may have as to water that is underground, down about the Platte, the Arkansas, or any other stream, we would be glad to have that information.

Mr. **WEST**. There are one or two other facts I would like to state concisely. One is that we have sold a number of those pumps for places where the streams run very sluggishly (2 to 4 feet per mile) and where it is impossible to take out ditches. In other cases, for instance in Bear River, in Routt County, the condition there is that of a great difference (12 feet) between high water and low water in the streams. There the valleys are narrow and the people are not able to take out large ditches. For that reason their ditches are too small and are built for high water. When that water drops, their ditches are left dry, and their crops have to dry up for want of water. That is the condition of many localities, particularly in the parks and mountains. On Bear River they have coal that they can put right into a wagon without any cost of hauling.

The **CHAIRMAN**. In your statement give us an explanation of raising of the water up from a distance of 4 or 5 feet. It may be useful.

Mr. **WEST**. You mean the fuel expense for different elevations?

The **CHAIRMAN**. Yes.

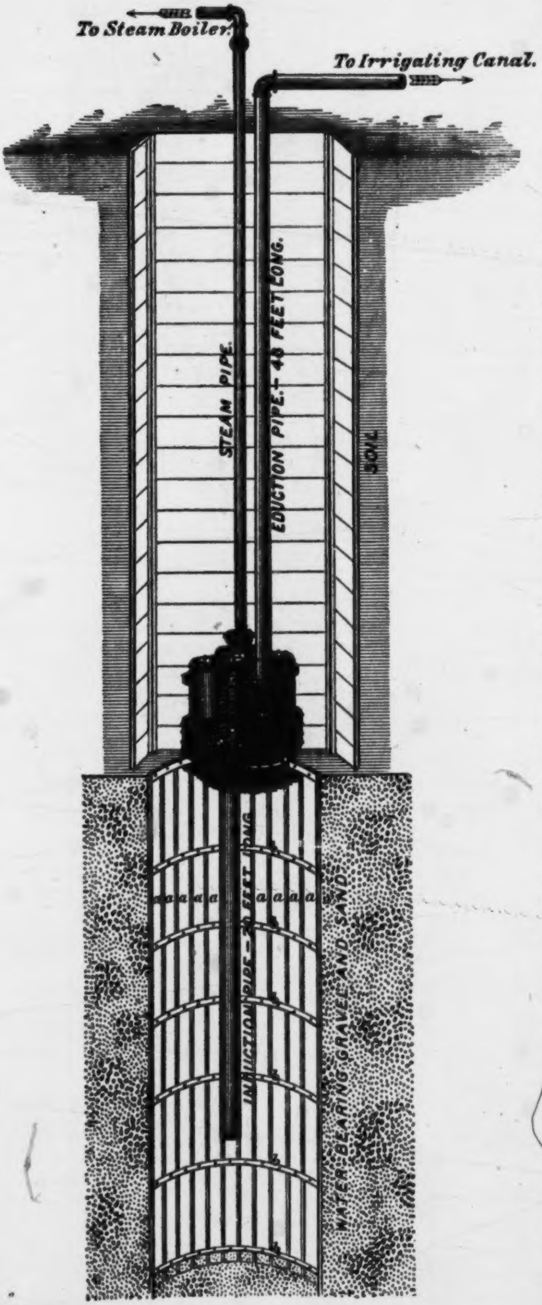
Mr. **WEST**. Yes. It might be well for me to state also that we have had letters from Arizona, New Mexico, western Kansas, western Texas, Utah, Montana, and elsewhere, giving indications that there are localities where it is impossible to irrigate except by raising the water by mechanical power, and where they have regular rivers of water under ground.

The CHAIRMAN. You can condense all of that information that will be of use. When received it will be placed in evidence.

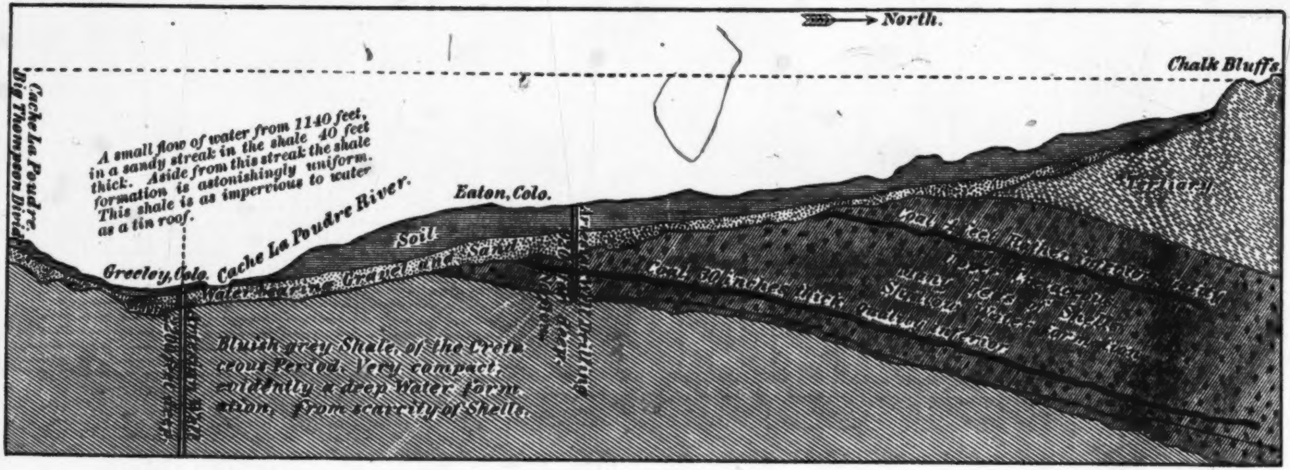
FURTHER STATEMENT OF GEORGE H. WEST.

In Greeley we have given much attention this season to elevating the underground water to the surface for irrigation. This idea had its inception in the lack of water to mature our crops under the old irrigating-canals in this section. In the year 1888 the loss on the potato crop tributary to this city was estimated at $250,000, this year at $300,000, from lack of water solely, the crop being perhaps three-fourths made and then burned up. This loss occurred with an abundant supply of water under every ranch in the valley at from 4 to 30 feet from the surface in coarse gravel. Much study has been given to this matter and the machinery used is cheap, simple, durable, and economical. The pumps commonly used in Colorado are of the class called steam vacuum pumps, operated with steam-boilers, requiring no engine, and lifting the water by vacuum or atmospheric pressure through automatic condensation of steam in the two pump cylinders alternately. They are of two kinds, one making the atmospheric lift only, say, 22 feet here, and the other the same lift of water into the pump, thence forcing it above 150 feet higher, by steam-pressure in the cylinder. Being without plungers or pistons, muddy water, sand, and gravel do not interfere with their operation. On a simple vacuum lift they can be operated with less than 1 pound steam-pressure and discharge their nominal capacity with 5 to 10 pounds steam-pressure and on a lift of only 4 to 12 feet with from 25 to 30 pounds steam-pressure the discharge is about doubled. Figuring on a pump of nominal capacity of 450 gallons a minutes, being 1 cubic feet per second, or 50 miners' inches, the theoretical discharge is as follows: One pound of coal in an average boiler should convert 1 gallon of water into steam. Water at the altitude of Greeley—4,778 feet—is converted into steam at about 202 degrees. Steam occupies here relatively 1,993 times the space of water. Allowing 493 parts steam for waste, and also that the water displaces the steam in the cylinders space for space, we should get 1,500 gallons of water for every pound of coal used and every gallon of water converted into steam. In actual practice we have done about one-half of this, discharging 1 cubic foot of water per second 20 feet high with 35 to 40 pounds of good soft coal per hour. The ranchmen in actual use, often use consume 50 per cent. more coal than this.

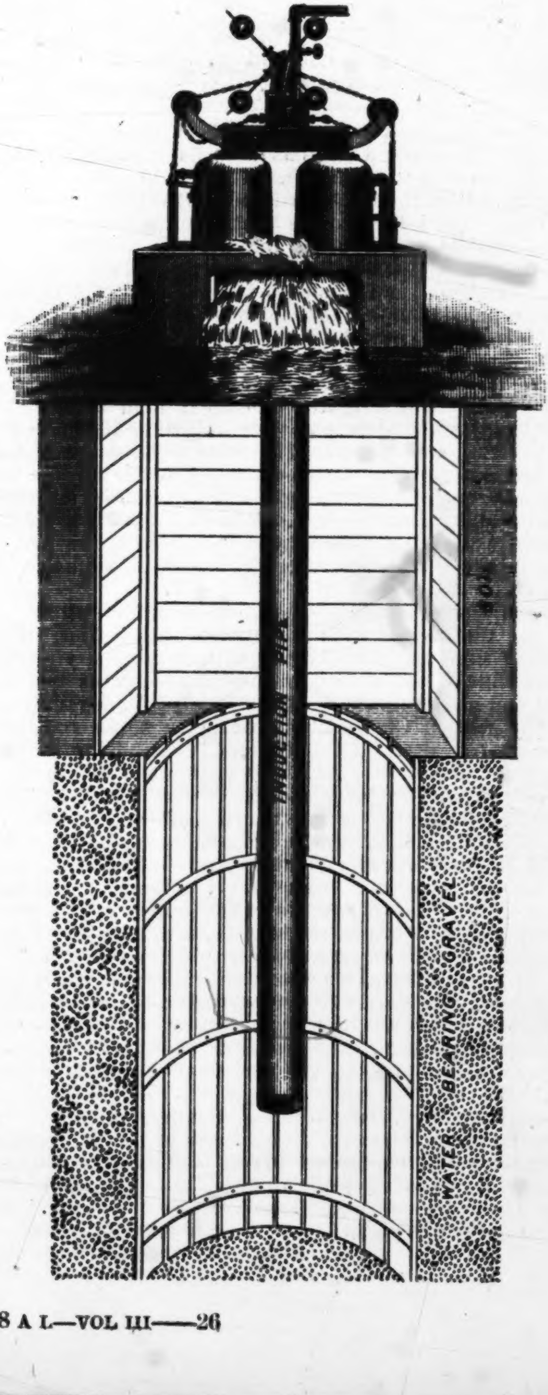
The accompanying sketch (No. 1) is a section (one-half) of a deep well (Albert Howard's) on the bluff north of this city. There are two pumps in this well, set on top of the curb just above the water level, both operated by one steam boiler. Mr. Howard has irrigated 200 acres of land with this plant at an expense of $2 per acre for fuel and labor for the season's irrigation. This well is 68 feet deep, 46 feet from the surface of ground to water, and with 22 feet depth of water. The discharge is 2 feet above the surface of the ground. These pumps, operated twelve hours per day continuously, lower the water 11 feet, and the average lift is 53½ feet. A 60-horse-power horizontial steam boiler is used, consuming about 1¼ tons of inferior slack coal in twelve hours, costing $1.50 per ton. The water-bearing strata is coarse gravel. These pumps discharge about 1,400 gallons per minute, being about 3


To Steam Boiler.
To Irrigating Canal.
STEAM PIPE.
EDUCTION PIPE.– 48 FEET LONG.
SOIL
INDUCTION PIPE – 20 FEET LONG
WATER BEARING GRAVEL AND SAND
a a a a a a a a a

Sketch No. 1—Represents Albert Howard's well and pump on the bluff 2 miles north of Greeley, Colo. Length of square curb is 48 feet; length of round curb 25 feet, of 2 inch plank by hoops of iron bolted through each plank. The 2 inch plank are bolted on the *outside* of the iron circles. There is one-half an inch of space between each piece of timber, through which the water finds its way freely into the well. There are two pumps in this well, only one being shown in this drawing. The water stands level with the top of the round curb in this well when the pumps are not running. Water-bearing gravel and sand indicated by the dotted work.


North.
Chalk Bluffs.
Cache La Poudre.
Big Thompson Divid
A small flow of water from 1140 feet, in a sandy streak in the shale 40 feet thick. Aside from this streak the shale formation is astonishingly uniform. This shale is as impervious to water as a tin roof.
Eaton, Colo.
Cache La Poudre River.
Greeley, Colo.
Soil
Water-bearing Gravel and Sand
Tertiary
Bluish grey Shale, of the Cretaceous Period. Very compact, evidently a deep Water formation, from scarcity of Shells.
Artesian Well 200 feet deep.
Artesian Well Drilling

Sketch No. 2—This is of an actual well in sections. The horizontal line work indicates the dry soil, and the dotted-work the water-bearing gravel.


INDUCTION PIPE
WATER BEARING GRAVEL

Sketch No. 3—Shows a purely vacuum pump, from a photograph of the pump, when doing actual work. This pump makes a total lift of 22 feet.

cubic feet of water per second, or 150 miner's inches, under a 4-inch head of pressure. These pumps will deliver about one-half more water on a 22-foot lift. The entire cost of this pumping plant was less than $2,000. Mr. Howard's experiment was the pioneer one in the United States.

A simple steam vacuum pump on the Robert Boyd ranch near this city is shown by sketch No. 3. It has a normal capacity of 500 gallons discharge per minute on a 20-foot lift. This pump is elevating seepage water 14 feet high from the Cache-la-Poudre River through tiling laid in a trench dug horizontally into the bank some 20 feet. One 14-horse-power vertical steam boiler is used, and with 30 pounds pressure the pump discharges about 1,000 gallons of water per minute, being about 2¼ cubic feet per second, or 110 miner's inches. One ton of slack coal is used in three days' pumping of twelve hours per day. A boy runs the plant. More water could be furnished by this pump than was required for the area cultivated. The expense for fuel and labor was 50 cents per acre for each irrigation. The entire cost of the plant was $700, and the pump will irrigate 80 acres of land on a 20-foot lift. The cost of a similar complete plant for irrigating 160 acres would be $1,000, and for 320 acres $1,200. The price of these plants and the cost of fuel and care per acre decrease rapidly as the acreage increases. In a general way, complete pumping plants of this kind for large tracts of land would cost $3 to $5 per acre. When the land is in small tracts, the best results would be obtained by co-operation in the use of large plants. The form of wells constructed for use of these pumps is shown in sketch No. 2.

The valleys of Colorado on the eastern plateau have all been formed by denudation; the streams from the mountains have left on the bed rock deposits of sand and gravel filled with water, varying in thickness from a few inches to 64 feet at Eaton, Colo. This bed of water-bearing sand and gravel in the Cache-la-Poudre Valley extends from Greeley to the foot of Chalk Bluffs, 39 miles north and 1,220 feet higher. The sketch presented illustrated this. Near the foot-hills large bowlders lie next the bed-rock, and farther east on the plains their size decreases regularly to large stones, coarse gravel and sand, all filled with water. From the surface to bed rock the conditions are reversed, and below the soil we reach quicksand or sand, then fine gravel, coarse gravel, large stones, etc. Water is usually found on the plâteau east of the mountains as soon as the gravel is reached, and back from the rivers for miles in the valleys water is usually found beneath the surface at the same level as in the surface streams. The water-bearing strata near the surface is comparatively narrow at the foot-hills, but widens out many miles as we reach the valleys, where the surface streams have less fall to the mile. Since the construction and use of irrigation ditches the amount of water in the gravel strata has greatly increased, often standing much higher than the level of water in the natural streams, and coming to the surface as seepage in lakes and ponds.

The distance from the surface to the subterreanean water varies from a few feet to more than 50 feet in the valleys of the Cache-la-Poudre, South Platte, and Big Thompson Rivers and their tributaries. At Greeley, in the river valley proper, water is found from 4 to 16 feet from the surface, and the water-bearing gravel is 44 feet thick; at Eaton, 8 miles north this water strata is 20 to 25 feet from the surface and is 64 feet in depth; at Pierce, 10 miles still farther north, this water strata is 30 feet from the surface, and continuing 20 miles again north, to the Maynard Flats, near Carr station, water is but 8 feet from the surface, in gravel. The depth of the water-bearing strata in the latter locations have not been determined. Water is found also in gravel on Crow Creek and Little Crow flats, 40 to 50 miles northeast from Greeley, at varying depths from 4 to 20 feet, in large quantities. At Denver, bed rock comes to within a few feet of the surface, and good results have not been obtained; but large amounts of water are found in the sands of Cherry Creek and in the valleys adjacent thereto. North from Denver, along the South Platte Valley, water is found at varying depths from 8 to 30 feet, and the water-bearing gravel is 50 feet thick at Brighton, 55 feet at Fort Lupton, 60 feet at Platteville, and 86 feet at Evans; 100 miles still east, at Sterling, Colo., water is 4 to 20 feet from the surface, in sand and gravel. The gravel there is much smaller than at other localities named, and there is more quicksand above it.

The amount of water that may be stored in a cubic foot of sand or gravel, when fully saturated, has been ascertained by careful experiment to be as follows: Fine sand 2 gallons, coarse sand 2½ gallons, sand and fine gravel 3 gallons, coarse gravel and small stones the size of hen's eggs 3.6 gallons. As a cubic foot contains 7.5 American gallons, it will be seen that very large gravel beds contain fully one-half water. Water is found in all the dry creeks and the valleys adjacent thereto in northern Colorado, east of the mountains, at varying depths from 2 to 20 feet. Actual tests have been made verifying this matter on Lone Tree, Big Crow, Little Crow, Wild Cat, Pawnee, Lewis, and Cedar Creeks north of the South Platte River, and on Cherry Creek, Sand Creek, Lost Creek, Box Elder, Kiowa, Bijou, Big Beaver, and Little Beaver south of this river. As investigation goes on, the area of land known to have underground reservoirs of water at a nominal depth from the surface is largely increased.

In twenty counties in Colorado, lying east of the base line, which runs through Pueblo, there are some 25,000,000 acres of land. Fully 20,000,000 acres of this is suitable for cultivation, and probably one-fourth of this, or 5,000,000 acres, are underlaid with an ample water supply near the surface, available for use for irrigation by mechanical power—that by lifting or pumping.

A major part of the water from the eastern slope of the mountains, in the South Platte River and its tributaries, taken for irrigation, is used west of this line. From a residence in this locality of seventeen years, and a close connection practically with the operation of ten large irrigating ditches, I believe there is a loss of fully 40 per cent. of the water between the heads of irrigation canals and the application of the water to the lands at varying distances along the line of distribution. The Colorado State engineer, it is understood, testified in Denver that there was in use for this season's irrigation about 1 cubic foot of water per second for each 342 acres of land cultivated in the State—about one-fourth the amount actually needed. This accounts for the large loss in the later crops of potatoes, alfalfa, etc. If all the water in the natural streams on the eastern slope of the mountains in Colorado be stored in reservoirs and used in this State, it will no more than fairly irrigate the land lying under the present irrigating canals, as fully one-half the land under said canals in the State is not in cultivation at the present time. Attention is called to the testimony given as to the condition of the water supply in the lower part of the Rio Grande and Rio Pecos, also in the lower Arkansas Valley. The same condition exists, and to a greater degree, in the lower South Platte Valley, where a greater development has been made in farming by irrigation. This condition of a shortage of water supply in the lower valleys increases every year even with the construction of reservoirs by private capital each season.

Careful investigation in Arapahoe and Jefferson Counties indicate that as much more land as is now cultivated can be watered by mechanical power. The average depth to water on the bottom-lands is about 8 feet; on second bottom-lands 20 feet, and the supply seems inexhaustible. In dry gulches and sand creeks the depth to water is from 2 to 12 feet. Lump coal, near Denver, costs about $5 per ton; slack coal, about $1.25 per ton retail, and 90 cents per ton in car lots. These facts are necessary in estimating the cost of pumping.

In Rio Grande, Saguache, Conejos, Costilla, Huerfano and Las Animas Counties, Colorado, estimates are made that 300,000 acres can be reclaimed by such mechanical power, and not otherwise. There is much waste land in these counties. The depth to water averages from 6 to 25 feet, and the supply seems enormous, entire rivers and creeks flowing into the sand, and being lost for surface irrigation. Fuel is plentiful and cheap in these counties, coal costing from $1 to $6 per ton, according to locality.

In New Mexico it is estimated that 1,500,000 acres can be reclaimed by mechanical power. There is much waste land in this Territory. The depth to water is usually from 10 to 50 feet, and the supply of water near the surface seems very large. Fuel is plentiful, and usually cheap. Coal costs from $1 to $6 per ton. Mesquite is used for fuel in some localities. Letters from the States and Territories in the arid West indicate a very large area of land that can be reclaimed only by mechanical power in elevating water for irrigation. The conditions of such use would vary, and can be named, as follows:

(1) Where irrigation is not much developed, and where capital is not readily interested in large irrigation enterprises.

(2) Where the streams having an ample surface water supply are sluggish, and run on a grade of from 2 to 5 feet per mile; also, in elevating water from lakes, where the land adjacent thereto is in broad and comparatively level valleys, as at Utah Lake, in Utah, and Tulare Lake, California.

(3) Where the streams run deep in the ground at all stages, and the agricultural lands adjoining are on mesas, at varying heights of from 20 to 100 feet.

(4) Where the level of water in running streams varies greatly at flood tide and low water, the valleys being narrow and the streams tortuous. (This condition necessitates the construction of small irrigation ditches. The fall of water in the streams, later in the season, leaves these ditches high above water.)

(5) In the lower valleys of the larger streams, like the South Platte, Arkansas, and Rio Grande, where the water is all used in upper ditches for the lands adjacent thereto.

(6) In many parts of the arid district, where there are no running streams on the surface, but where the under-flow from lost rivers and creeks, or the general under-drainage of storm-waters and mountain streams gives an ample supply near the surface.

FURTHER STATEMENT OF BENJAMIN H. EATON.

The **CHAIRMAN**. Do you wish to add anything to what you said this morning?

Mr. **EATON**. Yes. There seems to be a misunderstanding as to the increase of our water supply. By reservoirs and canals the whole of the Poudre River is held back. There is no doubt but that it is flowing a little more every year. One gentleman here said there was no more water than is enough to irrigate the land under cultivation. I know as much about it as he does, though I do not pretend to know any more. I built these ditches and I built the upper end of No. 2, and 5 miles out I dug a well 35 feet deep and could not get water to supply my camp. Now the water is running on the surface. Mr. La Grange dug down, I think, 33 feet before he got any water. You can now dip the water out of his well with a cup.

This Larimer & Weld canal is 50 miles long, and I tried at one time to get water along its line, but could not get it. I hired a man to dig wells along there and he did not find water. In this flat country that we have made these ditches over there is not any "wash" to amount to anything. There is a deposit. The earth above the hard pan that retains the water is from 50 to 60 feet. At Eaton at one time we dug 25 feet for water. Now it is only 15 feet to water. A seepage ditch, holding only the accumulated water of 3 miles, was sold for $5,000. I think it was worth double that sum.

By holding this water back, with the flow toward the east, it can not help but increase the irrigation to the extent of the water we have. After irrigation there comes seepage streams, and to my mind it will never be known to us how much water there is.

Senator **TELLER**. I would like to have the record show that Governor Eaton is a practical farmer.

The **CHAIRMAN**. Please state how much land you farm.

Mr. **EATON**. Eight thousand acres, by renting and what I farm myself.

Senator **TELLER**. You overlook and attend in all to 8,000 acres?

Mr. **EATON**. Yes.

Senator **TELLER**. That gives you a good opportunity to observe.

Mr. **EATON**. Yes.

STATEMENT OF B. S. LA GRANGE, OF GREELEY.

The **CHAIRMAN**. What is your occupation?

Mr. **LA GRANGE**. My original occupation is farming. I am also water commissioner on the Caché la Poudre. My principal occupation at present is water commissioner; distributing water in that district.

The **CHAIRMAN**. How long have you been engaged in agriculture in this vicinity?

Mr. **LA GRANGE**. Nineteen years.

The **CHAIRMAN**. What do you say is the duty of water? That is, what quantity of water is required in Greeley and vicinity to produce ordinary crops?

Mr. **LA GRANGE**. From 60 to 100 cubic feet per second per 80 acres for the season. I might explain why I make that difference of "60 to 100." Our soil is so variable that in the different localities even on the same farm there is a vast difference in the duty of water. Where we have a soil that is 60 per cent. sand it takes more water to do duty in growing the crop than it does when the soil has a less quantity of sand.

The CHAIRMAN. Is that much water used and consumed in plant growth and evaporation?

Mr. LA GRANGE. To some extent.

The CHAIRMAN. Is it all used?

Mr. LA GRANGE. No.

The CHAIRMAN. What proportion is not consumed and what becomes of the water that is not so consumed?

Mr. LA GRANGE. The earth becomes infiltrated with it.

The CHAIRMAN. Does it show itself anywhere?

Mr. LA GRANGE. It shows itself along the margins of the streams, when it is returned to the streams again.

The CHAIRMAN. What has it produced along the margins of streams?

Mr. LA GRANGE. Increased soil.

The CHAIRMAN. Has it produced swamps?

Mr. LA GRANGE. I do not know exactly the acreage along our irrigation district.

The CHAIRMAN. I am not asking for exact acreage, but whether there is more or less swamp ground on the lower bottoms in consequence of irrigation?

Mr. LA GRANGE. On the Caché la Poudre it goes pretty nearly the entire length of the interval lands along the bottoms. Wherever irrigation is practiced, there is found made soil.

The CHAIRMAN. The low bottoms nearly the whole length are mud swamps.

Mr. LA GRANGE. Yes.

The CHAIRMAN. What is necessary to reclaim them?

Mr. LA GRANGE. Drainage.

The CHAIRMAN. Does this drainage furnish any accumulation of water that could be used for further irrigation?

Mr. LA GRANGE. It does.

The CHAIRMAN. How does the seepage from the water that is not consumed by irrigation show in the stream?

Mr. LA GRANGE. By an increased supply in the stream below.

The CHAIRMAN. How does the Caché la Poudre compare below Greeley, say 5 miles, with what it was before any water was taken out and used, during the dry season, I mean?

Mr. LA GRANGE. We have measured it, and the quantity of water is increased 87 cubic feet per second in the very dry season. It is so today.

The CHAIRMAN. It has increased in the stream below the irrigation?

Mr. LA GRANGE. Yes.

The CHAIRMAN. How far down does that increase manifest itself?

Mr. LA GRANGE. About 2½ miles below Greeley, according to our last observations.

The CHAIRMAN. There is more water in the Caché la Poudre below the irrigated district in the dry season than there was before irrigation commenced there?

Mr. LA GRANGE. Yes.

The CHAIRMAN. How is it as to the water coming to the surface; is the country irrigated nearer the surface than when you began irrigating?

Mr. LA GRANGE. It is.

The CHAIRMAN. How much nearer? How deep did you have to dig before irrigation commenced, and how deep do you have to dig now?

Mr. La Grange. It formerly varied from 12 to 40 feet. In the case of some of the old original wells, where it was 12 or 16 feet deep, you can now take water out with a bucket in your hand?

The Chairman. Then the earth has become filled with water?

Mr. La Grange. Yes.

The Chairman. Does it require as much water to irrigate, now that the earth is saturated, as it did then?

Mr. La Grange. Not so much in some places, but in others about the same.

The Chairman. No as much as you did the first year, of course?

Mr. La Grange. No.

The Chairman. Commencing with perhaps about the third year, there are some places that have not decreased the amount required, and some places that have, even since then?

Mr. La Grange. Yes.

The Chairman. Are they still decreasing the amount required each year?

Mr. La Grange. Yes.

The Chairman. What is your mode of distributing the water when there are various persons interested?

Mr. La Grange. We take the cubic foot as the unit of measure, and, under our laws, priority of appropriation gives the better right. There is decreed to each canal the amount of water necessary to be used upon the land.

The Chairman. Then you distribute the necessary amount of water according to the date of priority?

Mr. La Grange. Yes.

The Chairman. Have you adopted the plan of giving a certain amount, or giving on certain days, to one and then to another?

Mr. La Grange. Yes; notwithstanding the priority of appropriation, our people are so educated to the necessity of having service that they have left it to the commissioner to so rotate the water so as to get the highest duty and best service.

The Chairman. State how that will effect a better service.

Mr. La Grange. By running it on the plan of priority of appropriation strictly the water becomes lost, because our canals are of such great length that the amount appropriated for one canal is lost along the line.

By "bunching the canals," as it is called, we get a sufficient head to get a better duty.

The Chairman. That is, you get a sufficient amount of water to run down the ditch and do some good?

Mr. La Grange. Yes.

The Chairman. Whereas, if you distributed the water by priority, a ditch company would not have enough to do any good and yet would consume a great deal of water?

Mr. La Grange. Yes.

The Chairman. Would it not be much more economical if there were just two ditches, one on each side of the river, and no more, to carry the water and distribute it?

Mr. La Grange. Yes; that is one of the troubles of our early settlement.

The Chairman. Too many ditches?

Mr. La Grange. Too many ditches.

The Chairman. That wastes a great deal of water.

Mr. La Grange. Certainly. We have an illustration at Fort Collins. We have 16,000 acres there in cultivation. There are four lines of ditches running across. Two of them are nearly parallel, and in some cases these are not 200 feet apart. We have another up in the foot-hills.

The Chairman. All should have been carried to the upper ditch, you think?

Mr. La Grange. We could not very well have carried them to that ditch to get the best service. It is too high up, and we would have had to have two great lines of distributing mains along down. But it should have been differently arranged in the first instance.

The Chairman. The economy of water depends a good deal on having ditches located in the right place and carrying the water in the fewest number of ditches?

Mr. La Grange. Yes, that is one of the troubles we have. We have too many ditches for the area of land.

The Chairman. What is the best grade for a ditch?

Mr. La Grange. It depends on the character of the soil.

The Chairman. How is it in your locality?

Mr. La Grange. It depends there, too, upon the character of the soil From 2 to 4 feet to the mile on the average.

The Chairman. That depends something on the size of the ditch, too does it not?

Mr. La Grange. Yes; about 3 feet to the mile is about right?

The Chairman. In your small ditches or in the large ones.

Mr. La Grange. In the large ones.

The Chairman. That is ample?

Mr. La Grange. Yes.

The Chairman. Does it "wash?"

Mr. La Grange. Yes, in some localities, but not in other places. The usual grade on the large canals is about 2.40 feet per mile.

The Chairman. Is there much of the water wasted?

Mr. La Grange. Yes. The American people are all new to the subject of irrigation, and have not arrived at that stage of nice preparation of our soils with reference to getting at the highest duty of water. I am aware of this fact: That in Caché la Poudre Basin we could do double the duty of water with our present flow, taking an average of five or six years.

The Chairman. Without storage or anything else of that sort?

Mr. La Grange. Yes.

The Chairman. Merely by economic use?

Mr. La Grange. Yes, merely by economic use.

The Chairman. With storage, then, you could increase that still further. Could you not do that by saving the waste water from running off?

Mr. La Grange. We have, on that water-shed, been taking observations now for six years, and with a storage systematized in a proper way we could treble our irrigation.

The Chairman. How much land have you there?

Mr. La Grange. About 225,000 acres irrigated.

The Chairman. With economy of water, without storage, could that be increased?

Mr. La Grange. Nearly double.

The Chairman. With storage how much could it be increased?

Mr. La Grange. I am satisfied that with the proper storage system we could readily irrigate from 600,000 to 800,000 acres.

The CHAIRMAN. Of course that would involve having proper ditches and economizing the water?

Mr. LA GRANGE. Yes.

The CHAIRMAN. Is it better to irrigate near the mountains than far away on the plains?

Mr. LA GRANGE. It is better to get near the mountains.

The CHAIRMAN. Why?

Mr. LA GRANGE. On account of the loss, by escape, in the transportation such a very long distance.

The CHAIRMAN. What produces the loss?

Mr. LA GRANGE. Filtration, principally.

The CHAIRMAN. What else?

Mr. LA GRANGE. Evaporation to some extent, but that is comparatively small.

The CHAIRMAN. What is the loss in a ditch of the size you have there?

Mr. LA GRANGE. We have 35-feet ditches.

The CHAIAMAN. That is, 35 feet on the bottom?

Mr. LA GRANGE. Yes.

The CHAIRMAN. How deep?

Mr. LA GRANGE. From 5 to 6 feet.

The CHAIRMAN. With a fall of from 2.40 feet to 3 feet to the mile, what would be the probable loss of running water in a ditch over that country, say 20 miles?

Mr. LA GRANGE. From 15 to 25 per cent. It depends upon the kind of soil we are running over.

The CHAIRMAN. You think it would make that difference in 20 miles of length?

Mr. LA GRANGE. I think I would make the distance 40 miles.

Director POWELL. Suppose you should change the section of your ditches in this country, what would the effect be? You have wide and shallow ditches which require a great declivity—a high grade. Suppose you change that and have a rounded bottom instead of a flat bottom, and increase the depth of your ditches two or three fold, what effect would that have on the conservation of the water?

Mr. LA GRANGE. If the conditions of the water were all the same as they are now, it would decrease the loss and get a more rapid discharge at the end of the ditch, or at any given point along it. But after we have made these flat bottoms, by use they get a subgrade fixed by themselves.

Director POWELL. They cut out themselves?

Mr. LA GRANGE. Yes.

The CHAIRMAN. They cut out and round out.

Mr. LA GRANGE. Yes; nature always fixes those things.

Director POWELL. When you open your ditches at the commencement of the irrigating season—that is, each time you open them—a large body of water is absorbed before the water can get to the foot of the ditch. Is that not the fact?

Mr. LA GRANGE. It is.

Director POWELL. Have you anything to suggest as to how that loss could be prevented?

Mr. LA GRANGE. I could not suggest anything now as to that. The percentage of loss will vary more or less in accordance with the head that you put in at the time. When I want to let water down through the ditch, to be let out by the main stream,, I get the ditch two-thirds full; that will run through in thirty hours, whereas, if I take half of that quantity it will be possibly sixty hours. That percentage of loss will vary according to the size of the head and the condition of the ditch. It varies also with the seasons. Atmospheric conditions have much to do with it.

Director POWELL. Have you, in your community, ever thought of lining your ditches by silting with gypsum or any heavy material which would be impervious to water?

Mr. LA GRANGE. We will do that when we get better off, and get a more dense population, so that we can stand it.

Director POWELL. I mean lining by silting and not by masonry.

Mr. LA GRANGE. I understand. When we first put the water in the Caché la Poudre, No. 2 ditch, in 1872, it ran down 6 miles and sunk. It ran very nearly a week. Our mountain streams, when rising, bring down a vast amount of stuff caused by erosion and it silts the ditch. The ditches do silt up and become comparatively tight.

Director POWELL. You have a very great variety of material in your region. Have your people thought of some material which you could powder and float down, which would have that same effect, only to do the thing more thoroughly?

Mr. LA GRANGE. Yes; we have large bodies of gypsum right near Fort Collins and north of there, which if powdered up and properly applied to our canals would prevent large wastage of water, just the gypsum itself.

The CHAIRMAN: How do you communicate with the different points where the water is to be let out?

Mr. LA GRANGE. We have a man at the head-gate, and he is in communication by telephone with the central office. That system is now about completed.

The CHAIRMAN. What are the advantages of that?

Mr. La GRANGE. In order to distribute the water, we must know what definite quantity we have to deal with, so we telephone to the head-gate man.

Adjourned.

CONSTITUTION AND LAWS OF COLORADO—PROVISIONS RELATING TO WATER RIGHTS.

PRIORITIES AND RIGHTS THEREUNDER.

[Constitution, Art. XVI.]

Sec. 5. Water Public Property.]

The water of every natural stream not heretofore appropriated, within the State of Colorado, is hereby declared to be the property of the public, and is dedicated to the use of the people of the State, subject to appropriation as hereinafter provided.

Sec. 6. Diverting Unappropriated Water—Priority.]

The right to divert unappropriated waters of every natural stream for beneficial uses shall never be denied. Priority of appropriation shall give the better right, as between those using the water for the same purpose; but when the waters of any natural stream are not sufficient for the service of all those desiring the use of the same, those using the water for domestic purposes shall have the preference over those claiming for any other purpose, and those using the water for agricultural purposes shall have the preference over those using the same for manufacturing purposes.

RIGHT OF WAY AND SERVITUDE.

Art. II, Sec. 14. When Private Property may be taken for Private Uses.]

Private property shall not be taken for private use unless by consent of the owner, except for private ways of necessity, and except for reservoirs, drains, flumes, or ditches, on or across the lands of others, for agricultural, mining, milling, domestic, or sanitary purposes.

Art. II, Sec. 15. Compensation for Property taken.]

Private property shall not be taken or damaged for public or private use without just compensation. Such compensation shall be ascertained by a board of commissioners of not less than three freeholders, or by a jury when required by the owner of the property. in such manner as may be prescribed by law, and until the same shall be paid to the owner. or into court for the owner, the property shall not be needlessly disturbed, or the proprietary rights of the owner therein invested [divested]; and whenever an attempt is made to take private property for a use alleged to be public, the question whether the contemplated use be really public shall be a judicial question, and determined as such without regard to any legislative assertion that the use is public.

Art. XVI, Sec. 7. Right of Way for Ditches, etc.]

All persons and corporations shall have the right of way across public, private, and corporate lands for the construction of ditches, canals, and flumes, for the purpose of conveying water for domestic purposes, for the irrigation of agricultural lands, and for mining and manufacturing purposes, and for drainage, upon payment of just compensation.

Art. XVI, Sec. 8. County Commissioners fix Rates for Water.]

The general assembly shall provide by law that the board of county commissioners in their respective counties shall have power, when application is made to them by either party interested, to establish reasonable maximum rates to be charged for use of water whether furnished by individuals or corporations.

Art. X, Sec. 3. When Free from Taxation.]

Ditches, canals, and flumes owned and used by individuals or corporations for irrigating lands owned by such individuals or corporations, or the individual members thereof, shall not be separately taxed so long as they shall be owned and used exclusively for such purposes.

WATER AND IRRIGATION PROVISIONS IN STATUTES OF COLORADO.

General Statutes, 1711, (1861). Owners of Land on Streams Entitled to Use of Water.]

All persons who claim, own, or hold a possessory right or title to any land or parcel of land lying within the boundary of the State of Colorado, as defined in the constitution of said State, when those claims are on the bank, margin, or neighborhood of any stream of water, creek, or river, shall be entitled to the use of the water of said stream, creek, or river, for the purpose of irrigation and making said claims available to the full extent of the soil, for agricultural purposes.

1729. Vested Rights of Mill and Ditch Owners.]

Nothing in this chapter contained shall be so construed as to impair the prior vested rights of any mill or ditch owner or other person to use the water of any such water course.

Under the provisions of this act [*eminent domain*] private property may be taken for private use for private ways of necessity, for reservoirs, drains, flumes, or ditches on or across the land of others for agricultural, mining, milling, domestic, or sanitary purposes. (Session Laws of 1885, pp. 201, 202.)

PRIORITY—HOW SECURED.

1730. New Ditches—Sworn statement must be filed—Contents—Maps.]

Every person, association, or corporation hereafter constructing or enlarging any ditch, canal, or feeder for any reservoir, for irrigation, and taking water directly from any natural stream, and of a carrying capacity of one cubic foot per second of time, as so constructed or enlarged, shall within ninety days after the commencement of such construction or enlargement, file and cause to be recorded in the office of the county clerk of the county in which such ditch, canal, or feeder may be situated, or if such canal, ditch, or feeder be situated in any water district, in the office of the county clerk of such [each] county in which such water district may extend, a sworn statement in writing, showing the name of such ditch, canal, or of the reservoir supplied by such feeder, the point at which the head-gate thereof is situated (if it be a new construction), the size of the ditch, canal, or feeder, in width and depth, and the carrying capacity thereof in cubic feet per second, the description of the line thereof, and the time when the work was commenced, and the name or names of the owner or owners thereof, together with a map showing the route thereof, the legal subdivisions of the land, if on surveyed lands, with proper corners and distances, and in case of an enlargement, the depth and width, also the carrying capacity of the ditch enlarged, with the width and depth of the ditch, canal, or feeder as enlarged, and the increased carrying capacity of the same thereby occasioned, and the time when such enlargement was commenced, and no priority of right for any purpose shall attach to any such construction or enlargement until record is made. (Sec. 2, p. 162, acts 1881.)

1721.]

This act shall apply to and affect only ditches, canals, or feeders used for carrying water for the purposes of irrigation and for no other purposes whatever. (Sec. 3, p. 162, Acts 1881.)

814. Shall Commence Work in Ninety Days—Complete in Three Years—Forfeit.]

Any company formed under the provisions of this (corporations) act, for the purpose of constructing any ditch, flume, * * * shall, within ninety days from the date of their certificate, commence work on such ditch, flume * * * line as shall be named in the certificate, and shall prosecute the work with due diligence until the same is completed, and the time of completion of any such ditch * * * line shall not be extended beyond a period of two years from the time work was commenced as aforesaid; and any company failing to commence work within ninety days from the date of the certificate, or failing to complete the same within two years from the time of commencement as aforesaid, shall forfeit all right to the water so claimed, and the same shall be subject to be claimed by any other company; the time for the completion of any flume constructed under the provisions of this act shall not be extended beyond a period of four years: *Provided*, This section shall not apply to any ditch or flume * * * constructed through and upon any grounds owned by the corporation: *And provided further*, That any company formed under the provisions of this act to construct a ditch for domestic, agricultural, irrigating * * * purposes, or any or either thereof, shall have three years from the time of commencing work thereon within which to complete the same, but no longer. (Sec. 296 (106) pp. 179–80, G. L.)

1727. Wheels, etc., on Streams.]

All persons on the margin, brink, neighborhood, or precinct of any stream of water shall have the right and power to place upon the bank of said stream a wheel or other machine for the purpose of raising water to the level required for the purpose of irrigation. (Sec. 8, pp. 68–69, Acts 1861; sec. 6, p. 364, R. S.; sec. 1377 (6) p. 516, G. L.)

1728. Irrigation of Meadows.]

All persons who shall have enjoyed the use of the water in any natural stream, for the irrigation of any meadow land, by the natural overflow or operation of the water of such stream, shall, in case the diminishing of the water supplied from such stream from any cause prevents such irrigation therefrom in as ample a manner as formerly, have right to construct a ditch for the irrigation of such meadow, and to take water from such stream therefor, and his, her or their right to water through such ditch shall have the same priority as though such ditch had been constructed at the time he, she or they first occupied and used such land as meadow ground. (Sec. 37, p. 106, Acts 1879.)

1719. Extending Head of Ditch Up Stream.]

In case the channel of any natural stream shall become so cut out, lowered, turned aside or otherwise changed from any cause as to prevent any ditch, canal, or feeder of any reservoir from receiving the proper inflow of water to which it may be entitled from such natural stream, the owner or owners of such ditch, canal, or feeder shall have the right to extend the head of such ditch, canal, or feeder to such distance up the stream which supplies the same, as may be necessary for securing a sufficient flow of water into the same, and for that purpose shall have the same right to maintain proceedings for condemnation of right of way for such extension as in case of constructing a new ditch, and the priority of right to take water from such stream through such ditch, canal, or feeder, as to any such ditch, canal, or feeder, shall remain unaffected in any respect by reason of such extension: *Provided, however*, That no such extension shall interfere with the complete use or enjoyment of any other ditch, canal, or feeder. (Sec. 1, pp. 161, 162, Acts 1881.)

1762. Jurisdiction of Courts. How Vested.]

For the purpose of hearing, adjudicating, and settling all questions concerning the priority of appropriation of water between ditch companies and other owners of ditches drawing water for irrigation purposes from the same stream or its tributaries within the same water district, and all other questions of law and questions of right growing out of or in any way involved or connected therewith, jurisdiction is hereby vested exclusively in the district court of the proper county; but when any water district shall extend into two or more counties, the district court of the county in which the first regular term after the first day of December in each year shall soonest occur, according to the law then in force, shall be the proper court in which the proceedings for said purpose, as hereinafter provided for, shall be commenced; but where said proceedings shall be once commenced, by the entry of an order appointing a referee in the manner and for the purpose hereinafter in this act provided, such court shall thereafter retain exclusive jurisdiction of the whole subject until final adjudication thereof is had, notwithstanding any law to the contrary now in force. (Sec. 19, pp. 99–100, Acts 1879.)

1763. Filing Statements of Claim—Ditch, Name, Description—Post-Office Address.]

In order that all parties may be protected in their lawful rights to the use of water for irrigation, every person, association, or corporation owning or claiming any interest in any ditch, canal, or reservoir, within any water district, shall, on or before the 1st day of June, A. D. 1881, file with the clerk of the district court having jurisdiction of priority of right to the use of water for irrigation in such water district, a statement of claim, under oath, entitled of the proper court, and in the matter of priorties of water rights in district number * * *, as the case may be, which statement shall contain the name or names, together with the post-office address of the claimant or claimants claiming ownership, as aforesaid, of any such ditch, canal, or reservoir, the name thereof (if any), and, if without a name, the owner or owners shall choose and adopt a name, to be therein stated, by which such ditch, canal, or reservoir shall thereafter be known, the description of such ditch, canal, or reservoir, as to location of head-gate, general course of ditch, the name of the natural stream from which such ditch, canal, or reservoir draws its supply of water, the length, width, depth, and grade thereof, as near as may be, the time, fixing a day, month and year as the date of the appropriation of water by original construction, also by any enlargement or extension, if any such thereof may have been made, and the amount of water claimed by or under such construction, enlargement, or extension, and the present capacity of the ditch, canal, or feeder of reservoir, and also the number of acres of land lying under and being or proposed to be irrigated by water from such ditch, canal, or reservoir. Said statement shall be signed by the proper party or parties. (Sec. 1, pp. 142, 143, Acts 1881.)

1764. Secretary of State Shall Make Publication—Publisher's Certificate.]

The secretary of state shall, without delay, after the passage of this act, cause a certified copy of the foregoing section, giving the date of the approval of this act, to be published in one of the public newspapers published in such county in which part or portion of any water district is or shall be established by law at the time of such publication; and said section 1 shall be published, as aforesaid, once in each and every week continuously in said paper until said 1st day of June, 1881, and in case in the meantime any one of said papers shall cease to be published, then such publication shall be made in some other paper in same county (if any), and on conclusion of such publication such publisher of such paper shall deliver to the secretary of state his sworn certificate of publication in duplicate, showing that such publication has been made in his paper in compliance with the preceding section hereof, and stating the first and last day of such publication; and he shall thereupon be entitled to receive from the secretary of state a certificate of the amount due him for such publication, on presentation of which to the auditor of state, he shall draw his warrant for the amount in favor of the holder on the state treasurer, who shall pay the same according to law. (Sec. 2, pp. 143, 144, Acts 1881.)

When at any time after the 1st day of June, A. D. 1881, any one or more persons, associations, or corporations, interested as owners of any ditch, canal, or reservoir in any water district shall present to the district court of any county having jurisdiction of priority of rights to the use of water for irrigation in such water district according to the provisions of (sec. 19, G. S., 1762) an act entitled an act to regulate the use of water for irrigation and providing for settling the priority of rights thereto, and for payment of the expenses thereof, and for payment of all costs and expenses incident to said regulation of use, or to the judge thereof in vacation, a motion, petition, or application in writing, moving or praying said court to proceed to an adjudication of the priorities of rights to use of water for irrigation between the several ditches, canals, and reservoirs in such district, the court, or judge thereof in vacation, shall, without unnecessary delay, in case he shall deem it practicable to proceed in open court, as prayed for, by an order to be entered of record upon such motion, petition, or application, appoint a day in some regular or special term of said court for commencing to hear and take evidence in such adjudication, at which time it shall be the duty of the court to proceed to hear all evidence which may be offered by or on behalf of any person, association, or corporation interested in any ditch, canal, or reservoir in such district, either as owner or consumer of water therefrom, in support of or against any claim or claims of priority of appropriation of water made by means of any ditch, canal, or reservoir, or by any enlargement or extension thereof, in such district, and consider all such evidence, together with any and all evidence, if any, which may have been heretofore offered and taken in such district in the same matter by any referee heretofore appointed under the provisions of said act above herein mentioned, and also the arguments of parties or their counsel, and shall ascertain and find from such evidence, as near as may be, the date of the commencement of such ditch, canal, or reservoir, together with the original size and carrying capacity thereof as originally constructed, the time of the commencement of each enlargement or extension thereof, if any, with the increased capacity thereby occasioned, the time spent severally in such construction and enlargement, or extension and re-enlargement, if any, the diligence with which the work was in each case prosecuted, the nature of the work as to difficulty of construction, and all such other facts as may tend to show the compliance with the law, in acquiring the priority of right claimed for each such ditch, canal, or reservoir, and determine the matters put in evidence, and make and cause to be entered a decree determining and establishing the several priorities of right, by appropriation of water, of the several ditches, canals, and reservoir [reservoirs] in such water district, concerning which testimony shall have been offered, each according to the time of its said construction and enlargement or enlargements or extensions, with the amount of water which shall be held to have been appropriated by such construction and enlargements or extensions, describing such amount by cubic feet per second of time, if the evidence shall show sufficient data to ascertain such cubic feet, and if not, by width, depth, and grade, and such other description as will most certainly and conveniently show the amount of water intended as the capacity of such ditch, canal, or reservoir, in such decree. Said court shall further order that each and every party interested or claiming any such ditch, canal, or reservoir shall receive from the clerk, on payment of a reasonable fee therefor, to be fixed by the court, a certificate under seal of the court showing the date or dates and amount or amounts of appropriations adjudged in favor of such ditch, canal, or reservoir under and by virtue of the construction, extension, and enlargements thereof severally; also specifying the number of said ditch and of each priority to which the same may be entitled by reason of such construction, extension, and enlargements. (Sec. 4, pp. 144-5-6, Acts 1881.)

1767. Copy of Decree—Authority of Commissioner—Recording Copy—Evidence.]

The holder of such certificate shall exhibit the same to the water commissioner of the district when he commences the exercise of his duties, and such water commissioner shall keep a book in which shall be entered a brief statement of the contents of such certificate, and which shall be delivered to his successor, and said certificate, or statement thereof in his book, shall be the warrant of authority to said water commissioner for regulating the flow of water in relation to such ditch, canal, or reservoir. Said certificate shall be recorded, at the same rates of charges as in cases of deeds of conveyance, in the records of each county into which the ditch, canal, or reservoir to which such certificates relates shall extend; and said certificate, or said record thereof, or a duly certified copy of such record, shall be prima facie evidence of so much of said decree as shall be recited therein in any suit or proceeding in which the same may be relevant. (Sec. 5, pp. 146-7, Acts 1881.)

1768. Clerk Publish Notice—Post Copy—Ten Copies Posted by Party Petitioning.]

Notice shall be given by the clerk of said court of the time so appointed by publishing the same in one public newspaper in such county into which such water district may extend, which notice shall be so published in such paper once in each week until four successive weekly publications shall have been made, the last of which shall be on a day previous to the day appointed as aforesaid. Said notice shall contain a copy of said order, and shall notify all persons, associations, and corporations interested as owners in any ditch, canal, or reservoir in such water district to appear at said court at the time so appointed and file a statement of claim under oath, in case no statement has been before filed by him, her, or them, showing the ditch, canal, or reservoir, or two or more such, in which he, she, or they claim an interest, together with the names of all the owners thereof, which statement may be made by any one of the owners of such ditch, canal, or reservoir for and in behalf of all; and also that all persons interested as owners or consumers may then and there present his, her, or their proofs for or against any priority of right of water by appropriation sought to be shown by any party by or through any such ditch, canal, or reservoir (either as owner or consumer of water drawn therefrom). Ten printed copies of said notice shall also be posted in ten public places in such water district not less than twenty days before the day so appointed, which copies shall be so posted by the party or parties moving the adjudication. (Sec. 6, p. 147, Acts 1881.)

1769. Proof of Publication—Of Posting Copies—Entry by Clerk.]

Proof of the proper publication of said notice or notices in said public papers shall consist in such case of the sworn certificate of the publisher of such newspaper, showing the publication to have been made in accordance with the provisions of section 3 of this act, which certificates shall be procured by the party or parties moving the adjudication at his or their expense, and on said certificate being filed the clerk shall enter the amount of the printer's fee therefor as costs advanced by the party procuring the same, which sum shall be counted to his, her, or their credit in distribution of costs. Proof of the posting of said printed copies shall be made by the affidavit of some credible person, certified to be such by the clerk or other officer administering the oath, showing when, where, and how said copies were posted. (Sec. 7, pp. 147-8, Acts 1881.)

1770. Notices Served on all Parties—How Served—Notice by Mail.]

The party or parties moving such adjudication shall cause a printed or written copy of the notice aforesaid, published as aforesaid, to be served on every person, association, or corporation shown by the statement of claim on file, as provided in section 1 hereof, which service shall be made within ten days from the time of the first publication by the clerk, by any credible person certified by said clerk or referee to be such, by delivering such copy as aforesaid to the person to be served, if such person by due diligence can be found in the county of his residence. If such person can not be found, as aforesaid, then by leaving such copy at his or her usual place of residence, if he or she have such residence, in charge of some person of the age of fourteen years or over there residing; and on any corporation by delivering the copy to the president, or vice-president, or secretary, or treasurer thereof, or the manager or superintendent in charge of their ditch, canal, or reservoir, or authorized agent or attorney, or by leaving such copy at the office or usual place of business of such corporation, and the proof of such service shall be made by affidavit of the person or persons serving said copies, showing when and how such service has been made on such party. In case of parties not served in any manner as aforesaid the clerk shall deposit in the post-office, duly inclosed in an envelope with the proper postage stamp thereon, a copy directed to the address of such party, shown in the statement of claim aforesaid, filed by him or her under section one hereof. (Sec. 8, pp. 148-9, Acts 1881.)

1771. Court Numbers all Ditches—Reservoirs—Number Appropriations.]

The court, in making such decree, as aforesaid, shall number the several ditches and canals in the water district concerning which adjudication is made in consecutive order, according to priority of appropriation of water thereby made by the original construction thereof, as near as may be, having reference to the date of each decree as rendered, and shall also number the reservoirs in like manner separately from ditches and canals, and shall further number each several appropriation of water consecutively, beginning with the oldest appropriation, without respect to the ditches or reservoirs by means of which such appropriations were made; whether such appropriation shall have been made by means of construction, extension, or enlargement, which number of each ditch, canal, or reservoir, together with the number or numbers of any appropriations of water held to have been made by means of the construction, extension, or enlargement thereof, shall be incorporated in said decree and certificate of the clerk, to be issued to the claimants, as provided in section 1 of this act, so as to show the order in priority of such ditch or canal; and of such reservoir, and also of such successive appropriation of water pertaining thereto, for the information of the water commissioner of the district in distributing water, such numbering to be as near as may be having reference to date of decrees as rendered. (Sec. 9, p. 149, Acts 1881.)

1772. When Court may Appoint Referee—What Referred.]

If for any cause the judge of said court shall deem it impracticable or inexpedient to proceed to hear such evidence in open court, he shall, instead of the order mentioned in section 4 of this act, make and cause to be entered of record an order appointing some discreet person, properly qualified, a referee of said court, to whom shall be referred the statement of claim aforesaid on file in said matter, the matter of taking evidence and reporting the same, making an abstract and findings upon the same, and preparing a decree in said adjudication; and also in case of any water district in which a referee has been heretofore appointed, and evidence taken by him under the provisions of the act, the title of which is recited in section 4 of this act; such evidence so already taken, together with the abstract thereof and report of the referee who took the same, shall be also referred to said referee, to be appointed as aforesaid, and he shall proceed with his duties as hereinafter provided, first taking an oath [of] office, such as is required to be taken by referees in other cases under the provisions of the code of civil procedure. (Sec. 10, pp. 149-50, Acts 1881.)

1773. Contents of Notice—How Published—Posting Copies.]

Said referee shall prepare and publish a notice containing a copy of the order appointing him, in which notice he shall appoint a time or times and place or places suitable and convenient for the claimants in such water district at which he will attend for the purpose of hearing and taking evidence touching the priority of right of the several ditches, canals, and reservoirs in said district, and notifying all persons, associations, and corporations interested as owners or consumers of waters [water] to attend by themselves, their agents, or attorneys, at the times and places appointed in said notice, and notifying such owners to then and there file a statement of claim in case such statement has not been already filed under the provisions of section 1 hereof, such as mentioned in section 6 hereof, and present their proofs touching any priority of right claimed by them for any ditch, canal, or reservoir in said district, which notice shall be published in same manner and times and in all respects according to the provisions for publication of the newspaper notices mentioned in section 6 of this act, and proof of such publication shall be made in the same manner as is provided in section 7 of this act; and he shall also post ten or more printed copies of such notice in ten or more public places in said district, which copies shall be so posted at least twenty days before the time of commencing to take said evidence. (Sec. 11, p. 150, Acts 1881.)

Proof of the posting of said copies shall be made by the affidavit of said referee or other person certified by him to be a credible witness, which shall show when, where, and how the said copies were posted, and shall be filed by him with his report. (Sec. 12, p. 151, Acts 1881.)

1775. Who May Offer Evidence—Former Evidence.]

Said referee shall attend at the times and places mentioned in his said notice, for the purpose therein mentioned; and all persons, associations, choosing to do so, and being interested as owners of or consumers of water from any ditch, canal, or reservoir in said district, and may also attend by themselves, their agents or attorneys, before said referee, at some one or more of said times and places so appointed, and shall have right to offer any and all evidence they may think advisable for their interests in the matter to be adjudicated, as well in districts in which evidence has been heretofore taken as in other districts. All such evidence as has been heretofore taken, if any, in such district, shall be kept present by said referee, subject to inspection by any party desiring to examine the same for purposes of the investigation. (Sec. 13, p. 151, Acts 1881.)

1776. Powers and Duties of Referee—Books and Records—Evidence.]

Said referee shall have power to administer oaths to all witnesses, and to issue subpœnas for witnesses and subpœnas *duces tecum*, which subpœnas may be served by any party, or constable, or sheriff, or deputy sheriff, and may require witnesses to appear at any of the places appointed by said referee for taking evidence. He shall permit all witnesses to be examined by the parties calling them respectively and to be cross-examined by any party interested, and he shall take all testimony in writing and note all objections offered to any part of the testimony taken, with the cause assigned for the objection, and shall proceed in all other respects as in case of taking depositions. He shall certify all books and papers offered by any one in his own behalf, and preserve them with the testimony offered concerning the same, and in case of books and papers offered in evidence, which shall not be under the control of the party desiring the evidence for which such books may be offered, said referee shall make a true copy of the parts demanded and certify the same, and preserve the same, together with the evidence offered concerning the same and concerning said books and papers, as part of the evidence in the matter. (Sec. 14, pp. 151-2, Acts 1881.)

1777. Refusal to Produce Books or Papers—Effect.]

No person, association or corporation willfully refusing to produce any book or paper, if in his or their power to do so, when rightfully demanded for examination and copying, shall be allowed the benefit of any testimony or proofs in his, her, or their behalf, in making final adjudication, if the court shall be satisfied, from all the evidence shown concerning such refusal, that the same was willful. (Sec. 15, p. 152, Acts 1881.)

1778. What Facts to be Ascertained by Proofs.]

Said referee shall also examine all witnesses to his own satisfaction, touching any point involved in the matter in question, and shall ascertain as far as possible the date of the commencement of each ditch, canal, or reservoir, with the original size and carrying capacity thereof, the time of the commencement of each enlargement thereof, with the increased carrying capacity thereby occasioned, the length of time spent in such construction or enlargement, the diligence with which the work was prosecuted, the nature of the work as to difficulty of construction, and all such other facts as may tend to show compliance with the law in acquiring the priority of right claimed for such ditch, canal, or reservoir; and upon all the facts so obtained shall be determined the relative priorities among the several ditches, canals, and reservoirs, the volume or amount of water lawfully appropriated by each, as well as by means of the construction, as by the enlargements thereof, and the time when each such several appropriations took effect. (Sec. 16, p. 152, Acts 1881.)

1779. Disturbing Proceedings—Penalty.]

Every person present before said referee at any time when he shall be engaged in hearing testimony, who shall willfully disturb the proceedings; and every person who shall willfully refuse or neglect to obey any subpœna issued by said referee, when his lawful fees shall be tendered him for his attendance before the referee, shall be guilty of contempt of the court appointing such referee, and on complaint, under oath of the referee or other person, before the said district court, or judge thereof in vacation, may be brought before the court or judge and dealt with accordingly. (Sec. 17, pp. 152-3, Acts 1881.)

1780. Fees of Witnesses—By Whom Paid.]

Every witness who shall attend before said referee under subpœna, by request of any party, shall be entitled to the same fees and mileage as witnesses before the district court in the county in which he shall so attend, and shall be paid by the party requiring his testimony. (Sec. 18, p. 153, Acts 1881.)

1781. Duties of Referee—Rights of Parties—Adjournment—Notice.]

The said referee shall take all the testimony offered, and for that purpose shall give reasonable opportunity to all parties to be heard, and may at any place, when the time limited thereat shall expire, adjourn the further taking of testimony then proposed or desired to be offered to the next place in order according to his said published appointments, and at the last place may continue until all testimony shall be taken or make furthur appointments at any former place or places as may seem best and most convenient for all parties, giving reasonable notice thereof. (Sec. 19, p. 153, Acts 1881.)

1782. Referee Shall Examine all Testimony—Numbering—Findings—Decree.]

Said referee, upon closing the testimony, shall proceed to carefully examine the same, together with all testimony and proofs which may have been heretofore taken by any former referee in the same district, if any such shall have been taken under the provisions of said act, the title of which is recited in section 4 of this act; he shall make an abstract of all the testimony and proofs in his possession concerning each ditch, canal, and reservoir separately, and shall number each ditch and canal in order, and likewise each reservoir, each class consecutively, and also number the several appropriations of water shown by the evidence, all in manner and form as provided in section 9 hereof, and shall make a separate finding of all the facts connected with each ditch, canal, and reservoir, touching which evidence shall have been offered; and he shall prepare a draught of a decree in accordance with his said findings, in substance the same as the decree mentioned in section four of this act, and conformable also to the provisions of section 9 hereof, so far as the same are applicable, which decree, so prepared by him, shall be returned with his report to the court, and he shall file his report with said evidence, abstract, and findings, and said decree, with the clerk of the court, and inform the judge of so doing without delay. (Sec. 20, pp. 153-4, Acts 1881.)

1783. Filing Report—Court Proceed to Determine—Exceptions—Approval—Entry.]

Upon the filing of said report the court, or judge thereof in vacation, shall cause an order to be entered setting some day in a regular or special term of said court as soon as practicable, when the court will proceed to hear and determine the report, at which time any party interested may appear, himself or counsel, and move exceptions to any matter in the findings or decree made by said referee, and after hearing the same the court shall, if the decree reported be approved, cause the same to be entered of record, or otherwise such modifications thereof, or other decree as shall be found just and conformable to the evidence and the true intent of this act, and to so much of any and all former laws of the State as shall be adjudged consistent herewith. (Sec. 21, p. 154, Acts 1881.)

1784. Failure to Offer Evidence—Water Commissioner Disregard Claims until, etc.—Party obtain Decree and present Certificate.]

No claim of priority of any person, association or corporation, on account of any ditch, canal, or reservoir, as to which he, or she, or they, shall have failed or refused to offer evidence under any adjudication herein provided for, or heretofore provided by this act, the title of which is recited in section 4 hereof, shall be regarded by any water commissioner in distributing water in times of scarcity thereof, until such time as such party shall have by application to the court, having jurisdiction, obtained leave and made proof of the priority of right to which such ditch, canal, or reservoir shall be justly entitled, which leave shall be granted in all cases upon terms as to notice to other parties interested, and on payment of all costs, and upon affidavits or petition sworn to, showing the rights claimed, and the ditches, canals, and reservoirs, with the names of the owners thereof against which such priority is claimed, nor until a decree adjudging such priority to such ditch, canal, or reservoir has been entered, and certificate, such as mentioned in section 4 hereof, shall have been issued to claimant and presented to the water commissioner. (Sec. 22, pp. 154-5, Acts 1881.)

1785. Rights of Parties against Referee for Neglect, Oppression, etc.]

Every party interested shall have the right to complain to the court of any act of willful neglect or oppression on the part of the said referee in exercising his powers under this act, whereby such party shall have been aggrieved, either by refusal of said referee to hear or take evidence offered, or by preventing reasonable opportunity to offer such evidence; and the court may order such proceedings in the premises as will give redress of the grievance, at the cost of said referee, if he appear willfully in fault; otherwise, in case of accident or mistake, costs shall be awarded as to the court shall seem just. (Sec. 23, p. 155, Acts 1881.)

1786. Power of Court to make just Rules—Law construed liberally.]

The district court, or judge thereof in vacation, shall have power to make all orders and rules consistent with this act which may be found necessary and expedient, from time to time during the progress of the case, for carrying out the intent of this act, and of all parts consistent therewith of the said act, the title of which is recited in section 4 hereof; as well as touching the proceedings in court as of the acts and doings of said referee, for the purpose of securing to any party aggrieved by the acts of said referee or any proceeding of the court, opportunity for redress; and this act shall be construed liberally in all courts, in favor of securing to all persons interested the just determination and protection of their rights. (Sec. 24, p. 155, Acts 1881.)

1787. Party must File Claim before offering Evidence.]

No persons, associations, or corporation representing any ditch, canal, or reservoir, shall be permitted to give or offer any evidence before said referee until he, she, or they shall have filed a statement of claim in substance the same in all respects as is required to be filed under the provisions of section 1 hereof. (Sec. 25, p. 155, Acts 1881.)

1788. Re-Argument—Review—Limitation two years.]

The district court, or judge thereof in vacation, shall have power to order, for good cause shown, and upon terms just to all parties, and in such a manner as may seem meet, a re-argument or review, with or without additional evidence, of any decree made under the provisions of this act, whenever said court or judge shall find from the cause shown for that purpose by any party or parties feeling aggrieved, that the ends of justice will be thereby promoted; but no such review or re-argument shall be ordered unless applied for by petition or otherwise within two years from the time of entering the decree complained of. (Sec. 26, p. 156, Acts 1881.)

1789. Who May Appeal—Statement—Approval—Contents—Order—Bond—Conditions.]

Any parties or parties representing any ditch, canal, or reservoir, or any number of parties representing two or more ditches, canals, or reservoirs, which are affected in common with each other by any portion of such decree, by which he or she or they may feel aggrieved, may have an appeal from said district court to the supreme court, and in such case the party or parties joining, desiring an appeal, shall be the appellants, and the parties representing any one or more ditches, canals, or reservoirs affecting in common adversely to the interests of appellants shall be the appellees. The party or parties joining in such appeal shall file a statement in writing, verified by affidavit properly entitled in such cause in the district court, which statement shall show that the appellants claim a valuable interest in the ditch, canal, or reservoir, or two or more of such, which are affected in common with each other by some portion of said decree; also stating the name or names, or otherwise the description of the same, and the name or names, or otherwise the description of any one or more other ditches, canals [or] reservoirs, which by said decree derive undue advantage in respect of priority as against that or those represented by appellants; and also setting forth the name or names of the party or parties claiming such other one or more ditches, canals or reservoirs, affected in common by said decree adversely to the interest of appellant or appellants, and praying that an appeal be allowed against such other parties as appellees. If the court or judge in vacation, on examination, find such statement in accordance with the statements of claim filed by the parties named as appellees, mentioned in section 1 of this act, he shall approve the same and make an order to be prepared and presented by the appellants allowing the appeal and showing the name or names of the appellants and appellees, with the name or names or description of the one or more ditches, canals or reservoirs claimed by the party or parties appellant and appellee, as shown by their several statements of claim filed as aforesaid, before the taking of testimony, and fix the amount of the appeal bond, which bond shall be executed by one or more of appellants, as principal or principals, and by sufficient securities, and approved by the court or judge in vacation, and shall be conditioned for the payment of all costs which may be awarded against the appellants or any of them in the supreme court. (Sec. 27, pp. 156-157, Acts 1881.)

1790. Copy of Order served on Appellees—Publication posting copies—Proof.]

The order last aforesaid shall be entered of record, and the appellant or appellants shall cause a certified copy thereof to be served on each of the appellees, by delivering the same to him or her, if he or she may be found, or otherwise serving the same in manner the same as may be at the time provided for serving summons from the district court by the laws then in force, and shall also cause the said order to be published in the same manner as the notices required to be published by the referee mentioned in section 11 of this act, and proof of the publication in any newspaper shall be the same as in case of said referee's notice, and proof of the posting of the ten printed copies in the district shall be by affidavit of the parties posting the same, with the certificate of the clerk of the district court appealed from, that the affiant is a known and credible person. (Sec. 28, p. 157, Acts 1881.)

1791. Transcript to be Filed in Six Months—Bill of Exceptions.]

The appellant or appellants shall file the transcript of record of the district court with the clerk of the supreme court at any time within six months after the appeal shall be allowed as aforesaid. Only so much of the decree appealed from, and so much of the evidence as shall affect the appropriations of water claimed by means of the construction or enlargement or re-enlargement of the several ditches, canals and reservoirs mentioned in the order allowing the appeal, need be copied into the bill of exceptions. (Sec. 29, pp. 157-158, Acts 1881.)

1792. Costs in Supreme Court.]

The supreme court, on dismissal of such appeal, or on affirming or reversing the parts of the decree appealed from, in whole or in part, shall award costs, as in its discretion shall be found and held to be equitable. (Sec. 30, p. 158, acts 1881.)

1793. Supreme Court amend or make new Decree, or remand with Instructions.]

The supreme court, in all cases in which judgment is rendered, and any part of the decree appealed from is reversed, and in which it may be practicable, shall make such decree in the matters involved in the appeal as should have been made by the district court, or direct in what manner the decree of that court should be amended. (Sec. 31, p. 158, Acts 1881.)

1794. Filing Proof of Service and Notice—Sixty Days—Supreme Court make Rules.]

The said proof of the service and publication of said order allowing the appeal shall be filed with the clerk of the supreme court within sixty days after the making of said order, and if not so filed the supreme court shall, on motion of the appellee or any of the appellees, at any time after such default in filing said proof, and before the said proof shall be filed, dismiss such appeal, and if the transcript of record be not filed within the time limited by section 29 of this act, such appeal shall, on motion, be dismissed. After the filing of the record and proof of service aforesaid the cause on appeal shall be proceeded with as the rules of the supreme court, or such special rules as said court may make in such cases, and their order from time to time thereunder may require. Said court shall have power to make any and all such rules concerning such appeals as may be necessary and expedient in furtherance of this act, as well as to preparation of the case for submission as to supplying deficiencies of record, if any, and for avoiding unnecessary costs and delay. (Sec. 32, p. 158, Acts 1881.)

1795. Court may Dismiss Referee—Vacancy—new Appointment.]

The district court, or judge thereof in vacation, in case of the death, resignation, illness, absence, or other disability of the referee hereby provided for, or for any misconduct in him, or other good cause to such judge appearing, shall appoint such other properly qualified person in his stead as he shall deem proper, who shall proceed without delay to perform all the duties of his office, as herein pointed out, which shall remain unperformed by his predecessor in office. (Sec. 33, p. 159, Acts 1881).

1796. Suits must be Brought in Four Years—Injunctions in what Cases—what Districts—Commissioner's Duty.]

Nothing in this act or in any decree rendered under the provisions thereof, shall prevent any person, association or corporation from bringing and maintaining any suit or action whatsoever hitherto allowed in any court having jurisdiction to determine any claim of priority of right to water, by appropriation thereof, for irrigation or other purposes, at any time within four years after the rendering of a final decree under this act in the water district in which such rights may be claimed, save that no writ of injuction shall issue in any case restraining the use of water for irrigation in any water district wherein such final decree shall have been rendered, which shall effect [affect] the distribution or use of water in any manner adversely to the rights determined and established by and under such decree, but injunctions may issue to restrain the use of any water in such district not affected by such decree, and restrain violations of any right thereby established, and the water commissioner of every district where such decree shall have been rendered shall continue to distribute water according to the rights of priority determined by such decree, notwithstanding any suits concerning water rights in such district, until in any suit between parties the priorities between them may be otherwise determined, and such water commissioner have official notice by order of the court or judge determining such priorities, which notice shall be in such form and so given as the said judge shall order. (Sec. 34, p. 159, Acts 1881).

1797. After Four Years Suit Barred.]

After the lapse of four years from the time of rendering a final decree in any water district, all parties whose interests are thereby affected shall be deemed and held to have acquiesced in the same, except in case of suits before then brought, and thereafter all persons shall be forever barred from setting up any claim to priority of rights to water for irrigation in such water district adverse or contrary to the effect of such decree. (Sec. 35, p. 160, Acts 1881).

1798. Compensation of Referee—how Paid—His Duty to keep Account.]

The referee appointed [as provided] in this act shall be paid the sum of $6 per day while engaged in discharging his duties as herein provided, and also his reasonable and necessary expenses and mileage at the rate of 10 cents for each mile actually and necessarily traveled by him in going and coming in the discharge of his duties as such referee, which said per diem allowance, expenses, and mileage shall be paid out of the treasury of the county in which such water district shall lie, if it be contained in one county, and if such water district shall extend into two or more counties, then in equal parts thereof, shall be paid out of the treasury of such county into which such district shall extend. He shall keep a just and true account of his services, expenses, and mileage, and present the same from time to time to the district court, or judge in vacation, verifying the same by oath, and the judge, if he find the same correct and just, shall certify his approval thereof thereon, and the same shall thereupon be allowed by the board of county commissioners of the county in which said water district shall lie, but if said [water district] extend into two or more counties, he shall receive from the clerk of the district court separate certificates under seal of the court, showing the amount due him from each county, upon which certificate the board of county commissioners of the respective counties shall allow the same on presentation thereof. (Sec. 36, p. 160, Acts 1881.)

1799. Repeal.]

All laws and parts of laws heretofore in existence inconsistent with the provisions of this act, shall be and the same are hereby repealed. (Sec. 37, p. 160, Acts 1881.)

1800. Sheriff not to Serve Writ outside his County.]

Nothing herein contained shall be construed to authorize any sheriff to serve any writ outside the limits of his own county, or give effect to any record by way of notice or otherwise, in any county other than that in which it belongs. (Sec. 35, p. 106, Acts 1879.)

1801. Fees of District Clerk—How Audited—Paid.]

The fees of the clerk of the district court for a service rendered under this act shall be paid by the counties interested in the same manner as the fees of the water commissioners, upon the said clerk rendering his account, certified by the district judge to the board or boards of county commissioners of said county or counties embracing the water district in case of which the services shall have been rendered. (Sec. 43, p. 108, Acts 1879.)

Session Laws, 1885. Evidence.]

Whenever testimony shall or may be taken in any district created by this act for the purpose of procuring a decree as to appropriation of water and priorities thereof, under the statutes of this State, any testimony therefore taken before any former referee may be introduced, and shall be received as evidence. (Sec. 28, p. 259.)

309. Right of Way—Of water—Crossing—Priority.]

Any ditch company formed under the provisions of this (corporations) act shall have the right of way over the line named in the certificate. (Sec. 275 (85), p. 171, G. L.)

1712. Right of Way of Owners near Streams.]

When any person owning claims in such locality (on the bank, margin, or neighborhood of any stream) has not sufficient length of area exposed to said stream to obtain a sufficient fall of water to irrigate his land, or that his farm or land used by him for agricultural purposes is too far removed from said stream, and that he has no water facilities on those lands, he shall be entitled to a right of way through the farms or tracts of lands which lie between him and said stream, or the farms or tracts of lands which lie above or below him on said stream, for the purposes hereinbefore stated. (Sec. 2, p. 67, acts 1861. Sec. 2, p. 362, R. S. Sec. 1373 (2), p. 515, G. S.)

1713. Extent of such Right of Way.]

Such right of way shall extend only to a ditch, dike, or cutting sufficient for the purpose required. (Sec. 3, p. 67, acts 1861. Sec. 3, p. 363, R. S. Sec. 1734 (3), p. 515, G. L.)

1715. Condemnation of Right of Way.]

Upon the refusal of the owners of tracts of land or lands through which said ditch is proposed to run to allow of its passage through their property the person or persons desiring to open such ditch may proceed to condemn and take the right of way therefor (under the provisions of the "Eminent Domain Act"). (Sec. 1376 (5), p. 516, G. L.)

1716. Only one Ditch if Practicable.]

No tract or parcel of improved or occupied land in this State shall, without the written consent of the owner thereof, be subjected to the burden of two or more irrigating ditches constructed for the purpose of conveying water through said property to lands adjoining or beyond the same when the same object can feasibly and practicably be attained by uniting and conveying all the water necessary to be conveyed through such property in one ditch. (Sec. 1, p. 164, acts 1881.)

1717. Shortest Route must be taken.]

Whenever any person or persons find it necessary to convey water for the purpose of irrigation through the improved or occupied lands of another, he or they shall select for the line of such ditch through such property the shortest and most direct route practicable upon which said ditch can be constructed with uniform or nearly uniform grade and discharge the water at a point where it can be conveyed to and used upon the land or lands of the person or persons constructing such ditch. (Sec. 2, p. 164, acts 1881.)

1718. Owner must Permit Others to Enlarge.]

No person or persons having constructed a private ditch for the purposes and in the manner hereinafter provided shall prohibit or prevent any other person or persons from enlarging or using any ditch by him or them constructed in common with him or them upon payment to him or them of a reasonable proportion of the costs of construction of said ditch. (Sec. 3, p. 164, acts 1881, eminent domain.)

1727. Right of Way to Owners of Wheels, etc.]

The right of way shall not be refused by the owner of any tract of land upon which it is required (by those who wish to place wheels upon the bank of a stream), subject of course to the like regulations as required for ditches, and laid down in sections hereinbefore enumerated. (Sec. 8, pp. 68-9, acts 1861. Sec. 6, p. 364, R. S. Sec. 1377 (6), p. 516, G. L.)

338. Ditch, etc., Company may Condemn Real Estate Needed.]

If any corporation formed under this (corporations) act for the purpose of constructing a * * * ditch * * * shall be unable to agree with the owner for the purchase of any real estate required for the purposes of any such corporation or company, or the transaction of the business of the same, or for right of way, or any other lawful purpose connected with or necessary to the operations of such company, such corporations may acquire such title in the manner provided by law. (Sec. 304 (114), p. 182, G. L.)

339. Entry on Land to Survey, etc.]

Any company formed under the provisions of this act for the purpose of constructing a * * * ditch * * * may cause such examination and survey as may be necessary to the selection of the most advantageous route, and for such purpose, by its officers, agents, or servants, may enter upon the lands of any person or corporation, but subject to liability for all actual damages which shall be occasioned thereby. (Sec. 305 (115), p. 183, G. L.)

1724. Reservoirs—Right to Water—Right of Way—Embankments.]

Persons desirous to construct and maintain reservoirs for the purpose of storing water shall have the right to take from any of the natural streams of the State and store away any unappropriated water not needed for immediate use for domestic or irrigating purposes; to construct and maintain ditches for carrying such water to and from such reservoir, and to condemn lands for such reservoirs and ditches in the same manner provided by law for the condemnation of lands for right of way for ditches: *Provided*, no reservoir with embankments or a dam exceeding ten feet in height shall be made without first submitting the plans thereof to the county commissioners of the county in which it is situated and obtaining their approval of such plans. (Sec. 38, pp. 106-7, acts 1879.)

1725. Conducting Water in Natural Streams.]

The owners of any reservoir may conduct the water therefrom into and along any of the natural streams of the State, but not so as to raise the waters thereof above ordinary high-water mark, and may take the same out again at any point desired without regard to the prior rights of others to water from said stream; but due allowance shall be made for evaporation and seapage, the amount to be determined by the commissioners of irrigation of the district; or, if there are no such commissioners, then by the county commissioners of the county in which the water shall be taken out for use. (Sec. 39, p. 107, acts 1879.)

1726. Damages.]

The owners of the reservoirs shall be liable for all damages arising from leakage or overflow of the waters therefrom, or by floods caused by breaking of the embankments of such reservoirs. (Sec. 40, p. 107, acts 1879.)

312. Keeping Ditch in Repair.]

Every ditch company organized under the provisions of this (corporations) act shall be required to keep their ditch in good condition, so that the water shall not be allowed to escape from the same to the injury of any mining claim, road, ditch, or other property; and whenever it is necessary to convey any ditch over, across, or above any lode or mining claim, or to keep the water so conveyed therefrom, the company shall, if necessary to keep the water of said ditch out or from any claim, flume the ditch so far as necessary to protect such claim or property from the water of said ditch. (Sec. 278 (88), pp. 172-3, G. L.)

1726. Liability for Damages.]

The owners of reservoirs shall be liable for all damages arising from leakage or overflow of the waters therefrom, or by floods caused by the breaking of the embankments of such reservoirs. (Sec. 40, p. 107, acts 1879.)

1728. Maintaining Embankments—Tail Ditch.]

The owner or owners of any ditch for irrigation or other purposes shall carefully maintain the embankments thereof, so that the waters of such ditch may not flood or damage the premises of others, and shall make a tail ditch so as to return the water in such ditch with as little waste as possible into the stream from which it was taken. (Sec. 7, p. 36, R. S., with first clause, amendment 1872, p. 144, sec. 1, second clause, sup. by sec. 2, p. 78, acts 1876.)

1730. Crossing Highways—Bridge.]

Any ditch company constructing a ditch, or any individual having ditches for irrigation, or for other purposes, wherever the same be taken across any public highway or public traveled road, shall put a good substantial bridge, not less than 14 feet in breadth, over such water-course where it crosses said road. (Sec. 10, p. 364, R. S. Sec. 1381 (10), p. 516, G. L.)

1731. Ditch must be Bridged in Three Days—Duty of Supervisor.]

When any such ditch or water-course shall be constructed across any public traveled road, and not bridged within three days thereafter, it shall be the duty of the supervisor of the road district to put a bridge over said ditch or water-course, of the dimensions specified in section 10 of this chapter, and call on the owner or owners of the ditch to pay the expenses of constructing such bridge. (Sec. 11, p. 364, R. S. Sec. 1382 (21), p. 517, G. L.)

1732. Proceedings against Owner for Payment—Damages.]

If the owner or owners of such ditch refuse to pay the bill of expenses so presented, the supervisor may go before any justice of the peace in the township or precinct and make oath to the correctness of the bill, and that the owner or owners of the ditch refuse payment; and thereupon such justice of the peace shall issue a summons against such owner or owners, requiring him or them to appear and answer to the complaint of such supervisor in an action of debt for the amount sworn to be due, such summons to be made returnable and served, and proceedings to be had thereon as in other cases; and in case judgment shall be given against such owner or owners the justice shall assess, in addition to the amount sworn to be due as aforesaid, the sum of $10 as damages arising from the delay of such owner or owners, such judgment to be collected as in other cases, and to be a fund in the hands of the supervisor of roads for the repairs of roads in such precinct or district. (Sec. 12, p. 365, R. S. Sec. 1383 (12), p. 517, G. L.)

2988. Allowing Water to Waste on Roads.]

No person or persons, or corporation * * * shall cause waste water, or the water from any ditch, road, drain, or flume or other place, to flow in or upon any road or highway so as to damage the same, and any such person or persons or corporation so offending or violating any of the provisions of this section or any of the sections of this act, for which there is no specific penalty provided, shall pay a fine of not less than $10 nor more than $300 for each offense, and a like fine of $10 for each day that such obstruction shall be suffered to remain in said highway, and shall also be liable to any person or persons or corporation in a civil action for any damages resulting therefrom; and it shall be the duty of the road overseer in the district in which such violation shall occur to prosecute any person, persons, corporation, or corporations violating the provisions of this act. (As amended, p. 326, Session Laws, 1885.)

2990. Bridging Ditch at Road-Crossing.]

Any person or persons, corporation or company, owning or constructing any ditch, race, drain, or flume, in, upon, or across any highway, shall keep the highway open for safe and convenient travel by constructing bridges over such ditch, race, drain, or flume; and within five days after any ditch is constructed across, in or upon any highway at any point thereof so as to interfere with or obstruct such highway, the person or persons owning or constructing such ditch shall erect a good and substantial bridge of not less than 20 feet in width across the same, which shall thereafter be maintained by the county: *Provided*, That all such bridges which shall be of greater length than 20 feet, shall be constructed as herein provided, and thereafter maintained in proper condition for safe travel by the owner or owners of said ditch. Any person or persons, corporation or company, constructing any ditch, race, drain, or flume, in, upon, or across any highway, and failing to keep the highway open for safe and convenient travel, as in this act provided, shall forfeit the sum of $25 to the county for each and every day of failure to keep the same open for safe and convenient travel as aforesaid. And any person or persons, corporation or company, who shall fail to erect a good and substantial bridge across any ditch, race, drain, or flume, within five days after the same is constructed in, upon, or across any highway, and keep the same in proper condition and repair, as herein provided, shall forfeit the sum of $25 to the county for each and every day of failure to erect such bridge and keep the same in repair, as aforesaid, together with the cost of constructing there a good and substantial bridge, or making necessary repairs, which the road overseers of the district shall at once proceed to build or repair, and such party or parties so neglecting shall also be liable in damages to any person or persons damaged by such neglect. (As amended, Session Laws, 1885, p. 324.)

1733. Owner of Ditch must Prevent Waste.]

The owner of any irrigating or mill ditch shall carefully maintain and keep the embankments thereof in good repair, and prevent the water from wasting. (Sec. 1, p. 78, Acts 1876. Sec. 1385 (1), p. 518, G. L.)

1734. Running Excess of Water Forbidden.]

During the summer season it shall not be lawful for any person or persons to run through his or their irrigating ditch any greater quantity of water than is absolutely necessary for irrigating his or their said land, and for domestic and stock purposes; it being the intent and meaning of this section to prevent the wasting and useless discharge and running away of water. (Sec. 2. p. 78, Acts 1876. Sec. 1386 (2), p. 518, G. L.)

1735. Penalty for Violation of this Act.]

Any person who shall willfully violate any of the provisions of this act, shall, on conviction thereof before any court having competent jurisdiction, be fined in a sum of not less than $100. Suits for penalties under this act shall be brought in the name of the people of the State of Colorado. (Sec. 3, p. 78, Acts 1876. Sec. 1387 (3), p. 518, G. L.)

1736. Owner Keep Head-gate—Size of Timbers.]

That the owner or owners of every irrigating ditch, flume or canal, in this State shall be required to erect and keep in good repair a head-gate at the head of their ditch, flume, or canal. Such head-gate, together with the necessary embankments, shall be of sufficient height and strength to control the water at all ordinary stages.

The frame-work of such head-gate shall be constructed of timber not less than 4 inches square, and the bottom, sides, and gate or gates, shall be of plank not less than 2 inches in thickness. (Sec. 1, p. 165, Acts 1881.)

1737. Liability of Owner for Neglect, Refusal.]

Owners of all ditches shall be liable for all damages resulting from their neglect or refusal to comply with the provisions of section 1 (G. S. 1736) of this act. (Sec. 2, p. 165, Acts 1881.)

Ditch owners are also required to construct and maintain a weir or measuring device at the heads of their ditches. (Ch. XIV.)

1755. Interfering with Head-gate, etc.]

Every person who shall willfully open, close, change, or interfere with any headgate or water box, without authority, shall be guilty of a misdemeanor, and on conviction thereof shall be fined not less than $50, nor more than $300, and may be imprisoned not exceeding sixty days. (Sec. 44, p. 108, Acts 1879.)

1759. Destroying Head-gate, Bank, etc.]

Any person or persons who shall knowingly and willfully cut, dig, break down, or open any gate, bank, embankment, or side of any ditch, canal, flume, feeder, or reservoir in which such person or persons may be a joint owner, or the property of another, or in the lawful possession of another or others, and used for the purpose of irrigation, manufacturing, mining, or domestic purposes with intent maliciously to injure any person, association, or corporation, or for his or her own gain, unlawfully, with intent of stealing, taking, or causing to run or pour out of such ditch, canal, reservoir, feeder, or flume, any water for his or her own profit, benefit, or advantage, to the injury of any other person, persons, association, or corporation, lawfully in the use of such water or of such ditch, canal, reservoir, feeder, or flume, he, she or they so offending shall be deemed guilty of a misdemeanor, and on conviction thereof shall be fined in any sum not less than $5 nor more than $300, and may be imprisoned in the county jail not exceeding ninety days. (Sec. 1, p. 163, Acts 1881.)

1760. Jurisdiction of Justices of the Peace.]

Justices of the peace shall have jurisdiction of all offenses under the provisions of this act (G. S. 1759), saving to any party defendant the right to be tried by a jury, as in other criminal cases before such justices now provided for by law; and also the right to appeal, in manner and form as by law now, or hereafter to be provided for by law, in criminal cases before such justices. (Sec. 2, p. 163, Acts 1881.)

Session Laws 1885. Trespass.]

Every person who shall willfully commit any trespass by entering upon the improved or inclosed land of another, without the permission of the owner thereof, with intent to cut, injure, or destroy any dam, dyke, or embankment kept or maintained for the purpose of storing water in any lake, creek, or reservoir, shall, upon conviction therefor, be punished by imprisonment in the county jail not less than ten days nor more than one year, or by a fine not less than $50 and not more than $1,000, or by both such fine and imprisonment. (P. 165.)

903. Malicious Mischief.]

If any person shall unlawfully, wantonly, willfully, or maliciously cut down, break down, level, demolish, or otherwise destroy or damage any bridge, embankment, milldam, or ditch, being the property of another * * * where the value of the personal property destroyed or injured shall exceed $20, shall, on conviction, be punished by imprisonment in the State penitentiary not more than five years, or by a fine not exceeding $1,000; or where the value of the personal property destroyed or injured shall be $20 or under, shall, on conviction, be punished by a fine not exceeding $100, or imprisonment in the county jail not more than three months, or both such fine and imprisonment in the discretion of the court. (As amended Session Laws 1885, p. 167.)

315.]

Any person who shall willfully or maliciously damage or interfere with any * * * ditch, flume, * * * or any of the fixtures, tools, implements, appurtenances, or any property of any company which may be organized under the provisions of this act, upon conviction thereof before any court of competent jurisdiction in the county where the offense shall have been committed, shall be deemed guilty of a misdemeanor, and shall be punished by fine or imprisonment, or both at the discretion of the court, said imprisonment not to exceed one year, and said fine not to exceed $500, which fine shall be paid into the county treasury for the use of the common schools, and said offender shall also pay all damages that any such corporation may sustain, together with costs of suit. (Sec. 297 (107), p. 180, G. L.)

882. Polluting Stream or Ditch.]

If any person or persons shall hereafter throw or discharge into any stream of running water, or into any ditch or flume in this State, any obnoxious substance, such as refuse matter from slaughter-house or privy, or slops from eating-houses or saloons, or any other fleshy or vegetable matter which is subject to decay in the water, such person or persons shall, upon conviction thereof, be punished by a fine not less than $100 nor more than $500 for each and every offense so committed. (Sec. 1, Acts 1874, p. 99. Sec. 165, p. 307, G. L. In force Feb. 13, 1874.)

3259. Damage to Ditches, etc., by Persons Floating Timber.]

That it shall be lawful for any person or persons to float any and all kinds of timber, such as saw logs, ties, fencing poles or posts, and firewood down any of the streams of this State: *Provided*, That any person or persons desiring to float any such timber down said streams shall first execute a bond running to the people of each county through which such timber is floated, in a sum sufficient to cover all damages that may be done to any bridges, dams, or irrigating ditches that are now or may hereafter be constructed in or across any streams of this State, such bond to be approved by the board of county commissioners of the county or counties through which such timber is to be floated. (Sec. 1856 (1), p. 643, G. L.)

3472. How Measured.]

Water sold by the inch by any individual or corporation shall be measured as follows, to wit: Every inch shall be considered equal to an inch square orifice under a 5-inch pressure, and a 5-inch pressure shall be from the top of the orifice of the box put into the banks of the ditch to the surface of the water; said boxes, or any slot or aperture through which such water shall be measured, shall in all cases be 6 inches perpendicular, inside measurement, except boxes delivering less than 12 inches, which may be square, with or without slides; all slides for the same shall move horizontally, and not otherwise; and said box put into the banks of ditch shall have a descending grade from the water in ditch of not less than one-eighth of an inch to the foot. (Sec. 2779 (3), pp. 926–7, G. L. Sec. 6, p. 638, R. S. Amd. Sec. 1, pp. 308–9, Acts 1874 and 1877.)

3478. Illegal Measurement.]

All persons for the purpose of weighing or measuring goods, wares, merchandise, water, or other articles actually sold by him, not in accordance with this chapter, shall be deemed guilty of a misdemeanor, and upon conviction thereof may be imprisoned not exceeding one year, or fined not exceeding $1,000, at the discretion of the court in which the conviction shall be obtained. (Sec. 2785 (9), p. 928, G. L. Sec. 9, p. 309, Acts 1874.)

Colorado Constitution, Art. XVI, Sec. 8. County Commissioners fix Rates for Water.]

The general assembly shall provide by law that the boards of county commissioners in their respective counties shall have power, when application is made to them by either party interested, to establish reasonable maximum rates to be charged for the use of water, whether furnished by individuals or corporations.

311. When Corporation must furnish Water.]

Any company constructing a ditch under the provisions of this act shall furnish water to the class of persons using the water in the way named in the certificate, in the way the water is designated to be used, whether miners, mill men, farmers, or for domestic use, whenever they shall have water in their ditch unsold, and shall at all times give the preference to the use of water in said ditch to the class named in the certificate; the rates at which water shall be furnished to be fixed by the county commissioners as soon as such ditch shall be completed and prepared to furnish water. (Sec. 277 (87), p. 172, G. L.)

1788. Regulating Charges—Proceedings before County Commissioners.]

The county commissioners of each county shall, at their regular January session in each year, hear and consider any and all applications which may be made to them by any party or parties interested in procuring water for irrigation by purchase from any ditch or reservoir furnishing and selling water, or proposing to furnish water for sale, the whole or upper part of which shall lie in such county, which application shall be supported by such affidavit or affidavits as the applicant may see proper to present, showing reasonable cause for such board to proceed to fix the price of water to be thereafter sold from such ditch or reservoir, and [if] such board of commissioners shall, upon examination of such affidavit or affidavits, or from the oaths of witnesses in addition thereto, find that the facts sworn to show the application to be in good faith, and that there is reasonable grounds to believe that unjust prices are, or are likely to be, charged for water from such ditch or reservoir, they shall enter an order fixing a day, not sooner than forty days thereafter nor later than the third day of the [next] regular session of their board, when they will hear all parties directly or indirectly interested in said ditch or reservoir, or in procuring water therefrom for irrigation, who may appear, as well as all the testimony by witnesses or depositions taken on notices as hereinafter provided, touching the said ditch or reservoir, and the cost of furnishing water therefrom, at which time all persons or corporations interested in said ditch or reservoir, as well as all interested in obtaining water therefrom, or in lands which may be irrigated therefrom, may appear by themselves, their agents, or attorneys, and said commissioners shall then proceed to take action in the matter of fixing such price of water; provided the applicant shall, within ten days from the time of entering such order, cause a copy thereof, duly certified, to be delivered to the owner of such ditch or reservoir, if it be owned by one person, or each of the owners if it be owned by several persons, or to the president, secretary, or treasurer of the company if it belongs to a corporation or association having such officers, or if such owner can not be found he shall cause such copy to be left at his usual place of residence, with some person or member of his family residing there, and over fourteen years of age, and if such ditch officer cannot be found, he shall cause such copy to be left at the office or place of business of the company of which he is such officer, or at his residence if such company have no place of business, and if such ditch is owned by several owners, not an incorporated company, it shall be sufficient to serve such notice by delivering one such copy each to a majority of them, and such applicant shall make affidavit of the manner in which such copy or copies have been served. Depositions mentioned in section 1 hereof, to be used before said commissioners, shall be taken before any officer in the State authorized by law to take depositions, upon reasonable notice being given to the opposite party of the time and place of taking such depositions. (Sec. 1, pp. 94-5-6, Acts 1879.)

1739. Powers and Duties of Board—Subpœnas—Compulsion—Adjournments—Examinations—Facts—Order—Proviso as to Contracts.]

Said board shall hear and examine all legal testimony or proofs offered by any of the parties interested, as before mentioned, as well concerning the value of the construction of such ditch and reservoir as the cost and expense of maintaining and operating the same, and all matters which may affect the just price and value of water to be furnished therefrom; and they shall have power to issue subpœnas to witnesses and compel their attendance, which subpœnas shall be served by the sheriff of the proper county when required; and also to compel the production of books and papers required for evidence in as full and ample a manner as the district court now has. They may adjourn the hearing from time to time to further the ends of justice or suit the general convenience of parties. Upon hearing an [and] considering all the matters and facts involved in the case, the board of commissioners shall enter an order naming and describing the ditch or reservoir with sufficient certainty, and fixing a just price upon all water to be thereafter sold, which price shall not be thereafter changed oftener than once in two years: *Provided,* That no price so fixed shall effect [affect] the rights of parties, or their lawful assignees or grantees, who may have contracts with the company, association, or person owning such ditch or reservoir, or their lessees, grantees, or successors, nor the rights of such owners, lessees, or grantees under such contract, nor shall it in any way affect or hinder the making of such contract. (Sec. 2, p. 96, Acts 1879.)

1740. Right to continue Purchasing Water—Tender of Price—Stockholders—Rights.]

Any person or persons, acting jointly or severally, who shall have purchased and used water for irrigation for lands occupied by him, her, or them, from any ditch or reservoir, and shall not have ceased to do so, for the purpose or with the intent to procure water from some other source of supply, shall have a right to continue to purchase water to the same amount for his, her, or their lands, on paying or tendering the price thereof fixed by the county commissioners as above provided; or, if no price shall have been fixed by them, the price at which the owners of such ditch or reservoir may be then selling water, or did sell water during the then last preceding year. This section shall not apply to the case of those who may have taken water as stockholders or shareholders after they shall have sold or forfeited their shares or stock, unless they shall have retained a right to procure such water by contract, agreement, or understanding, and use between themselves and the owners of such ditch, and not then to the injury of other purchasers of water from or shareholders in [the] same ditch. (Sec. 3, pp. 96, 97, Acts 1879.)

1741.]

The lands now irrigated, or which may be hereafter irrigated, from ditches now taking water from the following described rivers or natural streams of the State of Colorado, are hereby declared to constitute irrigation districts. (Sec 5, p. 97, Acts 1879.)*

---

*The act of 1879, by which the first ten districts were created, also provides: "Other irrigation districts may be formed from time to time by the governor on petition of parties interested." Several districts were formed under this power and commissioners appointed, and these new districts were incorporated into the new act.

1802.]

For the better regulation of the distribution of water for irrigation among the several ditches, canals, and reservoirs into which such water may be lawfully taken in times of scarcity thereof, the water districts now or to be hereafter established by law shall be constituted into water divisions, as follows. [Boundaries of districts are omitted.]

1752. Water Commissioners—How Appointed—Vacancies—Removal.]

There shall be one water commissioner for each of the above-named districts and for each district hereafter formed, who shall be appointed by the governor, to be selected by him from persons recommended to him by the several boards of county commissioners of the counties into which water districts may extend, and the water commissioner so appointed shall hold his office until his successor is appointed and qualified. The governor shall, by like selection and appointment, fill all vacancies which may be occasioned by death, resignation, or continued absence from the district, removal or otherwise. Said county commissioners may, from time to time, recommend persons to be appointed as above provided, and the governor may at any time remove any water commissioner in his discretion. (Sec. 16, pp. 98, 99, Acts 1879.)

1753. Oath of Office within ten days.]

That within ten days after his appointment, and before entering upon the duties of his office, such water commissioner shall take and subscribe the oath of office prescribed by the constitution of this State. (Sec. 17, p. 99, Acts 1879.)

1754. Duty of Water Commissioners—Open and shut Head-gates.]

It shall be the duty of said water commissioners to divide the water in the natural stream or streams of their district among the several ditches taking water from the same, according to their prior rights of each respectively; in whole or in part to shut and fasten, or cause to be shut and fastened, by order given to any sworn assistant, sheriff, or constable of the county in which the head of such ditch is situated, the head-gate of any ditch or ditches heading in any of the natural streams of the district, which, in a time of a scarcity of water, shall not be entitled to water by reason of the priority of the rights of others below them on the same stream. (Sec. 18, p. 99, Acts 1879.)

1756. Pay of Commissioners—Duty to keep Accounts—How Paid.]

The water commissioners herein provided shall be each entitled to pay at the rate of $5 per day for each day he shall be actually employed in the duties of his office, not to exceed eighty days in any one year, to be paid by the county or counties in which his irrigation district may lie. Each water commissioner shall keep a just and true account of the time spent by him in the duties of his office, and shall present a true copy thereof, verified by oath, to the board of commissioners of the county in which his district may lie, and said board of commissioners shall allow the same; and if said irrigation district shall extend into two or more counties, then such water commissioner shall present his account for his said services, verified as aforesaid, to the board of county commissioners of each county into which such district extends, and each board of county commissioners shall allow an equal part thereof. (P. 254, Acts 1885.)

1757. Commissioner to Appoint Assistant—Oath—Pay.]

Said water commissioner shall have power, in case of emergency, to employ a suitable assistant to aid him in the discharge of his duties. Such assistant shall take the same oath as the water commissioner, and shall obey his instructions, and shall be entitled to $3 per day for every day he is so employed, not to exceed twenty-five days, to be paid upon the certificate of the water commissioner, in the same manner as provided for paying water commissioners. (Sec. 41, p. 107, Acts 1879.)

1758. Commissioner to begin Work when called on.]

Said water commissioners shall not begin their work until they shall be called on by two or more owners or managers, or persons controlling ditches in their several districts, by application in writing, stating that there is necessity for their action; and they shall not continue performing services after the necessity therefor shall cease.

1722. Pro rata Division among Owners.]

If at any time any ditch or reservoir from which water is or shall be drawn for irrigation shall not be entitled to a full supply of water from the natural stream which supplies the same, the water actually received into and carried by such ditch, or held in such reservoir, shall be divided among all the consumers of water from such ditch or reservoir, as well as the owners, shareholders or stockholders thereof, as the parties purchasing water therefrom; and parties taking water partly under and by virtue of holding shares, and partly by purchasing the same, to each his share pro rata, according to the amount he, she or they (in cases in which several consume water jointly) shall be then entitled, so that all owners and purchasers shall suffer from the deficiency arising from the cause aforesaid each in proportion to the amount of water which he, she or they should have received in case no such deficiency of water had occurred. (Sec. 4, p. 97, Acts 1879.)

1807. Governor shall Appoint—May Remove—Office—Salary.]

The governor shall appoint a state hydraulic engineer, who shall hold his office for the term of two years, or until his successor may be appointed and qualified. The governor may at any time, upon good cause shown, remove said state engineer. Said state engineer shall have general supervision over the water companies [commissioners] of the different water districts in the State. He shall have his office at the State capitol, in an office to be provided for him by the secretary of state, and be subject to his direction and control; who shall also furnish him with suitable furniture, postage, and such proper and necessary books and instruments as will best enable him to discharge the duties of his office. He shall be paid a salary of $2,000 per annum, payable quarterly, by the state treasurer, on warrants drawn by the state auditor. No person shall be appointed as such hydraulic engineer who is not known to have such theoretical knowledge and practical skill and experience as shall fit him for the position. (Sec. 6, pp, 119-20, Acts 1881.)

1808.—Engineer shall Measure Streams—Collect Facts—Report on Reservoirs—Record.]

Said state engineer shall make, or cause to be made, careful measurements and calculations of the maximum and minimum flow in cubic feet per second of water in each stream from which water shall be drawn for irrigation, as may be best for affording information for irrigating purpose, commencing with those streams most used for irrigation; also, to collect facts and make report as to a system of reservoirs for the storage of water, their location, capacity and cost; and he shall keep proper and full records of his work, observations and calculations. (Sec., 7 p. 120, Acts 1881.)

1809—Oath—Bond—Condition.]

Said state engineer shall, before entering on the discharge of his duties, take and subscribe an oath before some officer authorized by law to administer oaths, to faithfully perform the duties of his office, and file with the secretary of state said oath and his official bond, in the penal sum of $2,000, with sureties to be approved by the secretary of state, and conditioned for the faithful discharge of the duties of his office, and for delivering to his successor or other officer authorized to receive the same, all moneys, implements, books and other property belonging to the State then in his hands or under his control, or with which he may be legally chargeable as such officer. (Sec. 8, pp. 120-1, Acts 1881.)

1810. May appoint Assistants—Pay—Certificate—Warrant.]

Said state engineer will have power to employ assistants at an expense not to exceed $1,500 in any one year, who shall be paid out of any moneys appropriated for that purpose, on certificate of said state engineer, showing the services rendered and the amount therefor [thereof], and on presentation of such certificate to the state auditor by the person entitled thereto, he shall issue his warrant on the state treasurer for the amount thereof, to be paid out of any appropriation as aforesaid, and not otherwise. (Sec. 9, p. 277, Acts 1883.)

1811. Annual Report—When to be made.]

Said state engineer shall prepare and render to the government [governor] yearly, and oftener if required, full and true reports of his work, touching all the matters and duties devolving upon him by virtue of his office, which report shall be delivered at the time when the reports of other State officers are required by law to be made, in order that they may be laid before the general assembly at each regular session thereof. (Sec. 10, p. 121, Acts 1881.

1812. Shall measure Ditches' Feeders—Reservoirs.]

Said state engineer shall, on request of any party interested, on payment of his per diem, charges, and reasonable expenses, measure and ascertain the carrying capacity of any ditch, canal, or feeder, or any reservoir, hereafter constructed or enlarged, and give to the party or parties requiring his services an official certificate of the size and carrying capacity of such ditch, canal, or feeder, in cubic feet per second, as he shall find it to be at the time of measuring the same. (Sec. 11, p. 121, Acts 1881.)

1813. Owners of Ditches shall construct Weirs—State Engineer shall compute Water per second.]

For the more accurate and convenient measurement of any water appropriated pursuant to any judgment or decree rendered by any court establishing the claims of priority of any ditch, canal, or reservoir, the owners thereof shall construct and maintain, under the supervision of the state engineer, a measuring weir or other device for measuring the flow, in cubic feet per second, the water at the head of such ditch, canal, or reservoir, or as near thereto as practicable. The state engineer shall compute and arrange in tabular form the amount of water that will pass such weir or measuring device in cubic feet per second, at the different stages thereof, and he shall furnish a copy of a statement thereof to any water commissioners having control of such ditch, canal, or reservoir. (Sec. 12, pp. 121-2, Acts 1881.)

308. What Certificate must Contain.]

Whenever any three or more persons associate under the provisions of this act to form a company for the purpose of constructing a ditch for the purpose of conveying water to any mines, mills or lands, to be used for mining, milling, or irrigating of lands, they shall, in their certificate, in addition to the matters required in section 2 of this (corporation) act, specify as follows: The stream or streams from which the water is to be taken out; the point or place on said stream at or near which the water is to be taken out; the line of said ditch, as near as may be; and the use to which the said water is to be applied. (Sec. 274 (84), p. 171, G. L.)

309. Right of Way and Water.]

Any ditch company formed under the provisions of this act shall have the right of way over the line named in the certificate, and shall also have the right to run the water of the stream or streams named in the certificate through their ditch; *Provided*, That the line proposed shall not interfere with any other ditch whose rights are prior to those acquired under this act and by virtue of said certificate, except the right to cross by flume; nor shall the water of any stream be diverted from its original channel to the detriment of any person or persons who may have priority of right. (Sec. 275 (85), p. 171, G. L.)

310. Assessment of Stock.]

Any corporation owning any ditch or canal for conveying, or reservoirs for storing water for irrigation purposes, and the capital stock being fully subscribed and paid up, and when such corporation shall have no income sufficient to keep its ditch, canal or reservoir in good repair, such corporation shall have power to levy an assessment upon the capital stock thereof, to be levied pro rata on all the shares of stock, payable in money or labor, or both, for the purpose of keeping the property of such corporation in good repair, and for the payment of any claim against said corporation not otherwise provided for. But no such assessment shall be made unless the question of making such assessment shall first be submitted to the stockholders of such corporation at an annual meeting, or at a special meeting called for that purpose, and a majority of the stockholders, either in person or by proxy, voting thereon, shall vote in favor of making such assessments; and an action may be maintained to recover any assessment against any delinquent shareholder as provided in section 2 of this act. (Sec. 276 (86), p. 172 G. L.)

312. Consolidation.]

Companies organized under the laws of this State, holding ditches or canals by virtue of their organization, which derive their supply of water for their respective ditches or canals from the same head-gate or gates, or the same source or sources of supply, may consolidate their interests and unite their respective companies under one name and management, by filing a certificate of that fact in the office of the secretary of this State, and a counterpart thereof in the office of the recorder of the county or counties in which such ditches or canals are situated, which certificates shall be signed by the presidents of the companies so uniting, with the common seals of the companies affixed thereto, and shall set forth the fact of such union of interests, and give the name of the new company thus formed. (Sec. 1, Acts 1876, p. 68—omitted in G. L.)

1761. When Free from Taxation.]

All ditches used for the purpose of irrigation, and that only when the water is not sold for the purpose of deriving a revenue therefrom, be, and the same are hereby, declared free from all taxation, whether for State, county, or municipal purposes. (Sec. 1, p. 143, Acts 1872. Sec. 1384 (1), p. 517, G. L.)

3472. Measurement of Water.]

Water sold by the inch by any individual or corporation shall be measured as follows, to wit: Every inch shall be considered equal to an inch square orifice under a 5-inch pressure, and a 5-inch pressure shall be from the top of the orifice of the box put into the banks of the ditch to the surface of the water; said boxes or any slot or aperture through which such water shall be measured shall in all cases be 6 inches perpendicular, inside measurement, except boxes delivering less than 12 inches, which may be square, with or without slides; all slides for the same shall move horizontally, and not otherwise; and said box put into the banks of ditch shall have a descending grade from the water in ditch of not less than one-eighth of an inch to the foot.

3312. May Construct Reservoirs, Ditches, etc.]

The city council and board of trustees in towns shall have the following powers:

Seventy-second. They shall have power to construct public wells, cisterns, and reservoirs in the streets and other public and private places within the city or town, or beyond the limits thereof, for the purpose of supplying the same with water; to provide proper pumps and connecting pipes or ditches; to regulate the distribution of water for irrigating and other purposes, and to levy an equitable and just tax upon all consumers of water for the purpose of defraying the expense of such improvements.

Seventy-third. They shall have the right and privilege of taking water in sufficient quantity for the purpose hereinbefore mentioned, from any stream, creek, gulch, or spring in the State: *Provided*, That if the taking of such water in such quantity shall materially interfere with or impair the vested right of any person or persons or corporation heretofore acquired, residing upon such creek, gulch, or stream, or doing any milling or manufacturing business thereon, they shall first obtain the consent of such person or persons or corporations, or acquire the right of domain by condemnation, as prescribed by the constitution and laws upon that subject, and make full compensation or satisfaction for all the damages thereby occasioned to such person or persons or corporation.

Seventy-fourth. When it shall be deemed necessary by any municipal corporation to enter upon or take private property for any of the above uses, the same shall be examined, appraised, and the damages thereon assessed, and the proceedings in connection therewith shall be in all respects the same as is now or may hereafter be provided by general law for the taking of private property for public or private use. (Sec. 2655 (14), pp, 879-892, G. L.)

4317. May Lease or Purchase Canal.]

Any incorporated town or city in this State shall have power to purchase or lease any canal or ditch already constructed, or which may hereafter be constructed, and all the rights, privileges, franchises of any person or persons, or corporations owning the same or having any interest or right therein, and to hold or operate the same in the same manner as the persons or corporation from whom the same may be purchased or leased might otherwise do: *Provided*, That such purchase or lease shall be made for the purpose of supplying, by said ditch or canal, water for the use of said city or town: *And provided further*, That a majority of the qualified electors of such city or town, who shall vote at any regular election which may be held for the election of town officers, shall vote in favor of said purchase. (Sec. 1, p. 198, Acts 1879.)

3418. Obligations—Repair—Management.]

Any town or city making such purchase or lease shall thereby assume all obligations and other duties which by law devolve upon the owner or owners of such ditch or canal, of whom the same may be purchased or leased by virtue of this act, and shall have power to repair, improve, or enlarge the same, or any flume, dam, or gate connected therewith, and for such objects may levy and collect taxes in the same manner as other taxes are levied and collected by law. The management of such ditch or canal shall be under the control of the board of trustees or councils, as the case may be, of such city or town. (Sec. 2, pp. 198,19, Acts 1879.)

A municipal corporation will, of course, have the same general rights, and be subject to the same general liabilities and duties as any other owner of a ditch or reservoir.

2724. Sale of Arid Lands Conditioned on the Construction of Ditches, etc.]

For the purpose of encouraging cultivation and the making of irrigation ditches, the State board of land commissioners are hereby authorized to sell at public sale, at not less than the appraised value, not more than one-half of any tract of arid land belonging to the State, except the school land, in alternate quarter sections as nearly as may be, to any responsible person or corporation, on condition that said person or corporation dig an irrigation ditch in such location, and of sufficient capacity to furnish water for the entire tract. All contracts for the sale of State lands under the provisions of this section shall be drawn by the attorney-general, and signed by the governor and the secretary of the board, in behalf of the State, and by the other parties in interest; and in no case shall the titles to any of said lands pass from the State until such ditch is completed in a manner satisfactory to the State board, and the purchasers have given, in addition to such price as may be fixed by the State board, a suitable contract or agreement, secured by a sufficient bond, that they will furnish water for the remaining portion of the tract of land, as aforesaid, at not to succeed [exceed] such rates as the State board may agree. Upon the fulfillment of the above conditions patent may issue for not more than one-half of said tract, and the remaining portion of said tract may be subsequently disposed of in the same manner as other State lands. (Sec. 8, p. 226, Acts 1881.)

2744. Sale of Lands Conditioned on the Construction of Ditches, etc.]

The State board of land commissioners may sell in parcels of not more than 5,000 acres, at public sale, at not less than its appraised value, any of the lands granted to the State for public improvements, under the act approved September 4, 1841, conditioned upon the location of colonies thereon, or the construction of extensive lines of ditches covering such lands: *Provided*, That not more than one-half of any one section of land shall be sold, in alternate half sections: *And provided further*, That every alternate one-half section unsold shall not be sold for three years thereafter. (Sec. 2196 (22), p. 728, G, L.)

Sec. 1. Purification of Water—Commission.]

By and with the consent of the senate, the governor shall appoint a commission, consisting of two persons, as follows: One person engaged in farming in this State where irrigation is practiced, and one person engaged in mining in the State. Such commission shall make practical and scientific tests and experiments in attempting to settle and purify the water after being used by stamp mills and smelters, and shall report the results of such tests and experiments to the next general assembly of this State: *Provided*, That all scientific and chemical tests shall be made by the employés of the State school of mines, without any expense to the State: *Provided further*, That the commissioners shall receive no compensation, other than their actual expenses, which shall in no event exceed the sum appropriated by this act.

SEC. 2. The sum of $600, or so much thereof as may be necessary, is hereby appropriated to defray the expenses incurred in carrying out the provisions of this act. (Session Laws, 1885, p. 260.)

316. Flume—What Certificate shall Specify.]

When any company shall organize under the provisions of this act to form a company for the purpose of constructing a flume, their certificate, in addition to the matters required in the second section of this act (G. S. 238), shall specify as follows: The place of beginning, the terminus, and the route as near as may be, and the purpose for which such flume is intended, and when organized, according to the provisions of this act, said company shall have the right of way over the line proposed in such certificate for such flume, provided it does not conflict with the rights of any former fluming, ditching, or other company. (Sec. 279 (89), p. 173, G. L.)

COLORADO STATUTES, 1888.

AN ACT to regulate the mode of fixing the rates of compensation by boards of county commissioners for water furnished and delivered for irrigation and other lawful purposes from ditches, canals, conduits, and reservoirs, and to repeal laws inconsistent therewith, and punish offenses contrary thereto.

Be it enacted by the general assembly of the State of Colorado:

SEC. 1. The county commissioners of each county shall, at their regular sessions in each year, and at such other sessions as they, in their discretion, may deem proper, in view of the irrigation and harvesting season and the convenience of all parties interested, hear and consider all applications which may be made to them by any party or parties interested either in furnishing and delivering for compensation in any manner, or in procuring for such compensation water for irrigation, mining, milling, manufacturing, or domestic purposes from any ditch, canal, conduit, or reservoir, the whole or any part of which shall lie in such county; which application shall be supported by such affidavits as the applicant or applicants may present, showing reasonable cause for such board of county commissioners to proceed to fix the rate of compensation for water to be thereafter delivered from such ditch, canal, conduit, or reservoir within such county.

SEC. 2. Every such board of commissioners shall, upon examination of such affidavit or affidavits, or from the oaths of witnesses in addition thereto, if they find that the facts sworn to show the application to be in good faith and that there are reasonable grounds to believe that unjust rates of compensation are, or are likely to be charged or demanded, for water from such ditch, canal, conduit, or reservoir, shall enter an order fixing a day not sooner than twenty days thereafter, nor later than the third day of the next regular session of their board, when they will hear all parties interested in such ditch or water works as aforesaid, or in procuring water therefrom for any of the said uses, as well as all documentary or oral evidence or depositions, taken according to law, touching the said ditch or other work as aforesaid, and the cost of furnishing water therefrom.

SEC. 3. At the time so fixed all persons interested as aforesaid on either side of the controversy, or in lands which may be irrigated from such ditch or other work aforesaid, may appear by themselves, their agents, or attorneys, and said commissioners shall then proceed to take action in the matter of fixing such rates of compensation for the delivery of water: *Provided*, The applicant or applicants—if the application be made by a party or parties as aforesaid, desirous of procuring water—shall, within ten days from the time of entering the said order fixing the hearing, cause a copy of such order, duly certified, to be delivered to the owner or owners of such ditch, canal, conduit, or reservoir, or to the president, secretary, or treasurer of the company, if it be owned by a corporation or association having such officers. If any such owner can not be found, a copy shall be left at his usual place of abode, with some person residing there, over twelve years of age, and if such officer of any corporation or association can not be found, such copy shall be left at the usual place of business of the company of which he is such officer, or at his residence, if such company have no place of business, and if such ditch or other work aforesaid shall be owned by several owners, not being an incorporated company, it shall be sufficient to serve such notice by delivering one copy each to a majority of them. If the applicant be the owner or party controlling such ditch, canal, conduit, or reservoir, such notice shall be given by causing printed copies of such order, in hand-bill form, in conspicuous type, to be posted securely in ten or more public places throughout the district watered from such ditch or other work aforesaid—if the water be used for irrigation—and one copy shall be posted for every mile in length of such ditch; but if such ditch or other work be for the supply of water for milling or mining, it shall be sufficient to serve such copy on the parties then taking water therefrom. The person or persons making such service or posting such printed copies shall make affidavit of the manner in which the same has been done, which affidavit shall be filed with the said board of county commissioners. Depositions mentioned in section 2 hereof, to be used before said commissioners, shall be taken before any officer in the State authorized by law to take depositions, upon reasonable notice being given to the opposite party of the time and place of taking the same.

SEC. 4. Said board of commissioners may adjourn or postpone any hearing from time to time, as may be found necessary, or for the convenience of parties, or of public business; and they shall hear and examine all legal testimony or proofs offered by any party interested as aforesaid, as well concerning the original cost and present value of works and structure of such ditch, canal, conduit, or reservoir, as the cost and expense of maintaining and operating the same, and all matters which may affect the establishing of a reasonable maximum rate of compensation for water to be furnished and delivered therefrom; and they may issue subpœnas for witnesses, which subpœnas shall be served by the sheriff of the county, who shall receive the lawful fees for all such service; and said board may also issue a subpœna for the porduction of all books and papers required for evidence before them. Upon hearing and considering all the evidence and facts and matters involved in the case said board of commissioners shall enter an order describing the ditch, canal, conduit, reservoir, or other work in question with sufficient certainty, and fixing a just and reasonable rate of compensation for water to be thereafter delivered from such ditch or other work as last aforesaid within the county in which such commissioners act; and such rate shall not be changed within two years from the time when they shall be so fixed, unless upon good cause shown. The district court of the proper county, or the judge thereof in vacation, may, in case of refusal to obey the subpœna of the board of county commissioners, compel obedience thereto, or punish for refusal to obey, after hearing, as in cases of attachment for contempt of such district court.

SEC. 5. Every person who shall swear or affirm falsely in any matter or testify falsely after being duly sworn or having affirmed as a witness in any proceeding provided for in this act shall be deemed guilty of perjury, and on conviction shall be punished accordingly.

SEC. 6. All acts and parts of acts inconsistent with this act are hereby repealed; but such repeal shall not work any interference with any proceeding by any board of county commissioners now pending, saving that any such proceeding may, at the request of either party, be carried on to completion under the provisions hereof.

SEC. 7. In consequence of the near approach of the irrigating season it is deemed that an emergency exists, and therefore this act shall take effect from and after the time of its approval.

Approved and in force April 4, 1887.

AN ACT to define, prohibit, punish, and restrain extortion and other abuses in the management of ditches, canals, and reservoirs.

Be it enacted by the General Assembly of the State of Colorado:

SEC. 1. It shall not be lawful for any person owning or controlling, or claiming to own or control, any ditch, canal, or reservoir carrying or storing, or designed for the carrying or storing, of any water taken from any natural stream or lake within this State to be furnished or delivered for compensation for irrigation, mining, milling, or domestic purposes to persons not interested in such ownership or control, to demand, bargain for, accept, or receive from any person, who may apply for water for any of the aforesaid purposes, any money or other valuable thing whatever, or any promise or agreement therefor, directly or indirectly, as royalty, bonus, or premium, prerequisite or condition precedent to the right or privilege of applying or bargaining for or procuring such water; but such water shall be furnished, carried, and delivered upon the payment or tender of the charges fixed by the county commissioners of the proper county, as is or may be provided by law. Any and all moneys, and every valuable thing or consideration of whatsoever kind which shall be so as aforesaid demanded, charged, bargained for, accepted, received, or retained contrary to the provisions of this section shall be deemed and held an additional and corrupt rate, charge, or consideration for the water intended to be furnished and delivered therefor, or because thereof, and wholly extortionate and illegal, and when paid or delivered, or surrendered may be recovered back by the party or parties paying, delivering, or surrendering the same from the party to whom or for whose use the same shall have been paid, delivered, or surrendered, together with all costs of suit, including reasonable fees of attorneys of plaintiff, by proper action in any court having jurisdiction.

SEC. 2. Every person owning or controlling, or claiming to own or control, any ditch, canal, or reservoir, as is mentioned in the first section of this act, who shall, after demand in writing made upon him for the supply or delivery of water for irrigation, mining, milling, or domestic purposes, to be delivered from the ditch, canal, or reservoir owned, possessed, or controlled by him, and after tender of the lawful rate of compensation therefor in lawful money, demand, require, bargain for, accept, receive, or retain from the party making such application any money or other thing of value, or any promise or contract or any valuable consideration whatever, as such royalty, bonus, premium, prerequisite, or condition precedent, as is by the provisions of the said first section of this act prohibited, shall be deemed guilty of a misdemeanor, and on conviction thereof shall be punished by fine of not less than one hundred dollars nor more than five thousand dollars, or imprisonment for a term not less than three months nor more than one year, or both such fine and imprisonment, in the discretion of the court.

SEC. 3. Every person owning or controlling, or claiming to own or control any ditch, canal, or reservoir such as is mentioned in the first section of this act, who shall, after demand in writing made upon him for the supply or delivery of water for irrigation, mining, milling, or domestic purposes, to be delivered from the ditch, canal, or reservoir owned, possessed, or controlled by him, and after tender of the lawful rate of compensation therefor in lawful money, refuse to furnish or carry and deliver from such ditch, canal, or reservoir, any water so applied for, which water can or may be by use of reasonable diligence in that behalf and within the carrying or storage capacity of such ditch, canal, or reservoir, be lawfully furnished and delivered, without infringement of prior rights, shall be deemed guilty of a misdemeanor, and upon conviction thereof shall be punished by fine of not less than one hundred dollars nor more than five thousand dollars, or imprisonment for a term of not less than three months nor more than one year, or both such fine and imprisonment in the discretion of the court.

SEC. 4. When any corporation in defiance or by attempted evasion of the provisions of this act, shall after tender of the compensation hereinbefore provided for, refuse to deliver water such as is mentioned in the third section of this act, to any person lawfully entitled to apply therefor, it shall be the duty of the attorney-general, upon request of the county commissioners of the proper county, or upon his otherwise receiving due notice thereof, to institute and prosecute to judgment and final determination proceedings in *quo warranto* for the forfeiture of the corporate rights, privileges, and franchises of any such corporation so offending, or by *mandamus* or other proper proceedings to compel it to its duty in that behalf.

SEC. 5. The word person as used in this act shall include corporations and associations and the plural as well as the singular number; and every officer of a corporation or member of an association or co-ownership, and every agent violating any of the provisions of this act, shall be liable to restore the unlawful consideration extorted, and be punishable under the penal provisions of this act, the same as if the thing done in disobedience to its provisions were done for his own sole benefit and advantage.

SEC. 6. All laws and parts of laws in conflict with any of the provisions of this act are hereby repealed.

Approved, April 4, 1887. In force, July 3, 1887.

AN ACT to amend section 42 (16), chapter LVII, of the general statutes of the State of Colorado, entitled "Irrigation," requiring the water commissioners to give bond in an amount to be fixed by the board of county commissioners, and providing for the governor to fix the amount of such bond in the event that the county commissioners disagree thereon.

Be it enacted by the general assembly of the State of Colorado:

SEC. 1. That section 42, of chapter 57, of the general statutes of the State of Colorado, entitled "Irrigation," the same being general section 1752 thereof, be, and the same is hereby, amended so as to read as follows:

SEC. 42. There shall be one water commissioner for each of the above named districts, and for each district hereafter formed, who shall be appointed by the governor, to be selected by him from persons recommended to him by the several boards of county commissioners of the counties into which water districts may extend, and the water commissioner so appointed shall, before entering upon his duties, give a good and sufficient bond for the faithful discharge of his duties, with not less than three sureties, in a sum not less than one thousand dollars nor more than five thousand dollars; the amount of said bond to be fixed by the county commissioners and approved by the governor and state engineer. The commissioner so appointed shall hold his office until his successor is appointed and qualified: *Provided, however,* that if such water district shall be embraced in more than one county, and the several counties in which such water district is situated disagree as to the amount of the bond as herein required of water commissioners, then and in that event the governor shall fix the amount thereof, with the same effect as though fixed by the county commissioners.

SEC. 2. The governor shall, by like selection and appointment, fill all vacancies which may be occasioned by death, resignation, or continued absence from the district, removal or otherwise. Said county commissioners may, from time to time, recommend persons to be appointed as above provided; and the governor may at any time remove any water commissioner, in his discretion.

Approved March 15, 1887. In force June 13, 1887.

AN ACT regulating the distribution of water, and the superintendence of canals or ditches used for the purpose of irrigation, and providing a penalty for the violation thereof.

Be it enacted by the general assembly of the State of Colorado:

SEC. 1. Every person or company owning or controlling any canal or ditch used for the purposes of irrigation shall, during the time from April 15th, to November 1st, in each year, keep a flow of water therein, so far as may be reasonably practicable for the purpose of irrigation, sufficient to meet the requirements of all such persons as are properly entitled to the use of water therefrom, to the extent, if necessary, to which such persons may be entitled to water, and no more: *Provided, however,* That whenever the rivers or public streams, or sources from which the water is obtained, are not sufficiently free of ice, or the volume of water therein is too low and inadequate for that purpose, then such canal or ditch shall be kept with as full a flow of water therein as may be practicable; subject, however, to the rights of priorities from the streams or other sources, as provided by law, and the necessity of cleaning, repairing, and maintaining the same in good condition.

SEC. 2. The owners or persons in control of any canal or ditch used for irrigating purposes shall maintain the same in good order and repair, ready to receive water by April 15th in each year, so far as can be accomplished, by the exercise of reasonable care and diligence, and shall construct the necessary outlets in the banks of the canal or ditch for a proper delivery of the water to persons having paid up shares, or who have purchased rights to the use of the water: *Provided, however,* That a multiplicity of outlets in the canal or ditch shall at all times be avoided, so far as the same shall be reasonably practicable, and the location of the same shall be under the control of, and shall be at the most convenient and practicable points consistent with the protection and safety of the ditch for the distribution of water among the various claimants thereof; and such location shall be under the control of a superintendent.

SEC. 3. It shall be the duty of those owning or controlling such canals or ditches to appoint a superintendent, whose duty it shall be to measure the water from such canal or ditch through the outlets, to those entitled thereto according to his or her pro rata share.

SEC. 4. Any superintendent or any person having charge of the said ditch who shall willfully neglect or refuse to deliver water as in this act provided, or any person or persons who shall prevent or interfere with the proper delivery of water to the person or persons having the right thereto, shall be guilty of a misdemeanor, and upon conviction thereof shall be subject to a fine of not less than ten nor more than one hundred dollars for each offense, or imprisonment not exceeding one month, or by both such fine and imprisonment, and the money thus collected shall be paid into the general fund of the county in which the misdemeanor has been committed, and the owner or owners of such ditches shall be liable in damages to the person or persons deprived of the use of the water to which they were entitled, as in this act provided.

SEC. 5. Any water commissioner, or his deputy or assistant, who shall willfully neglect or refuse, after being called upon in accordance with section 1758 of the general statutes of the State, to promptly measure water from the stream or other source of supply into the irrigating canals or ditches in his district, according to their respective priorities, to the extent to which water may be actually necessary for the irrigation of lands under such canals or ditches, shall be deemed guilty of a misdemeanor, and shall be subject to the same penalty as provided in section four of this act.

SEC. 6. In all cases declared misdemeanors by this act, any justice of the peace of the county in which the offense was committed, may, upon complaint being made as is now required by law, issue a warrant directed to any proper officer of the county, for the arrest of any person so charged with any such misdemeanor, and upon the arrest of such person or persons, the justice of the peace before whom such person or persons may be brought for trial shall hear and determine the cause, and if he find the accused guilty, shall assess the fine, and if imprisonment be a portion of the sentence, then to fix the term of imprisonment, or both, as provided in section 4 of this act: *Provided*, The accused may have a trial by jury, which shall be summoned as in cases before justices of the peace for assault and battery.

Approved March 19, 1887. In force June 17, 1887.

AN ACT providing for the appointment of superintendents of irrigation for the water divisions of this State; fixing their compensation and providing for the payment thereof; prescribing their duties, and requiring a bond for the faithful performance of such; requiring clerks of district courts to furnish such superintendents with certain certified decrees, and providing for the payment of such clerks' fees.

***Be it enacted by the general assembly of the State of Colorado*:**

SEC. 1. That the governor shall appoint a superintendent of irrigation for each of the water divisions now existing within the State, or which may hereafter be created. Such superintendents of irrigation to hold office for a period of two years from the date of their respective appointments, or until their successors may be appointed and qualified. The governor may at any time in his discretion remove said superintendents of irrigation, or any of them and appoint others in their stead for the remainder of said term of two years: *Provided*, That the governor shall not appoint a superintendent of irrigation in any district [division] until the board of county commissioners of some one or more of the counties whose territory or any part of whose territory is included in such water district [division] shall have at a meeting regularly called and held, adopted a resolution requesting such appointment to be made, and have had the same certified to the governor.

SEC. 2. Said superintendent of irrigation shall have general control over the water commissioners of the several districts within his division. He shall, under the general supervision of the State engineer, execute the laws relative to the distribution of water in accordance with the rights of priority of appropriation as established by judicial decree, and perform such other functions as may be assigned to him by the State engineer.

SEC. 3. Said superintendent of irrigation shall, in the distribution of water, be governed by the regulations of this act and acts that are now in force, but, for the better discharge of his duties, he shall have the authority to make such other regulations to secure the equal and fair distribution of water, in accordance with the rights of priority of appropriation as may in his judgment be needed in his division: *Provided*, Such regulations shall not be in violation of any part of this act, or other laws of the State, but shall be merely supplementary to and necessary to enforce the provisions of the general laws and amendments thereto.

SEC. 4. Any person, ditch company or ditch owner who may deem himself injured or discriminated against by any such order or regulation of such superintendent of irrigation, shall have the right to appeal from the same to the State engineer, by filing with the State engineer a copy of the order or regulation complained of, and a statement of the manner in which the same injuriously affects the petitioner's interest. The State engineer shall, after due notice, hear whatever testimony may be brought forward by the petitioner, either orally or by way of affidavits, and through the superintendent of irrigation shall have power to suspend, amend or confirm the order complained of.

SEC. 5. Said superintendent of irrigation shall commence the discharge of his duties in his division as soon as the first water commissioner in any district within his division shall be called out, and shall continue to discharge his duties until the last water commissioner in any district of his division ceases to be needed. Each water commissioner shall report immediately to the superintendent of irrigation of his division when he is called out and when he ceases to be needed, and shall, during the continuance of his duties, be under the control of the superintendent of irrigation of his division. The superintendent of irrigation shall receive as compensation five dollars per day for every day during which he is employed in the discharge of his duty.

SEC. 6. Within thirty days after the appointment of said superintendent of irrigation, it shall be his duty to give bond to the amount of ten thousand dollars for the faithful discharge of his duty, said bond to be approved by the board of county commissioners of the county wherein said superintendent of irrigation may reside, and to be filed in the office of the county clerk and recorder of such county.

SEC. 7. Within thirty days after his appointment, said superintendent of irrigation shall send to the clerk of the district court, within his division, of such counties as have had rendered by the district court of such county, judicial decrees fixing the priorities of appropriation of water for irrigation purposes for any water district, a notification of his appointment to such office, and shall request of the said clerk a certified copy of every decree of the district court establishing priorities of appropriation of water used for irrigation purposes within that district. Thereupon it shall be the duty of the clerk within ten days after the receipt of such request from said superintendent of irrigation, to prepare a certified copy of all decrees of such district court establishing priorities of water rights made within that district, under the provisions of the general statutes of the State of Colorado, and transmit the same to the superintendent of irrigation requesting it. Said superintendent of irrigation shall then cause to be prepared a book to be entitled "The register of priorities of appropriations of water rights for water division No. ——, State of Colorado," within which he shall enter and preserve such certified copies of decree. Said superintendent of irrigation shall then, from such certified copies of decree, make out a list of all the ditches, canals and reservoirs entitled to appropriations of water within his division, arranging and numbering the same in consecutive order according to the dates of their respective appropriations within his division, and without regard to the number such ditches, canals and reservoirs may bear within their respective water districts. Such superintendent of irrigation shall then enter from his register a tabulated statement of all the ditches, canals and reservoirs in his division, whose priorities have been decreed, which statement shall contain the following information concerning each ditch, canal and reservoir arranged in separate columns: The name of the ditch, canal or reservoir, its number in his division, the district in which it is situated, the number of it in its proper district, and the number of cubic feet of water per second to which it is entitled, and such other and further information as he may deem useful to the proper discharge of his duty. In case any decrees of court establishing priorities of appropriation of water for irrigation purposes are made after the transmittal of the copy of previous decrees to the superintendent of irrigation, it shall be the duty of the clerk of the court wherein such decree is rendered, to transmit to the superintendent of irrigation of the division within which such county is situated, within ten days after it is rendered, a copy of such decree, and the superintendent of irrigation shall enter the same in his register. Such register to be filed and kept in the office of the State engineer.

SEC. 8. Said superintendent of irrigation shall have the right to call out any water commissioner of any water district within his division at any time he may deem it necessary, and he shall have the power to perform the regular duties of water commissioner in all the districts within his division.

SEC. 9. All water commissioners shall make reports to the superintendent of irrigation of their division as often as may be deemed necessary by said superintendent. Said reports shall contain the following information: The amount of water necessary to supply all the ditches, canals and reservoirs of that district; the amount of water actually coming into the district to supply such ditches, canals and reservoirs; whether such supply is on the increase or decrease; what ditches, canals and reservoirs are at that time without their proper supply; the probability as to what the supply will be during the period before the next report will be required; and such other and further information as the superintendent of irrigation of that division may suggest. Said superintendent of irrigation shall carefully file and preserve such reports, and shall from them ascertain what ditches, canals and reservoirs are, and what are not, receiving their proper supply of water, and if it shall appear that in any district in that division any ditch, canal or reservoir is receiving water whose priority post dates that of the ditch, canal or reservoir in another district, as ascertained from his register, he shall at once order such post-dated ditch, canal or reservoir shut down and the water given to the elder ditch, canal or reservoir. His orders being directed at all times to the enforcement of priority of appropriation, according to his tabulated statement of priorities, to the whole division, and without regard to the district within which the ditches, canals and reservoirs may be located. The reports of water commissioners, by the superintendents of irrigation, shall be filed and kept in the office of the State engineer.

SEC. 10. In case any ditch, canal or reservoir, in any district within such superintendent of irrigation's division, shall fail to receive its regular supply of water, the owner of such ditch, canal or reservoir may report such fact to the water commissioner of that district, who shall immediately apportion the water in his district, and send forthwith, by telegram if necessary, a report of such fact to the superintendent of irrigation of his division; and thereupon it shall be the duty of the superintendent to compare such report with his register, and if any ditch, canal or reservoir of any other district of his division is receiving water to which any ditch, canal or reservoir of any other district is entitled, he shall at once order the shutting down of the post-dated ditches, canals or reservoirs, and the water given to the ditches, canals or reservoirs having the priority of appropriation: *Provided, however*, That nothing in this act shall be construed as interfering with the priority of water for domestic use.

SEC. 11. Such superintendent of irrigation shall, in the discharge of his duties, be clothed with the powers of justice of the peace, and any person violating his orders relative to the opening or shutting down of head-gates, or the using of water for irrigation purposes, shall be deemed guilty of contempt, and summary punishment may be inflicted, not exceeding ninety days' imprisonment, or three hundred dollars fine, or both.

SEC. 12. The expenses and salary of the superintendents of irrigation shall be paid *pro rata* by the counties interested, in the same manner as the fees of water commissioners are paid; and the fees of the clerks of the district courts, for services rendered under the provisions of this act, shall also be paid by the counties interested, upon the said clerk rendering his account, certified by the district judge, to the boards of county commissioners of the counties embraced in the water divisions, in case of which the services have been rendered.

SEC. 13. That it is the opinion of this general assembly that an emergency exists; therefore, this act shall take effect and be enforced from and after its passage.

Approved and in force April 4, 1887.

AN ACT to provide for the better protection of water rights and to declare a liability in damages for the infringement thereof.

Be it enacted by the general assembly of the State of Colorado:

SEC. 1. That it shall be the duty of every person who is entitled to take water for irrigation purposes from any ditch, canal, or reservoir to see that he receives no more water from such ditch, canal, or reservoir through his head gate or by any ways or means whatsoever than he is entitled to, and that he shall at all times take every precaution to prevent more water than he is entitled to coming from such ditch, canal, or reservoir upon his land.

SEC. 2. That it shall be the duty of every such person taking water from any ditch, canal, or reservoir to be used for irrigation purposes, on finding that he is receiving more water from such ditch, canal, or reservoir either through his head gate or by means of leaks or by any means whatsoever immediately to take steps to prevent his further receiving more water from such ditch, canal, or reservoir than he is entitled to, and if knowingly he permits such extra water to come upon his land from such ditch, canal, or reservoir and does not immediately notify the owner or owners of such ditch, or take steps to prevent its further flowing upon his land, he shall be liable in damages to any person, company, or corporation who may be injured by such extra appropriation of water for the actual damage sustained by the party aggrieved, which damages shall be adjudged to be paid together with the costs of suit and a reasonable attorney's fee to be fixed by the court and taxed with the costs.

SEC. 3. That it is the opinion of this general assembly that an emergency exists; therefore, this bill shall be in force and take effect from and after the day of its passage.

Approved and in force April 4, 1887.

AN ACT to compel the owners of canals and ditches situated within cities of the first class, or cities existing by special charter of a population equal to or exceeding said cities of the first class, to confine flume and cover the same at their own expense.

Be it enacted by the general assembly of the State of Colorado:

SEC. 1. That every corporation and company, whether created by special act or organized under the general incorporation laws of this State, and every partnership, person, or persons who now, or may at any time hereafter, own or control any canal or ditch, or any part thereof, being two feet in width or over, and carrying water to the depth of twelve inches or over, which canal or ditch or any part thereof is within the corporate limits of any city denominated in the law as of the first class, or any city existing by special charter of a population equal to or exceeding said cities of the first class, or any of the additions thereto, shall, at their own expense, within sixty days after this act shall take effect, confine flume, and cover all or any part of such canal or ditch, whether located on, or across private property, public highways or alleys in said city or additions thereto in a reasonable and sufficient manner and with such materials as will render such fluming or covering safe and a sure protection to the lives and property of the inhabitants of said city; and any such corporation, company, partnership, person, or persons shall at all times thereafter keep and maintain any and all such structures confining fluming and covering of such canal or ditch in good order and repair at their own expense.

SEC. 2. Such corporation, company, partnership, person, or persons shall, at their own expense, safely and securely lattice or slat the head of such flume or covering with proper materials, so that persons or animals can not accidently enter such flume or covering at the head thereof and pass or be carried down the current of said canal or ditch, and shall thereafter maintain and keep the same in good order and repair at their own proper cost and expense.

SEC. 3. If any such corporation, company, partnership, person, or persons shall fail or refuse to comply with any of the provisions of the two preceding sections, such corporation, company, partnership, person, or persons shall forfeit and pay to the county, for the use of the common school fund the sum of fifty dollars for each and every day such failure or refusal shall continue; to be recovered by a civil action in the name of the people of the State of Colorado, in any court of competent jurisdiction: *Provided*, That nothing in this act shall be construed to bar an action for special damages by any person who shall have suffered such damages by reason of any failure to comply with any of the provisions of this act.

SEC. 4. Whereas in the opinion of this general assembly an emergency exists; therefore, this act shall be in force from and after its passage.

Approved and in force March 29, 1887.

AN ACT to amend section two of an act of the general assembly of the State of Colorado, entitled "An act to provide for the extension of the right of way for ditches, canals, and feeders of reservoirs in certain cases, and requiring registration of all such hereafter made or enlarged," approved February 11, 1881, being general section No. 1720 of the general statutes of the State of Colorado, which is section 10 of chapter LVII of said general statutes, entitled "Irrigation."

Be it enacted by the general assembly of the State of Colorado:

SEC. 1. That section two (2) of said act (approved February 11, 1881, being general section No. 1720 of the general statutes of the State of Colorado, which is section 10 of chapter 57 of said general statutes, entitled "Irrigation," be, and the same is hereby, amended so as to read as follows:

SEC. 2. Every person, association, or corporation hereafter constructing or enlarging any ditch, canal, or feeder for any ditch or reservoir for irrigation, and taking water directly from any natural stream, and of a carrying capacity of more than one cubic foot of water per second of time, as so constructed or enlarged, shall, within ninety (90) days after the commencement of such construction or enlargement, file in the office of the county clerk and recorder of the county in which the head-gate of such ditch or feeder may be situated, and also in the office of the State hydraulic engineer a map showing the point of location of such head-gate, the route of such ditch or canal, or the high-water line of such reservoir or reservoirs, and the route of the feeder to and ditches or canals from such reservoir or reservoirs; the legal subdivisions of the lands upon which such structures are built or to be built, if on surveyed lands; the names of the owners of such lands as far as the same are of record in the office of the county clerk of the county in which they are situated; such courses, distances, and corners, by reference to legal subdivisions, if on surveyed lands, or to natural objects if on unsurveyed lands, as will clearly designate the location of such structures. Upon or attached to such map shall be a statement showing:

First. The point of location of the head-gate above mentioned.

Second. The depth, width, and grade of such ditch, canal, or feeder.

Third. The carrying capacity of such ditch, canal, or feeder, in cubic feet per second of time, and the capacity of such reservoir or reservoirs in cubic feet when filled to the high-water mark.

Fourth. The time of commencement of work on such structures, which time may be dated from the commencement of the surveys therefor. In case of an enlargement, such statement shall also show the matters required in items second, third, and fourth above, as to the enlargement, and state the increased capacity arising from such enlargement. If such statement be filed within the time above limited priority of right of way and water accordingly shall date from the day named as the day of commencing work; otherwise only from the date of the filing of the same: *Provided*, That nothing herein contained shall be taken to dispense with the necessity of due diligence in the prosecution of such structures on the part of the projectors of the same. Such statement shall be signed by the person, association, or corporation on whose behalf it is made, and the truth of the matters shown in such map and statement shall be sworn to by some person in whose personal knowledge the truth of the same shall lie.

Approved April 20, 1887. In force July 19, 1887.

WYOMING DIVISION.

CHEYENNE, WYO., *September* 17, 1889.

The committee met pursuant to call of the chairman.

Present: Mr. Stewart (chairman) and Mr. Jones, of Arkansas; also Director Powell.

STATEMENT OF CHARLES BELLAMY, OF LARAMIE.

The CHAIRMAN. What is your occupation?

Mr. BELLAMY. I am a civil engineer and a surveyor.

Mr. CHAIRMAN. How long have you resided in Laramie City?

Mr. BALLAMY. Off and on for ten years.

The CHAIRMAN. Are you familiar with the topography and water supply and the land to be irrigated in any portion of Wyoming; if so, what portions are you familiar with?

Mr. BELLAMY. Yes; I am familiar with the two Laramie rivers and their tributaries.

The CHAIRMAN. Are there two Laramie rivers?

Mr. BELLAMY. The Big and Little Laramie. They join 10 or 12 miles north of Laramie City, and then it is the main Laramie River from there on.

The CHAIRMAN. Of what altitude are the Laramie Plains?

Mr. BELLAMY. The altitude of Laramie City is 7,123 feet, and the plains average, I should say, from 7,000 to 6,000 feet where the Laramie River enters the hills.

The CHAIRMAN. What crops can you produce in the Laramie Plains at that altitude?

Mr. BELLAMY. I am not very familiar with the raising of crops, not being a ranch man.

The CHAIRMAN. You have been surveying there?

Mr. BELLAMY. Yes. I know that oats can be raised, of the very best quality.

The CHAIRMAN. Do they raise wheat there?

Mr. BELLAMY. Yes; very fair wheat has been raised, although not in any great quantity. It has been mostly experimental.

The CHAIRMAN. Do they raise vegetables of any kind?

Mr. BELLAMY. Yes; they raise all the vegetables, such as potatoes, cabbage, onions, etc.

The CHAIRMAN. Do the Laramie Plains require irrigation to produce crops?

Mr. BELLAMY. Certainly.

The CHAIRMAN. What is the chance to irrigate on the plains, and what is the water supply?

Mr. BELLAMY. I could best show that with the map. I have prepared a large map of those two rivers.

The **CHAIRMAN.** How is the map marked?

Mr. **BELLAMY.** It is marked "Map of the irrigating ditches of the Laramie Plains." [Describing the map.] The black lines show the rivers and the blue lines the ditches; the blue spots are the lakes or ponds. It is divided into townships and subdivided into sections. The scale is 1 inch to the mile. The map begins at a point 3 miles north of the Colorado line and runs to where the Laramie River enters the Black Hills.

The **CHAIRMAN.** That river passes through the Black Hills, does it?

Mr. **BELLAMY.** Yes.

The **CHAIRMAN.** It enters into the North Platte?

Mr. **BELLAMY.** Yes; on this side of the Black Hills.

The **CHAIRMAN.** How far north from here is the Laramie River when it gets through the hills?

Mr. **BELLAMY.** From 60 to 65 miles. That is, where it passes into the Black Hills it is that much, and where it enters the Platte River it is, I guess, 85 or 90 miles.

The **CHAIRMAN.** It is the largest fork of the Platte, is it?

Mr. **BELLAMY.** Yes.

The **CHAIRMAN.** You raise grass crops there, do you?

Mr. **BELLAMY.** Yes.

The **CHAIRMAN.** What kind of grass crops can you raise there with irrigation?

Mr. **BELLAMY.** I could not tell the names of them; I know there is blue grass, and timothy, and alfalfa, and also red-top. I do not know the names of the other kinds.

The **CHAIRMAN.** What do you say of the supply of water in the streams for irrigation; how extensive is it?

Mr. **BELLAMY.** There is a supply on both the forks of the Laramie that could be stored so as to be used when wanted, but it comes down with such a rush that it can not be used at all.

The **CHAIRMAN.** Are there other streams entering into the Laramie; has it many branches?

Mr. **BELLAMY.** Yes; quite a number.

The **CHAIRMAN.** Are they represented on the map?

Mr. **BELLAMY.** Yes.

The **CHAIRMAN.** Do they furnish much water in the spring time?

Mr. **BELLAMY.** Yes; when the spring freshets are on almost all these little creeks furnish water enough for irrigation, but they last only two weeks, sometimes, and that is not long enough for irrigation.

The **CHAIRMAN.** Are there opportunities for storing the water?

Mr. **BELLAMY.** Yes; quite a number. In Sand Creek, for example, which heads in Colorado, there is a chance, in two or three different places, on each farm on Sand Creek, by just damming across the cañon to store a considerable quantity of water.

The **CHAIRMAN.** Has the land in the valley been entered; that is, the even sections? The railroad, I suppose, has the other sections or most of them?

Mr. **BELLAMY.** Most of them.

The **CHAIRMAN.** And along the creeks, how is it?

Mr. **BELLAMY.** It is pretty much taken up on the creeks.

The **CHAIRMAN.** As to the plain between the streams the even sections are still Government lands, are they?

Mr. **BELLAMY.** Yes.

Senator **JONES.** How much land is irrigated of the sixty-six townships that you show on this map?

Mr. BELLAMY. I have not figured that out, but I should think there are about 500,000 acres under ditch.

Senator JONES. I mean what is actually irrigated?

Mr. BELLAMY. That I can not say.

Senator JONES. Is it three-fourths, or one-half, or 10 per cent., or what?

Mr. BELLAMY. Perhaps a little more than 10 per cent.

The CHAIRMAN. That would be about 50,000 acres?

Senator JONES. Actually in irrigation and under cultivation?

Mr. BELLAMY. Yes.

Senator JONES. Are they actually under irrigation and under cultivation?

Mr. BELLAMY. Yes.

Senator JONES. Is there water enough in the country to irrigate the balance of the 500,000 acres?

Mr. BELLAMY. I think there is, if it were stored.

Senator JONES. There is not enough in the season?

Mr. BELLAMY. At present there is enough, but during the freshet there is more water than they can use, though it does not last long.

Senator JONES. That is, in the spring?

Mr. BELLAMY. Yes.

Senator JONES. I am speaking of the water in the ditches. Do the ditches, during the irrigating season, furnish water enough to irrigate the land?

Mr. BELLAMY. Yes. They would, during the high water, if they had a full supply and were running full.

Senator JONES. Do they run full during the entire irrigating season?

Mr. BELLAMY. Not during the entire irrigating season; only about two weeks.

Senator JONES. The difficulty then is, that there is not enough water in the streams to furnish the water required for the ditches?

Mr. BELLAMY. No.

Senator JONES. Would storage be the remedy for that?

Mr. BELLAMY. Yes.

The CHAIRMAN. Have you made any calculation to see how much could be irrigated if it were stored?

Mr. BELLAMY. I will tell you some work I have done. Here is a ditch in township 14 north, range 77 west. It comes out on the south boundary of the township, on the left bank of the Big Laramie River. The ditch at present is constructed, for about 2½ miles, 16 feet wide on the bottom, and 5 or 6 feet deep. The carrying capacity of that ditch is not large enough for the land it could irrigate. From the present terminus of the ditch, if there were water enough in the Big Laramie River to last long enough, that ditch would irrigate almost the entire body of the land between the Big and Little Laramies.

Senator JONES. How long would that ditch have to be, to accomplish that which you suggest?

Mr. BELLAMY. The main ditch would have to be about 45 miles long, with, I should say, 100 miles of laterals.

Senator JONES. That would irrigate how much land?

Mr. BELLAMY. That would irrigate very nearly six townships.

The CHAIRMAN. Is there water enough at present to irrigate any such amount of land?

Mr. BELLAMY. Yes, by storage.

The CHAIRMAN. I mean without storage, is there enough?

Mr. **Bellamy**. I think not. It don't last long enough. It comes down with a rush and all is gone; not the whole of it, but there is not enough left in two weeks to supply all. The center of Lake Hattie, in the southwest corner of township 15 north, range 76 west, could be turned into a reservoir from this ditch, and then, from that lake the water could be carried over quite an extent of country.

Senator **Jones**. That lake would not be big enough to do anything, if it is correctly shown on the map.

Mr. **Bellamy**. It could be made a great deal larger from the ground around.

The **Chairman**. Is there any place higher up on the Laramie?

Mr. **Bellamy**. Yes; in Colorado there are quite a number of places. Above Cumming City, which is about 5 miles north of the Colorado line, the river runs into a cañon, and from there on back it would spread over quite a large extent of country.

The **Chairman**. Would it be private land or public land?

Mr. **Bellamy**. I can not say just how much of that is filed on and how much is not.

The **Chairman**. What other operations might be had in the valley?

Mr. **Bellamy**. With regard to the Little Laramie, that is a stream that is causing much trouble with the ranchmen. The people up above wanted to take the water and deprive the people below altogether. At the foot of the Snowy Range there are a number of lakes. Some of them run into the Little Laramie and other places, and I think there is the greatest chance for a large amount of storage of water.

The **Chairmam**. What other streams are there?

Mr. **Bellamy**. There is Rock Creek.

Senator **Jones**. If all the water coming down the Little Laramie should be stored in the lakes at the head of the river, would there be more than enough water to fill the ditch?

Mr. **Bellamy**. Yes.

Senator **Jones**. How much would it increase in quantity?

Mr. **Bellamy**. This ditch, in range 78 west, could be continued in to Lake James. That would irrigate all this land in between the lake and the Little Laramie.

Senator **Jones**. Would there be water enough for all of it?

Mr. **Bellamy**. Yes. Even now, when the the Little Laramie is up in the spring, with all these ditches running full, there is still the bank-full besides, for a little over two weeks.

The **Chairman**. How much of a lake is that?

Mr. **Bellamy**. It covers fully two sections.

The **Chairman**. Can you draw the water from it?

Mr. **Bellamy**. No; the banks all around it are too high.

The **Chairman**. What stream is there immediately beyond that?

Mr. **Bellamy**. There is Seven-Mile Creek and Four-Mile Creek. These two creeks have ditches on them, but they have no particular chance for reservoirs. Four-Mile Greek does not run into Lake James, but into the Laramie River.

The **Chairman**. There is another lake below that, is there not?

Mr. **Bellamy**. Yes; Cooper Lake.

The **Chairman**. Can that be made a storage reservoir?

Mr. **Bellamy**. I think it might be, but to supply that lake the water would have to be taken either from the Little Laramie or Rock Creek.

Senator **Jones**. Is the level of Cooper Lake high enough to irrigate the land on the level of it?

Mr. **BELLAMY.** It would have to be raised up 20 feet.

The **CHAIRMAN.** Could you run a cut or tunnel into it?

Mr. **BELLAMY.** I believe it is a little higher than the river, but I do not know that anybody has ever made a survey of it.

Senator **JONES.** Has there ever been any survey made of the water running down the Big and Little Laramie Rivers?

Mr. **BELLAMY.** Yes; Mr. Mead has that.

The **CHAIRMAN.** Is there anything further that you wish to say?

Mr. **BELLAMY.** I would like to add that in township 18 north, range 74 west, on this side of the Laramie, and for a distance of about 15 miles, there is a space for reservoir use that will irrigate a whole township. There is fully a half township under irrigation there.

STATEMENT OF ELWOOD MEAD, CIVIL ENGINEER, OF CHEYENNE.

The **CHAIRMAN.** What is your profession?

Mr. **MEAD.** Civil engineer.

The **CHAIRMAN.** Have you any official position?

Mr. **MEAD.** I am the engineer of this Territory, and have the general supervision of the waters of the Territory and of the officials in the engineer's department.

The **CHAIRMAN.** Have you given attention to the subject of irrigation, the water supply, and the lands to be irrigated in the Territory of Wyoming?

Mr. **MEAD.** Yes.

The **CHAIRMAN.** Have you prepared any statement on the subject of irrigation?

Mr. **MEAD.** I have one report here dealing with some of the general features of the subject and two supplementary reports giving statistics.

The **CHAIRMAN.** State generally what your report contains.

Mr. **MEAD.** A general statement of the character of the irrigation development here and some of the difficulties that we have encountered; also some criticisms of the present methods and recommendations as to suitable measures to improve them. The supplementary statements give the statistics.

The **CHAIRMAN.** Of what has been done.

Mr. **MEAD.** Yes.

Senator **JONES.** Does it give the quantity of land under cultivation by irrigation?

Mr. **MEAD.** Yes.

Senator **JONES.** And the quantity under ditch that is not in cultivation?

Mr. **MEAD.** No; it is impossible to determine between the two. It gives the quantity under ditch.

Senator **JONES.** It does not give the quantity under actual cultivation?

Mr. **MEAD.** No; there is no way to arrive at that.

Mr. **JONES.** In some instances nine-tenths of the land under ditch is not in cultivation and it is important to know when there is any material difference.

Mr. **MEAD.** Yes; but it would be impossible at the present time to ascertain that.

Senator **JONES.** Do you approximate it.

Mr. **MEAD.** No; I can not attempt that. The statistics given of ditch construction are of the ditches actually constructed and which are in a condition to water these lands, as far as we could make it so.

The **CHAIRMAN**. Are you familiar with the different localities, having passed over the country personally?

Mr. **MEAD**. Yes; I am. Between two-thirds and three-fourths of the territory, or nearly so, has been visited by me personally.

The **CHAIRMAN**. Are you familiar with the Laramie Plains?

Mr. **MEAD**. Yes.

The **CHAIRMAN**. Have you made a report on those?

Mr. **MEAD**. Not a specific report on those.

The **CHAIRMAN**. Are they capable of producing crops with irrigation?

Mr. **MEAD**. Yes.

The **CHAIRMAN**. What kind of crops?

Mr. **MEAD**. All the hardier cereals and hardier vegetables.

The **CHAIRMAN**. How is it as to grasses?

Mr. **MEAD**. They will produce excellent grass.

The **CHAIRMAN**. We have had a map of the Laramie Valley presented here. What proportion of the valley is susceptible of irrigation, that is, that you could get a water supply for? Have you made a calculation on that?

Mr. **MEAD**. No, I have not made any estimate. I would not undertake to say.

The **CHAIRMAN**. You have never gauged the streams?

Mr. **MEAD**. Yes, I have a complete record for this year.

Senator **JONES**. Is that information in the statistics that you will present to the committee?

Mr. **MEAD**. Yes.

The **CHAIRMAN**. Have you examined the valley with a view of ascertaining the opportunities for storage, to increase the supply of water by saving what water does flow?

Mr. **MEAD**. I have only made a partial examination of that. I went over every part of the streams and there are a number of favorable places for reservoirs—a number that are not shown on the map that Mr. Bellamy showed you. The country is not sufficiently settled for me to locate them with sufficient accuracy to mention them on the map.

The **CHAIRMAN**. What are the other basins or water sheds?

Mr. **MEAD**. I have a statement covering this matter in type, that will be presented to you describing these drainage basins. I can go over it now if you desire it.

Senator **JONES**. I think it will be as well to have the statement filed.

The **CHAIRMAN**. You need not go over it particularly, but I would like to ask some questions about the different basins.

Mr. **MEAD**. Very well, I will commence with the first. Here [referring to the map] is an outline of division No. 1, comprising the drainage of the Platte River, which is absolutely independent of any other portion of the Territory.

The **CHAIRMAN**. The Platte River and its tributaries?

Mr. **MEAD**. Yes.

The **CHAIRMAN**. What tributaries are there to the Platte, within its drainage basins?

Mr. **MEAD**. Several hundred streams that are used for irrigation.

The **CHAIRMAN**. They are already used, are they, for that purpose?

Mr. **MEAD**. There are almost two hundred streams in that one basin that are used for irrigation. Many of them are small.

The **CHAIRMAN**. About what amount of land lies so that it can be covered by the water in that basin?

Mr. **MEAD**. It would be impossible to state at present how much of it would be covered, for it would take an examination of almost every one of those streams to determine that matter and it has been impossible to make it.

The **CHAIRMAN**. Is it large or small, the amount that is susceptible of irrigation?

Mr. **MEAD**. Quite a large area. In the eastern portion, nearly the whole capacity of the tributaries of the Platte has been utilized.

The **CHAIRMAN**. Has there been any storage resorted to for its increase?

Mr. **MEAD**. Not to any considerable extent; only a few small basins.

The **CHAIRMAN**. You say they have exhausted the water that runs through the basin in the irrigation season, in the eastern portion?

Mr. **MEAD**. Yes.

The **CHAIRMAN**. But no effort has been made to save the water?

Mr. **MEAD**. No.

The **CHAIRMAN**. Have you any idea of the amount of the water that runs to waste?

Mr. **MEAD**. There has not been much this season, but generally there is. Quite a considerable portion runs to waste in the early spring, when there has been much snow-fall, but it has been practically all utilized this year. On the main stream of the Platte but very little has been done. The main channel itself has had no considerable irrigation. The principal development has been in the upper portion where it could be done cheaply.

The **CHAIRMAN**. Give us a description of the Platte River from the time it leaves the mountains, where the Laramie River enters into it, down into Nebraska.

Mr. **MEAD**. From the time it leaves Colorado, in the upper portion, there are great facilities both for diverting ditches and for constructing storage reservoirs. That is one of the best sections of this country that I have examined for that purpose. There are large numbers of natural basins situated from half a mile to a mile from the stream. One company has been incorporated to irrigate a large quantity of land there. Nothing has been done about the incorporation yet, but it is feasible. After the stream enters the territory, for about 100 miles, the banks become higher.

The **CHAIRMAN**. What is its character where it leaves the territory and enters Nebraska?

Mr. **MEAD**. It follows a country where it could be diverted, but at more expense. It becomes broader and has a more extensive bend. I should say about 150 miles of it would be of that character.

The **CHAIRMAN**. Above that it has a rocky bottom so that you can take it out.

Mr. **MEAD**. It is not exactly a rocky bottom. It has a rocky bottom in some places and earth bottom in others. Nearly all the streams come back to the surface. Next to the Little Laramie the next important tributary of the Big Laramie is the Sweetwater, with 1,000 cubic feet per second.

The **CHAIRMAN**. Do you put the Sweetwater in that division?

Mr. **MEAD**. Yes. The Little Laramie and the Sweetwater are the two important tributaries, although there are a number of other smaller streams that are excellent streams for irrigation.

The **CHAIRMAN**. What is the next division on your map?

Mr. **MEAD**. The next includes the streams that are east of the Big Horn Mountains. It is northeast on that map, but there is a very slight curve. All the streams that leave the Big Horn are good streams.

The **CHAIRMAN**. Where do they discharge their waters?

Mr. **MEAD**. Into the Missouri and its tributaries.

The **CHAIRMAN**. They all get into the Yellowstone pretty much, do they not?

Mr. **MEAD**. Those streams that have their heads north of the Big Horn Mountains have not so much importance for irrigation. There are a number of streams in the northeastern portion of the territory in which it needs as little water for irrigation as any.

The **CHAIRMAN**. What is the altitude of that section?

Mr. **MEAD**. From 3,500 feet to 6,000 feet. Sheridan is the lowest point I know of.

The **CHAIRMAN**. That section is lower than the Laramie plains?

Mr. **MEAD**. Yes.

The **CHAIRMAN**. Is there much population in that section?

Mr. **MEAD**. Yes, Johnson and Sheridan Counties are the principal farming districts of the State at this time.

The **CHAIRMAN**. Have you visited those counties?

Mr. **MEAD**. Yes.

The **CHAIRMAN**. How much land is irrigated in that division.

Mr. **MEAD**. Let me describe the situation and you will understand the difficulty of making an estimate.

The **CHAIRMAN**. Describe it.

Mr. **MEAD**. Each one of the valleys of these streams will vary in width from half a mile to 3 or 4 miles. Then you go over a divide. In some places, owing to the immense fall of the country, they have carried the water over those ridges; they are not too steep to prevent irrigation but you can not get a view of the country. You can not form any estimate of it. You will look at one valley and you can see a certain portion of it, but it is impossible to form any estimate.

The **CHAIRMAN**. Is there nobody who knows how much, whether it is a large quantity or a small quantity?

Mr. **MEAD**. I should say that there are 100,000 acres, perhaps, that are being farmed there, but I may be mistaken. That includes the hay that is cut as well as the grain.

The **CHAIRMAN**. What is the character of the crops grown over in that section?

Mr. **MEAD**. Everything that is grown in Iowa and Kansas.

The **CHAIRMAN**. Are the crops good?

Mr. **MEAD**. Yes, the finest yield of wheat I have ever seen is in Johnson County. I understand that it yielded 90 bushels to the acre last year, and that the yields are uniformly large. The yield of all small grains, however, in this whole territory is large. The finest timothy I ever saw is grown there—6 feet high. It seems to be peculiarly adapted to that crop.

The **CHAIRMAN**. Is there anybody present who farms over there?

Mr. **MEAD**. Both Mr. Burt and Mr. Coffeen can give you that information, I think.

The **CHAIRMAN**. What is the other district?

Mr. **MEAD**. The third district is the Big Horn and its tributaries.

The **CHAIRMAN**. Is that all in your statement?

Mr. **MEAD**. Yes.

Senator **JONES**. It seems to be better to have it in that shape?

Mr. **MEAD**. On the Big Horn, this part of the country north of the reservation, I have never examined, but I have had a number of reports from surveyors.

Senator **JONES**. Are those included in the statements you are going to file?

Mr. MEAD. No; not the reports. I have had no time to include duplicates of them. It is included in correspondence running over a couple of years.

Senator JONES. Is there anybody here who can explain the Big Horn country?

Mr. MEAD. Yes; but I can describe the general features of that country. I am familiar with it, although I have never been over it.

Senator JONES. That is not in your report, is it?

Mr. MEAD. No. A great many of those streams have banks of considerable height, so that it would be expensive to divert the water, but in the southern portion there are large areas that can probably be reclaimed in time, whenever they will justify the expense of constructing the headworks. I think there will be no difficulty in utilizing the flow of the Big Horn basin. There is a large valley 60 miles by 30 miles that could all be watered from one system. One canal would water the whole tract. The third division is the Greene, the Bear, and the Snake Rivers.

Senator JONES. That is in the western portion?

Mr. MEAD. Yes. The waters of the Greene can best be diverted in the upper portion.

Senator JONES. North of the railroad?

Mr. MEAD. North of the railroad; from 50 to 125 miles north.

Senator JONES. What is the character of the country up there?

Mr. MEAD. It is a fine country—as fine as you ever saw.

Senator JONES. The Greene is a good river, is it, up there?

Mr. MEAD. Yes. And there are a large number of storage basins there. You will see the natural lakes that exist on the head-waters of those streams. After you get down below the country becomes rolling and is of no value for irrigating purposes. All those streams on the west side of the Greene have narrow valleys and there is quite a considerable settlement in them, but no large areas can be brought under cultivation on the west side of the Greene. The Bear River flows out of Colorado into Wyoming and crosses over into Idaho, then re-enters the Territory and again leaves it and passes again into Idaho.

Senator JONES. Is there much water on the Bear?

Mr. MEAD. All the water on the Bear River was diverted this year by a Utah corporation.

Senator JONES. Where does the Bear empty its waters?

Mr. MEAD. It finally empties them into Salt Lake. The valley varies in width usually from 2 to 3 miles. In many places it is wider than that and in some places it is narrower. It is easy to divert the water. It was all utilized this year.

Senator JONES. Have you never heard any estimates made as to the amount of land in Wyoming that may ultimately be brought under cultivation?

Mr. MEAD. Yes, all the way from 5,000,000 to 10,000,000 acres.

Senator JONES. The estimates vary that much, do they?

Mr. MEAD. Yes.

Senator JONES. You are not prepared to say which is the nearest correct, the 5,000,000 or the 10,000,000?

Mr. MEAD. I would not want to state unless with modifications. I have stated that in my report.

STATEMENT OF M. C. BROWN, OF LARAMIE CITY.

The **Chairman**. Do you know the character of the crops that may be produced in the Laramie Valley?

Mr. **Brown**. Yes.

The **Chairman**. Please state them.

Mr. **Brown**. All of the hardier cereals and vegetables, and with perfect success. They grow abundantly. I think that the best quality of barley that I have ever seen in my life I saw grow near Laramie City, on the plains; also as fine oats as have ever been grown in any country on earth.

The **Chairman**. Is that regular? Are the crops reliable?

Mr. **Brown**. Every year when there is sufficient water.

The **Chairman**. There is no other difficulty than want of water?

Mr. **Brown**. No.

The **Chairman**. The altitude and frost do not affect them?

Mr. **Brown**. I have never known frost to affect grain or the hardier vegetables.

The **Chairman**. It is too high to raise corn?

Mr. **Brown**. Yes; corn has been grown there, but not with success.

The **Chairman**. What is regarded as a good crop of wheat, barley, and oats?

Mr. **Brown**. From 30 to 40 bushels an acre of wheat; from 30 to 50 bushels of oats to the acre.

Senator **Jones**. Is that an average crop year after year?

Mr. **Brown**. Yes.

Senator **Jones**. The average over the entire country and for a number of years?

Mr. **Brown**. The extent of farming in that country is limited; the people have never indulged in that business to any great extent, because they have never had water sufficient to irrigate their crops.

Senator **Jones**. I understand that; what I mean, are your estimates the general average over the country that is irrigated for a series of years?

Mr. **Brown**. Yes.

The **Chairman**. Do you raise good potatoes there?

Mr. **Brown**. Yes; as good as grow anywhere on the earth, and in large quantities.

The **Chairman**. You have lived there sometime?

Mr. **Brown**. Twenty years.

The **Chairman**. Have you observed the flow of water in the streams?

Mr. **Brown**. Somewhat. I am not very familiar with the flow of water, but have visited the streams frequently through the year and know something of them.

The **Chairman**. Do they have considerable floods?

Mr. **Brown**. Yes. In the early spring, say from the middle of April, the water begins to flow in considerable quantities, increasing from week to week until July. I think it reaches its height in the early part of July.

The **Chairman**. What is the irrigation season?

Mr. **Brown**. From the 1st of June on.

The **Chairman**. To how late a period?

Mr. **Brown**. Up to about the middle or last of July.

The **Chairman**. And you want irrigation during that time?

Mr. **Brown**. Yes. In some years they need to irrigate in May.

The **CHAIRMAN**. Not to exceed sixty days, then?

Mr. **BROWN**. From sixty to ninety days.

Senator **JONES**. At what time do you harvest your wheat there?

Mr. **BROWN**. In August and September, usually.

Senator **JONES**. You have no trouble with early frost?

Mr. **BROWN**. We have early frosts, but the grain usually ripens before that; sufficiently so that the frost does not harm it.

Senator **JONES**. Has there been any effort made to increase the efficiency of your streams by reservoirs?

Mr. **BROWN**. No, not to any great extent.

Senator **JONES**. Has there been any resort to artesian wells in the Laramie Plains?

Mr. **BROWN**. Yes, there are quite a number of artesian wells, but the flow from such wells is not large.

The **CHAIRMAN**. Not large enough to be of any value for irrigating purposes?

Mr. **BROWN**. I can not say that it would not be of any value, but it would be of no very considerable value unless the wells were of greater depth than any we have made up to this time.

Senator **JONES**. Do you know how deep they are, as a rule?

Mr. **BROWN**. The deepest I know of is about 1,500 feet.

Senator **JONES**. Do you know anything about the volume of the waters afforded by those wells?

Mr. **BROWN**. I do not as from measurement. I can say nothing about that except to say that a number of wells produce quite a stream of water.

Senator **JONES**. Is that water used for irrigating purposes?

Mr. **BROWN**. I think in a few instances, to a very limited degree. It is used for irrigating trees, plants, and things of that kind more than for any other purpose.

Senator **JONES**. There is no idea prevailing there that artesian wells can be made a material factor in the question of irrigation?

Mr. **BROWN**. I think not.

The **CHAIRMAN**. Do you wish to make any further suggestion?

Mr. **BROWN**. I want to make this suggestion in answer to some remarks of Senator Jones: If the United States can distribute the water in such a way as to irrigate these lands then homesteads are possible, and I agree with him that those lands should be distributed among the citizens of this country as homes. But they can not have homes without water on those arid lands. In Illinois and Iowa the lands were valuable without irrigation. Let the United States make these lands, by irrigation, what the lands of Iowa are without irrigation, and we will be satisfied with the same amount of land as homes for our people.

STATEMENT OF CHARLES W. BURDICK, OF SARATOGA.

The **CHAIRMAN**. In what part of the Territory is Carbon County?

Mr. **BURDICK**. In the southern portion, at the head of the Platte River.

The **CHAIRMAN**. How far from here?

Mr. **BURDICK**. One hundred and ninety miles west. I believe that is the distance by railroad. It is a little shorter by the overland line.

The **CHAIRMAN**. Is there any irrigation practiced in your locality?

Mr. **BURDICK**. Yes; the small streams are used to the extent of their capacity. The Platte is not used to any great extent.

The **CHAIRMAN.** Is there any water running to waste in the flood time usually?

Mr. **BURDICK.** There is water that runs to waste.

The **CHAIRMAN.** Has any effort been made to retain it?

Mr. **BURDICK.** No, never.

The **CHAIRMAN.** Has there been any digging out of the streams in the mountains or hills above to make them flow more water?

Mr. **BURDICK.** No.

The **CHAIRMAN.** In the Territory of Utah they have increased their supply immensely by scraping out the stream beds and thereby opening the streams. They have not stored any water. Is there opportunity to do that in the small streams that come into the Platte?

Mr. **BURDICK.** I do not recollect any places where it could be done. Possibly I am not familiar enough with the method.

Senator **JONES.** That can only be done where the streams go back to the cañons. They could go to the cañons, remove obstructions there and in the stream beds, so as let the water flow better.

Mr. **BURDICK.** I do not believe that that would have any material effect. The only thing I think of that would have an effect there would be the cutting down to bed-rock and obtaining the water that flows underneath.

The **CHAIRMAN.** Is that one of the things that is done?

Mr. **BURDICK.** I do not know that that is done here, but I think it might be done. It is a fact that in low-water seasons the water sinks and then rises in places; then sinks again for a mile or so, and then again rises to the surface.

The **CHAIRMAN.** What is the extent of irrigation in your county? How much ground is under irrigation?

Mr. **BURDICK.** I estimate that in what we call the Platte Valley there are now probably 200,000 acres under ditches. I do not mean by that that it is all irrigated.

The **CHAIRMAN.** How much of that is irrigated and cultivated?

Mr. **BURDICK.** Not over 25,000 acres, I think. That includes what you call hay land and river bottom.

The **CHAIRMAN.** Is there water for the ditches?

Mr. **BURDICK.** There is water for the ditches, but there would not be water enough in the ditches to cultivate and irrigate the land lying below the ditches.

The **CHAIRMAN.** Do the ditches come from the small streams or from the Platte?

Mr. **BURDICK.** From the small streams principally. I think all the land is cultivated now that can be cultivated by the water that runs in the ditches, unless we waste the water.

The **CHAIRMAN.** It is usually the case that two-thirds of the water is wasted. You do differently from most people if you do not waste it. What kind of crops do you raise there?

Mr. **BURDICK.** Small grains and vegetables. The elevation is about 7,000 feet. I have never noticed any effect of the frost on our crops.

The **CHAIRMAN.** Do you raise fair crops of small grains?

Mr. **BURDICK.** Fair; about 30 bushels to the acre of oats and 25 of wheat.

Senator **JONES.** How much of potatoes?

Mr. **BURDICK.** Thirty-five bushels is the average, but we raise them very fine and very large. The soil seems to be particularly adapted to potatoes.

The **CHAIRMAN.** But your crop is only 35 bushels?

Mr. **Burdick.** Only that. I am giving you the exact figures from my own experience. I do not believe in exaggerated figures. I have raised all those grains myself.

STATEMENT OF MARK HOPKINS, OF ROCK SPRINGS.

The **Chairman.** In what part of the Territory is Sweetwater County?

Mr **Hopkins.** In the southwestern part of the Territory; it is in what is called water district No. 4.

The **Chairman.** On what stream do you live?

Mr. **Hopkins.** I live on Bitter Creek.

The **Chairman.** On what part of Bitter Creek?

Mr. **Hopkins.** Within 20 miles of the mouth of the stream.

The **Chairman.** Is there any cultivation on Bitter Creek?

Mr. **Hopkins.** Very little; in fact, none that I know of.

The **Chairman.** There may be a little up in the mountains in the springs, where the creek comes out?

Mr. **Hopkins.** No, I do not think there is any land in cultivation on Bitter Creek whatever. The water that would have to be relied on for cultivation in Sweetwater County would be on Greene River and its tributaries.

The **Chairman.** Do you know anything of that river and its tributaries?

Mr. **Hopkins.** Yes, there is plenty of water in the river and the land seems to be productive.

The **Chairman.** Have you examined it?

Mr. **Hopkins.** I have seen some small gardens.

The **Chairman.** Is there anybody here who is familiar with the Greene River north of the road?

Mr. **Hopkins.** The country is uninhabited.

The **Chairman.** Entirely uninhabited?

Mr. **Hopkins.** Yes.

The **Chairman.** Have you been over it?

Mr. **Hopkins.** Yes.

The **Chairman.** Is it fit for habitation?

Mr. **Hopkins.** Yes; there is a very nice valley about 40 miles long located between Sandy Creek and Bitter Creek, about 3 to 5 miles wide and about 40 miles long.

The **Chairman.** Can that be irrigated?

Mr. **Hopkins.** I am not prepared to say. It would be a matter of survey to determine whether it could be irrigated. The waters of the Sandy, as I understand, could be diverted into that valley, and instead of following the regular course of Greene River Valley they could be flumed across a sandy district there.

Senator **Jones.** Could the water be carried out of Greene River into that valley?

Mr. **Hopkins.** I think it could be done, but only a survey could determine that.

Director **Powell.** There would be no trouble about it. Itcan be done. I have personally surveyed that country.

Senator **Jones.** Is there any farming at all in the locality you live in?

Mr. **Hopkins.** There is some farming, though it is not what you would call farming. There is some grass grown by water that they get from the springs, but nothing of any amount. It would be a great boon to have some farm lands in that district. In other words, there is a home market for productions of that character.

The **Chairman**. It is an extensive coal-producing district?

Mr. **Hopkins**. Yes.

STATEMENT OF C. W. HOLDEN, OF UINTAH COUNTY.

The **Chairman**. Where do you reside?

Mr. **Holden**. I reside on the Fontenelle, in Uintah County.

The **Chairman**. Into what stream does the Fontenelle discharge its waters?

Mr. **Holden**. It empties into Greene River.

The **Chairman**. Is that country inhabited much?

Mr. **Holden**. Yes.

The **Chairman**. Are there farmers there?

Mr. **Holden**. Yes.

The **Chairman**. Is there much irrigation there?

Mr. **Holden**. Yes.

The **Chairman**. What amount of land is under irrigation in Uintah County?

Mr. **Holden**. I have a statement here prepared under the auspices of the board of county commissioners of that county, bearing directly on that question, furnished me for use before this committee. I think this statement is more to the point and contains less that you do not care to know. I would like to read it.

The **Chairman**. You can read it if is not too lengthy.

Mr. **Holden**. I think it contains all the information I could give myself, and perhaps much more.

The following is the letter:

EVANSTON, WYO., *September* 13, 1889

Dear Sir: Your letter of the 10th instant, addressed to I. C. Winslow, chairman board of county commissioners, was handed to me with the request that I should furnish you with such data as I could gather regarding the number of irrigating ditches constructed in the county of Uinta, together with the amount of land being and proposed to be irrigated by water therefrom. The total claims for water rights of record is about 400. There has been over 65,000 acres of land entered under the provisions of the desert-land act; about 25,000 acres under the homestead act; about 9,000 acres under the timber-culture act, and over 6,000 acres pre-emption cash entries. There are valid pre-emption filings of record, covering about 8,000 acres. Besides the foregoing, there is a large area of land embraced in the grant to the Union Pacific Railway Company, a portion of which is susceptible of irrigation. There are also many settlers living upon unsurveyed lands, holding squatters' claims.

In the summer of 1886, I measured one hundred and eight ditches in this county, to ascertain their carrying capacity. This work was done by order of the board of county commissioners under Territorial law. I found the aggregate carrying capacity of said ditches to be 516 cubic feet per second of time, being sufficient to irrigate about 50,000 acres of land.

A great number of ditches have been constructed since the date of my official survey, of which I am unable to give you reliable data.

I think it would be safe to say, however, that fully 100,000 acres of lands in this county are now covered by irrigating ditches, but during the present unprecedented dry season the water supply has been deficient, and a partial failure of crops has been the result. It is surprising how productive some of our sage-brush lands can be made by proper cultivation and irrigation. I will cite the case of a small tract of 22 acres adjoining our town site, owned by A. V. Quinn. This tract has been carefully prepared and seeded to timothy and alfalfa, and thoroughly irrigated; two crops of hay have been harvested therefrom the present season, the first crop yielding about 3 tons per acre, and the second crop 2 tons per acre. The hay is worth $15 per ton.

There are many available sites for reservoirs for the storage of water to be used during the latter part of the irrigation season when the natural flow in the streams become deficient.

In my judgment these storage reservoirs should be located as near the head of the natural stream as practicable. Using small valleys for reservoirs at points where the fall in the stream is but slight, by the erection of dams of moderate height, storage room can be made for large bodies of water.

I know of one point on Bear River where it is practicable to construct a dam not exceeding 25 feet in height at a cost of less than $5,000, where storage room can be obtained for over 800,000,000 cubic feet of water, not interfering with any vested rights. Doubtless suitable sites for reservoirs can be found upon the most of the large natural streams of our county.

As to the amount of land within our county which would or could be made susceptible of irrigation by additional water supply, it is a question that can only be solved by ascertaining the amount of water that can be stored for that purpose.

With our present and prospective water supply it is probable that over one-half of the arable lands in our county will ever be reclaimed and cultivated.

WM. HINTON.

Mr. HOLDEN. Mr. William Hinton, who signs that letter, was the surveyor of the county at the time those ditches were surveyed.

The CHAIRMAN. What is the character of the crops produced in that county? There is nothing said in that statement about the production of wheat.

Mr. HOLDEN. The altitude of that county has rather been considered too great to make grain-growing a profitable branch of farming, and for that reason not a great deal of grain has been sown as compared with the vast amount of ground used for meadow-land.

The CHAIRMAN. Has the experiment been tried?

Mr. HOLDEN. Yes. On the Fontenelle, last year for the first time, a neighbor of mine raised about 30 acres of oats. I have lived the greater part of my life in the State of Illinois, and I can safely say I never saw a better crop of oats in Illinois than was grown there. As a result, there was about 100 acres put out on the Fontenelle this present season.

Director POWELL. Whereabouts on the Fontenelle is that?

Mr. HOLDEN. The Fontenelle is only settled up from the mouth about 12 miles. There is a cañon in the foot-hills, and this settlement is all below the foot-hills. The creek is fenced for about 12 miles. The ranches average in width from a half a mile to a mile wide, and those lands are nearly all of them under irrigation. It was estimated last year that there was in the neighborhood of 1,500 tons of hay raised on that creek.

Senator JONES. The land under cultivation is devoted mostly to hay?

Mr. HOLDEN. Yes; but, as I say, there were about 100 acres of wheat this year, and it turned out all right. I put out about 12 acres myself, and part of that was upon sage-brush land. We worked off that sage-brush with a machine moved by ten horses, and after breaking and tearing down the sage-brush and grease-wood the ground was then, without plowing, sowed with timothy and red-top. For that reason I did not plow it. Upon that ground I am thoroughly satisfied that I had about 2 tons of feed to the acre, grass and oats. The oats did not come up regularly. There would be spots that would be as nice as any place in the world, but there were vacant spaces also. If all was like the grown spaces there would be, I think, 50 bushels to the acre.

The CHAIRMAN. The small grains can then be raised in that county?

Mr. HOLDEN. Yes; and on the Bear River there is a great deal of oats, barley, and wheat raised.

The CHAIRMAN. At about what altitude?

Mr. HOLDEN. I think between 6,000 and 7,000 feet, from Evanston down to Cokeville, where the stream goes down into Idaho.

The CHAIRMAN. Is there anything further you wish to say?

Mr. HOLDEN. There is a point that perhaps I might mention. At the upper end of this cañon (I speak of the foot-hills) a reservoir might be constructed at a small cost, and an immense body of water might be stored. There is a basin 4 or 5 miles wide and 10 or 12 miles long, and a reservoir there would not interfere with any vested rights.

STAMEMENT OF JOHN W. HOYT, OF LARAMIE.

The CHAIRMAN. Will you be good enough to give the committee any facts in your possession that will be of interest in connection with the inquiry on which we are engaged?

Mr. HOYT. I may not be in possession of the exact facts which you desire.

The CHAIRMAN. Have you observed that crops can be raised on the Laramie Plains?

Mr. HOYT. Yes.

The CHAIRMAN. Tell us what you know about that.

Mr. HOYT. I simply know that the experiment has been made of producing the different cereals, wheat, rye, oats, and barley. The work was begun five years ago and proved successful; in some places even without irrigation. I presented more than five years ago, at the exposition at Denver, specimens of grains grown on the bottom lands just outside of Laramie City by Mr. Fee. That was a very large production of those grains. The experiment was not a large one, covering only perhaps 10 or 20 acres, but it was very satisfactory.

The CHAIRMAN. Has it been tried elsewhere in that valley?

Mr. HOYT. Yes, it has been tried elsewhere.

The CHAIRMAN. How is it with the vegetable crops?

Mr. HOYT. It is always successful. Potatoes are grown in the garden plats of the city of Laramie. The product is very fine and the yield very large.

The CHAIRMAN. Have you observed the flood waters of the Laramie that run to waste; are they large or not?

Mr. HOYT. There is a large amount of water in the spring season.

The CHAIRMAN. A good deal of snow falls upon the mountains?

Mr. HOYT. Yes; the streams have their sources in the Medicine Bow Range, and the streams very often are flooded and overflow at the banks, so that a very large amount of water could be saved at that season of the year that now goes to waste. If that could be stored (and there are natural basins in which it could be stored) the waters of the Big Laramie would be able, from a reservoir supply, to irrigate a large body of land. There are about 200,000 acres of beautiful land lying between the Big and Little Laramie Rivers, very rich, productive soil, which would produce very handsome crops of nearly every sort except Indian corn, if watered. There is already a ditch there taking some of the water of the Laramie, but there is a large quantity of water still in reserve, and there are natural basins in which the surplus could be stored when not needed.

The CHAIRMAN. Then, according to your observation, the Laramie Plains make a fair agricultural country?

Mr. HOYT. I have no question as to the possibility of producing fine crops there.

Senator JONES. What yield of crops do you get per acre?

Mr. HOYT. The specimens that I saw must have yielded 40 bushels to the acre, and they have claimed 50 bushels, I think, of wheat. Oats were produced in very large yields.

Senator JONES. Have you seen one crop of wheat grown?

Mr. HOYT. I have seen patches of wheat in a number of places.

Senator JONES. Is wheat grown to any considerable extent there?

Mr. HOYT. No; none of those crops, I ought to say, are grown to any considerable extent as yet. The water supply has not been sufficient and the persons who own the lands and would be encouraged under favorable conditions to commence the cultivation of crops have been delaying on account of the condition of the water supply.

Senator JONES. What is the yield of potatoes to the acre?

Mr. HOYT. I hear extravagant accounts. I may not be able to furnish exact data on that subject, but I hear of 300 and 400 bushels to the acre. No finer potatoes have ever been seen, I think.

The CHAIRMAN. Is there anything further that you wish to say?

Mr. HOYT. I do not know that there is. The vegetable crop, I ought to say, is very remarkable. The root crops are very fine. There is a beginning also in the cultivation of small fruits and even with apples, so that many of our people are beginning to think of planting fruits. I am speaking of the Laramie Plains especially.

STATEMENT OF H. A. COFFEEN, OF SHERIDAN.

The CHAIRMAN. In what part of the Territory is that?

Mr. COFFEEN. It is in the central-north part.

The CHAIRMAN. On what stream?

Mr. COFFEEN. At the head of the Town River and branches of the Poudre River.

The CHAIRMAN. Into what streams do Town River and Poudre River discharge their waters?

Mr. COFFEEN. Into the Yellowstone, I believe, in Montana. We are next to the line thereof on the north of this Territory.

The CHAIRMAN. Will you describe the county in which you live?

Mr. COFFEEN. The character of the soil is surprisingly rich under irrigation, as compared with the land in Illinois and Indiana, where I have formerly lived. The surface is undulating, so that the farms are mostly in valleys on the small streams, but the table lands on the hillsides are equally fertile when irrigated.

The CHAIRMAN. And they are not too precipitous to be cultivated?

Mr. COFFEEN. Not in many parts. In some places they would be too precipitous to be cultivated.

The CHAIRMAN. You say the soil is rich; what crops do people raise there?

Mr. COFFEEN. We are raising grains of the usual kinds, vegetables of high quality and in great abundance; also fruits. I wish to refer particularly to fruits. Wheat, oats, and barley are raised there by many farmers who have settled there. Our region is known in this Territory as a specially fine agricultural country. Corn is being raised now sufficient to supply almost all home needs for fattening pork. The increase of the growth of corn is doubling. Five years ago they scarcely knew that they could raise corn. I have heard people in the northern part of the county stating that they raised 60 to 80 bushels to the acre. It was rather astonishing, but I know the gentlemen and I think they are correct. Fifty to 53 bushels to the acre of wheat is accounted an average. Of barley I can not speak as to the average. Oats average 45 to 50 bushels to the acre, but there have been 100 bushels to the acre raised there in many instances. On Prairie Dog

Creek and some of the other smaller streams the average has been well up to 60 and 75 bushels to the acre.

The CHAIRMAN. Do you raise potatoes?

Mr. COFFEEN. Yes.

The CHAIRMAN. What is a good crop of oats?

Mr. COFFEEN. I fear I may not be able to state precisely the average, but they have been as much as any crops I have known in the country.

The CHAIRMAN. How is it as to fruits?

Mr. COFFEEN. Our farmers have been experimenting on fruits for a few years, and they find they can raise strawberries and raspberries. I am a little doubtful about blackberries. As to apples, at our agricultural fair last year one of my neighbors exhibited a half bushel or more of very fine varieties, such as the Duchess, the Oldenburg, and others,—good sized apples. This year there will be many farms where they will have from 1 to 6 and more bushels on very small places.

The CHAIRMAN. What do you say of the quantity of land susceptible of irrigation in your county?

Mr. COFFEEN. I do not feel competent to state that with any degree of correctness. We have probably 50,000 acres of land now under irrigation, much of it, however, in grasses.

The CHAIRMAN. You have as much as that under actual irrigation?

Mr. COFFEEN. I think we have. And we have probably 300,000 or 400,000 acres of land that can be irrigated with great profit.

The CHAIRMAN. Have you a water supply for this amount of land?

Mr. COFFEEN. Not without storage.

The CHAIRMAN. But with storage, have you?

Mr. COFFEEN. With storage, I believe we have an abundant water supply for that.

The CHAIRMAN. How many acres?

Mr. COFFEEN. I wish to give that with many degrees of allowance; 300,000 or 400,000 acres is what I have estimated.

The CHAIRMAN. What is the character of the streams you have in your county; are they large and numerous or otherwise?

Mr. COFFEEN. they are numerous, and are small streams, rushing down from the mountains.

The CHAIRMAN. From what range of mountains do they come?

Mr. COFFEEN. From the Big Horn Mountains. That is the first range, from which the snows melt away in May, generally. Then there is the back range, of which Cloud's Peak would be a representative, from which the snows melt away chiefly in June, but not entirely during the whole year. The snows remain in part during the whole year.

STATEMENT OF CHARLES H. BURRITT, OF BUFFALO.

The CHAIRMAN. In what part of the Territory is Buffalo?

Mr. BURRITT. In the northern portion, in the Poudre River drainage basin.

The CHAIRMAN. What have you to say of that county in regard to irrigation?

Mr. BURRITT. I can not give you any statistics of any value in reference to Johnson County alone. Johnson and Sheridan Counties, as the drainage map of Wyoming on the wall shows, are all in one drainage basin. During the last three years, as secretary of the North Wyoming Fair Association and secretary of the Immigration Board for that part of the Territory, I have prepared careful statistics on that drainage basin.

The CHAIRMAN. Showing what?

Mr. BURRITT. Showing the number of acres under ditch, the number of ditches, and the number of acres irrigated, the number of acres graded, the amount of crops raised, etc.

The CHAIRMAN. And the amount of land susceptible of irrigation?

Mr. BURRITT. Yes.

The CHAIRMAN. Have you anything in the form of a written document?

Mr. BURRITT. I have a part of my immigration report.

The CHAIRMAN. Does it cover the whole Territory?

Mr. BURRITT. It covers all of Johnson and Sheridan Counties both east and west of the Big Horn Mountains. That west of the Big Horn is in the drainage basin of the Big Horn, but there is but a very small portion of that territory cultivated as yet.

The CHAIRMAN. Will you file your report?

Mr. BURRITT. Yes.

The CHAIRMAN. I would like to have you speak of the Big Horn country if you are familiar with it.

Mr. BURRITT. I am not so familiar with it as with the eastern side of the range.

The CHAIRMAN. Make to the committee such statement about it as will be useful to them.

Mr. BURRITT. As to the eastern side of the range, the creeks or principal streams, which are all forks, center about Cloud's Peak. It is the highest point of the Big Horn range of mountains. That range is a very wide and big range at the top. Around Cloud's Peak are a series of lakes from which all the streams coming down on the Big Horn and the Poudre River have their source. There is a large range of those mountains. Some of them are so arranged as that they could be used for storage reservoirs with very little expense. There are already four ditches taken from those lakes by private enterprise and dropped over into various branches of the "Clear Fork of Poudre River," or "Clear Creek," as it is called. By small expenditure a considerable number of acres of land could be irrigated in addition to what is already irrigated in the two counties on the east side of the range. The same is true of the west side of the range. The rivers that run into the Big Horn practically head in those lakes.

The CHAIRMAN. Have you ever made an estimate of the land that could be irrigated in the two counties by storing water?

Mr. BURRITT. In the two counties there are 6,200,000 acres. By preserving the water I have no doubt that it could be increased at least five times what it is at present. There are about 450,000 acres at present under irrigating ditches.

The CHAIRMAN. Is there water enough to supply that 450,000 acres?

Mr. BURRITT. There is, in an ordinary season. There has not been this season, on account of the light fall of snow last winter.

The CHAIRMAN. Can it be increased to that by conserving the water?

Mr. BURRITT. The present water supply, if properly distributed, would irrigate at least 640,000 acres. I think that by the construction of storage reservoirs in the Big Horn and preserving the waters, 2,000,000 or 2,500,000 acres can be irrigated, counting both sides of the range in Johnson and Sheridan Counties.

The CHAIRMAN. What do you say in regard to the character of the soil?

Mr. Burritt. On the east side of the range it is a black sandy loam, very rich. On the western side of the range it is principally a red gypsum soil, very deceptive to look at, but very rich in the production of crops, being mixed with the loam.

Senator Jones. There are 45,000 acres under ditch you say?

Mr. Burritt. Yes.

Senator Jones. How much is irrigated?

Mr. Burritt. That is all under ditch and between 300,000 and 350,000 acres are already practically irrigated. The other portion—100,000,—is not yet fully reclaimed. It is mostly the second or third bench or mesa land.

The Chairman. Do you know what proportion of the 300,000 acres under irrigation is in grass and how much in other crops?

Mr. Burritt. I have the exact figures for it. In 1887 there were 1,729 acres cropped to wheat; 7,816 cropped to oats. The amount cropped to barley was quite small—perhaps not over 150 or 200 acres. The oat and wheat portion has been increased very nearly if not quite 100 per cent. since that time. The barley area has probably been increased to 1,000 acres. About one-half the balance of the land was, in 1887, cropped to hay. That has been increased to about 75 per cent., owing to the lack of facilities for getting the products out of the country on account of the long distances from the railroads. The people have complied with the law, so far as is necessary, by the reclamation of the land, but have not expended much beyond, because they have not the opportunity to market the product. This is a short statement from my report.

The Chairman. Have you your report complete?

Mr. Burritt. I have it here.

The Chairman. Can you furnish a copy of it to the committee?

Mr. Burritt. Yes.

The Chairman. You may state the average crops shown by it.

Mr. Burritt. The average crops in Sheridan and Johnston counties vary from 20 to 60 bushels of wheat; as high as 80 bushels of wheat has been raised to the acre, but of course such a crop as that was under particular cultivation. The average crop of wheat is about 30 bushels to the acre. It is a class of wheat that grades in Minneapolis and St. Paul as "A No. 1," and makes a superior quality of flour. The average crop of oats is 50 to 60 bushels to the acre. On 5 acres on Crazy Woman Creek 105 bushels to the acre were raised. On Prairie-Dog Creek, north of Buffalo, 85 bushels to the acre was the crop of 1887, on 40 acres of ground. Barley was cultivated quite largely in the immediate vicinity of the town in which I live, and the crop runs from 40 to 60 bushels to the acre. The average is higher than the medium between those two. A common crop of potatoes is 200 bushel to the acre. A not extraordinary crop is 300 bushels, and on one tract of land near the city of Buffalo 650 bushels were raised on one acre which had been sage-brush and greasewood land. I saw it cleared myself and knew what it was. Corn was about as stated by Mr. Coffin. In the northern Wyoming fair we had five specimens raised in five dfferent parts of Johnston and Sheridan counties of pieces of corn. The fair was held on the 7th and 8th days of September. All small fruits are easily cultivated. I do not think that the apple cultivation of Johnston and Sheridan counties, except in favored localities, will be a success; the winters freezing out the trees. I am not, however, as competent a judge of that as I am of other things.

STATEMENT OF NOYES BALDWIN, OF LANDER.

The CHAIRMAN. In what part of the Territory is Fremont County?

Mr. BALDWIN. In the northwestern portion. The northern boundary of our county is Montana. It embraces the headwaters of the Big Horn River.

The CHAIRMAN. Have you a map of that county?

Mr. BALDWIN. I have a map, of a portion of it.

The CHAIRMAN. How is it marked?

Mr. BALDWIN. It is marked "Plat of Popo Agie River and tributaries." The most thickly settled portion of the county is the vicinity of Lander.

The CHAIRMAN. Is Lander your county seat?

Mr. BALDWIN. Yes.

The CHAIRMAN. What streams run through your county?

Mr. BALDWIN. The Popo Agie, the Big Wind River, and the Little Wind River, which, after it passes through the cañon in the Big Horn range, is then called the Big Horn River. It has many tributaries.

The CHAIRMAN. Have you irrigation in your county?

Mr. BALDWIN. We have 108,000 acres under ditch now, in this section. Then there is a considerable portion north that I know very little about.

The CHAIRMAN. How much of the land under ditch is actually cultivated?

Mr BALDWIN. Probably 50,000 or 60,000 acres.

The CHAIRMAN. What is the character of the crops raised there?

Mr. BALDWIN. All the small grains and vegetables grown in other portions of our Territory. The vegetable crop is a very productive crop.

The CHAIRMAN. What is about the altitude of that valley?

Mr. BALDWIN. About 5,500 feet.

The CHAIRMAN. That is about the average altitude of the valley portion of it?

Mr. BALDWIN. Yes.

The CHAIRMAN. All the small grains and vegetables are raised there?

Mr. BALDWIN. Yes.

The CHAIRMAN. What is the character of the soil?

Mr. BALDWIN. Excellent. The bottom land is loam and the bench lands are sandy and gravely soil.

The CHAIRMAN. Have you a water supply to irrigate all the 108,000 acres under ditches?

Mr. BALDWIN. Yes, we have an ample supply of water.

The CHAIRMAN. What amount of land in Fremont County is susceptible of cultivation?

Mr. BALDWIN. There is a very large portion of it. It will be difficult to estimate it all.

The CHAIRMAN. Compared with what is under ditch, how much? Is one-half of it under ditch?

Mr. BALDWIN. It is, in this immediate vicinity of Lander; but the county is a very large county. It embraces about two thousand square miles. The northern portion of it I am not very well acquainted with.

The CHAIRMAN. Are the valleys large?

Mr. BALDWIN. Yes; very large.

The CHAIRMAN. Is the water supply good?

Mr. BALDWIN. It is abundant. The streams are mountain streams, and are fed from the mountains.

The **Chairman**. Are there lakes there?

Mr. **Baldwin**. There are large lakes at the heads of those streams.

The **Chairman**. Furnishing opportunities for storage?

Mr. **Baldwin**. Yes. There are narrow cañons from which these streams mostly flow.

The **Chairman**. You have no means of actually estimating the extent of country that could be brought under cultivation?

Mr. **Baldwin**. No; but it would amount to many hundred thousand acres.

The **Chairman**. You may add anything now that you desire.

Mr. **Baldwin**. We raise all manner of grasses here, such as alfalfa, timothy, red-top. We raise two and three crops of alfalfa each year. The yield of wheat each year is about 40 bushels to the acre, and about 45 to 50 bushels of oats to the acre. Potatoes and every kind of vegetables grow to great perfection and the yield is abundant.

STATEMENT OF ANDREW GILCHRIST, OF CHEYENNE.

The **Chairman**. What is your occupation?

Mr. **Gilchrist**. I am a banker, a ranchman, a cattle-raiser, and an agriculturist.

The **Chairman**. Where do you reside?

Mr. **Gilchrist**. In Cheyenne.

The **Chairman**. In what portion of the Territory are you pursuing agriculture?

Mr. **Gilchrist**. In Laramie County.

The **Chairman**. The committee will be glad to hear any statement you may wish to make in regard to the water supply, the land to be irrigated, and the crops that can be produced in Laramie County.

Mr. **Gilchrist**. In the spring of the year, when there is a flood, the water from the mountains comes down, and there is sufficient for about a month or six weeks. In that period we get considerable water from Dale Creek, Crow Creek, Pole Creek, Horse Creek, Bear Creek, Sybille Creek, the Laramie River, and the Platte.

The **Chairman**. Are the waters of the Platte exhausted?

Mr. **Gilchrist**. No; the water of the Platte is not exhausted at present through Laramie County, for the reason that it flows through quite a cañon and in a deep valley, and there is very little of the land along the Platte River in Laramie County that is susceptible of irrigation.

The **Chairman**. You have to go lower down on the Platte to use these waters?

Mr. **Gilchrist**. Either lower down or higher up; probably lower down. Before it enters into Nebraska there are some lands susceptible of irrigation in the Goshen country.

The **Chairman**. Is there any opportunity to increase the water supply so as to furnish sufficient to irrigate these 300,000 acres that are under ditch.

Mr. **Gilchrist**. Yes; there are good opportunities at the head of the Laramie River and also at the head of the Platte. I believe there are good storage basins there that could be used to preserve the waters in the flood time and bring it down to Laramie County to utilize on the land susceptible of irrigation.

The **Chairman**. Have any efforts been made to store the water?

Mr. **Gilchrist**. Not any up to this time, of any consequence.

The **Chairman**. How much land is actually under cultivation in Laramie County?

Mr. **Gilchrist**. There are about 150,000 acres actually irrigated.

STATEMENT OF DELEGATE JOSEPH M. CAREY, OF CHEYENNE.

The CHAIRMAN. You are the Delegate to Congress from this Territory?

Mr. CAREY. Yes.

The CHAIRMAN. How long have you resided in the Territory of Wyoming?

Mr. CAREY. Twenty years.

The CHAIRMAN. Are you familiar with its general characteristics as to the lands susceptible of irrigation, the water to irrigate it with, and the land that is already irrigated, and what has been done in that line?

Mr. CAREY. I have a general knowlege of the Territory. Of course I have no statistics at hand, but tables have been prepared by the Territorial engineer showing the acreage under cultivation, etc.

The CHAIRMAN. He has the acreage under ditches, but not the amount cultivated.

Mr. CAREY. Owing to the prevailing business of the Territory a very large portion of the land that is irrigated is cultivated for hay, especially in sections of the country where there are no markets for grain. A good deal of time is spent in cropping it, storing it, and baling for the market, when there is a market, and feeding it to the stock in the winter. I can not tell the acreage that is actually plowed and cultivated during the year. I think Professor Mead can approximate that.

Mr. MEAD. I could do so with a little time. I have not prepared that for the committee now.

The CHAIRMAN. Will you send it to the committee?

Mr. MEAD. Yes.

The CHAIRMAN. The cattle industry is a large industry in this Territory.

Mr. CAREY. Cattle-raising was, I believe, the first business in this Territory, with coal mining.

The CHAIRMAN. You have other mines besides coal mines?

Mr. CAREY. We have gold and some silver and copper deposits and very large iron deposits.

The CHAIRMAN. The farming, as I understand you, in the portion of the Territory best adapted for farming, is remote from the railroads.

Mr. CAREY. The best country for farming in this Territory (because it is easy to irrigate it) is, I should say, comprised in Sheridan, Johnston, Fremont, and Crook Counties, which, as you see, are in the northeastern portion of the Territory. Sheridan is in the northern part and Johnston comes down toward the center. Fremont County is being cultivated south of the Wind River Reservation, which you see in the outline of Greene. There is some farming up north of the reservation on the Big Horn River.

The CHAIRMAN. The stock-raisers in the Territory are, then, turning their attention to cultivating the land and raising forage for stock?

Mr. CAREY. There is a great deal of forage raised by the stockmen.

The CHAIRMAN. They have ceased to rely wholly on the range for their winter supply?

Mr. CAREY. There is still a great deal of range business in the Territory, where cattle and horses are kept without putting up any hay whatever. Other stockmen put up considerable material which they feed to their cattle in winter. It is becoming quite general in this Territory, where men have cattle of more than ordinary value, or cattle that happen to be thin in the fall of the year, that they wish to be in such a position as that they can have their own feed.

The **CHAIRMAN**. The cattle industry is growing, is it?

Mr. **CAREY**. Yes, very rapidly. The greatest number of people employed for strict farming, is, I suppose, in the counties I have named. There are a good many people carrying on the grange business in Converse County and Laramie County and Albany County—in fact almost all the counties.

The **CHAIRMAN**. Has any considerable attention been paid to the storage of water and increasing the water supply for irrigating purposes?

Mr. **CAREY**. Not to any great extent. I can not say that there has been a great deal of attention given to it, yet it is carried on to some extent, especially around this town.

The **CHAIRMAN**. From what has been done around this town, what do you say of the opportunities in this Territory of increasing the water supply by the various methods suggested for storage?

Mr. **CAREY**. There is every opportunity for it. So far as I have been able to see, nature has favored us in that respect, because there are spaces where great storage and great lake basins can be found at very small cost. Natural depressions are found where the construction of a dam will, if placed across a very narrow cañon, make a very large basin in which large quantities of water can be accumulated.

The **CHAIRMAN**. It was stated by the Territorial engineer here that the amount of arable land that can be brought under cultivation by irrigation, if the water were stored reasonably well, was estimated at from 5,000,000 to 10,000,000 acres of land. Have you known anything about the estimates?

Mr. **CAREY**. I place every reliance upon Professor Mead's estimate. He is a very conservative man.

The **CHAIRMAN**. He has given himself 5,000,000 acres by way of latitude.

Mr. **CAREY**. He is not as liable to exaggerate about such things as some people who are holding up to the world all the time the natural wealth of the Territory in which we live; but I heard Major Powell make an estimate before the Committee on the Territories of the House of Representatives at Washington. He estimated that there was enough water precipitated in this territory, if it could all be accumulated and saved, to reclaim about one-fifth of the area of the Territory, or what would amount to 12,000,000 or 13,000,000 acres. From what I have seen right at this town, as to the amount of water that we can store up from a very small stream, I am inclined to believe that Major Powell has not overestimated the amount that may be reclaimed.

Mr. **MEAD**. The question which the Chairman asked me was what was the opinion in the Territory.

The **CHAIRMAN**. That is so. I understood you as not making any estimate yourself.

Mr. **CAREY**. If you examine that map of Wyoming you will find that most of those streams that come into the Territory, or which are in Wyoming, have their origin within our boundaries, take their rise in the ridges and mountains within this Territory, and right at the place, or near the place where these basins can be readily constructed. For that reason I think a very large portion of our land can be watered by water rising in our own Territory, if we can save it.

The **CHAIRMAN**. Is your population increasing?

Mr. **CAREY**. Yes; our farming population is increasing.

STATEMENT OF LIONEL SARTORIS, OF LARAMIE.

The **CHAIRMAN**. Have you ever been engaged in irrigation in Albany County?

Mr. **SARTORIS**. I have been irrigating there for the last six years.

Mr. **CHAIRMAN**. How near Laramie City?

Mr. **SARTORIS**. About 20 miles west of Laramie City, on the Little Laramie River.

The **CHAIRMAN**. What crops do you raise?

Mr. **SARTORIS**. For the last two years, oats, wheat, and a little barley. We tried alfalfa this year for the first time. Oats have been our principal crop there. Last year 44 bushels to the acre was the yield. That was the first year and we were very short of water. This year I am just cutting oats (we have not thrashed out yet), but I do not think it will be very much better on account of the early frost we had about a week ago. In a good year I think we could thrash 60 to 80 bushels to the acre.

The **CHAIRMAN**. Would wheat succeed here?

Mr. **SARTORIS**. Wheat would be an undoubted success, but of course, people will not grow what they can not get a market for.

The **CHAIRMAN**. How about barley?

Mr. **SARTORIS**. We grew such a small piece last year that we did not measure it.

The **CHAIRMAN**. Do you grow potatoes?

Mr. **SARTORIS**. About 15 acres this year.

The **CHAIRMAN**. How much did you get of those?

Mr. **SARTORIS**. I have not measured them.

The **CHAIRMAN**. Is the water supply abundant?

Mr. **SARTORIS**. Yes, when there is plenty of snow in the timber. This year the water has been somewhat short.

The **CHAIRMAN**. Does it run to waste in the flood season?

Mr. **SARTORIS**. Yes; because there is hardly anybody up in the country that knows anything about how to irrigate the land properly. If we had people there that understood irrigation there could be ten times the amount of land used that is irrigated now.

The **CHAIRMAN**. How much water do they use to irrigate?

Mr. **SARTORIS**. I do not know exactly.

The **CHAIRMAN**. They flood the land, do they?

Mr. **SARTORIS**. Yes.

The **CHAIRMAN**. Have you ever been engaged in irrigation elsewhere?

Mr. **SARTORIS**. No.

The **CHAIRMAN**. Have you any other remark which you desire to make?

Mr. **SARTORIS**. No; except about the possibility of storing water up there. There are enormous facilities in that part of the county for making reservoirs. It can easily be done.

The **CHAIRMAN**. Is there enough snow falling and enough precipitation generally to fill reservoirs if they were constructed?

Mr. **SARTORIS**. Yes; except in very exceptional years such as last year, when scarcely any snow fell at all. The soil there is as good as any part of the world I think. It is a light sandy loam, composed chiefly of silica and lime, and will grow anything you please except corn.

STATEMENT OF M. M. GRANT, OF LARAMIE.

The **CHAIRMAN.** We would like to have such information as you possess in regard to irrigation in this Territory, and the opportunities for it.

Mr. GRANT. In Albany County I think there could be about 400,000 acres of land irrigated by ditch and by storage reservoirs. I believe it could even be doubled.

The **CHAIRMAN.** You think 800,000 acres could be brought under cultivation?

Mr. GRANT. Yes, by storage reservoirs.

The **CHAIRMAN.** Could sufficient water supply be got for 800,000 acres?

Mr. GRANT. I think so. There's another thing I wanted to state in connection with that, which I regard as being very important. That is, the preservation of the timber from forest fires. Timber has a greater bearing on the preservation of water than anything else; it holds the snows. I think I can safely say that in our county there has been at least twenty times as much timber destroyed by fire as there has been cut by settlers. Those fires are very destructive, and I think should be guarded against. I regard that as being very important.

The **CHAIRMAN.** Have you any suggestion to make as to how to accomplish that?

Mr. GRANT. I think there should be timber reservations set aside in these mountains. I think there should be a timber commissioner, and that he should be vested with authority to employ men to help him to suppress forest fires when they start and, if possible, to compel the people to assist him. Of course they should have proper compensation. I believe that with proper watching these fires if taken in time are easy to stop. There are millions of dollars' worth of timber that has been destroyed in the Territory. It is a matter that I think bears very strongly on the question of irrigation.

The **CHAIRMAN.** It undoubtedly does.

Mr. GRANT. As to the storage of water in Albany County. There are a great many places where dams could be placed for storing water. In fact, in nearly all of those streams where they come out of the mountains there are good opportunities for water storage. I believe that the area that could be irrigated would be doubled.

The **CHAIRMAN.** You think it could be increased to 800,000?

Mr. GRANT. I think so.

The **CHAIRMAN.** And it is good land for all sorts of crops, small grains and vegetables?

Mr. GRANT. Yes; especially for hay. There is no place anywhere in the world where you can grow finer hay than in that section. I should think from 30,000 to 40,000 tons of hay are grown in that county. I have been over nearly all the Territory and I am satisfied from my observation (and I have lived here for twenty years) that there could be at least 5,000,000 acres of land irrigated without storage reservoirs, and I believe that by storage reservoirs that it could be doubled.

The **CHAIRMAN.** Ten millions, you think, could be irrigated by storage reservoirs?

Mr. GRANT. Yes.

The **CHAIRMAN.** Mr. Mead did not make an estimate himself, but stated what the estimate of the people was?

Mr. GRANT. Yes.

The **CHAIRMAN**. Your estimate then is, that through storage, there are 10,000,000 acres of land in the Territory that can be brought under cultivation?

Mr. **GRANT**. Yes; and I think this could be further increased by boring artesian wells.

The **CHAIRMAN**. That is a new experiment, but probably might be done to some extent.

Mr. **GRANT**. Yes; probably 300,000 or 400,000 acres, if the water could be had. It would depend upon whether the water could be had or not.

STATEMENT OF J. A. JOHNSTON, OF LARAMIE.

The **CHAIRMAN**. Where do you reside?

Mr. **JOHNSTON**. In Laramie, Wyo.

The **CHAIRMAN**. What is your occupation?

Mr. **JOHNSTON**. It has been for the last twelve or fourteen years constructing and operating irrigation works.

The **CHAIRMAN**. And in what portions of the Territory?

Mr. **JOHNSTON**. I have operated in Colorado; but for the last five years I have been employed in this Territory.

The **CHAIRMAN**. What do you say in regard to the water supply for irrigation, the land to be irrigated, and the result of irrigation in Wyoming generally?

Mr. **JOHNSTON**. I am not familiar with any portion of it but Laramie County and some little in Albany County.

The **CHAIRMAN**. State what the opportunities are there for obtaining water, and what the land is that is to be irrigated.

Mr. **JOHNSTON**. That has been covered pretty well by Mr. Gilchrist, who has spoken before me. He has stated the number of streams, etc. The Laramie River is the place where I was operating. I constructed works to reclaim about 60,000 acres of land about 100 miles north from here.

The **CHAIRMAN**. Have you a sufficient supply of water to irrigate the 60,000 acres?

Mr. **JOHNSTON**. In ordinary seasons we have.

The **CHAIRMAN**. Without storage?

Mr. **JOHNSTON**. Yes, in ordinary seasons. The water is taken out in what is known as the Laramie range. We also get seepage from the lower plains, after the water has been used there, and from the small streams that come in from the Laramie range.

The **CHAIRMAN**. What is your opinion in regard to developing more water—as by storage and improvement of the streams?

Mr. **JOHNSTON**. It could be greatly developed, not only by storing the waters, but by securing the waters that have under-currents. My observation has been that most of the streams are underlaid with bed-rock, and that by tapping the streams at the bed-rock we could secure an increased flow of water almost invariably. We have an example of that in the water-works of this town. We would be practically without water to-day on account of the dryness of the season if it were not for having applied that system. I made some observations recently on the heads of the North Platte and the Laramie Rivers, and I believe there is in that vicinity at high altitudes on the summits of these ranges and on the plateaus great facilities for storing water, immense facilities at very slight expense. I have also had some experience in crops in this county. I have raised crops on these lands that I speak of for the last two or three years, and have demonstrated to my satisfaction that they will produce all the cereals—rye, wheat, oats, and good corn—that is, north of here, at the altitude of about 4,800 feet. We have raised there from 30 to 60 bushels of oats, 30 to 40 bushels of wheat; barley we have never tried, but we have raised from 30 to 60 bushels of corn of good quality; some of it is on exhibition at the fair at this present time; also potatoes and other vegetables in that vicinity, which will compare favorably with anything grown east or west.

STATEMENT OF GOVERNOR FRANCIS E. WARREN.

The **CHAIRMAN**. You are the present governor of this Territory?

Mr. **WARREN**. Yes.

The **CHAIRMAN**. How long have you resided in the Territory?

Mr. **WARREN**. Nearly twenty-two years.

The **CHAIRMAN**. Have you directed your attention to agriculture by means of irrigation?

Mr. **WARREN**. To some extent, yes.

The **CHAIRMAN**. You have heard the statements made here this evening. The committee would be glad to have from you any statement that you think would be useful in the inquiry that it is making on this subject.

Mr. **WARREN**. My observation of the Territory of Wyoming has been that while there is a great deal of land under irrigation and the smaller streams and valleys have been quite generally utilized, yet as a matter of fact the Territory has been scarcely scratched as to the possibilities that may result from a system of irrigation which would provide for the use of the waters that rise within the boundaries of the Territory. And when I speak of using the waters that rise within the boundaries of the Territory, I do so without prejudice to the States and Territories around us in cases where the streams flow out into them. On the other hand, I think it would be as much a benefit to them as to this Territory if a system of irrigation and storage could be devised that would provide for the storage of our waters, and also provide for the taking out of the large streams where expensive work is required, and for the storing back of the flood waters in the winter, and allowing the water necessary for crops to flow out during the summer or irrigating season. That would not only secure the flood waters at the time they come, but would also secure the waters to our contiguous Territories and States. We have in Wyoming the heads of almost all the streams that run to the Mississippi. They run largely into both Montana and Nebraska.

The **CHAIRMAN**. You have the sources of the streams in very high mountains, too, have you not?

Mr. **WARREN**. Yes. One-fifth to one-seventh of this Territory is capable of raising crops if water is provided. I believe one-seventh would be a safe estimate. There are about 64,000,000 acres in the Territory. (I am not giving this from statistics or close figuring, but as a matter of observation and general information.) The greater portion of the waters run away at flood times—run down the large streams and sink in the sand outside of the Territory and are not used at present. Irrigation has heretofore been confined principally to small ditches easily taken out. That arises first from the fact of its being a newly settled country, and secondly from the United States land laws, which have not provided for corporate work. When I say corporate work I mean that the expenditure of large sums for reservoirs and canals for taking out the water from the large streams would certainly be the most successful way of irrigating, but the land can only be procured at the present time by various claims under the law, and it is difficult to assemble enough land at any one point to guaranty and make profitable the taking out of large ditches and the storing of the waters.

The CHAIRMAN. We have found some instances where corporations and individuals have constructed ditches and sold the water rights sometimes in advance of construction at so much money for a quantity of water or so much money for enough to irrigate a given quantity of land, selling it outright to those who hold the land, making the contracts as they went along and arranging it so that when they got through the water belonged to the land-owners. Has that been tried in this Territory?

Mr. WARREN. Not to a large extent, and I do not think it would be as successful in the early portion of the settlement of the Territory as it would be later on. We have not yet arrived at that stage. If a company can get a guaranty that they can get a profit on their money by immediate introduction of the water on their land they will expend money for the purpose.

The CHAIRMAN. Would you think it wise to have the land owned by one set of owners and the ditch by another, who would rent the water from year to year?

Mr. WARREN. The most successful schemes that I have observed have been where the corporation has been prepared to do both. It has had some land of its own and has sold such water as there was a demand for, using the residue upon lands that it might itself own. Of course I do not speak of that to recommend the ownership of large blocks of land by private individuals and private corporations in advance of the actual taking out of the water. But if the State or Territory could own bodies of land which might pass into the hands of others as soon as reclaimed by them, I think no harm could come from its being passed out in larger bodies than 40 acres, or 80 acres, or 160 acres.

The CHAIRMAN. The result that you would want would be to get settlers on small quantities.

Mr. WARREN. That is it. But that result is hard to attain at present under the land laws and with the water so that the ditches, etc., can only be taken out in a small way.

The CHAIRMAN. Would a careful survey, determining where reservoirs could be located, ascertaining the amount of the water supply by gauging the rivers and measuring the rain-fall and also determining as nearly as practicable the amount of land to be irrigated, the estimate of cost, etc., be valuable to this Territory?

Mr. WARREN. It would be valuable, but to get that definite information would probably require a good deal of time, whereas sufficient knowledge is already had to warrant the feasibility of a storage system and the taking out of water from the large streams by canals, etc. While the survey would be valuable as I say, the practicability of the work is already proved. We have the natural basins and we have good soil.

The CHAIRMAN. Would the reservoirs or basins be generally on public land or would they be on private land in this Territory?

Mr. WARREN. Those that are nearest to the head of the streams and on the mountains would be on public lands entirely.

The CHAIRMAN. The designation of those, then, would be important to private enterprise at once?

Mr. WARREN. Yes. It might sometimes appear that those reservoirs should be in the valley where the streams would run through, yet it often happens that a canal, by rounding the bluffs, flows into large natural basins that would be more successful in every way than to have reservoirs placed on the stream.

The CHAIRMAN. Is it not important to have these surveys made to show the storage sites as they are to be reserved?

Mr. WARREN. Yes.

Senator JONES. I believe you said awhile ago that the use in the Territory of Wyoming of all the water lying in the Territory of Wyoming would be beneficial to other States.

Mr. WARREN. Yes; I certainly think so.

Senator JONES. Please explain your view in detail in regard to that.

Mr. WARREN. Take the case of a stream flowing water enough when the ditches are first taken out to irrigate, we will say, 500 acres. By taking the water out farther away from the stream and higher up, irrigating little by little, the land that is irrigated forms itself to some extent a reservoir. That is, I have in mind now a stream in Colorado which was barely sufficient to irrigate 1,000 acres ten or twelve years ago, but which now, by the establishment of a system of ditches carried wider out, irrigates 30,000 or 40,000 acres. While they are all the time taking out water from above the lands below are becoming more wet. The water soaks into the land and gets out again and goes on down, and the water is more continuous in the season by being used. Take any stream where the water passes down at 10 or 12 miles an hour and a shower comes up. It is only a little while until it has passed down. There may be floods in the rivers or the water may be taken into the soil in the process of irrigation; nearly all of it finds the level of the stream again and therefore makes a continuous flow.

Senator JONES. That is on the hypothesis that all the water taken from the stream finds its way back?

Mr. WARREN. Partly.

Senator JONES. I thought the fact was that considerable water was taken up by the plant life, that with much irrigation there was a material decrease in the amount of water, and that if the process was kept on long enough not a drop of water would, after awhile, be found. So that, if my idea is correct, it would seem to be possible that if all the water rising in Wyoming should be used to the fullest extent that it might be used there would be a deprivation of the other States.

Mr. WARREN. I do not propose to explain it scientifically, but observation demonstrates what I have said. I have observed this also, the plant life appears to provide in great measure for itself. We have no dew here, for example, on the prairies, yet if we go into a growth of wheat or grass in the morning we find that there is considerable moisture. The plants are wet. Explain it as we may, the plant seems to provide for itself.

The CHAIRMAN. Your idea is that it would increase the rain-fall or the amount of moisture in the atmosphere?

Mr. WARREN. I believe there is no question of that. With irrigation a certain percentage of it will be taken up at first by the soil, but almost all of it will get back to the river if we save the water at times when all along the stream there is a superabundance of it, and use the spare water on the land.

The CHAIRMAN. The advantage, then, you think is in the uniformity of the flow?

Mr. WARREN. Partly. I suppose you have visited Fort Collins and probably you have evidence from there, but I remember when all the water of the Poudre River was used to irrigate less than 1,000 acres.

You know what a vast territory it irrigates now. The head-waters have not increased at all. Go to the head of Cachéla Poudre and if anything, you will find less water there now than formerly, owing to the destruction of timber.

Senator JONES. Then how is the water increased?

Mr. WARREN. It is increased in its irrigating capacity.

Senator JONES. Do you mean to say that the volume of water has been increased or that it is used over and over again?

Mr. WARREN. I mean to say that it is used over and over again; and that the soil takes it in the spring, at the flood time, while it formerly went down the stream uninterrupted.

Senator JONES. I have no doubt that your idea is correct, that there will be more uniformity in the flow.

Mr. WARREN. I do not mean to assert that it will make the aggregate flow in twelve months any larger. I do not believe that any more water will reach the sea in the course of a year, but it will flow more uniformly.

Senator JONES. And your idea is that it will be an advantage to all the States outside of Wyoming?

Mr. WARREN. Yes.

Senator JONES. If it should be the fact that plant-growth and aerial evaporation do lessen the volume of water to such an extent that the arid lands of Wyoming would consume all the water in the Territory, then there would be no benefit to the other States from the use of the water here?

Mr. WARREN. No matter how fully we would use the water in Wyoming, I can not conceive of any system that would not benefit the surrounding States and Territories. It is possible that some evidence may have been adduced, or may be offered, showing that the Platte River has less water east of here on account of irrigation. In answer to that, I should say that if it is so, it is because the water is largely taken out in the first year's irrigation of large tracts of land. If you take out a stream and distribute the water over a great area, it will show less water the first season for a few miles below, but it never fails, later, to irrigate sufficiently with less water. There is one stream I know of that has been controlled by one company for eight or ten years. Originally that was a stream coming from springs that would run down about fifty rods, probably, and sink again. At many points that stream would be totally dry for three months in the year. They have taken out the water, and at the present time the water is not used at all upon what was formerly irrigated land, but is spread on the hillside. What was formerly irrigated is now ditched, and the water is taken from there. That is a surplus of water which is carried down the hill, so that the purpose is to drain out the water down below.

Senator JONES. There have been a number of instances where streams have been dried up before irrigation, but which have since become full.

Mr. WARREN. I say this very frankly that if I were a citizen of Nebraska or any other State, and had interest in the waters that flowed from Wyoming, I would be glad to see irrigation practiced just as extensively as the water would warrant.

The CHAIRMAN. In other words you would like to have the waters kept back and stored in the land rather than have them come down in the flood time.

Mr. WARREN. Yes.

Mr. HOYT. You would expect to suffer for a year or two?

Mr. Warren. Yes, except on some large stream where very large operations could be conducted. But as a general thing the operations on any one stream would not be felt.

The Chairman. While you are filling the soil it would certainly be felt, but when you got the soil once filled it would operate to make the land need less irrigation?

Mr. Warren. Yes.

Governor Warren filed with the committee the Irrigation laws of Wyoming, which are as follows:

TITLE 19. *IRRIGATION.*

Chapter 1. *Rights to use of water and right of way for ditches.*
Chapter 2. *Appropriation of water—Procedure.*
Chapter 3. *Official survey of ditch.*

Chapter 1.

RIGHTS TO USE OF WATER AND RIGHT OF WAY FOR DITCHES.

Sec.
1317. Rights of riparian owners.
1318. When land owner entitled to right of way—Damages.
1319. Extent of right of way.
1320. Petition to commissioners—Notice of appointing appraisers.
1321. Proceedings of appraisers—Payment of assessment.
1322. Owner may raise water from stream.
1323. Ditches to be kept in repair.
Sec.
1324. Vested rights preserved.
1325. Ditches to be bridged.
1326. When commissioners to bridge ditches—Expenses.
1327. Claim for right of way may be arbitrated.
1328. Appointment and proceedings of arbitrators.
1329. Appeal to commissioners.
1330. If no appeal taken, award is final.

Sec. 1317. All persons who claim, own, or hold a possessory right or title to any land or parcel of land within the boundary of Wyoming Territory, when those claims are on the bank, margin or neighborhood of any stream of water, creek, or river, shall be entitled to the use of the water of said stream, creek, or river for the purposes of irrigation and making said claim available to the full extent of the soil for agricultural purposes. [C. L. 1876, ch. 65, § 1.]

Sec. 1318. When any person owning claims in such locality has not sufficient length of area exposed to said streams to obtain a sufficient fall of water to irrigate his land or his farm, or land used by him for agricultural purposes is too far removed from said stream, and he has no water facilities on those land he shall be entitled to a right of way through the farms or tracts of land which lie between him and said stream, or the farms or tracts of land which lie above and below him, on said stream, for the purposes hereinbefore stated: *Provided*, That, in the construction, keeping up, and using any ditch through the lands of another person, the person or persons constructing or using said ditch, or whose duty it shall be to keep the same in repair, shall be liable to the person owning or claiming such land, for all damages accruing to such person by reason of said construction, keeping up, and using such ditch. [C. L. 1876, ch. 65, § 2.]

Sec. 1319. Such right of way shall extend only to a ditch, dyke, or cutting sufficient for the purposes required. [C. L. 1876, ch. 65, § 3.]

Sec. 1320. Upon the refusal of the owners of tracts of land, or lands through which said ditch is proposed to run, to allow of its passage through their property, the persons desiring to open such ditch may present to the county commissioners of the county in which said lands are located, a petition, signed by the person or persons, describing with convenient accuracy the lands so required to be taken as aforesaid, setting forth the name or names of the owner or other person interested, and praying the appointment of three appraisers to ascertain the compensation to be made to such owner or persons interested. Upon the receipt of said petition, the said county commissioners shall give notice, at least thirty days prior to the appointment of said appraisers, by public notice in a newspaper, when published in the county or by posting three or more notices in three different places in said county, stating that such appraisers will be appointed on the——day of——. [C. L. 1876, ch. 65, § 5.]

Sec. 1321. The said appraisers, before entering upon the duties of their office, shall take an oath to faithfully and impartially discharge their duties as said appraisers. They shall hear the proofs and allegations of the parties, and any two of them, after reviewing the premises, shall, without fear, favor, or partiality, ascertain and certify the compensation proper to be made to said owner or persons interested, for the lands to be taken or affected, as well as all damages accruing to the owner or person interested, in consequence of the condemnation of the same, taken or injuriously affected as aforesaid, making such deduction or allowance for real benefits or advantages which such owner or parties interested may derive from the construction of said ditch or flume. They or a majority of them shall subscribe a certificate of their said ascertainment and assessment, which shall be recorded in the county clerk's office of the county in which said lands are situated, and upon the payment of the compensation (if any), the said person or persons shall have the right of way of construct said ditch or flume. [C. L. 1876, ch. 65, § 6.]

SEC. 1322. All persons on the margin, bank, neighborhood, or precinct of any stream of water shall have the right and power to place upon the bank of said stream a wheel or other machine for the purpose of raising water to the level required for the purpose of irrigation, and the right of way shall not be refused by the owner of any tract of land upon which it is required, subject, of course, to the like regulations as required for ditches and laid down in the last preceding section. [C. L. 1876, ch. 65, § 7.]

SEC. 1323. The owner or owners of any ditch for irrigation or other purposes shall carefully maintain the embankments thereof, so that the waters of such ditch may not flood or damage the premises of others. [C. L. 1876, ch. 65, § 8.]

SEC. 1324. Nothing in this chapter contained shall be so construed as to impair the prior vested rights of any mill or ditch owner, or other person, to use the waters of any such water-course. [C. L. 1876, ch. 65, § 9.]

SEC. 1325. Any ditch company constructing a ditch, or any individual having ditches for irrigation or for other purposes, whenever the same be taken across any public highway or public traveled road, shall put a good substantial bridge (not less than fourteen feet in breadth), over such water-course where it crosses said road. [C. L. 1876, ch. 65, § 11.]

SEC. 1326. When any such ditch or water-course shall be constructed across any public traveled road, and not bridged within three days thereafter, it shall be the duty of the county commissioners of the county in which said ditch and road are located to put a bridge over said ditch or water-course, of the dimensions specified in the foregoing section, and call upon the owner or owners of the said ditch or water-course to pay the expenses of constructing said bridge, and if payment therefor be refused, a civil action may be maintained for the recovery of the same, together with all accruing costs. [C. L. 1876, ch. 65, § 12.]

SEC. 1327. Upon the refusal of the owner or owners of land or lands through which any person or persons are desirous of constructing any irrigation ditch or ditches, then it shall be lawful for the parties interested to settle the matter by the appointment of a board of arbitration consisting of three men as hereinafter provided. [S. L. 1882, ch. 57, § 1.]

SEC. 1328. The creation of the board of arbitration shall be as follows: The person or persons desiring the construction of such ditch or ditches and the owner or owners of the land or lands through which the construction of such ditch or ditches is contemplated shall each choose one disinterested resident property holder of the county in which the land or lands mentioned above are situated, and the two so chosen shall designate a third person with like qualifications as themselves, and it shall be lawful for these persons to immediately proceed to hear the proof and allegations of the parties concerned. It shall be lawful for any two of such board of arbitration to make such assessment of damages as may in their judgment be deemed just and right, taking into consideration the benefits, if any, that may accrue to the owner or owners of the land or lands through which the construction of such ditch or ditches is contemplated. [S. L. 1882, ch. 57, § 2.]

SEC. 1329. Should the verdict or assessment of such board of arbitration be unsatisfactory to either or both of the parties interested, then recourse may be had by an appeal made in writing within ten days from the rendering of such verdict by such board of arbitration, addressed to the board of county commissioners of the county in which the contestants reside, in which case the party taking the appeal shall give bonds for all the costs; then the case shall stand as though no action had been taken in the matter and the parties may then proceed under this chapter in the same manner as though the proceedings to ascertain the compensation to be given had been taken before the county commissioners in the first instance. [S. L. 1882, ch. 57, § 3.]

(For proceedings before commissioners see §§ 1320 and 1321.)

SEC. 1330. In case no appeal be taken as above provided by either of the parties interested, then the finding of such board of arbitration shall be binding and final; *Provided*, The sum of money agreed upon by the board of arbitration has been tendered or paid, or a deed for such right of way executed and delivered or tendered by the party or parties over whose land the right of way is sought. [S. L. 1882, ch. 57, § 4.]

CHAPTER 2.

APPROPRIATION OF WATER—PROCEDURE.

Sec.
1331. Irrigation districts defined and numbered.
1332. Appointment of water commissioners.
1333. Oath of commissioners.
1334. Duties of commissioners.
1335. Molesting head-gates, etc.—Penalty—Commissioners may make arrests.
1336. Compensation of commissioners.
1337. Employment of assistant commissioners—Compensation.
1338. Commissioners to perform duties only when necessary.
1339. Jurisdiction of courts to settle water rights.
1340. Statement of existing water rights to be filed, etc.
1341. Filing and index of statement.
1342. Fees of clerk of court.
1343. Statement of contemplated ditch—Apportionment of water—Construction to begin in sixty days.
1344. Streams open to appropriation.
1345. Manner of determining priority of water rights in district court.
Sec.
1346. Notice of trial of rights to water.
1347. Destroying water improvements—Penalty.
1348. Appeal to supreme court—Notice—Undertaking.
1349. Service of notice in case of appeal.
1350. Transcript to be filed in six months.
1351. Decree of supreme court.
1352. Effect of failing to offer evidence of priority of water rights.
1353. Effect of failure to file statement of water right.
1354. Decision may be reviewed in district court.
1355. Right of persons constructing reservoirs.
1356. Liability of owners of reservoirs.
1357. Fees of witnesses.
1358. Rights of incorporated companies to take water.
1359. Water commissioners to prevent waste of water.
1360. Ditch owners to protect fish.
1361. Vested rights preserved.

SEC. 1331. The lands now irrigated, or which may be hereafter irrigated, from ditches taking water from the following described rivers and natural streams of the Territory of Wyoming, are hereby declared to constitute irrigation districts:

District number one shall consist of all lands irrigated from ditches from the North Platte River and its tributaries, except the Laramie River, between its intersection with the boundary line between Nebraska and Wyoming and its intersection with the western boundary line of Laramie County, Crow Creek, Lone Tree Creek, Pole Creek, Horse Creek, Chugwater Creek, Cheyenne River, Niobrara or Running Water River, and their tributaries.

District number two shall consist of all lands irrigated from ditches taking water from the Laramie River and tributaries, except Chugwater Creek, North Platte River and its tributaries, between its intersection with the western boundary line of Laramie County and the mouth of the Sweetwater, Sabille Creek and North Laramie Creek; and also the following-named streams, situate in whole or in part in the County of Albany, namely: Douglass Creek, Lake Creek, the three Beaver Creeks, Four-Mile Creek, Dutton Creek, Cooper Creek, Rock Creek and tributaries, Sabille, Sheep Creek, Deer Creek and tributaries, Antelope Creek, Fish Creek and its tributaries, Dale creek and its tributaries, and also the following-named lakes, to-wit: Cooper Lake, James Lake, Ione Lake, Sportsman's Lake, Lake Hutton, Lake Creighton, Lake George, Steamboat Lake, Horse Creek Lake, Lake Hattie, and Lake Owen.

District number three shall consist of all lands irrigated from ditches taking water from the North Platte River and its tributaries to the line of Carbon County, and all streams or continuations of streams lying within Carbon County.

District number four shall consist of all lands irrigated from ditches taking water from the Green River and its tributaries.

District number five shall consist of all lands irrigated from ditches taking water from the Powder, Tongue, and Big Horn Rivers and their tributaries, except Wind River.

District number six shall consist of all lands irrigated from ditches taking water from the Little Powder River, Little Missouri River, and the Belle Fourche and their tributaries.

District number seven shall consist of all lands irrigated from ditches taking water from that portion of Green River lying within Uinta County and Bear River.

District number eight shall consist of all lands irrigated from ditches taking water from Wind River to Johnson County line.

Other irrigation districts may be formed from time to time by the governor, on petition of the parties interested, comprising territory not within any of the above-established irrigation districts. [S. L. 1886, ch. 61, § 1.]

SEC. 1332. There shall be one water commissioner for each of the above-named districts, and for each district hereafter formed, who shall be appointed by the governor, to be selected by him from persons recommended to him by the several boards of county commissioners of the counties into which water districts may extend, and the water commissioners so appointed shall hold their office for two years, or until their successor is appointed and qualified. The governor, by like selection and appointment, shall fill all vacancies which may be occasioned by death, resignation, or continued absence from the district, removal or otherwise, and the governor may at any time remove any water commissioner for failure to perform his duties, or for any other cause. [S. L. 1886, ch. 61, § 2.]

SEC. 1333. Within twenty days after his appointment, and before entering upon the duties of his office, such water commissioner shall take and subscribe an oath to faithfully and impartially perform the duties of his office, which oath shall be deposited with the clerk of the court having jurisdiction over the priority of rights to use of water in his district. [S. L. 1886, ch. 61, § 3.]

SEC. 1334. It shall be the duty of the said water commissioners to divide the water in the natural stream or streams of their districts among the several ditches taking water from the same, according to the prior rights of each, respectively, in whole or in part, and to shut and fasten, or cause to be shut and fastened, the head-gates of any ditch or ditches heading in any of the natural streams of the district, which in time of a scarcity of water, makes it necessary, by reason of the priority of the rights of others above or below them on the stream. [S. L. 1886, ch. 61, § 4.]

SEC. 1335. Every person who shall willfully open, close, change, or interfere with any head-gate or water-box without authority shall be guilty of a misdemeanor, and on conviction thereof shall be fined in any sum not exceeding one hundred dollars, or imprisoned in the county jail for a term not exceeding six months, or both fine and imprisonment. The water commissioners or their assistants, within their districts, shall have authority to arrest any person or persons offending and turn them over to the sheriff of the proper county. [S. L. 1886, ch. 61, § 5.]

SEC. 1336. The water commissioners herein provided shall be entitled to pay at the rate of five dollars per day for each day he shall be actually employed in the duties of his office, not to exceed fifty days in any one year, to be paid by the county in which his irrigation district may lie. Each water commissioner shall keep a just and true account of the time spent by him in the duties of his office, and shall present a true copy thereof, verified by oath, to the board of county commissioners of the county in which his district may be, and said board of county commissioners shall allow the same, and if said irrigation district shall extend into two or more counties then said water commissioner shall present his account for his said services, verified as aforesaid, to the board of county commissioners of the county in which sits the district court having jurisdiction over the priorities of the rights to use of water for the purposes for which it was appropriated in such districts. [S. L. 1886, ch. 61 § 6.]

SEC. 1337. Said water commissioners shall have power, in case of emergency, to employ suitable assistants to aid him in the discharge of his duty; such assistants shall take the same oath as the water commissioner and shall obey his instructions, and each shall be entitled to four dollars per day for every day he is employed, not to exceed thirty-five days in any one year, to be paid upon the certificate of the water commissioner in the same manner as is provided for payment of water commissioners. [S. L. 1886, ch. 61, § 7.]

SEC. 1338. Said water commissioners shall not begin their work until they shall be called on by two or more owners or managers, or persons controlling ditches in the several districts, by application in writing, stating that there is a necessity for their action, and they shall not continue performing services after the necessity therefor shall cease. [S. L. 1886, ch. 61, § 8.]

SEC. 1339. For the purpose of hearing, adjudicating, and settling all questions concerning the priority of appropriation of water, between ditch companies and other owners of ditches, drawing water for beneficial purposes, from the same stream, or its tributaries, within the same irrigation district, and all other questions of law and questions of right growing out of or in any way involved or connected therewith, jurisdiction is hereby vested, exclusively in the several district courts, as follows: For district number one, in the district court of Laramie County; for district number two, in the district court of Albany County; for district number three, in the district court of Carbon County; for district number four, in the district court of Sweetwater County; for district number five, in the district court of Johnson County; for district number six, in the district court of Crook County; for district number seven, in the district court of Uinta County; for district number eight, in the district court of Fremont County. All streams, lakes, and reservoirs not herein enumerated shall be, for all purposes, attached to and belong to the irrigation district in which the greater portion of its water is, it being the intent and meaning hereof to add to each irrigation district all waters not hereinbefore enumerated the majority of which lie in their respective are as, for the purposes of acquiring rights to the appropriation and use thereof and adjudicating the same. [S. L. 1886, ch. 61, § 9.]

SEC. 1340. In order that all parties may be protected in their lawful rights to the use of water for beneficial purposes, every person, association or corporation, owning or claiming any interest in any ditch, canal, or reservoir, within any water district shall, on or before the first day of September, eighteen hundred and eighty-six, if such statements are not already matters of record at the time this act is approved, file with the clerk of the district court having jurisdiction of priority of rights to the use of water for irrigation, in such water district, a statement of claim, under oath, entitled of the proper court, which statement shall contain the name or names, together with the post-office address of the claimant or claimants claiming ownership, as aforesaid, of any such ditch, canal, or reservoir, the name thereof (if any), and if without a name, the owner or owners shall choose and adopt a name, to be therein stated, by which such ditch, canal, or reservoir, shall thereafter be known. The description of such ditch, canal, or reservoir as to location of head-gate, general course of ditch, the name of the natural stream from which such ditch, canal, or reservoir draws its supply of water, the length, width, depth and grade thereof, as near as may be, the time, fixing a day, month and year, as the date of appropriation of water by original construction, also by any enlargement or extension, if any such thereof have been made, and the amount of water claimed by or under such construction, enlargement or extension, and the present capacity of the ditch, canal, or feeder, or reservoir, and also the number of acres of land lying under and being, or proposed to be, irrigated by water from such ditch, canal, or reservoir; or if such waters have been appropriated for other beneficial purposes than irrigation, a statement of such purpose; such statement shall be signed by the proper party or parties; and shall file with the county clerk and *ex-officio* register of deeds a like statement, which shall be be recorded by him in a book kept for that purpose. [S. L. 1886, ch. 61, § 10.]

SEC. 1341. Upon the filing of such statement, the clerk of the court shall endorse upon the back thereof the date of filing, and shall prepare an index of the same, in a book to be provided for that purpose by the county commissioners, which said index shall contain the date of filing, the name of the party, association, or corporation, the name of the ditch, the stream from which the water is taken by such ditch, canal, or reservoir, in general terms, the location of the head-gate, the date of the appropriation of the water, by construction, enlargement or extension; said index shall be prepared alphabetically, by reference to the name of the ditch, canal, or reservoir. [S. L. 1886, ch. 61, § 11.]

SEC. 1342. For filing and indexing such statement, the clerk of the court shall receive a fee of one dollar, to be paid by the party or parties filing the same. [S. L. 1886, ch. 61, § 12.]

SEC. 1343. Hereafter every person, company, or corporation, constructing, enlarging, or extending any ditch, canal, or reservoir, for beneficial purposes, and intending to use or appropriate any water from any natural stream within a water district, for such beneficial purposes, shall file with the county clerk and *ex-officio* register of deeds and the clerk of the district court, of the proper county, before the commencement of the construction, enlargement, or extension of such ditch, canal, or reservoir, a statement showing the stream or streams from which the water is to be taken; the point or place on said stream at or near which the water is to be taken out, the line of said ditch or ditches as near as may be; the use or uses to which said water is intended to be applied; the dimensions of such ditch or ditches, and each thereof, giving width on bottom and top, slope of banks, and grade of ditch; and likewise of any and all enlargements thereof; which statement shall be filed and indexed as is provided in section thirteen hundred and forty, and from the time of filing any such statement water sufficient to fill such ditch or ditches, and to subserve the use or uses aforesaid, if a lawful and just use, shall be deemed and adjudged to be appropriated; *Provided*, That nothing herein contained shall be permitted to interfere with a prior right to said water, or to any thereof; *And provided further*, That such person or persons, or corporation, shall within sixty days next ensuing the filing of such statement, begin the actual construction of said ditch or ditches, and shall prosecute the work of the construction thereof diligently and continuously to its completion; *And provided further*, That the beginning of all necessary surveys of such ditch shall be construed as the beginning of said work of construction. [S. L. 1886, ch. 61, § 13.]

SEC. 1344. The water of every natural stream not heretofore appropriated within this Territory is hereby declared to be the property of the public and the same is dedicated to the use of the people, subject to appropriation as herein provided. The provisions of this chapter shall apply to all cases where water of natural streams is appropriated for beneficial purposes, whether the water be conducted through ditches, canals, flumes or tunnels, and shall apply also to cases where for irrigation purposes the water is stored in reservoirs and the owner or owners of any ditch, canal, flume or tunnel through which water is conducted for irrigation purposes, and also the owners of reservoirs may conduct the water therefrom into and along any of the natural streams of the Territory, but not so as to raise the waters thereof above high water mark, and may take the same out again at any point desired, but due allowance shall be made for evaporation and seepage, the amount to be determined by the water commissioner of the proper district, subject to review and determination by the court having jurisdiction over priorities in such district. [S. L. 1886, ch. 61, § 14.]

SEC. 1345. Whenever any person or persons, association or corporation, interested as owners of any ditch, canal, or reservoir, in any district, shall desire a determination of the priorities of rights to the use of water from stream or streams, from which they draw the water for their ditch or ditches, canals or reservoirs, they shall present to the district court having jurisdiction over the rights in such water district, or to the judge thereof in vacation, a motion, petition or application in writing, moving or praying said court to proceed to an adjudication of the priorities of rights to the use of water for irrigation, between the several ditches, canals or reservoirs in such district, on the stream or streams named in the motion, petition or application. The said motion, petition or application shall state the names of the ditches, canals or reservoirs, claiming water from said stream or streams, as appears by the final statements in the clerk's office, together with the names of the persons, associations or corporations interested therein, taken from said statements, and shall set forth the nature of the claim or claims of the applicant or applicants, and such motion, petition or application shall be entitled "in the matter of an application for an adjudication of the priorities of rights to use water for beneficial purposes in water district number ——, on ———" (stating the stream or streams). Upon the filing and docketing of such application, the court, or judge thereof, in vacation, shall without unnecessary delay, by an order to be entered of record, upon such motion, petition or application, appoint a day, in some regular term of said court, or in vacation thereof, for commencing to hear and take evidence in such adjudication, at which time it shall be the duty of the court, or judge thereof in vacation, to proceed and hear all evidence that may be offered by or in behalf of any person, association or corporation interested in such stream or streams in such district, in any ditch, canal or reservoir, either as owner or consumer of water therefrom, in support of or against any claims of priority of appropriation of water made by means of any ditch, canal or reservoir, or by an enlargement or extension thereof in such district, or on such stream or streams, and consider all such evidence, also the arguments of the parties or their counsel, and shall ascertain and find from such evidence, as near as may be, the date of the commencement of such ditch, canal or reservoir, together with the original size and carrying capacity thereof, as originally constructed, the time of the commencement of each enlargement or extension thereof, if any, with the increased capacity thereby occasioned, the time spent severally in such construction, enlargement, or extension and re-enlargement, if any, the diligence with which the work was in each case prosecuted, the nature of the work as to the difficulty of construction, and all such other facts as may tend to show the compliance with the law in acquiring the priority of right claimed for each such ditch, canal or reservoir, and determine the matters put in evidence, and make and cause to be entered, a decree determining and establishing the several priorities of right, by appropriation of water of the several ditches, canals and reservoirs, in such water district, in such stream or streams, concerning which testimony shall have been offered, each according to the time of its said construction and enlargement or enlargements and extensions, with the amount of water which shall be held to have been appropriated by such construction and enlargement, or extensions, describing such amount by cubic feet per second of time (which shall also be the method of measurement for the sale of water), if the evidence shall show sufficient data to ascertain such cubic feet, and if not, by width, depth and grade, and such other description as will most certainly and conveniently show the amount of water intended, as the capacity of such ditch, canal or reservoir in such decree. Such court or judge thereof, in vacation, shall further order that each and every person interested or claiming any such ditch, canal or reservoir, shall receive from the clerk on payment of a reasonable fee therefor, to be fixed by the court or judge, in vacation, a certificate under seal of the court, showing date or dates, and amount or amounts of appropriations adjudged in favor of such ditch, canal or reservoir, under and by virtue of the construction, extension and enlargement thereof severally, also specifying the number of said ditch as determined by the court, with reference to priority, and of each priority to which the same may be entitled by reason of said construction, extension and enlargement; *Provided*, That any party or parties claiming any right to the use of water for beneficial purposes in such district, and on such stream or streams, by reason of being owner of or interested in any ditch, canal or reservoir, who is not mentioned in the motion, petition or application filed and presented to the court, shall be notified by the clerk of such application, and shall become parties to such proceedings, and shall have their rights adjudicated therein. The court or judge thereof, in vacation, may, instead of taking the testimony orally or in open court, refer the matter to some person to take and reduce to writing the testimony to the court or judge thereof, in vacation, and the person to whom such cause shall be referred for that purpose, shall have the same power and duties concerning the taking of testimony, and compelling the attendance of witnesses, as masters in chancery. [S. L. 1886, ch. 61, § 15.]

SEC. 1346. Upon the order of the court fixing the time of hearing being made, the clerk shall place a certified copy of such order, which order shall contain the names of all the parties alleged in application to be interested in the matter, in the possession of the sheriff of the proper county, which shall be thereupon served upon each of the parties therein named in the same manner as a summons, and a return of the service shall be made and filed with the clerk within fourteen days after the delivery of said order to the sheriff, or if served by any other person, in cases where a summons could be served, then return shall be made within fourteen days after date of order. It shall be the duty of the clerk also to give public notice of such application and order, by publication in a newspaper, if any be printed and in circulation, in some county wherein such water district is situated, which notice shall be published at least once each week for two consecutive weeks, and which said notice shall contain the date of the filing of said motion, petition, or application, the name or names of the parties filing the same, a copy of the order made by the court for hearing, and shall notify all parties interested as owners in any ditch, canal, or reservoir on such stream or streams in such water district, as well as the persons named in the motion, petition, or application, to appear at said court or before the judge thereof, in vacation, at the time appointed and stated in the order, and that all persons interested as owners or consumers may then and there present his, her, or their proofs for or against any priority of right of water by appropriation sought to be shown by any party, by or through any ditch, canal, or reservoir (either as owner or consumer of water drawn therefrom), and in case any party mentioned in the motion, petition, or application can not be personally served in any county embraced in such water district, the published notice above provided shall be deemed sufficient service of notice: *Provided further*, That in addition to such publication the clerk shall mail such published notice to each party mentioned in the motion, petition, or application, directing the same to the address of such parties as stated in the sworn statement on file. Proof of the proper publication shall consist in the sworn certificate of the publisher of the paper in which notice is published, to which shall be attached a printed copy taken from such paper. [S. L. 1886, ch. 61, § 16.]

SEC. 1347. Any person or persons who shall knowingly and willfully cut, dig, or break down, or open any gate bank, embankment, or side of any ditch, canal, or reservoir, flume, tunnel, or feeder in which such person or persons may be joint owners, or on the property of another, or in the lawful possession of another or others, and used for the purpose of irrigation, milling, manufacturing, mining, or domestic purposes, with intent maliciously to injure any person, association, or corporation, or for his or her own gain, unlawfully, with the intention of stealing, taking, or causing to run, or pour out of such canal, or reservoir feeder, or flume, any water for his or her own profit, benefit, or advantage, to the injury of any other person, persons, association, or corporation lawfully in the use of such water, or of such ditch, canal, tunnel, feeder, or flume, he, she, it, or they, so offending, shall be deemed guilty of a misdemeanor, and, on conviction thereof, shall be fined in any sum not exceeding one hundred dollars, and may be imprisoned in the county jail not exceeding six months, or both, at the discretion of the court. [S. L. 1886, ch. 61, § 17.]

SEC. 1348. Any party or parties, representing any ditch, canal, or reservoir, or any number of parties, representing two or more ditches, canals, or reservoirs, which are affected, in common with each other, by any portion of the decree rendered by the district court, by which he, she, it, or they may feel aggrieved, may have an appeal from said district court to the supreme court, and in such case the party or parties joining, desiring an appeal, shall be the appellants, and the parties representing any one or more ditches, canals, or reservoirs affected in common, adversely to the interests of appellants, shall be appellees. The party or parties in such appeal shall, within sixty days after the date of the decree, file in the district court wherein any decree is entered under this chapter a notice of appeal in writing, stating that such party or parties appeals to the supreme court of the Territory from the decree rendered in the case, or any part thereof. When only a part of the decree is appealed from the notice of the appeal should so state, and shall also in that case specify the portion or part of the decree appealed from. Upon filing of such notice of appeal the cause shall be deemed to be appealed to the supreme court of the Territory: *Provided, however*, That the party or parties appealing as aforesaid, shall, within sixty days aforesaid, enter into an undertaking, to be approved by the district court, or judge thereof, and to be given to all parties in said suit or proceeding, other than the parties appealing, and to be in such an amount as the court or said judge shall fix, conditioned that the parties giving their said undertaking shall prosecute their appeal to effect, and without unnecessary delay, and will pay all costs and damages which the parties to whom the undertaking is given, or either or any of them may sustain in consequence of such appeal. [S. L. 1886, ch. 61, § 18.]

SEC. 1349. The order last aforesaid shall be entered of record, and the appellant or appellants shall cause a certified copy thereof to be served on each of the appellees, by delivering the same to him or her, if he or she may be found, or otherwise serving the same, in manner the same, as may be provided for serving summons from the district court by the laws then in force. [S. L. 1886, ch. 61, § 19.]

SEC. 1350. The appellant or appellants shall, within six months after the appeal be allowed as aforesaid, file in the office of the clerk of the supreme court of this Territory a certified transcript of the proceedings had in the case in the district court containing the pleadings and the statements of the parties filed herein and all evidence of record offered on the hearing of the cause, or so much thereof as shall effect the appropriation of water claimed by the means of construction, enlargement, or reenlargement of the several ditches, canals, and reservoirs mentioned in the order allowing the appeal. When the evidence has been taken in the open court, or before the judge, in vacation, such evidence, or the substance thereof, reduced to writing and signed by the judge, or in case notes of said testimony have been taken by the official stenographer, a transcription of the same, signed by the stenographer and attested by his official seal, filed with the clerk of the court, shall be deemed a record of the evidence taken in said court. [S. L. 1886, ch. 61, § 20.]

Sec. 1351. The supreme court, in all cases heard before it under this chapter, shall, where it can properly be done, render such decree as the court, or the judge below, should have rendered. It may either reverse or modify the decree of the court or judge below, and in cases where the decree of the court below is reversed, in whole or in part, it may direct the court below as to its further proceedings therein. [S. L. 1886, ch. 61, § 21.]

Sec. 1352. No claim of priority of any person, association, or corporation on account of any ditch, canal, or reservoir, as to which he, she, it, or they have failed or refuse to offer evidence, under any adjudication herein provided for, shall be regarded by any water commissioner in distributing water in times of scarcity thereof, until such time as such party shall have by application to the court having jurisdiction obtained leave and made proof of the priority of right to which such ditch, canal, or reservoir shall be justly entitled, which leave shall be granted in all cases upon terms as to notice to other parties interested, and upon payment of all costs, and upon affidavit or petition sworn to, showing the rights claimed, and the ditches, canals, and reservoirs, with the names of the owners thereof, against which such priority is claimed, nor until a decree adjudging such priority to such ditch, canal, or reservoir has been entered, and certificate such as mentioned in section thirteen hundred and forty-six shall have been issued to claimant and presented to the water commissioner. [S. L. 1886, ch. 61, § 22.]

Sec. 1353. No person, association, or corporation representing any ditch, canal, or reservoir shall be permitted to give or offer any evidence before said court until he, she, it, or they shall have filed a statement of claim in substance the same in all respects as is required to be filed under the provisions hereof. [S. L. 1886, ch. 61, § 23.]

Sec. 1354. The district court, or judge thereof, in vacation, shall have power to order for good cause shown, upon terms just to all parties, and in such manner as may seem meet, a re-argument or review, with or without additional evidence, of any decree made under the provisions of this chapter, whenever said court or judge shall find from the cause shown for that purpose by any party or parties feeling aggrieved, that the ends of justice will be thereby promoted, but no such review or reargument shall be ordered unless applied for by petition or otherwise within two years of the time of entering the decree complained of. [S. L. 1886, ch. 61, § 24.]

Sec. 1355. Persons desiring to construct and maintain reservoirs for the purpose of storing water shall have the right to take from any of the natural streams of the Territory and store away any unappropriated water not needed for immediate use, for domestic or irrigation or other beneficial purposes, to construct and maintain ditches, canals, flumes, or tunnels, for carrying such water to and from such reservoirs, ditches, canals, tunnels, and flumes, in the same manner provided by law for the condemnation of lands for right of way for ditches: *Provided*, No reservoir with embankments or a dam exceeding ten feet in height shall be made without first submitting the plans thereof to the county commissioners of the county in which it is situated, and obtaining their approval of said plans: *And provided, further*, That no such reservoir shall be constructed or made in or across the channel of any natural and running stream. [S. L. 1886, ch. 61, § 25.]

Sec. 1356. The owners of reservoirs shall be liable for all damage arising from leakage or overflow of the waters therefrom, or by floods caused by breaking of the embankments of such reservoir. [S. L. 1886, ch. 61, § 26.]

Sec. 1357. Every witness who shall attend before the court, or the judge thereof in vacation, or before the person appointed to take testimony, in the causes provided for in this chapter, under subpœna, by request of any party, shall be entitled to the same fees and mileage as witnesses in civil cases in the district court, and shall be paid by the party requiring his testimony. [S. L. 1886, ch. 61, § 27.]

Sec. 1358. It shall not be necessary for any corporation heretofore organized and now existing, or for any corporation hereafter organized, under the laws of this Territory, which has heretofore, or shall have hereafter constructed, operated, or maintained any ditches, canals, flumes, tunnels, or reservoirs, or other appropriations of water, for the purpose of irrigation, mining, manufacturing, domestic uses, or for any beneficial purpose whatever, to incorporate as a ditch company, or companies, if the objects or purposes for which such corporation shall have been formed or incorporated, imply, permit, or make necessary, or advantageous, such use or uses of water; and such corporation for all the purposes of this chapter shall have all the rights of a natural person as defined herein, and shall have its rights determined in the same manner: *Provided*, No priority of water right shall take from any city or town the water required for the use of the the residents thereof. [S. L. 1886, ch. 61, § 28.]

SEC. 1359. Said water commissioners shall so divide, regulate, and control the use of the water of all streams within their respective districts in such manner, as near as may be, as will prevent unnecessary waste of water, and to that end such commissioners shall so shut and fasten the head-gate or gates of all ditches so that no more water will flow into said ditch than is actually required and will be used for the uses or purposes for which such water was appropriated, and any person who may be injured by the action of any water commissioner or by his failure to act pursuant to this chapter, may resort to any court of competent jurisdiction for such relief as he may be entitled to. [S. L. 1886, ch. 61, § 29.]

SEC. 1360. It shall be the duty of every person, corporation, or company, who shall construct, maintain, or operate any ditch or canal under the provisions of this chapter to construct and maintain, at the point and place where the water is diverted from its natural channel, some fit and proper obstruction whereby all fish will be prevented from entering said ditch or canal. Any person, company, or corporation violating the provisionsof this section shall be adjudged guilty of a misdemeanor, and on conviction thereof shall be punished by a fine of not more than one hundred dollars or by imprisonment in the county jail not less than ten nor more than sixty days, or by both such fine and imprisonment. [S. L. 1886, ch. 61, § 30.]

SEC. 1361. This chapter shall in no wise be construed as impairing or abridging any rights already vested in any person or persons, company or corporation, by virtue of the law heretofore in force. [S. L. 1886, ch. 61, § 31.]

CHAPTER 55.

IRRIGATION—APPROPRIATION OF WATER—TERRITORIAL ENGINEER.

AN ACT creating the office of Territorial engineer and concerning appropriation of water.

Be it enacted by the Council and House of Representatives of the Territory of Wyoming:

SECTION 1. There shall be a Territorial engineer, who shall be appointed by the governor, by and with the consent of the legislative council; he shall hold his office for the term of two years, commencing on the first day of April, A. D. eighteen hundred and eighty-eight, and until his successor shall be appointed and shall have qualified.

The governor may at any time, upon good cause being shown, remove the Territorial engineer, and fill the vacancy occasioned by such removal from office.

The Territorial engineer shall receive a salary of two thousand and five hundred dollars per annum, payable in monthly installments by the Territorial treasurer, upon warrants drawn by the Territorial auditor.

The Territorial engineer shall keep his office at the Territorial capitol, in a room in the capitol building, to be set aside for his use by the governor.

Before entering upon the duties of his office he shall take and subscribe an oath before some officer authorized by the laws of this Territory to administer oaths, to faithfully perform the duties of his office, and file with the secretary of the Territory said oath and his official bond, in the penal sum of five thousand dollars, with not less than two sureties to be approved by the governor of the Territory, and conditioned for the faithful discharge of the duties of his office, and for delivering to his successor, or other officer appointed by the governor to receive the same, all moneys, books, and other property belonging to the Territory then in his hands, or under his control, or with which he may be legally chargeable, as such officer. No person shall be appointed as such Territorial engineer who is not known to have such theoretical knowledge and practical skill and experience as shall fit him for the position.

SEC. 2. The Territorial engineer shall have general supervision of the diversion and division of the water of the various natural streams in the Territory, and shall have supervision of the work of the water commissioners of the different water districts of the Territory, and shall do and perform any and all work for the Territory which comes within the nature of his profession as an engineer, when called upon by the governor to do so.

SEC. 3. The Territorial engineer shall make, or cause to be made, careful measurements and calculations of the maximum, minimum, and ordinary flow, in cubic feet per second of time, of the waters flowing in each stream from which water shall be drawn for irrigation purposes, commencing such work upon those streams most used for irrigation; he shall collect facts and make a report as to a system of reservoirs for the storage of waters in those portions of the Territory where such a system is practicable, stating in such report the location, capacity, and cost of such reservoirs: he shall become conversant with the water-ways of the Territory, and needs of the Territory as to irrigation matters, and in his report to the governor he shall make such suggestions as to the amendment of existing laws, or the enactment of new laws, as his information and experience may suggest; and he shall keep full and proper records of his works, observations, and calculations, all of which shall be the property of the Territory.

Sec. 4. The Territorial engineer shall, onrequest of any party interested, measure and ascertain the carrying capacity of any ditch used for irrigation or other beneficial purposes, which may be now, or which may hereafter be constructed or enlarged, and give to the party or parties requiring such services an official certificate of the size and carrying capacity of such ditch, expressed in cubic feet per second of time, as he shall find it at the time of measuring the same. For such services he shall be entitled to receive from the party or parties requiring the same his per diem charges, not exceeding ten dollars per day, and his reasonable traveling expenses: *Provided*, That all per diem charges for such services received by the Territorial engineer shall be delivered by him to the Territorial treasurer, who shall credit the same to the general fund. If the applicant or applicants for such engineer's certificate shall state in writing to the engineer that the ditch to be measured is so remote from the office of the engineer as to render the expense of the engineer's personal examination too great, or if in the engineer's judgment such ditch is too far distant to prevent him, consistently with his public duties, to make such personal examination, it shall in such cases be his duty to appoint some competent civil engineer, residing in the vicinity of such ditch, to make a sworn statement setting forth the width on top and bottom, depth, grade, and slope of the bank of such ditch or its enlargement, and all such other data concerning such ditch so to be measured as the Territorial engineer shall direct. Such civil engineer shall receive for his services such sum as may be agreed upon between himself and the party requiring his services, but in the absence of any agreement in writing such compensation shall not exceed ten dollars per day and his reasonable traveling expenses. The Territorial engineer shall furnish the person so appointed with blank certificates upon which to enter the necessary data concerning the ditch or its enlargement, so to be measured, which blank shall be properly filled out and verified by the oath of the party making such measurements and returned to the Territorial engineer, who shall make his own calculations of the carrying capacity of such ditch or enlargement, expressed in cubic feet per second of time, and certify to the same. The certificates provided for in this section shall set forth the time of making the measurement, the location of the headgate of the ditch measured, the name of the natural stream of water from which such ditch draws its supply of water, the width of such ditch both on top and on bottom, its depth and grade, and its carrying capacity expressed in cubic feet per second of time, and also the name of the ditch and of the owner or owners thereof, if known. All such certificates shall be recorded at length in the office of the said Territorial engineer, and copies of such record duly certified to by the said engineer, shall be received in all the courts of this Territory, as prima facie evidence of the fact therin set forth, as hereby required.

Sec. 5. The Territorial engineer, with the consent of the governor, shall have power to employ assistants at an expense not to exceed one thousand dollars in any one year, who shall be paid out of any moneys appropriated for that purpose, on the certificate of said Territorial engineer, approved by the governor, showing the reason for such employment, the services rendered, and the amount thereof, and on presentation of such certificate to the Territorial auditor, by the person entitled thereto, he shall issue his warrant on the territorial treasurer for the amount thereof to be paid out of any appropriation, as aforesaid, and not otherwise.

Sec. 6. When the Territorial engineer is called away from his office in the discharge of his public duties, he shall be entitled to his actual traveling expenses, which shall be paid out of any money appropriated for that purpose, on the certificate of the said engineer; such certificate shall be presented by the said engineer to the Territorial auditor, who shall thereupon draw his warrant upon the Territorial treasurer for the amount thereof, to be paid out of such appropriation: *Provided*, That this section shall not be so construed as to authorize the payment of traveling expenses to said engineer when called away from his office to perform any of the work mentioned in section four of this act.

Sec. 7. The appropriator of any of the public waters in this Territory shall construct and maintain, under the direction of the Territorial engineer, a flume or other measuring device, at or as near the head of his ditch as is practicable, for the purpose of assisting the water commissioners in determining the amount of water that may be turned into the ditch or the amount that may be by his ditch diverted from the stream. In case any owner or appropriator of public waters that have been adjudicated upon neglect or refuse to put in such measuring device, after thirty days' notice to do so by the Territorial engineer, the said engineer may direct the water commissioner, of the district in which the ditch may be situate to put in such flume or measuring device, which being done by the water commissioner, he, the said commissioner, shall present the bill of the cost of such flume or measuring device to the owner or owners of the ditch, and if such owner or owners shall refuse or neglect, for three days after presentation of such bill, to pay the same, the said water commissioner may maintain a civil action in his own name, in any court of the Territory, for the recovery of the same, with all accruing costs. Said suit shall be prosecuted by the county and prosecuting attorney for the county wherein such suit may be brought, free of any charge against said commissioner.

SEC. 8. The Territorial engineer shall prepare and render to the governor yearly, and oftener if required, full and true reports of his work, touching all the matters and duties devolving upon him by virtue of his office, which report shall be delivered to the governor on or before the thirtieth day of November in each year, in order that the same may be laid before the legislative assembly at its regular sessions.

SEC. 9. In all cases in which the priorities to the right to the use of the waters of any of the streams of this Territory have have been adjudicated by any of the district courts of this Territory under the provisions of chapter two of title nineteen of the Revised Statutes of Wyoming, it shall be the duty of the clerk of the district court wherein such adjudication may have been made to forward a certified copy of such decree to the Territorial engineer immediately after the rendering of a decree in the matter of such adjudication, and for such copy there shall be paid to the said clerk, out of the treasury of the county wherein such decree was rendered, compensation at the rate of ten cents for each one hundred words contained in such decree. On receipt of such copy of such decree it shall be the duty of the Territorial engineer to cause the same to be recorded at length in a suitable book, to be provided for that purpose, and as soon thereafter as practicable to forward to the water commissioner of the water district wherein the stream adjudicated upon is situated a statement showing the title of the court in which such decree was rendered, the date of the decree, the name of each ditch the priority of which has been by such decree determined, its capacity, showing the width, depth, and grade of the said ditch and the quantity of water per second of time to which said ditch is declared by such decree to be entitled, to be expressed in cubic feet per second of time, and thereafter, in the supervision of the distribution of the waters of such streams by said ditches so adjudicated upon it shall be the duty of the said water commissioner to be guided by such statement. It shall be the duty of the Territorial engineer to procure and cause to be recorded in his office a description of the flume or other measuring device at the head of each ditch so adjudicated upon, showing the width, depth, and grade of each flume or other measuring device, and to calculate and determine the quantity of water, expressed in cubic feet per second of time, which will flow through such flume or other measuring devide at various depths, and furnish the proper water commissioner with a statement of the same.

SEC. 10. The water of every natural stream not heretofore appropriated, within the Territory of Wyoming, is hereby declared to be the property of the public, and the same is hereby dedicated to the use of the people of said Territory, subject to appropriation as hereinafter provided.

SEC. 11. Every person, company, or corporation hereafter constructing, enlarging, or extending any ditch, canal, or reservoir for irrigation or other beneficial purposes, and intending to use or appropriate any water from any natural stream within a water district for such purposes, shall, within ninety days after the commencement of the construction, enlargement, or extension of such ditch, canal, or reservoir, file and cause to be recorded in the office of the county clerk and ex-officio register of deeds of the county in which is situated the district court having jurisdiction of all questions concerning the priority of rights to the use of water in such water district, a statement of claim under oath, setting forth the name or names, together with the post-office address of the owner or owners of any such ditch, canal, or reservoir; the name thereof, if any, and if without a name, the owner or owners shall adopt a name to be therein stated, by which such ditch, canal, or reservoir shall thereafter be known; the number of the water district in which the same is situated; a description of such ditch, canal, or reservoir, as to location of head-gate and the general course of such ditch; the name of the natural stream from which such ditch, canal, or reservoir draws its supply of water; the length, width at top and bottom, depth, grade, and carrying capacity thereof, expressed in cubic feet per second of time, as near as may be; the time, giving the day, month, and year when work was commenced thereon by original construction, enlargement, or extension, as the case may be, and likewise the date when water was actualy appropriated therefrom for irrigation and other beneficial purposes; the number of acres lying under and being, or proposed to be, irrigated by water therefrom, and a map or plat on a scale of not less than one inch to the mile, showing the location or route of such ditch, canal, or reservoir, and the natural stream from which it draws its supply of water, and also the legal subdivisions of land through which they flow: *Provided,* That in case the said statement gives the direction or route of such ditch by courses and distances, according to the field-notes of the survey thereof, it shall not be necessary to include in any such statement the map or plat above referred to. Such statement shall be signed by the person owning such ditch, canal, or reservoir, or, in case of a copartnership, by any member thereof, for and in behalf of such copartnership, or in case of a corporation, by the president or secretary thereof, and such statement shall be recorded as aforesaid in a book to be kept for that purpose.

SEC. 12 If the owner or owners of any such ditch, canal, or reservoir shall prosecute the work of construction thereon diligently and continuously until completed, and shall otherwise comply with the provisions of law, such owner or owners shall, as regards the owner or owners of all other ditches subsequently constructed and drawing their supply of water from the same stream, have a priority of right to the use of such water from and after the date of the commencement of the construction thereof, but not otherwise. The beginning of all necessary surveys of such ditch shall be considered as the commencement of such work of construction.

SEC. 13. When the waters of any natural stream are not sufficient for the service of all those desiring the use of the same, those using the water for domestic purpose shall have preference over those claiming water for any other purpose, and those using the water for agricultural purposes shall have the preference over those using the same for manufacturing purposes.

SEC. 14. The priority of right to the use of such water shall be limited and restricted to so much thereof as may be necessarily used and appropriated for irrigation or other beneficial purposes as aforesaid, irrespective of the carrying capacity of the ditch, and all the balance of the water not so appropriated shall be allowed to run in the natural stream from which such ditch draws its supply of water, and shall not be considered as having been appropriated thereby; and in case the owner or owners of any such ditch, canal, or reservoir shall fail to use the water therefrom for irrigation or other beneficial purposes, or shall refuse to furnish any surplus water to the owner or owners of lands lying under such ditch as hereinafter provided, during any two successive years, they shall be considered as having abandoned the same, and shall forfeit all water rights, easements, and privileges appurtenant thereto, and the waters formerly appropriated by them may be again appropriated for irrigation and other beneficial purposes the same as if such ditch, canal, or reservoir had never been constructed; neither shall the owner or owners of any such ditch, canal, or reservoir have any right to receive from others any royalty for the use of the water carried thereby, but every such owner or owners having a surplus supply of water and furnishing the same to others from any ditch, canal, or reservoir as hereinafter provided, shall be considered common carriers and shall be subject to the same laws that govern common carriers.

SEC. 15. The owner or owners of any such ditch which carries a greater quantity of water than the owner or owners thereof necessarily use for irrigation and other beneficial purposes in connection with their own lands shall, when application is made to them for that purpose, furnish such surplus water at reasonable rates to the owners of lands lying under any such ditch for the purpose of reclaiming such lands and rendering the same productive, and in case of refusal so to do the owner or owners of any such ditch may be compelled by injunction suit to furnish such water on such terms as to the court may seem meet and proper: *Provided,* That the board of county commissioners in their respective counties shall have power, when application is made to them by either party interested, to establish reasonable maximum rates to be charged for the use of water, whether furnished by individuals or corporations.

SEC. 16. The cubic foot of water per second of time shall be the legal standard for the measurement of water in this Territory, both for determining the flow of water in natural streams and ditches and also for the purpose of distributing water therefrom.

SEC. 17. Nothing in this act contained shall in any wise interfere with any prior right to the use of said water; neither shall the owner or owners of any such ditch, canal, or reservoir who have heretofore complied with the laws relating thereto enacted by the ninth legislative assembly of Wyoming be required to file any additional statement of claim under the provisions of this act.

SEC. 18. Section thirteen hundred and forty-three of the Revised Statutes of Wyoming and all laws and parts of laws inconsistent herewith are hereby repealed.

SEC. 19. This act shall take effect and be in force from and after its passage.

Approved March 8, 1888.

CONSTITUTIONAL PROVISIONS.

[FILED WITH THE COMMITTEE BY JOHN K. JEFFREY, SECRETARY OF STATE CONSTITUTIONAL CONVENTION.]

ARTICLE I.—*Declaration of rights.*

SEC. 31. Water being essential to industrial prosperity, of limited amount, and easy of diversion from its natural channels, its control must be in the State, which in providing for its use shall equally guard all the various interests involved.

SEC. 32. Private property shall not be taken for private use unless by consent of the owner, except for private ways of necessity, and for reservoirs, drains, flumes, or ditches on or across the lands of others for agricultural, mining, milling, domestic, or sanitary purposes, nor in any case without due compensation.

ARTICLE VIII.—*Irrigation and water rights.*

SECTION 1. The water of all natural streams, springs, lakes, or other collection of still water, within the boundaries of the State, are hereby declared to be the property of the State.

SEC. 2. There shall be constituted a board of control, to be composed of the State engineer and superintendents of the water divisions, which shall, under such regulations as may be prescribed by law, have the supervision of the waters of the State and of their appropriation, distribution, and diversion, and of the various officers connected therewith. Its decisions to be subject to review by the courts of the State.

SEC. 3. Priority of application for beneficial uses shall give the better right. No appropriation shall be denied except when such denial is demanded by the public interests.

SEC. 4. The legislature shall by law divide the State into four water divisions, and provide for the appointment of superintendents thereof.

SEC. 5. There shall be a State engineer, who shall be appointed by the governor of the State and confirmed by the senate; he shall hold his office for the term of six years, or until his successor shall have been appointed and shall have qualified. He shall be president of the board of control, and shall have general supervision of the waters of the State and of the officers connected with its distribution. No person shall be appointed to this position who has not such theoretical knowledge and such practical experience and skill as shall fit him for the position.

ARTICLE X.—*Corporations.*

SECTION 1. The legislature shall provide for the organization of corporations by general law. All laws relating to corporations may be altered, amended, or repealed by the legislature at any time when necessary for the public good and general welfare, and all corporations doing business in this State may as to such business be regulated, limited, or restrained by law not in conflict with the Constitution of the United States.

SEC. 2. All powers and franchises of corporations are derived from the people, and are granted by their agent, the government, for the public good and general welfare, and the right and duty of the State to control and regulate them for these purposes is hereby declared. The power, rights and privileges of any and all corporations may be forfeited by willful neglect or abuse thereof. The police power of the State is supreme over all corporations as well as individuals.

SEC. 3. All existing charters, franchises, special or exclusive privileges, under which an actual and bona fide organization shall not have taken place for the purpose for which formed and which shall not have been maintained in good faith to the time of the adoption of this constitution, shall thereafter have no validity.

FURTHER STATEMENT OF ENGINEER ELWOOD MEAD.

The CHAIRMAN. Do you wish to add anything to what you have already said?

Mr. MEAD. I wish to say that there is a condition of affairs that prevails here that your questions do not touch directly. I do not know whether it is peculiar to this territory or not, but I think it is important that it should be understood. The land laws at the present time make it difficult for the individuals who take the land to combine to make a ditch. A large expensive ditch takes a large amount of capital to build it, and a considerable length of time to complete its construction so that the people can get water from it. The settlers will starve to death before the ditch can be completed because they can not raise anything on the land while they are doing it.

The CHAIRMAN. That is not always the case. I have known instances where individuals, by combining together, have gone into gigantic enterprises.

Mr. MEAD. They can not do it here. I believe it is best for the settler and best for every one that these ditches should be built in advance of settlement. If we could by some mean secure the proper location for large canals, so that a few canals would distribute the water, we would get the water on better land, there would be a great saving in the water supply and it would be a manifest advantage to the people who came here to settle. I have seen many attempts by actual settlers to settle on these arid lands. They had to wait until the ditch was built. I have seen too much of the privation of their families to believe that that is a satisfactory method. If the ditch were built, so that a man could at once begin farming, there would be no suffering.

Senator JONES. What is your plan?

Mr. MEAD. I want to say first, what has been the development of this Territory, before I give the plan. We have found it impossible and unsatisfactory to combine under the present system of land owning. The result has been that people have combined and built a ditch to water merely their own claims. We have in this Territory to-day probably three thousand ditches built, though there are on record only two thousand five hundred and fifty. The great majority of those are individual ditches. Each settler who went on a stream built an individual ditch to water his own claim. Another settler came and did likewise. I can show you on the office maps twenty-six ditches on one stream in one township. The Territory is charged with a division of water between those several claimants. Take a stream 80 miles long and undertake to divide the water between eighty claimants, and you will understand the difficulty. That plan is immensely wasteful of water and of everything. It is very difficult to maintain those ditches. The average expense of watering land by that system is over $10 an acre. If we could have highland channels that would water those areas, it should not cost half that much to get the water on the land, and more water would get on it. My idea is to turn this land over to the Territory or to the local government, under such regulations as will secure its final disposal to actual settlers, and the Territory could put the companies under such restrictions as would secure ditches, and could also manage the work of their being settled by actual settlers. We would then have a system that could be intelligently planned.

The **CHAIRMAN.** Do you know of any State or Territory that has managed its lands well that has adopted that plan?

Mr. **MEAD.** Yes, I think that on the whole the management of the land by Colorado has been fully as wise as the management of the land by the Government.

Senator **JONES.** Would you advise the Government to authorize the States to make any other disposition of those lands except by homestead settlements?

Mr. **MEAD.** This would be my plan: To turn these lands over to the States. The proper procedure would then be, either for the State or the National Government to locate these canals on the streams, say where they ought to be. Then it can make a close estimate as to the cost of construction and what it would cost to operate the same. I would then allow private capital to build that ditch, and would permit the companies to charge (to have an agreement in the first place that they might charge) a fair rental for the water, and I would provide for that to be continued subsequently, if necessary. Then in regard to the land, I would do this: I would permit the ditch companies, perhaps, to have the management of the settlement. I would make them colonization agents, but I would have the State itself pass the title to the settler. I would not make any title absolute until I knew that it was a bona fide settlement; but I would put the settlement of it in the hands of the ditch companies. They will have the greatest interest in securing settlement. What the ditch company needs is an assurance that the land will be settled when the water is there. They want to be in a position so as soon as the ditch is built, to run it the next year to its full capacity. If they can do that they can furnish water at a much less rental.

Senator **JONES.** That is true; but get back to the main question. Would you authorize or advise the National Government to convey this land to the State for any purpose except to be used for homesteads?

Mr. **MEAD.** No; nothing else.

The **CHAIRMAN.** Then the State would get nothing on earth by the conveyance from the Government to the State, because the land is now within the State, and it is already subject to homestead settlement.

Mr. **MEAD.** I do not understand your question. Do you mean that you would not permit the State to derive any revenue whatever from this land?

Senator **JONES.** I want to know whether you would allow the State to mortgage the land to the ditch companies, for instance?

Mr. **MEAD.** I would not allow the Government to transfer to the State only under the condition that it was to be disposed of to an actual settler and cultivator; but I would permit the State to charge for it and sell it.

Senator **JONES.** Then your idea is to turn the land over to the States to enable them to create a fund to build the ditches?

Mr. **MEAD.** To create a fund to manage and, if necessary, to create a fund to build the ditches. I state in my report that I do not think reservoirs can be built unless conditions change. If they are built they must be subsidized.

The **CHAIRMAN.** They are building them in some places.

Mr. **MEAD.** That is my judgment in regard to this Territory. There are but few favored places where they will be built, but I have in view a comprehensive system. The places where reservoirs can be built as a business proposition are restricted.

The **CHAIRMAN.** You speak of selling the water. Do you think it will be advantageous to have the water owned and controlled by corporations?

Mr. MEAD. No; the water would not be owned at all. It would be a common carrier that had built the ditch and that carrier could only make a charge for transportation.

Senator JONES. Suppose it did not result as you anticipate it would, what would happen?

Mr. MEAD. In what way do you mean?

Senator JONES. How is the ditch company to get its money? Suppose this State makes a contract for a company to go out into one of the valleys and expend a million dollars to bring water on the land; that money is expended, and suppose the place did not settle up, then what?

Mr. MEAD. The company would lose. But the difficulty at the present time is that the ditch companies have no control over settlement.

Senator JONES. And they ought not to have.

Mr. MEAD. I should not want the ditch companies to have it in their power to prevent settlement, but I would wish them to assist settlement.

Senator JONES. I am something of a crank on the idea that the remaining lands of the United States should be made into homes.

Mr. MEAD. That is right.

The CHAIRMAN. How would you regulate the price of water?

Mr. MEAD. Land upon which there is no ditch in this Territory will have a price varying from 15 cents to $1.50 per acre—I mean grazing lands. If you construct a ditch over such land, say a large ditch, so as to make it certain that there will be a considerable settlement there, that land is ultimately reclaimed, and the result will be that the land will enhance in value from the construction of that ditch from $5 to $15 per acre. Suppose a ditch company goes in at the present time to build that ditch and make it possible for the pre-emptor or homesteader or any one with a timber claim to go and file on the land, settle down, and get a title to the land, without in any way contributing to that enterprise of the ditch company, it makes it possible for him to reap that unearned increment.

Senator JONES. But he does not get any value from the ditch.

Mr. MEAD. Suppose a man files on the pre-emption claim and lives on it six months; if that land enhances in value he can sell it. Now, does he not reap the benefit?

Senator JONES. Not a bit. He has to get the water. The possibility of getting the water is one thing, but when he gets the water he has to pay for it. The water may be there and, when he buys the ditch, he figures that up in connection with the possibility of getting the water. But the truth is there is not any value in any of this land. The value is in the water.

Mr. MEAD. Exactly; and we want a system that will distribute that water to the best advantage and save it.

Senator JONES. There is no doubt that there ought to be some changes made.

REPORT SUBMITTED BY ELWOOD MEAD, TERRITORIAL ENGINEER.

IRRIGATION IN WYOMING.

No. I.

1.—Water Supply.

The mountains are the great condensers of moisture and the conservators of our summer water supply. The more extensive and elevated these are the more abundant and long-continued the summer discharge. The extent of the mountain area is therefore as important as that of the plain in estimating the ultimate extension of our irrigated area.

The mountains contributing to the water supply of this Territory are the main range of the Rockies in Colorado and southern Wyoming, the Big Horn and Wind River Mountains in the north, and the mountains of Uinta County in the west. In addition there are the minor ranges, including the Sweetwater and Rattlesnake Mountains in the central portion, the Laramie Range in the east, and the Black Hills Range in the northeast. Taken as a whole, the mountains which form the culmination of the water-sheds of our streams are equal in area to fully one-third of the Territory, or about 35,000 square miles, or 22,400,000 acres.

It is difficult to arrive at a satisfactory conclusion as to the amount of precipitation which falls on these mountains owing to no regular observations having been kept. That it is unusually heavy is known. The reports of the explorations of the Yellowstone Park region state that the snow-fall of that section is above the average for the Rocky Mountains. From this and other data I am led to believe that the rain and melted snow must cover these mountain summits to an average depth of between 2 and 3 feet, giving approximately 60,000,000 acre-feet of water deposited each year. If we suppose that two-thirds of this disappears by evaporation and in other ways there still remains 20,000,000 acre-feet passing down the streams and available for irrigation. Taking the average duty of water at 1 cubic foot per second for 80 acres, this is sufficient water to serve 10,000,000 acres, and it only requires the utilization of the resources here to see our agricultural area extended to this limit.

2.—Location and Distribution.

The location of these mountain areas is such as to cause the Territory to be exceptionally well watered. The streams flow down from their slopes in every direction and penetrate all portions. Although there are over four hundred streams from which water is diverted for irrigation, they form themselves into four natural divisions or drainage systems. These divisions, although differing from the water districts defined by law, will, for convenience, be used in this statement, being designated as 1, 2, 3, and 4.

Of these, the Platte River and its tributaries form the first, the North Platte being the principal stream, and is one of the most important leaving the eastern slope of the Rockies. Having its source on the western slope of Long's Peak, in Colorado, it drains an extensive mountain area before entering this Territory. Owing to its detour to the north it waters a large district within our borders; its length from the Colorado to the Nebraska border being about 350 miles. Of this distance there is probably no section 50 miles in length where its waters can not be diverted, but owing to the expense involved in constructing the necessary head works to withstand the floods of a stream of such volume the principal development has occurred on its tributaries. Maps showing the ditches on three of these streams, the Laramie River, Horse and Crow Creeks, accompany this statement.

Division No. 2 comprises all the streams east of the Big Horn Mountains. In this division irrigation has attained its greatest success and importance, the counties of Johnson and Sheridan having a fine water supply from the streams flowing from the Big Horn Mountains. The rapid fall of this region to the east and north offers unusual facilities for diverting water; a peculiar feature in this section being the large number of canals carrying water across the divides from the stream into the valley of another. The stability of the water supply and the enormous fall which can be readily obtained marks this as a suitable location for the development of extensive water-powers when the country is made accessible by railroads. As yet the development has been restricted by the lack of capital to undertake the construction of large canals to rent water, but there are fine opportunities throughout this region for such enterprises. The main reason for the delay in their inauguration being stated in my main report.

The third division includes the Big Horn River and its tributaries. It is one of the best watered portions of the arid region, as it drains both the Wind River and Big Horn Mountains. Owing to the enormous discharge of these streams, and the fact that the uplands can only be watered by costly works, the settlers have had thus far but little apprehension of any scarcity in the supply, and have consequently been negligent in recording their ditches. Hence the statement of the ditches diverting water from the streams of this division, given further on, is much below the truth.

The Green, Bear, and Snake Rivers are the tributaries from the fourth division. Considerable work has been done on Bear River and a few of the tributaries of Green and Snake Rivers, but this division as a whole, like number 3, is practically untouched as compared to the possibilities here presented. The large surplus of water here has operated, as in division 3, to make ditch owners neglect to record their claims. The records of Sweetwater County being so manifestly below the truth, I have omitted all statistics from that county.

The valleys of the Green and Big Horn offer to-day the best opportunities for the construction of a system of irrigation works, according to a pre-arranged plan, of any section with which I am familiar. To a large water supply and immense tracts of valuable public land there is added the total absence of vested rights to interfere with the construction of the necessary works. It is to be hoped that suitable measures may be taken for the designing and construction of such system of works. It would prove a valuable object-lesson when placed in contrast with some of our former efforts.

No attempt has been made to estimate the extent of irrigation possible in each section, since the absence of stream gaugings gives no data on which to base one.

3.—IRRIGATION WORKS.

Under the Territorial laws the owners of the ditches are required to file, in the offices of the county clerks of the various counties, a statement showing their capacity, location, acreage watered, and such additional facts as are required to make a complete record. As there is no penalty attached to a failure to comply with this requirement many ditches are not recorded, probably five hundred in the whole Territory, and, owing to defective blanks used at first, many that are recorded have made incomplete statements, so that it is impossible to state accurately the area reclaimed. Below is given a table giving the present extent of our irrigation development as shown by the recorded statements, the majority of which have been verified by engineer's certificate as to the dimensions and capacity. It is an extraordinary record when it is remembered that it is principally the work of the past ten years. In extent the irrigated area exceeds the average of the land farmed in each of the New England States, and should forever put at rest the cavil or question as to the ultimate wealth and greatness of this commonwealth. If the pioneers in this work can, unaided and under great disadvantages, produce such results, what may not be accomplished through the intervention of ample capital or of State or national aid?

4.—EXPENSES OF RECLAIMING LAND.

Some time since there was issued from this office a letter of inquiry to ascertain the cost of reclaiming the arid lands. These inquiries were addressed to farmers of known intelligence and of considerable practical experience. The replies are of great value in throwing light on this subject, and I have had them arranged and copied, and they are herewith submitted as Appendix B.

Representing the views of all sections of the Territory, and based on actual experience their statements are entitled to a careful consideration, especially as to some of the perplexing questions which now confront us. While the views as to the proper course to be adopted are somewhat at variance there is a unanimity of sentiment as to the desirability of a more liberal policy in respect to the disposal of the public land. Their statements are also valuable in indicating the amount of money which has been expended in reclaiming the land already under ditches. The amount varies in the different statements from $5 to $25 per acre, so that $10 would be a low average, making the total expenditure for this work over $15,000,000.

5.—TERRITORIAL SUPERVISION.

The irrigation laws of this Territory are very largely copied from those of Colorado, but are in some respect in advance of the parent legislation.

The control of the water by the State is affirmed, and ditches are by law made common carriers. Priority of use gives the better right, and provision is made for settling disputed cases in the courts.

The engineer is the chief executive officer of the system and is charged with the "supervision of the diversion and distribution of the public waters, and of the officials connected therewith." The Territory is divided into nine water districts, in each of which a water commissioner controls the diversion of the water. The important defect of the system is the failure to exercise any control over the streams prior to construction of ditches, and to take steps to secure the proper location and construction of distributing works. The constitutional convention now in session has, however, provided a remedy for this when we become a State.

6.—Future Development.

The problems to be solved in connection with this subject are the obtaining of means for the construction of canals of too great magnitude and expense for combinations of farmers to attempt, and the improvement and utilization of storage reservoirs to hold the waste water of winter and the surplus from the summer floods. There are great possibilities in either direction. On all the important streams there are splendid opportunities for the construction of extensive works to water the uplands, and an abundance of water to supply them when built. With the building of these will come an era of growth and prosperity to our agriculture of which we can scarcely form a conception at the present time. These canals can and will under proper conditions be built by individual or co-operative enterprise, but I am persuaded that if any extensive system of reservoirs is to be brought into use it must be under different auspices.

On many of our streams is already felt the pressing need of an auxiliary summer's supply which the reservoir would furnish, but the expense of improving and making available these storage basins prevents the work being undertaken as a business enterprise. The value of the land and of the products grown thereon will only justify a certain outlay for water, and this, with us, must always be less than in the semitropical portions of the country where the higher-priced products will warrant a far greater outlay.

There are sites for such storage basins on nearly every stream and there would come an immense extension of cultivated area from their improvement. The chief beneficiary of such extension is the State and nation, since it results in an increase of the productive capacity of the country and makes a perpetual addition to the public revenue. I believe that the benefits to be derived therefrom will amply warrant and justify the giving of aid in this work by the National Government, and in fact renders this course the only sound public policy.

Should such aid be extended, it will result in such an irrigation development here as will, with the exception of Snake River, prevent the passage of any unutilized water beyond the borders of the Territory.

Summary of irrigation development by districts.

District.	Total No. of recorded ditches.	Total length as stated.	No. of claims, with statement of length omitted.	Total capacity as given.	No. of ditch claims, omitting statement of capacity.	Total acreage watered as given.	No. of ditch claims, omitting statement of acreage.
1*	643	1,322.385	39	5,911.584	48	482,434.00	89
2	327	582.793	31	6,649.844	53	379,164.64	62
3	282	317.419	91	3,644.078	72	395,563.00	114
4†							
5	502	996.398	32	10,422.70	57	440,540.00	50
6	124	196.955	46	1,556.325	36	58,162.00	55
7	322	518.24	50	1,658.905	96	108,976.78	95
8	182	212.41	52	3,095.487	70	35,395.00	96
9	49	91.43	1	342.00	25	42,460.00	3
‡	7	11.905		136.8		4,180.00	
Total	2,438	4,249.935	242	30,381.723	466	1,946,875.42	564

* Seven reservoirs additional.
† District No. 4 omitted because of incomplete record.
‡ Unorganized district.

Ditch record, water district No. 1.

Name of stream.	No. of ditches.	Length.	Capacity.	Acreage.	No. of ditches, omitting length.	No. of ditches, omitting capacity.	No. of ditches, omitting acreage.
		Miles.	*Cubic feet.*				
Alkali Creek	2	.933	10.8	1,760	......	......	......
Antelope Creek	2	2.35	6.5	320	......	......	......
Alum Creek	1	1.5	50.	100	......	......	......
Badger Creek	1	1.5	......	......	......	1	1
Bear Creek	40	53.282	374.27	11,480	3	2	16
Bear Creek, south fork	2	26.6	15.2	10,220	......	......	......
Beaver Creek	1	1.	6.	80	......	......	......
Blue Grass Creek	1	2.5	16.77	800	......	......	......
Box Elder Creek	3	3.281	9.1	3,360	......	......	......
Big Springs	2	2.	6.66	300	......	......	......
Cabin Creek	5	1.75	26.27	......	......	......	5
Canon Creek	5	4.314	22.14	1,420	......	......	......
Cherry Creek	2	11.5	19.2	8,320	......	......	......
Cheyenne River	8	36.4	29.35	21,220	......	......	......
Chugwater Creek	40	98.25	529.87	26,405	1	2	3
Clear Creek	11	8.5	18.11	2,520	......	......	......
Corn Creek	2	2.2	3.44	......	......	......	2
Cottonwood Creek	5	4.3	25.56	1,280	2	2	1
Crow Creek	38	96.35	377.02	38,480	......	1	3
Deadhead Creek	2	1.95	3.91	......	......	......	2
Dry Creek	8	15.75	66.35	370	......	......	6
Davis Springs	1	1.	.756	200	......	......	......
Donkey Creek	1	2.	9.	320	......	......	......
Dry Laramie Creek	1	4.	7.17	......	......	......	1
Duck Creek	10	12.625	44.625	3,680	......	......	......
East Beaver Creek	4	18.5	59.11	3,900	......	......	1
Fish Creek	4	......	......	......	4	4	4
Four-Mile Creek	3	4.96	13.8	1,840	1	1	......
Fox Creek	4	23.7	21.	12,995	......	......	......
Goose Creek	8	7.60	44.32	3,800	......	......	......
Hay Creek	2	3.6	33.3	1,920	......	......	......
Hanson Creek	1	1.	35.	200	......	......	......
Herrick Creek	2	1.75	10.8	250	......	......	......
Horse Creek	58	227.525	1,041.23	109,658	2	1	3
Horseshoe Creek	10	23.	74.3	12,675	......	......	......
Lance Creek	2	8.25	77.4	1,400	......	......	......
Laramie Creek	7	21.	152.78	4,280	......	......	......
Little Bear Creek	16	13.75	21.8	2,405	7	7	7
Little Horse Creek	6	16.25	92.55	5,670	......	......	......
Lodge Pole Creek	18	71.575	243.86	30,910	......	......	1
Lone Tree Creek	38	51.175	190.95	13,620	......	......	......
Maginnis Creek	1	.75	1.62	160	......	......	......
Main Beaver Creek	2	18.1	10.8	5,850	......	......	......
Marble Creek	1	.625	5.5	20	......	......	......
Maxwell Creek	9	4.	34.9	720	......	......	......
Middle Crow Creek	15	14.528	221.89	2,560	2	1	5
Middle Lodge Pole Creek	1	1.	4.92	160	......	......	......
Mills Creek	7	12.	44.43	1,985	......	......	......
Mountain Lion Creek	4	3.1	11.2	1,200	......	......	......
Muddy Creek	8	10.25	32.35	1,170	......	......	......
Mule Creek	4	3.75	19.3	......	......	......	4
Muskrat Creek	1	1.5	2.08	160	......	......	......
McShane Springs	4	3.	*14.2	640	2	2	3
North Bear Creek	2	4.	6.84	550	......	......	......
North Chugwater Creek	9	5.679	48.81	1,085	......	......	......
North Crow Creek	9	15.5	95.5	2,000	......	......	......
North Horse Creek	9	25.25	67.1	3,105	......	......	......
North Laramie River	4	9.5	84.86	3,100	1	1	1
North Old Ditch Ranch Springs	2	......	......	......	2	2	2
North Platte River	5	32.	248.5	23,280	1	2	1
North Pole Creek	10	17.611	56.67	2,270	......	......	......
North Reshan Creek	2	1.75	13.92	200	......	......	......
North Richard Creek	1	2.5	4.2	......	......	......	1
North Spring Creek	1	.75	(†)	100	......	1	......
Oil Creek	3	13.5	130.4	8,720	......	......	......
Old Woman Creek	1	......	......	......	1	1	1
Pappoose Creek	1	.75	4.5	160	......	......	......
Pine Bluff Creek	1	1.25	.14	360	......	......	......
Pole Creek	1	.75	5.25	160	......	......	......
Plum Springs	1	1.	.256	160	......	......	......

*Also two reservoirs containing 7,128,000 cubic feet.

† 360 square inches.

Ditch record, water district No. 1—Continued.

Name of stream.	No. of ditches.	Length.	Capacity.	Acreage.	No. of ditches, omitting length.	No. of ditches, omitting capacity.	No. of ditches, omitting acreage.
		Miles.	*Cubic feet.*				
Porter Creek	2	1.	6.	140	......	......	......
Rawhide Creek	10	25.833	92.68	7,240	......	......	......
Reshaw Creek	2	2.25	27.61	70	......	......	......
Richard Creek	14	30.175	115.49	9,960	......	......	......
Running Water Creek	7	8.	24.3	1,480	2	2	2
Sage Creek	3	6.05	12.9	640	......	......	1
Sand Creek	3	2.375	6.38	......	......	......	3
Seven Mile Creek	1	.75	3.2	300	......	......	......
Scratch Creek	4	2.25	12.	......	......	......	4
Skull Creek	5	10.	47.1	3,140	......	......	......
South Crow Creek	16	24.25	102.14	6,790	1	3	1
South Horse Creek	6	4.75	15.36	926	......	......	......
South Fork Fish Creek	2	......	......	......	2	2	2
South Chugwater Creek	12	19.25	148.25	1,825	......	......	1
South Branch South Chugwater Creek	1	5.125	1.33	35	......	......	......
South Pole Creek	6	14.	43.69	2,204	......	......	......
South Sundance	2	.75	13.1	260	......	......	......
South Spring Creek	1	1.25	(*)	160	......	1	......
Summit Spring	1	5.	......	......	......	1	1
Springs (Dyer)	1	.25	.62	40	......	......	......
Springs (not named)	2	2.	2.	350	......	......	......
Spring Creek	25	18.781	109.757	2,855	5	6	7
Spring Branch Creek	5	3.	30.1	1,310	......	......	......
Spotwood Creek	1	2.	2.4	400	......	......	......
Stockade Beaver	3	22.95	60.8	10,920	......	......	......
Three-Mile Creek	5	10.	†16.58	870	......	1	......
Upper Richards Creek	2	.933	4.	120	......	......	......
Van Tassel Creek	3	2.25	37.32	600	......	......	......
Willard Creek	1	1.5	......	......	......	1	1
Wyatt Creek	1	2.	4.57	280	......	......	......
Total	643	1,322.385	5,911.584	482,434	39	48	89

* 360 square inches. † Also 190 square inches.

Ditch record, water district No. 2.

Alkali Creek	1	.75	20.	140	......	......	......
Antelope Creek	7	5.2	49.922	1,240	2	......	......
Barbour Creek	1	1.33	25.5	1,200	......	......	......
Bear Creek	1	1.25	39.5	160	......	......	......
Big Laramie River	37	130.64	1,899.644	166,830	3	3	3
Blue Grass Creek	1	2.5	16.77	800	......	......	......
Body of Springs	1	.5	1.22	......	......	......	1
Boneder Creek	1	.75	3.	160	......	......	......
Box Elder Creek	5	13.85	163.33	6,070	......	......	......
Branch of Box Elder Creek	1	.5	2.93	60.	......	......	......
Brown Creek	4	9.75	47.	3,800	1	1	2
Cabin Creek	1	.4	36.7	1,000	......	......	......
Camp Creek	1	.33	......	......	......	1	1
Cañon Creek	2	.875	16.	100	......	......	......
Carroll Creek	1	2.5	23.46	680	......	......	......
Claude Creek	1	1.	3.59	500	......	......	......
Clear Spring Creek	1	.5	4.67	60	......	......	......
Cooper Creek	4	1.2	34.18	3,200	......	......	......
Deep Gulch	1	.25	1.	50	......	......	......
Deer Creek	2	4.08	70.81	1,200	......	......	......
Duck Creek	6	3.58	13.11	470	1	2	......
Dutton Creek	4	11.75	82.9	2,600	......	......	......
Dry Creek	1	6.	68.16	3,200	......	......	......
Dry Muddy Creek	2	4.4	81.	1,000	......	......	......
Fish Creek	8	10.	3.87	1,290	4	4	4
Five Mile Creek	5	8.1	228.1	1,600	......	......	......
Four Mile Creek	4	3.35	24.	1,280	......	......	......
Fox Creek	3	12.	126.84	4,500	......	......	......
Garden Creek	8	8.18	308.7	6,000	......	......	......
Goose Egg Creek	1	1.75	8.07	240	......	......	......
Grant Creek	2	.819	4.	90	......	......	......
Harney Creek	4	4.5	56.3	1,860	1	1	1

Ditch record, water district No. 2—Continued.

Name of stream.	No. of ditches.	Length.	Capacity.	Acreage.	No. of ditches, omitting length.	No. of ditches, omitting capacity.	No. of ditches, omitting acreage.
		Miles.	*Cubic feet.*				
Hay Creek	1	1.25	1.02	50	....	....	....
Indian Creek	2	1.	....	180	....	2	....
Knight Creek	3	1.75	8.	214	....	....	....
La Bank Creek	7	15.5	100.	1,800	2	4	6
La Prelle Creek	12	11.125	45.37	2,900	8	10	10
Little Box Elder Creek	3	2.35	33.	320	1	1	2
Little Laramie River	48	76.415	706.918	45,825	1	4	4
Meadow Creek	1	.75	....	....	....	1	1
Mill Creek	17	19.975	285.58	6,215	....	....	1
Middle Fork Chug Water	1	2.5	2.	160	....	....	....
Mountain Creek	2	.5	5.	200	1	1	1
Muddy Creek	4	1.9	58.	2,000	3	3	3
Muddy Wagon Hound Creek	1	1.	10.	640	....	....	....
Mule Creek	2	1.25	13.32	1,038.64	....	....	....
North Bed Leek	1	.25	1.	....	....	....	1
North Fork Little Laramie River	4	7.2	42.49	2,400	....	....	....
North Laramie River	1	15.	124.	10,000	....	....	....
Northwest Branch Fox Creek	1	1.	2.5	160	....	....	....
Pine Gulch Creek	2	1.75	3.3	300	....	1	....
Plumbago Creek	3	2.5	3.29	640	....	1	1
Poison Spider Creek	1	2.	12.	1,000	....	....	....
Red Mountain Creek	2	4.	....	....	....	2	2
Sand Creek	4	7.55	104.41	5,050	....	....	....
Seven Mile Creek	6	5.524	53.81	2,920	....	1	....
Sheep Creek	2	.33	....	....	1	2	2
Shell Creek	1	1.	22.38	1,200	....	....	....
Slate Creek	5	2.08	8.8	300	....	....	....
Soldier Creek	3	3.6	45.78	320	....	....	2
South Sybille Creek	3	2.75	19.61	347	....	....	....
Spring	3	1.17	3.5	215	....	....	....
Spring Creek	5	5.415	18.26	720	....	2	3
Steam-boat Lake	1	2.	8.	400	....	....	....
Sward Creek	3	2.5	28.60	....	....	....	3
Sybille Creek	21	81.55	1,124.83	71,130	2	5	8
Three Mile Creek	4	1.28	17.	520	....	....	....
Trail Creek	1	1.	....	140	....	1	....
Wagon Hound Creek	5	10.	99.78	3,040	....	....	....
Ward's Gulch Creek	5	12.125	52.92	4,220	....	....	....
Weber Mills Creek	3	2.55	23.	860	....	....	....
Willow Creek	12	10.82	74.01	2,300	....	....	....
Total	227	582.793	6,649.844	379,164.64	31	53	62

Ditch record, water district No. 3.

Austin Creek	2	2.25	80.66	520	....	....	....
Alemoosa Creek	1	1.25	....	160	....	1	....
Badger Creek	1	....	....	....	1	1	1
Bangs Creek	1	.5	5.	160	....	....	....
Bates Creek	4	8.776	74.18	3,010	....	....	....
Battle Creek	1	.75	25.	....	....	....	1
Bear Creek	2	....	7.5	....	2	1	2
Beaver Creek	7	3.	89.79	825	4	2	4
Big Creek	3	4.784	198.42	4,900	1	....	1
Big Creek, South Fork	1	.25	7.88	40	....	....	....
Brush Creek	8	10.5	135.3	6,960	4	3	2
Brush Creek, North Fork	1	....	....	....	1	1	1
Bush Creek	1	....	....	....	1	1	1
Big Bear Creek	2	1.5	45.	200	1	1	1
Big Squaw Creek	1	.5	6.	....	....	....	1
Calf Creek	1	1.	2.62	400	....	....	....
Carbon Creek	1	.5	2.5	160	....	....	....
Carp Creek	1	1.	....	....	....	....	....
Cedar Creek	6	5.	55.	570	3	2	3
Centennial Creek	1	....	....	....	1	1	1
Charley Catlin's Creek	1	....	14.4	....	1	....	1
Cherokee Creek	1	....	....	....	1	1	1
Cherry Creek	1	1.25	3.24	200	....	....	....
Claude and Elkhorn	1	....	....	....	1	1	1
Cole Gulch	1	.5	12.5	160	....	....	....

Ditch record, water district No. 3—Continued.

Name of stream.	No. of ditches.	Length.	Capacity.	Acreage.	No. of ditches, omitting length.	No. of ditches, omitting capacity.	No. of ditches, omitting acreage.
		Miles.	*Cubic feet.*				
Cole Springs	1	......	......	......	1	1	1
Carroll Creek	2	1.324	11.99	320	....	....	....
Cotton Creek	1	......	.174	......	1	....	1
Cottonwood Creek	3	.416	2.5	......	2	2	3
Cow Creek	6	6.881	29.835	985	2	....	2
Difficulty Creek	1	2.	8.64	200	....	....	....
Dobyns Spring	1	.75	2.	160	....	....	....
Dry Creek	4	4.5	64.64	938	2	1	2
Dutch Joe Creek	1	......	......	......	1	1	1
Dutton Creek	5	3.293	56.	300	....	....	3
East Elkhorn Creek	2	3.	30.	......	....	....	2
East Qualey Creek	1	.4	4.	320	....	....	....
Elkhorn Creek	3	5.5	43.55	1,240	....	....	1
Eureka Creek	1	.625	4.5	880	....	....	....
Field House Creek	1	1.25	4.74	320	....	....	....
Fish Creek	1	.5	3.	160	....	....	....
Foot Creek	4	4.	28.847	2,080	1	1	1
Fort Halleck Creek	7	......	105.573	......	7	2	7
Grand Encampment River	7	12.	80.632	2,300	4	1	4
Goshart Creek	1	......	......	......	1	1	1
Hat Creek	2	2.	19.47	800	....	....	....
Horse Creek	2	1.5	9.2	360	....	....	....
Hurt Creek	5	......	33.5	......	5	....	5
Jack Creek	5	11.25	7.5	200	....	3	3
Johnson Creek	2	2.	6.48	640	1	1	1
Joe Creek	1	.31	......	......	....	1	1
Kinney Creek	1	2.75	5.4	1,600	....	....	....
Lederhind Creek	1	.75	1.65	500	....	....	....
Lake Creek	3	3.25	76.62	940	....	....	....
Lake Creek (Smith Fork)	2	2.25	3.	290	....	....	....
Little Bear Creek	3	1.	19.08	240	1	1	1
Little Beaver Creek	5	.5	16.41	320	4	2	4
Little Medicine Bow	1	6.	45.1	3,000	....	....	....
Little Red Creek	1	......	......	......	1	1	1
Little Sand Creek	2	1.36	5.83	300	1	1	1
Little Squaw Creek	1	.66	4.	240	....	....	....
Loomis Creek	1	.75	1.25	80	....	....	....
Medicine Bow River	7	12.34	84.2	1,360	1	3	4
Mike Hanley Creek	2	.25	1.5	160	1	1	1
Milk Creek	2	2.75	(*)	520	....	....	....
Mill Creek	2	1.	7.5	160	1	1	1
Muddy Creek	8	5.48	70.5	1,110	3	3	5
North Platte River	14	25.01	596.54	8,095	5	4	6
North Spring Creek	7	7.5	68.43	1,930	1	....	2
North Spur Creek	1	3.875	7.	760	....	....	....
North W. L Creek	4	2.95	12.95	540	....	....	....
Otto Creek	1	2.	1.	400	....	....	....
Overland Creek	1	3.5	26.	500	....	....	....
Park Creek	1	......	.2	......	1	....	1
Pass Creek	17	28.5	343.56	15,798	5	5	6
Peto Creek	4	3.5	21.075	600	....	....	....
Pine Grove Creek	5	1.75	3.61	160	3	3	3
Rattlesnake Creek	1	1.4	11.9	200	....	....	....
Roaring Creek	1	1.5	9.08	320	....	....	....
Rock Creek	1	1.5	26.	500	....	....	....
Sage Creek	4	1.27	7.6	65	2	2	2
Sage Creek (South Fork)	1	......	......	......	1	1	1
Sand Creek	2	3.44	52.32	1,050	....	....	....
Savery Creek	5	6.56	53.	760	....	1	2
Separation Creek	4	2.405	36.79	740	1	1	1
Snake River	12	19.53	353.81	7,900	3	2	3
South Spring Creek	3	14.	122.382	3,500	....	....	....
Snow Shoe Cañon	1	......	......	......	1	1	1
Spencer Creek	1	......	......	......	1	1	1
Spring Creek	1	2.	.86	400	....	....	....
Sullivan Creek	5	7.4	36.1	1,000	....	....	....
Supply Creek	2	.63	9.95	150	....	....	1
Supply Lake	1	1.2	7.37	240	....	....	....
Sweetwater River	3	13.25	22.26	6,440	....	1	....
Thode Creek	1	1.	......	80	....	1	....
Three Mile Creek	2	3.5	24.24	825	....	....	....

* Also two reservoirs containing 7,128,000 cubic feet.

Ditch record, water district No. 4—**Continued.**

Name of stream.	No. of ditches.	Length.	Capacity.	Acreage.	No. of ditches, omitting length.	No. of ditches, omitting capacity.	No. of ditches, omitting acreage.
		Miles.	*Cubic feet.*				
Trent Creek	1	1.	....	200	....	1	....
Troublesome Creek	5	1.89	39.75	250	2	2	2
W. L. Creek	1	1.5	4.25	250	....	....	....
Upper Creek	1	.17	....	....	....	1	1
Wagon Hound Creek	4	3.79	67.1	1,200	....	1	1
Willow Creek	1	....	15.	....	1	....	1
Total	282	317.419	3,644.078	395,563	91	72	114

Ditch record, water district No. 5.

Name of stream.	No. of ditches.	Length.	Capacity.	Acreage.	No. of ditches, omitting length.	No. of ditches, omitting capacity.	No. of ditches, omitting acreage.
Alkali Creek	4	3.3	7.13	760	....	2	....
Amedem Creek	3	4.75	....	300	....	3	2
Ashworth Creek	1	2.	12.	160	....	....	....
Bear Gulch	1	1.5	3.	320	....	....	....
Beaver Creek	11	23.61	177.07	3,985	1	1	1
Beek's Ditch	1	3.75	.17	240	....	....	....
Big Goose Creek	18	35.78	252.79	12,795	2	6	5
Big Horn River	1	18.5	220.	16,000	....	....	....
Big Rapid Creek	4	9.	58.22	980	....	....	....
Big Piney Creek	2	2.25	17.39	320	....	....	....
Billy Creek	2	1.5	18.75	200	....	....	....
Blue Creek	2	2.6	81.2	910	....	....	....
Box Elder Creek	3	3.75	29.23	380	1	....	....
Broken Back Creek	3	4.99	49.	660	....	....	....
Buffalo Creek	3	28.5	236.92	5,540	....	....	....
Buffalo Springs	1	.1	5.1	40	....	....	....
Buffalo Flat Creek	1	1.	2.	160	....	....	....
Bumdage Creek	1	....	....	400	1	1	....
Cat Creek	1	2.	....	....	....	1	1
Cano Creek	2	1.	9.5	200	....	....	....
Chake Cherry Gulch	3	1.25	....	80	....	3	....
Clear Creek	26	93.66	765.59	31,250	1	1	2
Coal Creek	3	9.5	26.	3,280	....	1	....
Columbus Creek	4	11.75	80.	2,500	....	2	....
Coon Creek	1	.75	3.	80	....	....	....
Cottonwood Creek	2	3.	57.	2,620	....	....	....
Crazy Woman Creek	4	10.75	155.	4,100	1	....	1
Crocked Creek	3	2.95	81.84	3,500	....	....	....
Cross Creek	1	3.75	20.	....	....	....	1
Davis Creek	5	2.25	14.04	475	....	....	....
Day Creek	3	4.75	9.83	600	....	1	2
Dutch Creek	5	10.1	131.8	1,040	1	1	2
East Pass Creek	1	6.375	68.2	45,000	....	....	....
East Branch Dutch Creek	1	....	....	....	1	1	1
Eureka Creek	1	.6	4.5	880	....	....	....
Five Mile Creek	3	7.	2.5	720	....	....	....
Five Springs Creek	3	5.31	76.	....	....	....	3
Four Bear Gulch	1	1.37	1.25	320	....	....	....
Flume Gulch	1	....	....	....	1	1	1
Franks Forks Creek	2	6.37	46.6	1,800	....	....	....
French Creek	13	20.95	243.41	10,605	....	....	....
Goose Creek	1	4.	38.	1,200	....	....	....
Gooseberry Creek	1	.568	6.	80	....	....	....
Grass Creek	1	1.3	25.	100	....	....	....
Grey Bull River	12	23.29	261.2	8,390	3	2	3
Hanna Creek	2	2.75	5.	320	....	1	....
Hurlbut Creek	3	4.25	6.31	740	....	....	....
Herb Creek	1	2.5	....	500	....	1	....
Herford Creek	1	.2	3.	180	....	....	....
Hewes Creek	2	....	24.06	140	2	....	....
Horse Creek	2	1.	3.5	100	....	....	....
J. A. Creek	3	1.52	16.85	220	....	....	....
Jackson Creek	1	.125	15.	200	....	....	....
Johnson Creek	5	8.95	52.31	1,860	....	....	....
Kelly Creek	8	7.5	40.55	1,660	....	....	....
Kruse Creek	4	4.5	8.53	1,340	....	....	....
Large Spring	1	.5	4.5	20	....	....	....

Ditch record, water district No. 5—Continued.

Name of stream.	No. of ditches.	Length.	Capacity.	Acreage.	No. of ditches, omitting length.	No. of ditches, omitting capacity.	No. of ditches, omitting acreage.
		Miles.	*Cubic feet.*				
Little Horn (branch of)	1	5.5		1,500		1	
Little Canyon Creek	2	6.	32.	800			
Lake Creek	1	2.5	20.	1,200			
Little Fork, Left Branch Dutch Creek	1	1.5	6.	160			
Little Goose Creek	13	67.2	434.38	20,975		1	2
Little Muddy Creek	1	.2	4.	180			
Little North Fork Crazy Woman	1	6.75	26.5	1,500			
Little South Fork Crazy Woman	1	.6	2.15	75			
Little Piney Creek	6	7.25	78.4	1,140	2		1
Little Rapid Creek	1	1.	2.	160			
McKee Gulch	1	.5				1	1
Mead Creek	4	3.	26.77	460			
Medicine Lodge	1	3.6	14.	360			
Meteetse Creek	6	7.16	63.5	980	1	1	1
Middle Fork Crazy Woman	8	15.85	327.24	11,160	2	2	.1
Middle Fork Powder River	2	2.4	49.	2,000			
Mill Creek	1	.1	36.39				1
Muddy Creek	6	8.1	90.1	2,240			
Murphy Creek	1	1.	5.	60			
Natural Springs	4	2.465	45.22	1,180			
No Wood	2	1 75	36.	240			
North Fork Twin Creek	1	.5		100		1	
North Fork Piney Creek	3	1.25	525.9	15,125	2		1
North Fork Powder River	2	3.9	52.83	2,600			
North Fork Crazy Woman	8	10.1	406.55	31,100			
North Fork Clear Creek	3	8.5	291.2	8,700			
North Fork Pass Creek	3	1.5	9.5	400	1	1	2
North Fork Rock Creek	3	2.205	16.56	620			
North Fork Broken Back	1	1.	3.	160			
Owl Creek	7	8.	95.6	3,860			
Paint Rock Creek	6	11.06	168.1	2,120			
Pakee Flat Springs	1	1.6	14.1	800			
Park Creek	4	3.46	34.	650			
Papypo Creek	1	.6	15.33	120			
Parker Creek	1	.6	17.15	600			
Pass Creek	1	1.5	18.	1,000			
Pickett Creek	1	.3	11.	80			
Piney Creek	18	55.05	840.35	35,105			
Pale Creek	2	1.5	8.	235			
Powder River	3	14.5	144.9	4,300			
Prairie Dog Creek	6	11.	60.46	2,030	1	1	1
Rapid Creek	6	10.45	54.33	1,630		1	1
Red Cañon	1	1.5	4.	100			
Rock Creek	29	60.115	883.2	42,290	1	2	2
Sage Creek	3	5.5	31.6	1,500		1	
Sagles Creek	8	7.625	70.02	1,445			
Say Ho Creek	1	.4	18.2				1
Shell Creek	2	4.25	33.5	725			
Sheep Creek	2	6.	77.	6,000			
Sheridan Creek	2	2.	19.9	200			
Smith Creek	1	.25	7.5	240			
Soldier Creek	15	30.65	86.65	6,020			
South Owl Creek	3	3.55	19.	840	1	1	1
South Pass Creek	5	13.7	64.4	6,460		3	
South Fork Crazy Woman	6	5.68	40.78	1,055			
South Shell Creek	3	2.75	21.55	560			
South Fork Rock Creek	1	1.5	25.	1,500			
South Fork South Twin Creek	1	2.		300		1	
South Fork Tongue Creek	6	9.05	16.93	10,110		1	
Spring Creek	9	10.6	232.54	4,925	1		1
Steel Creek	1	1.25	5.5	200			
Stinking Water River	2	1.5	10.	80	1	1	1
Taffner Creek	1	2.	8.	200			
Ten Sleep Creek	4	4.55	232.25	1,860			
Taper Creek	1	4.75	25.	1,300			
Timber Creek	3	3.66	74.	1,320			
Tongue River	7	16.375	90.63	2,030			1
Traburg Creek	1	.5	16.5	100			
Trail Creek	2	3.5	23.5	560			
Trapper Creek	1	.875	14.	320			
Twin Creek	1	1.5		440		1	
Wild Cat Creek	3	2.25	6.	200	1	1	1

Ditch record, water district No. 5—Continued.

Name of stream.	No. of ditches.	Length.	Capacity.	Acreage.	No. of ditches, omitting length.	No. of ditches, omitting capacity.	No. of ditches, omitting acreage.
		Miles.	*Cubic feet.*				
Willow Creek	5	16.025	138.71	7,900	......	......	......
Wind Camon Creek	1	.33	3.	120	......	......	......
Wolf Creek	21	37.296	545.96	10,845	2	1	2
Young Creek	4	7.25	1.	570	......	3	2
Spring Branch Park Creek	1	.4	3.4	150	......	......	......
Total	562	906.380	10,422.70	440,540	32	57	50

Ditch record, water ditch, No. 6.

Alkali Creek	2	.93	10.8	1,760	......	......	......
Arkansas Creek	1	1.	1.8	65	......	......	......
Beaver Creek	7	11.5	193.1	4,820	4	2	4
Benton Creek	2	....	5.42	....	2	1	2
Belle Fourche River	5	....	....	....	......	......	......
Black Tail Creek	1	....	....	....	1	1	1
Cheyenne River	1	4.	3.67	3,840	......	......	......
Cañon Branch Sundance	2	1.5	3.40	31	......	......	......
Dickenson Creek	1	....	....	....	1	1	1
East Fork Skull Creek	1	....	....	....	1	1	1
East Beaver Creek	3	14.5	66.	3,900	......	......	......
Fisk Cañon Creek	1	....	.5	....	1	......	1
Government Creek	2	....	....	....	2	2	2
Garden Spring	1	....	5.	....	1	......	1
Hay Creek	2	3.6	33.3	1,920	......	......	......
Houston Creek	3	2.	18.47	200	......	......	2
Inyon Kara Creek	5	12.5	66.22	2,341	1	......	1
Little Beaver Creek	3	3.5	3.	800	1	1	1
Little Powder River	2	7.	24.65	135	......	......	1
Lytle Creek	1	1.5	5.18	400	......	......	......
Lost Cabin Creek	1	25.	2.5	....	1	......	1
Main Beaver Creek	2	18.1	10.8	5,850	......	......	......
Mail Oil Creek	1	....	....	....	1	1	1
Mason Creek	2	2.	4.23	....	......	1	2
Medicine Creek	1	....	....	....	1	1	1
Miller Creek	3	2.75	10.25	450	1	1	1
Middle Redwater	1	1.	14.	80	......	......	......
Missouri Butte Lake	1	3.	20.	200	......	......	......
North Redwater	2	1.	19.98	275	1	......	......
Mountain Spring	1	2.	12.	160	......	......	......
Oak Grove Springs	1	1.5	....	....	......	1	1
Oil Creek	3	3.5	200.	1,280	2	2	2
Plumb Creek	2	.5	....	....	1	2	2
Redwater Creek	1	....	....	....	1	1	2
Sand Creek	4	1.85	211.27	160	......	2	2
Sandstone Cave	1	4.	....	....	......	1	1
Shepherd Cañon	1	.5	72.	10	......	......	......
South Fork Beaver Creek	2	36.5	15.2	10,220	......	......	......
South Beaver Creek	1	1.7	5.85	200	......	......	......
South Sundance Creek	4	2.25	47.	680	......	......	......
South Redwater Creek	2	1.75	30.	280	......	......	......
South Branch Redwater Creek	1	2.	6.85	....	......	......	1
Stockade Beaver	3	20.2	9.6	10,530	1	1	1
Sweetwater Creek	1	2.	30.	100	......	......	......
Spring Creek	4	3.625	9.6	575	......	1	2
Spring Branch	4	....	....	....	4	4	4
Springs	6	....	2.375	....	6	3	6
Stream or Springs	1	....	....	....	1	1	1
Sundance Creek	7	1.7	73.55	560	4	1	3
Skull Creek	9	17.	301.86	6,160	1	1	1
White Tail Creek	1	.5	3.4	80	......	......	......
Unnamed	4	2.5	3.5	100	3	2	3
Total	124	196.955	1,556.325	58,162	46	36	55

Ditch record, water district No. 7.

Name of stream.	No. of ditches.	Length.	Capacity.	Acreage.	No. of ditches, omitting length.	No. of ditches, omitting capacity.	No. of ditches, omitting acreage.
		Miles.	*Cubic feet.*				
Alkali Creek	1	6.	......	......	....	1	1
Antelope Creek	2	3.	4.	640	....	1	1
Bear River	71	140.32	423.269	37,226.78	13	22	23
Big Muddy Creek	5	3.3	19.5	300	2	2	2
Beaver Creek	1	1.25	4.	160	....	....	....
Birch Creek	5	5.5	1.4	2,880	....	3	....
Bridger Creek	2	......	......	2,444	2	2	....
Burnt Forks	2	2.5	66.1	900	....	....	1
Byrnes Creek	2	3.	3.	80	1	1	1
Byrnes Creek (branch of)	1	1.75	......	......	....	1	1
Boiler Springs	3	......	......	......	3	3	3
Coyote Creek	1	.5	2.	160	....	....	....
Chalk Creek	1	.5	3.5	160	....	....	....
Clear Creek	5	4.5	27.	1,380	1	1	2
Cedar Creek	1	3.	2.	1,280	....	....	....
Cottonwood Creek	2	8.	86.	3,200	....	....	....
Chappo Creek	2	......	......	160	2	2	1
Dry Piney Creek	6	......	......	......	....	....	....
East Branch Sulphur Creek	1	1.25	3.	50	....	....	....
Fontello Creek	11	15.5	62.91	2,500	....	4	3
Hawkes Cañon	1	.25	.75	80	....	....	....
Green Canyon Branch	1	......	2.125	......	1	....	1
Grape Canyon	1	......	......	160	1	1	....
Hydraulic Creek	1	8.	3.	1,280	....	....	....
Henry's Fork Creek	2	2.25	8.02	320	....	....	....
Hams Fork Creek	18	33.5	102.875	8,040	....	4	2
Hard Creek	1	.5	.5	160	....	....	....
Kisto Creek	2	4.	5.	280	....	1	1
La Barge Creek	9	27.	113.83	5,830	....	1	1
Little Creek	1	1.5	6.	100	....	....	....
Little Muddy Creek	13	33.875	39.5	3,120	....	2	2
Muddy Creek	5	7.	31.808	2,280	...	1	1
Mill Creek	14	32.2	94.86	4,780	....	4	6
North Lake	1	4.	......	1,300	....	1	....
North Piney Creek	3	6.5	22.612	1,480	....	1	1
North Fork Muddy Creek	2	......	......	160	2	2	....
North Twin Creek	4	3.5	8.5	720	....	....	....
North Spring Creek	1	.5	4.5	60	....	....	....
North Branch Clear Creek	1	......	4.375	......	1	....	1
North Branch of South Fork Little Muddy Creek	3	......	......	......	3	3	3
Quackenasp Creek	1	.33	3.	120	....	....	....
Pine Creek	6	4.35	42.	2,440	1	1	1
Pine Cañon	1	1.5	......	......	....	1	1
Pleasant Valley	1	......	......	16	1	1	....
Pine Grove Valley	1	.5	.083	120	....	....	....
Poison Creek	1	.75	2.5	160	....	....	....
Piney Creek	9	6.5	16.921	320	7	2	8
Raymond Creek	1	......	......	280	1	1	....
Rock Creek	2	4.	6.	400	1	....	1
Republican Creek	1	1.1	13.02	......	....	....	1
Sulphur Creek	10	9.	48.5	1,210	6	5	5
Sulphur Spring Cañon	1	1.	......	......	....	1	1
South Spring Creek	1	1.5	2.	160	....	....	....
South Twin Creek	2	2.	3.5	300	....	1	1
South Fork of Twin Creek	5	8.	14.8	1,670	1	1	1
South Piney Creek	1	8.	8.	640	....	....	....
Spring Creek	9	8.	20.5	1,200	1	5	4
Sucker Springs	2	3.75	17.354	2,640	....	....	....
Springs	10	11.5	38.18	825	2	4	3
South Branch Smith Fork Creek	1	.75	......	......	....	1	1
South Fork Smith Fork Creek	7	8.5	57.	2,795	....	....	....
Smith Fork Creek	9	12.	65.	3,500	....	....	....
Shurtleff Creek	1	1.	......	200	....	1	....
Sublett Creek	8	5.75	9.41	480	....	5	6
South Lake Creek	1	5.5	......	130	....	1	....
Samson Creek	1	5.	8.	120	....	....	....
Salt Creek	1	1.5	4.	240	....	....	....
Slate Creek	2	2.75	3.	320	....	....	....
Twin Creek	4	14.75	43.703	5.520	....	....	....
Taumers Creek	1	.75	8.	240	....	....	....
West Branch Twin Creek	1	1.	2.5	320	....	....	....
Willow Creek	3	14.5	15.	800	....	....	1
Yellow Creek	7	7.765	51.	1,080	..	....	..
Leads Creek	1	.5	......	......	..	1	1
Total	322	518.24	1,658.905	108,976.78	50	96	9[illegible]

Ditch record, water district No. 8.

Name of stream.	No. of ditches.	Length.	Capacity.	Acreage.	No. of ditches, omitting length.	No. of ditches, omitting capacity.	No. of ditches, omitting acreage.
		Miles.	*Cubic feet.*				
Ashworth Creek	2	1.8	12.116	160	....	...	1
Alkali Creek	1	2.7	2.	160	....	...	....
Big Popo Agie	14	28.424	291.19	6,355	1	3	5
Big Popo Agie and Middle Fork	1	....	....	....	1	1	1
Big Popo Agie and New Fork	1	.04	....	....	....	1	1
Big Hermit	2	....	....	....	2	2	2
Baldwin Creek	13	16.814	159.02	2,435	....	3	3
Beaver Creek	5	10.75	60.	2,600	2	3	3
Badwater Creek	2	2.	300.	160	....	1	1
Bridge Creek	2	....	....	....	2	2	2
Bonner's Creek	1	1.062	13.5	160	....	....	....
Big Sandy River	1	....	....	....	1	1	1
Big Beaver	1	....	....	....	1	1	1
Bohack Springs	1	....	....	....	1	1	1
Big Spring Creek	1	.75	3.	80	....	....	....
Big Sulphur Springs	1	.875	1.	120	....	....	....
Buffalo Creek	1	3.333	....	....	....	1	1
Cherry Creek	1	1.4	10.2	100	....	....	....
Cottonwood Creek	2	1.75	7.	120	....	1	1
Crocked Creek	1	1.3	10.5	250	....	....	....
Carfer Creek	1	.25	125.	....	....	1	1
Christiana Lake and Big Popo Agie	2	6.	140.	....	....	....	1
Dry Creek	1	....	....	....	1	1	1
East Cottonwood	1	.75	25.	40	....	....	....
East Long Creek	4	2.4	12.59	620	....	....	....
East Timber Creek	1	2.3	.579	....	....	....	1
Four Bear Creek	3	4.75	13.194	320	....	1	2
Frank Forks Creek	2	4.925	31.757	1,200	....	....	1
Grass Creek	1	1.3	25.	100	....	..	....
Gray Ball River	4	4.	27.2	1,280	3	3	3
Little Popo Agie	11	15.412	177.1	2 860	....	....	....
Little Cañon Creek	2	....	....	....	2	2	2
Little Sandy Stream	1	....	75.	....	1	....	1
Mexican Creek	1	....	....	....	1	1	1
Meeteeke Creek	9	8.45	80.007	1,130	3	3	4
Meadow Creek	1	.25	....	....	....	1	1
Marguette Creek	1	1.	....	....	....	1	1
North Fork Willow	1	.75	....	....	....	1	1
North Fork Big Popo Agie	3	1.7	17.06	240	2	2	2
North Fork	5	17.05	167.25	5,120	....	1	1
North Fork Owl Creek	1	2.	640.	....	....	1	....
Owl Creek	3	2.	90.157	600	1	....	....
Oregon Ditch	2	4.5	....	....	1	2	2
Picketts	2	.4	11.	80	1	1	1
Papypo Creek	2	1.	15.561	120	....	....	1
Pat O'Hair Creek	4	10.75	32.1	1,660	....	1	....
Rock Creek	8	10.25	183.857	3,040	3	3	5
Squaw Creek	6	2.7	30.1	115	2	3	4
Silver Creek	1	....	....	....	1	1	1
Sheep Creek	2	1.	1.3	....	1	1	2
Sage Creek	4	8.	29.178	800	1	2	3
South Fork Owl Creek	1	1.	....	600	....	1	....
South Owl Creek	1	1.5	....	....	....	1	1
Stinking Water	1	....	....	....	1	1	1
Sweetwater	2	.5	29.1	....	1	1	2
Trib Rock Creek	1	....	....	....	1	1	1
Spring Branch North Fork Willow Creek	1	....	....	....	1	1	1
Twin Creek	13	7.25	36.55	470	7	8	9
Timber Creek	3	3.6	74.	1,320	....	....	....
Willow Creek	12	8.375	66.50	480	3	7	8
Warm Spring	1	.8	5.5	100	....	....	....
West Timber Creek	1	.6	.231	....	....	....	1
Wood River	1	1.9	28.	400	....	....	....
Total	182	212.41	3,059.487	35,395	52	79	96

Ditch record, water district No. 9.

Name of stream.	No. of ditches.	Length.	Capacity.	Acreage.	No. of ditches, omitting length.	No. of ditches, omitting capacity.	No. of ditches, omitting acreage.
		Miles.	*Cubic feet.*				
Birch Creek	2	3.5	27.	1,440	....	....	....
Cottonwood Creek	2	7.	....	3,360	....	2	....
Clear Creek	8	16.	15.	6,080	....	7	2
Cedar Creek Springs	2	1.5	68.	480	....	....	....
Crow Creek	3	13.5	....	17,560	....	3	....
Dry Creek	1	1.25	7.	320	....	....	....
Elkhorn Creek	1	.75	....	160	....	1	....
Lost Creek	1	4.	18.	160	....	....	....
Nicholas Spring Branch	2	2.	10.	160	....	....	....
Red Creek	3	3.25	....	840	....	3	....
Springs	2	.75	2.5	160	....	1	....
Slump Creek	3	2.5	....	740	....	3	....
Salt Creek	8	18.	56.5	7,480	....	4	....
Spring Branch	1	.5	3.	160	....	....	....
Sulphur Creek	2	2.5	28.	320	....	....	....
Spring Creek	1	1.5	15.	320	....	....	....
Strawberry Creek	3	8.5	61.	1,760	....	....	....
Swift Creek	2	3.68	25.	800	....	....	....
Vail Creek	1	.75	6.	160	....	....	....
Willow Creek	1	....	....	....	1	1	1
Total	49	91.43	342.00	42,460	[illegible]	25	3

Ditch record, water district unnamed.

Name of stream.	No. of ditches.	Length.	Capacity.	Acreage.	No. of ditches, omitting length.	No. of ditches, omitting capacity.	No. of ditches, omitting acreage.
Alkali Creek	1	2.53	2.	160	....	....	....
Big Spring	1	.75	1.3	80	....	....	....
Big Sulphur Spring	1	.875	1.	120	....	....	....
Cottonwood Creek	1	2.25	50.	2,500	....	....	....
Pacific Creek	1	1.	3.	320	....	....	....
Sage Hen Creek	1	2.	4.5	400	....	....	....
Stinking Water River	1	2.5	75.	600	....	....	....
Total	7	11.905	136.8	4,180	....	....	....

IRRIGATION, PUBLIC LANDS, AND CANAL CONSTRUCTION.

No. II.

[This paper was read by Engineer Meade to the committee.]

As the official head of the irrigation systems of this Territory, I have the honor to present this statement describing its agricultural resources and possibilities by the aid of irrigation, the character and extent of the work already performed, and of explaining the views of our people as to the measures necessary to secure the full utilization of our water supply in reclaiming the unoccupied arid lands.

Among the arid Commonwealths Wyoming stands the third in the extent of her irrigated land, while in the excellence of her laws and the legislative measures for the promotion of this interest she deserves even a higher rank. Although the youngest of the Territories and suffering greatly from the lack of railroad facilities, particularly between the agricultural districts of the north and the mines in the south, only California and Colorado surpass her in the mileage of canals or the area of land watered therefrom. This rapid development has been due to two causes, the first being the exceptional natural advantages of the Territory as a grazing region, and which at an early date made the raising of cattle its most important industry. With the cattle man to open the way and make settlement possible, the farmer soon followed. And as the necessity for winter feeding became apparent, the profits of the cattle business were invested in the construction of ditches to enable such food supplies to be grown.

The second reason is found in the abundance of the water supply and the ease and cheapness with which the waters of the streams can be diverted. The description of these streams and the nature of the works already built to divert their waters is given in Appendix A, attached to this report. It will be sufficient here to state that the principal streams have their sources in mountains of sufficient elevation and extent to make them abundant accumulators and conservators of the needed moisture, and that from these natural reservoirs these fruitful arteries of our agricultural life penetrate every section of our broad area. No other arid State or Territory equals this in the number of its streams whose waters can be diverted or in the uniformity of their distribution over its entire area. The location of the natural water-courses is such that if they carried sufficient volume of water all the lands could be easily and cheaply watered, while, on the other hand, there is but little land which would not be made productive if the water could be had. Hence it is that no subject has to this Commonwealth the same ultimate importance as the proper conservation and use of all water that falls on its surface.

The solution of the problem of how best to accomplish this involves an inquiry into two matters, first, the proper distribution of the water over the land, and, second, the conservation and storage of the flood water and the water running to waste in the non-irrigating season. In considering these questions regard must be had of the works already built and of the methods adopted and in practice among the farmers of the Territory, since no methods can be successfully carried out which do not accord in a measure with the views and interests of those already in the work. While the area irrigated is far less than that awaiting reclamation it is too important to be lost sight of in any plans for future work. The ditches now in operation and the acres of land which they water have involved the outlay of many millions of dollars of the earnings of our citizens. When they began their work the success of agriculture by irrigation was problematic. It was through their confidence and energy that the country now understands and appreciates its value and importance, and it is their efforts which has given the arid region whatever value it has. Hence, no action should be sanctioned which does not promise to promote the financial success and prosperity of the works already constructed. While the northern part of the Territory has outstripped all other portions in the extent and value of its irrigated lands, in all sections the construction of ditches has reached a surprising degree of importance and there is no portion in which the agricultural lands do not form an important part of the natural resources.

Much of the work done is faulty, resulting in heavy and unnecessary expenses for operation and maintenance and great loss of water in distribution. We have too many small canals watering the bottoms and not enough large canals watering the uplands. Our methods and system need reforming to prevent this in the future work. It is the result in part of the lack of means and experience on the part of the pioneer ditch-builders, but very largely of late years of the unfortunate circumstances of our land laws being wholly unsuited to the conditions of this region, and of their administration being in the hands of men ignorant of these facts.

It is a well-settled principle that lessening the number of ditches by building large high level canals results in both economy of water and saving in operating expense. It also, as a rule, secures the watering of more fertile and productive land. To build large ditches, however, requires either a community of effort on the part of the farmers owning the land or the introduction of capital to build canals to rent water. The first plan has seldom been successfully pursued. The length of time required to prepare for and complete the construction of a large canal, and the fact that farmers can produce nothing to support themselves or their families until this is accomplished, has prevented its successful adoption. Hence the majority of the large irrigation works have been built as common carriers of water, this plan seeming to best meet our conditions and needs. There is no objection so far as I am aware and many things in favor of this plan, provided the canals are properly built and furnish water at a reasonable rental. They are a necessary and valuable feature of our irrigation development, and we should have such laws as will make the investment a safe one and secure their construction under such conditions as will enable them to furnish water to farmers at a minimum cost.

Unfortunately, however, the building of large canals to furnish water to the settlers on the public lands gives rise to a condition of affairs which, while well understood here, is apparently not appreciated elsewhere. Before the canal is built these lands are valuable only for grazing purposes, which value in most cases does not exceed 50 cents per acre. The construction of the canal, however, carries with it the assurance of their reclamation, enhancing their value to that of farming land, so that without the purchase of a water right or without the owner of these lands having in any way contributed to their improvement their value is increased at a low estimate from $5 to $15 per acre. This unearned increment is due entirely to the expenditure and efforts of the ditch company which expects its return from the rentals of water to the settlers on the lands thus made susceptible of cultivation. If therefore all filings under the ditch were made by persons expecting to become cultivators of the soil, and who would at once become users of the water, no harm would ensue. Unfortunately, however, our land laws make possible an entirely different result. The increase in value resulting from the construction of the ditch is a rich field for the speculator. Parties having no desire or intention of becoming farmers can through the pre-emption law, the homestead law, and the timber-culture law obtain possession of 480 acres of this land without having to rent a gallon of water from the ditch company or in any way contributing to its maintenance or advantage. By the expenditure of 25 cents per acre they can in the same way obtain a three years' option on 640 acres additional by desert entry. Thus it is that over a thousand acres of land are withdrawn from honest settlement and the speculator or entryman is in a position to blackmail the ditch company, as it is only by its buying him out and disposing of these lands to bona fide farmers that it can derive any income from the water supply. This situation of affairs has made it impossible in this Territory to construct large ditches simply as common carriers of water. The success of the enterprise makes it necessary that the lands should at once be brought under cultivation, and to accomplish this there must be some control over their settlement. This neither the ditch company nor the Territorial authorities can attempt at present.

There are in the Territory a number of important canals built to rent water and all have suffered from the difficulty of securing a prompt settlement of the land reclaimed. Some of these have endeavored to protect their investment by securing this control of the lands, the most important instance of this being the Wyoming Development Company, its field of operation lying about 90 miles north of this city. It began originally with the intention of furnishing water to the farmers, but it soon became manifest that unless they could control the settlement of the lands that the only parties to derive any benefit from their efforts would be the parties filing on the land, and that if the lands were to be actually made productive they must take steps to control their settlement. This was done and in this work and in the construction of their canal about $500,000 was expended. The enterprise has been in every respect a most praiseworthy one. Over 50,000 acres of land have been watered by one of the best systems of canals to be found anywhere in the arid regions, yet owing to the lack of appreciation of the real situation of affairs and of the necessities of this region these lands lie idle and unproductive in the hands of the Government, and the projectors of one of the best enterprises yet inaugurated in this Territory have been put to the expense and annoyance of maintaining for five years a system of costly and unproductive irrigation works. The unfortunate outcome of this company's operation has been in the widest sense a disaster to the Territory. Its example is a menace and a virtual barrier to the inauguration of other enterprises of special magnitude, and has resulted in a return to the original practice of building small ditches, where each individual could manage and control his own claim, the opportunities presented for the diverting of water making possible an extraordinary development of this nature. The evil consequences of this state of affairs are many. It creates a system difficult to control, expensive to operate, and wasteful of water. Not only that, but many of our best lands can only be reclaimed through the medium of extensive and costly works. If during the past five years we could have had a system of land laws that would have enabled ditch companies to have secured actual settlers on the lands reclaimed, the number of important irrigation works and the extent and wealth of the irrigated territory would be fourfold that which exists.

A proper utilization, however, makes it desirable that additional changes, besides reforming our land laws, should at once be made. Since the area of land which can be irrigated is greater than the available volume of water, it is desirable that our irrigation works should be so located as to serve the best of these lands, and that the water supply should be so distributed as to insure the utmost economy in its use. To do this it is necessary that a careful examination of the streams should be made in advance of irrigation construction, and that these works should be built in accordance with an intelligent system and plan. It is further to the interest of the State that this should be done, since it is charged with the responsibility and expense of supervising these works after they are built and with the division of the water among the various claimants. Under the haphazard system which has heretofore prevailed, where there has been no limitation or supervision as to the number, location, and character of the works for diverting water, it becomes a practical impossibility to secure a just or satisfactory distribution of the water supply in a time of scarcity.

The ill results of this policy become more pronounced the longer it is pursued. They are more notorious in Colorado than with us, and will be felt here in ten years far more than at present. It is a counterpart of the old land system, or lack of system, which formerly prevailed in this country and in some of the Eastern and Southern States, where each settler blazed out his domain according to his inclination, regardless of the boundaries or rights of his neighbors. The litigation and ill-feeling which followed as a legacy of this practice in Kentucky and other States promises to be repeated in our water-right troubles if some more enlightened policy be not adopted. That our system is what it is is not due to the lack of appreciation of its defects on the part of our people or the want of the knowledge of a remedy. It is a system forced upon us by necessity, not choice. A Territory sparsely settled, with its resources undeveloped, was not in a situation to undertake any systematic public improvement or investigations, nor can we accomplish anything satisfactory towards this end with the public lands owned and controlled by the General Government. It is useless to make any investigation or examination as to the proper location of irrigation works while no control can be exercised over the settlement of the land.

The most satisfactory remedy for this state of affairs, and, in my judgment, the only efficient one, is for Congress to grant to each State of the arid region, or to each Territory upon its becoming a State, all the irrigable lands within its borders held by the General Government, such States to be charged with the supervision of their reclamation and with their disposal to actual settlers.

The reasons for asking this donation were stated in a letter prepared by a committee appointed at a conference held in this city in July last, and I can do no better than repeat them here:

"First. The reclamation of the lands of this region lays upon the people engaged and upon our local or State government requirements and expenses not encountered by the pioneer of the humid portion of the country. Not only does the construction of ditches and other distributing works add greatly to the first cost of a farm, but with their multiplication comes the necessity of the State assuming control of the distribution of the water supply, and its failure to do so leads inevitably to expensive litigation or to personal controversies which impair both the success and the growth of our agriculture. A further incentive to prompt action is the fact that the area of land susceptible of reclamation exceeds the amount of water supply. The water, therefore, possesses a greater value than the land, and on its economical distribution rests the limit of our future agricultural wealth. It is of the utmost importance, therefore, that no wasteful or improper diversions be permitted, and that the State should control the appropriations of water as well as its subsequent division among the various claimants. The expense of this work must of necessity be heavy. In Wyoming there are already two thousand five hundred ditches drawing their supplies from four hundred water-courses, and this work is yet in its infancy. In Colorado, with its greater advancement, the single work of regulating the division of the water supply requires the employment by the State of nearly one hundred men. This regulation is a necessity not to be avoided, but the preliminary examination of our streams and an efficient supervision of the construction of works to divert the water therefrom is of equal importance to our future welfare. In our present condition it will, however, be a practical impossibility for many of the States and Territories to provide means for this work by taxation; but the funds for its prosecution can be easily provided for in the disposal of the lands whose donation is asked.

"Second. Our experience during the past five years has shown the evils growing out of the control of the land being under one authority and the water under another.

"If this Territory could during the past five years have controlled the disposal of the irrigable lands within its borders, it could, while disposing of it to actual settlers only, have afforded such protection to canal companies as would have given our agriculture four times its present importance, and more than doubled our population. Instead of this there have been repeated instances where arbitrary and unreasonable rulings have subjected our people to heavy and wholly unnecessary expense, and to cause the whole land policy to be regarded as oppressive. It was, however, the inevitable result of land laws wholly unsuited to the needs of irrigation, and of their enforcement by officials in Washington whose experience had not prepared them to deal with the conditions which exist here.

"It is also impossible for Congress to pass a general law which will operate with equal justice and success on the arid belt as a whole. The conditions differ in the different sections as do our water laws. Wyoming differs from Utah, and Arizona from Montana or Idaho. The people of each section are the best calculated to determine the system best suited to their needs and should be given the means of carrying it into effect.

"Third. The results already achieved are a sufficient guaranty of what can be accomplished under favorable circumstances. Our legislation as to water has, on the whole, been wise, but it can never have the stability or success which would come with the control of both water and land. Our engineering works have elicited the praise of experts from other irrigated countries for both their economy of construction and adaptation to their use. At present the practical knowledge of the subject is almost wholly confined to those engaged in the work. The information gained through the labors and investigations of the geological survey can be utilized by local legislatures, while by placing the responsibility for this work upon our people a great impulse will be given to the diffusion of intelligence on the subject and to local pride in the character of our irrigation works. It will put the solution of this problem in the hands of the people best informed on the subject and most interested in its success.

"We will say further, that our people are afraid of the proposed withdrawal of the irrigable lands from settlement or the placing of the construction and control of our irrigation works under the charge of the National Government; the reason being in both cases that the delay and uncertainty which would be inseparable from such action would be disastrous. While the passage of laws to encourage individuals or companies to reclaim large bodies of arid lands would most speedily accomplish the desired end, namely, reclamation and settlement of the arid regions, yet public sentiment seems to be so adverse to this plan that we feel that it is scarcely worth our while to advance it."

The dangers attendant upon national legislation is shown in that clause of the law creating the irrigation survey which provides for the repeal of all land laws except the homestead act. This change has met with the disapproval of all persons acquainted with the situation in this Territory. To limit the acquirement of title to the public lands to the provisions of the homestead act would be disastrous restriction on settlement and there is no valid reason for its adoption. It offers no aid toward the construction of better works or the more economical diversion of water, the most important consideration connected with the whole subject. In this respect the desert land law was the best ever enacted, if it had been liberally construed or if the rulings of the land office had been uniform as to its meaning. The difficulty has been that the changes in the rulings have been of so radical a character as to practically constitute new legislation and to cause much hardship and expense to those honestly endeavoring to comply with the law. So onerous have been some of the restrictions that it has seemed as though the authorities regarded every claimant of the public lands as an object of suspicion who was guilty until proven innocent. It is time that more sensible and just conception prevailed. Every settler on these lands which in their present condition have no agricultural value, and who reclaims them and makes them productive, is a benefactor of the whole country and should receive the most liberal treatment. Instead, however, after having expended from $5 to $15 per acre in bringing the water on his land and preparing it for irrigation, he is compelled to pay the same price therefor that the settler on the broad prairies of Iowa and Kansas paid for land already prepared for the plow.

The commonwealths who are charged with the duty of guarding the public welfare should be aided in their efforts. Every consideration which justified and secured the donation of the swamp lands to the States of the humid region applies with greater force to the advisability of a similar donation of the arid lands to the several States and Territories interested. Not only are our local governments charged with heavy duties and responsibilities which none of the humid States had to confront, but the settlers who come here to engage in farming undertake the practice of an art whose mastery is both complicated and difficult, and of which they have had no previous experience. Our climatical conditions are exceptional, making much of our agriculture and experiment, and making certain that we are far from pursuing the best methods or that we are achieving anything like the results which are possible. The local government should aid private effort by conducting experiments to determine the best methods, and by disseminating information which will enable new comers to obtain their knowledge of the subject by some less difficult and costly road than that of experience. The success of irrigated agriculture enormously increases the value of the arid domain, and will be an important contributor to our national wealth and prosperity. The best results can only be secured through the nation's aid. I trust it may be generously extended.

TERRITORIAL ENGINEER'S REPORT TO THE GOVERNOR OF WYOMING.

[Copy with the committee, by Engineer Mead.]

No. III.

The work of this department may, for convenience, be divided into four classes, as follows:

(1) Preparation of instructions for water commissioners to enable them to perform their duties in accordance with the court decrees determining priorities.

(2) The gauging of canals and preparation of tables showing discharges of the various ditches; these tables to be furnished to both the commissioner and ditch-owner.

(3) The recording of decrees and recording and calculation of engineer's certificates as required by law.

(4) The gauging of streams, examination of reservoir sites, collection of data showing the location and extent of our irrigation resources, and such other work as will extend our knowledge of irrigation and advance our agricultural interests.

A beginning has been made in the work of each of these divisions. Three decrees have been rendered in District No. 1 and one in District No. 8, all of which have been recorded, and the proper instructions have been given the commissioners.

No gauging of ditches have as yet been made, but plans and instructions for the construction of measuring flumes have been prepared and furnished to the various ditch-owners, and the work of gauging these will be the first work to engage my time next spring.

A part of the present irrigating season was given to the gauging of streams and the examination of irrigation work. The tour of investigation began in May and ended in August, and included a large part of Laramie, Albany, Johnson, and Sheridan Counties, together with visits to Sweetwater and Uinta Counties.

Without attempting a detailed report of this examination it may be well to mention some of the conclusions to which it led.

The soil wherever examined is fertile, and wherever irrigated becomes exceptionally productive. Grasses and the hardier grains and vegetables do well in all parts of the Territory, but in some localities the elevation is too great to successfully grow corn and some kinds of vegetables. The eastern and northern portions of the Territory are able to produce nearly all kinds of fruits and vegetables grown in temperate regions, the lower elevation of the northern part (3,500 feet at Sheridan) compensating for the difference in latitude.

A distinctive feature of Wyoming's irrigation is that it outstrips all the States and Territories of the arid region in the number of its streams available for irrigation. The valleys bordering most streams are narrow, varying in width from one-half to 5 miles, and the uplands between these valleys too high to be watered, and which must remain as grazing land. This contiguity of large tracts of grazing land to that devoted to farming, affording as it does free summer pasturage for the farmer's stock, is a material advantage and is destined to increase the profits of the farmer and greatly enhance the value of the irrigated lands.

The counties of Albany and Laramie furnish the best examples of ditch building, the largest and best constructed ditches being found there. The irrigation works of these two counties also must nearly utilize the waters of their streams, on a majority of which the aggregate capacity of the ditches exceeds the average discharge of the stream during the irrigating season, and the further extension of the irrigated territory can only be accomplished through the construction of reservoirs to store up the surplus water of the spring floods. The fertility of these lands, and their nearness to a market for their products, make it extremely desirable that such works should be built, but their cost puts the work out of the field of individual effort.

In nearly every part of the Territory visited there are favorable locations for the investment of capital in the construction of irrigation works of too great magnitude for farmers to attempt; these no doubt will be utilized in the near future. It will be seen, however, in the statistics given further on in this report, that if the lands in this territory now under ditches, and susceptible of being irrigated, were being cultivated, Wyoming would take rank as an important agricultural commonwealth. At present, not one-twentieth part of this land has ever been tilled, the reason being found in the lack of railway facilities for transporting the produce of the farms to market, and in the lack of means on the part of the farmers to bring their lands under cultivation. Construction of laterals, and other work necessary to reclaim arid lands, entail a heavy burden of expense the first few years. In no part of this country, however, can agriculture be pursued with more success and profit than in this Territory, and the present condition of affairs must soon disappear.

DITCH STATISTICS.

One of the first needs which impressed itself upon me in the discharge of my duties was the almost indispensable necessity for having in this office a record of the ditches already built, together with the data showing their size, location, and data of construction. This information could only be had through an examination of the "claims to water" recorded in the offices of the various county clerks throughout the Territory. To properly examine these records, and make the necessary abstracts from them, required the expenditure of considerable time, but the importance of the record seemed to justify its being undertaken.

Below is given a tabular summary of the irrigation development of the Territory as far as the records have been completed; the statistics for Carbon and Fremont Counties having not as yet been compiled.

In preparing this summary, wherever the length, capacity or acreage of a ditch was omitted in the statement of claims, no attempt was made to supply the omission, nor has any addition been made to the totals on account of such omissions, while the tendency of statements is to exceed the actual facts, the fact that 20 per cent. of the statements failed to give the acreage and about 10 per cent. omitted giving the length will make the totals rather below than above the truth.

When the statistics of Carbon and Fremont counties are added to those below, it will increase the acreage under the ditch, and capable of being irrigated, to over 1,500,000 acres.

Table showing extent of irrigation in Wyoming.

County.	No. of ditches recorded.	No. of ditches omitting statement of length.	Length as given.	No. of ditches with statement of capacity omitted.	Capacity of those given.	No. of ditches with statement of acreage omitted.	Total acreage of those given.
					Cu. ft. pr. sec.		
Albany	288	27	496.32	45	6,024.99	62	345,341
Crook	115	46	198.90	40	562.17	64	58,937
Johnson*	434	33	729.86	55	9,117.30	48	303,300
Laramie†	590	30	1,122.38	42	4,300.00	79	390,803
Sweetwater‡	21	4	179.3	15	....	12	4,350
Uintah	270	27	482.2	95	1,202.87	82	107,452
Carbon §	....	....	....	....	....	....	....
Fremont §	....	....	....	....	....	....	....
Total	1,718	167	3,208.96	292	21,207.33	347	1,210.143

* Includes Sheridan County. † Includes Converse. ‡ Statistics very incomplete. § Not completed.

In the examination of these statements of claims it was found that in many of them essential facts were omitted and immaterial and irrelevant matter included, thus lessening the value of the record and greatly increasing the labor of examining it.

Believing that these incomplete statements were due to ignorance of what our law required, rather than to carelessness or neglect, and realizing that these imperfect records were likely to prove a fruitful field for controversies and expensive litigation, I took what steps lay in my power to secure the filing of complete statements in the future, by preparing a standard form of statement, which was mailed to the various county clerks with the following letter:

To the appropriators of water:

"An examination of a large part of the claims to water, now on file in the offices of the various county clerks of the Territory, has disclosed the fact that a wide diversity exists in the character of the statements contained in these claims.

"This is shown in the different orders in which the essential facts are arranged; in the use of the different units to designate the volume of water claimed, and in the various forms in which the dimensions and grades of ditches are expressed. This lack of uniformity proves a source of serious annoyance and perplexity to those who have occasion to examine the records. To reduce these varying units to a common standard, which becomes necessary whenever any use is made of these records, is a work involving considerable time and labor, which could be avoided by the use of a standard form in the original statements.

"Another, and more serious, defect which has been observed in these claims, is the failure of any to state all the facts necessary to the determination of the claimant's rights or his protection in them. These omissions include nearly every portion of a complete claim, but the most serious and numerous are the failures to state fully or properly the dimensions of the ditch or the volume of water claimed. The unit employed for the latter is often so indefinite as to be practically valueless. Claims for 'square inches,' 'agricultural inches,' 'California inches,' or 'miners inches' are decidedly out of place in this Territory, where the law recognizes no unit except the cubic foot per second.

"These incomplete statements are destined sooner or later to prove a source of serious annoyance, if not of expense, to the parties filing them, since, whereever an adjudication is had, the missing facts will have to be supplied.

"As an aid to secure the proper filing of these claims in the future, and the consequent protection of the rights and interests of claimants, I have prepared a standard form of claims, the use of which throughout the territory is strongly urged. The advantages of uniformity and systems to be secured by this means are so many and important that it is hoped that this request will, in all cases, be complied with.

"Copies of this form have been furnished to all the county clerks and county surveyors of this Territory, who will doubtless make arrangements for their being readily obtained."

All the county clerks have co-operated with me in this matter with a resulting gain to the public in the convenience, system, and reliability of our water records, which only time will enable us to properly appreciate.

The volunteer weather service has also been established in connection with this office, the signal service loaning the necessary instruments. Five stations have been thus far established, each in an agricultural district, at which observations of temperature and rainfall are being made.

Before closing this report I wish to call attention to one or two matters which seriously embarass the working of our irrigation system, and which will require the early attention of our lawmakers.

The irrigation laws of this territory, taken as a whole, are perhaps in advance of those of any other State or Territory of the arid region. All irrigation legislation in this country has, however, been tentative and fragmentary. There has been no attempt to frame a complete irrigation code, but only to enact such laws as the immediate necessities of the irrigation interests seemed to demand; the result of which, owing to the rapid growth of the irrigation interest, is that legislation calculated for its regulation and protection has not kept pace with the conditions developed by its growth.

While the evils resulting from this state of affairs have not been so serious or apparent here as in Colorado or California, our present laws are in some respects wholly inadequate, and will need to be supplemented by additional legislation.

Over two thousand ditches have already been completed in this Territory, and have their claims to water on file in the offices of the various county clerks. These ditches water an area equal in extent to the whole of the irrigated district of France and Spain combined, and one half that of Italy. They are distributed throughout a region almost as large as the whole of New England; yet, at the time I entered upon the performance of my duties, the service of only one man was available for the work of dividing the water supply in accordance with their claims, and his time of service was limited to fifty days.

The scarcity of water which prevailed in many locations made the need of proper supervision unusually urgent.

Requests from prior appropriators, who were unable to secure their rights, came from all parts of the Territory asking for the service of water commissioners to regulate the division of the water supply. As there were no commissioners to act, and their authority to act in such cases was doubtful, nothing could be done. The need of some action was, however, so apparent that I referred the matter to the attorney-general, asking if there was any authority by which the water commissioner could divide the water of streams whose ditch rights had not been adjudicated. I append below an abstract from his reply.

"I have carefully examined the Revised Statutes of Wyoming, as well as the late laws enacted, and I find nothing either directly or by implication on our statute books which will give you as Territorial engineer authority to determine the priorities on any streams of this Territory, nor is there anything in the laws that would permit the water commissioner to divide the waters of any stream whose priorities have not been determined as directed by law, nor can he perform his duties previous to receiving the instructions set forth in section 9 above referred to."

This law, therefore, as it now stands, limits the work of water commissioners to those ditches whose priorities have been determined by the court. The right of less than 5 per cent. of the ditches of this Territory have been so determined, and to leave the rights and interests of the remaining 95 per cent. without protection or regulation until the courts can attend to them, will inevitably give rise to bitterness of feeling and to conflicts which will not only seriously retard our agricultural progress, but will for the next quarter of a century embarrass the introduction of proper supervision.

As ditches are now being built faster than their rights are being determined, it is manifest that some provisional measure should be adopted to secure proper regulations in the interregnum. The plan which would best subserve this purpose would be, I think, for the Territorial engineer to be authorized to instruct the water commissioners to divide water on all streams where regulation is necessary, the engineer basing his instructions as to the manner of division on the statement of claims now on file.

It is not designed that this should do away with the final settlement of the rights of claimants by the court. There should be the right of appeal to the court from the engineer's decision at all times, and the final decree of priorities should be rendered by the same authority. What is needed, and what it is believed the proposed step will accomplish, is the protection of the rights and interests of the pioneers of our agriculture until such time as the courts can properly attend to these matters.

In fact it is desirable in many cases that the determination of priorities should be deferred until the era of rapid ditch construction has ended, in order that all the ditches of a stream may be included in the adjudication, and that a second or third consideration of the matter, due to subsequent ditch construction, be avoided. Another advantage of delay in adjudication will be that farmers will be better informed as to the nature of the laws and the importance of having their interests properly represented before the court renders the decree. That this is not now the case is shown in two of the decrees already rendered, where a large number of ditches already built were not represented in the proceedings nor included in the decrees.

Attention has been called to the defect in the present method of filing claims to water and the means employed to improve them. I am convinced, however, that the only effectual remedy lies in change from our present system which will provide for the examination of every claim before the filing. The tabular statement in a preceding part of this report illustrates the large number of omissions of essential facts exhibited in these statements. It does not, however, exhibit the imperfections of statement nor the irrelevant matter which encumbers so many and makes their examination or utilization so difficult.

While writing this report I was told by a farmer that in the filing of his claim he was obliged to make three visits to the county seat, a distance of 40 miles, and to pay for the recording of three statements before a correct record was secured. I have heard so many statements of the same character and have seen enough duplicate records to convince me that some radical change is necessary.

The remedy I would suggest would be—

First. To make it the duty of the Territorial engineer to prepare a standard form of water claim which shall embody the requirements of our present law; this form to be used by all persons filing claims to water.

Second. Every person wishing to file a statement of claim shall first forward a copy of such statement to the Territorial engineer, whose duty it shall be to examine this claim. If correct, he shall approve it and record it in his office and return the statement with his approval to the party making the claim, who shall then have recorded the approved claim in the office of the county clerk. If the statement forwarded to the engineer is imperfect or incomplete, it shall be his duty to return it for correction, designating the errors or omissions, which when remedied, shall be returned for examination as before, and if approved, to be recorded and returned as before stated.

The advantages which would accrue from this change would be, the engineer's office would at all times have a complete record of the location and progress of ditch building, and the public a source of information of the extent and character of our irrigation development. It would greatly improve the character of the record, making it more convenient to examine and preventing the filing of worthless statements. It would, by the correction of imperfect statements, serve as an educator, showing the ditch-owners the purpose and requirements of the law and would protect him from any annoyance and expense incident to the filing of such imperfect statements.

In calling attention to these features of our irrigation laws that need legislative revision, I have been more remindful of the demands of the future than of the disadvantages of the present. The subject of comprehensive irrigation legislation will be one of the most important to engage the attention of our next general assembly. The future development of our agricultural interests is certain to be rapid and important. As it is, with our irrigation system scarcely established, we have enough land under ditch and ready for the plow to make twenty thousand 80-acre farms, and to engage the efforts of a purely agricultural population of more than twice the number of all the people now in the Territory. Many of these ditches have been built under exceptionally unfavorable conditions; the best watered and most extensive agricultural districts being in the central and northern portions of the Territory, while, until within the past two years, all the materials and implements required in the construction of ditches, together with a large part of the provision for men and teams had to be hauled from the stations of the Union Pacific which traverses the southern border.

The transportation by wagon of all this material for distances varying from 100 to 300 miles almost doubled the cost of the work and materially lessened the prospect of profitable returns. So also the remoteness of a staple market and the difficulty and expense of obtaining the conveniences of life have been a serious drawback to many of our pioneer farmers. Where it required a three weeks journey to buy a plow, as it did until recently, in many cases there was not much plowing done.

The Territory still suffers from the lack of adequate railway facilities. There is a surplus of agricultural products in the north for which there is a ready market and good prices in the south. The completion of the railroads projected to bring these sections together will result in increased prosperity for both. It will encourage the cultivation of an increased acreage, and will make accessible to the capitalists a country now practically unknown.

In the counties of Johnson and Sheridan alone, the surplus water of the streams gauged by me this season would irrigate 500,000 acres, and I am reliably informed that there is double that extent of land susceptible of being watered. Were it necessary other illustrations of the same character could be given. It is certain, however, that agriculture is destined to be one of the most important, as it is one of the most stable, of the Territory's material interests and the perfection of the methods and practices on which its success and progress so largely depends should receive the most careful consideration.

ADDENDA TO TERRITORIAL REPORTS.

Attention is called to the table in the report giving the statistics of our irrigation development. Since that was written the corresponding statistics for Fremont and Carbon Counties have been compiled, and the result which follows more than justifies the statement in the report that there is land enough under ditches and susceptible of being irrigated to make twenty thousand 80-acre farms. The statistics are below the actual development, as many ditches have been built since the records were began and are not included, and a larger number have never been recorded. An addition of 25 per cent. to the totals would probably be nearer the actual situation.

Abstract from ditch records of Fremont and Carbon Counties.

	No. of ditches.	Length.	Capacity per second.	Acreage.
		Miles.	*Cubic feet.*	
Carbon Company	304	421.60	4,451.64	1,084.44
Fremont Company	181	226.27	....	441.81

This makes the totals for the Territory, so far as completed, as follows:

Total mileage	3,852.83
Total acreage under ditch	1,413,404

Four-fifths of these ditches have been completed within the past five years. It is probably the most rapid development yet recorded in any State or Territory, and when considered in connection with our unfavorable conditions incident to lack of railroad facilities, and to the fact that the present land laws are not suited to the conditions of the arid region and their technical enforcement has oftentimes caused great hardship and unnecessary expense to the pioneer farmers, it furnishes a gratifying evidence of the superior inducements of our agriculture and the facilities here presented for the economical construction of ditches. Nearly the whole of this is the result of the efforts and expenditures of the farmers and cattlemen of the Territory.

Water district No. 8.—Claims to water as taken from the records of Fremont County.

Name of stream.	Name of ditch.	Dimensions.					Grade per mile.	Amount claimed per second.	Date.	Number of acres under ditch.
		Length.	Bottom width.	Top width.	Average width.	Depth.				
		Miles.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Cu. feet.*		
Ashworth Creek	....	9/10	.....	.....	3	1	15.8	12	Aug. 26, 1886	160
	Ashworth Creek	9/10	.....	.....	.....	.....	.....	(*)	Sept. 2, 1885	.....
Alkali Creek	Alkali Ditch	2 1/10	3	3.5	.....	.9	6.33	2	Nov. 12, 1888	160
Big Popo Agie	....	1 1/4	7	10	.....	3	.....	.....	Dec. 4, 1883	.....
		1/4	1	1.5	.....	.8	.....	.....	July 13, 1885	.....
		1 1/16	.....	.....	.....	.....	.....	(†)	Nov. 13, 1885	.....
	Last Chance	2	.....	.....	4	1.5	5	14.3	July 29, 1886	160
	Gaylor Ditch	.....	3	5	.....	.....	5.3	.....	Mar. 4, 1887	.....
	Cemetery	4	5	.....	.....	1.5	10.5	32.1	May 5, 1887	960
	West End Ditch	1/4	.....	.....	2.7	1.5	47.5	18	May 23, 1887	15
	Dutch Flat	2 1/4	6	.....	.....	2.5	4.2	48	June 6, 1887	2,000
	Nicol and Meyers.	2 1/10	4.5	7	.....	1.2	5.2	9.5	May 18, 1888	400
	Hornecker Ditch	3 1/4	3	5	.....	2.5	17.16	21	June 22, 1888	600
Big Popo Agie and Middle Fork.	....	.....	.....	.....	.....	.....	.....	.....	Jan. 29, 1886	.....
New Fork	....	1/16	.....	.....	2.5	2	.....	.....	Jan. 29, 1886	.....
Big Hermit	....	.....	.....	.....	.....	.....	.....	.....	June 12, 1885	.....
	....	.....	.....	.....	.....	8.3	.....	.....	Aug. 12, 1885	.....
Baldwin Creek	....	2 3/8	.....	.....	.....	.....	.....	.....	June 17, 1885	.....
	First or Upper Ditch	3/8	.....	.....	2.5	1.25	.....	.....	Feb. 12, 1886	.....
	Second or Lower Ditch.	1/4	.....	.....	2.5	1.2	.....	.....	Feb. 12, 1886	.....
	Harting and Sharp.	1 3/8	.....	.....	3.5	2	35	46	July 10, 1886	254
	Lum, Williams and Sharp Ditch.	2 2/3	.....	.....	4.5	1.25	36	38	July 10, 1886	351
	St. John Ditch	1 1/16	.....	.....	3	1.5	11.06	15.02	July 27, 1886	160
	Jones Ditch	3/4	.....	.....	1.7	.7	31.7	5.2	July 15, 1887	80

* Claim 200 inches.

† Claim 1,800 inches.

No. IV.

EVIDENCE PREPARED THROUGH CIRCULAR LETTER TO CITIZENS.

CHEYENNE, *August* 17, 1889.

Mr. ——— ———:

DEAR SIR: I desire to place before the Senate Committee on Irrigation a correct and impartial statement of our present agricultural development, together with the circumstances and conditions under which it has been accomplished.

As an aid in doing this I wish to obtain the statements of a large number of farmers in different parts of the Territory of the difficulties and expense attending their efforts to reclaim the desert and the results which they have obtained.

I mail you with this a list of questions which I trust you can find time to answer. I am particularly desirous of learning your experience under our present land laws and your views as to what changes thereto are needed. The evidence thus collected will be arranged and presented to the committee.

The modifications of our land laws effected by the last Congress and the probability of further action by the coming one makes it of the highest importance that our wishes and necessities be properly presented and understood.

I trust I shall have your aid and co-operation to this end.

Respectfully,

ELWOOD MEAD,
Territorial Engineer.

TERRITORY OF WYOMING, ENGINEER'S OFFICE,
Cheyenne, September 22, 1889.

I hereby certify that the accompanying letter, asking for testimony to be used before the Senate committee, and the responses thereto, are a full, true, and exact copy of the originals now on file in this office.

ELWOOD MEAD,
Territorial Engineer.

Name, ANDREW GILCHRIST; county, Laramie; post-office, Cheyenne.

1. How long have you resided in the Territory?—About fifteen years.

2. In what year did you begin farming?—In 1877.

3. How much land have you under ditch?—Personally, about 2,000 acres.

4. If obtained from the Government, state the filings which were made.—Lands entered under the desert, pre-emption, and homestead acts, and lands purchased from the Union Pacific Railroad.

5. How many acres are now under cultivation?—About 2,000 acres.

6. By what ditch or ditches is it watered?—By nine ditches, named "Gilchrist No. 1 to No. 9."

7. From what stream or streams is water taken?—South, Middle, and North Crow Creeks.

8. Give history of construction of ditch:

(*a*) Names of owners.—Andrew Gilchrist and Mary Gilchrist.

(*b*) Date begun and time occupied in building.—Began April, 1877; the last ditch was completed in 1887.

(*c*) Dimensions.—The nine ditches are of various dimensions.

(*d*) How many acres does it water?—The nine ditches water about 2,000 acres.

(*e*) What was the cost of construction?—About $10,000 for the nine ditches.

(*f*) What is the cost per year for management and repairs?—About $200.

9. Do you buy or sell water; if so, state price paid or received.—I neither sell nor buy.

10. Have you all the water needed; if not, state the reason.—No, not every year. In dry seasons there being but little snow in the hills the supply of water in the creeks is therefore limited, and the city of Cheyenne claims first appropriation for domestic purposes.

11. What is the usual cost of bringing wild land under cultivation? This to include plowing, grubbing sage brush, fencing, etc.—About $10 per acre.

12. How many years' cultivation are required to bring wild land into proper condition for farming?—From two to three years.

13. What did it cost you to prove up and obtain title to your land, and what was the length of time required? If any difficulties were encountered, state what they were.—Cost from $8 to $10 per acre. Difficulties encountered in obtaining title from

the Government are many, principally on account of the tardy action of the General Land Office after final proof has been made.

14. What has your cultivated land cost you per acre? This to include cost of proving-up, cost of ditches and laterals, expense of preparing land for cultivation, fencing, and all permanent improvements.—See answers to previous questions.

15. What is its present market value per acre?—Probably it could not be sold for more than $10 per acre, on an average.

16. Can you raise crops without irrigation? If so, state what they are and yields obtained.—No crop can be raised without irrigation.

17. Do you think the present land laws are adapted to the conditions of this Territory? If not, what changes would you suggest?—I do not think the present land laws are well adapted to this Territory. My opinion is that if the land, like the water in the streams, was under the control of the Territory or State much more satisfactory results would be obtained, as under the present existing conditions they do not work harmoniously, and large irrigating enterprises suffer a great deal of injustice, and the progress of the settlement of the lands and the development of the resources of the Territory are retarded.

18. What should be done with grazing land which cannot be irrigated? What is its value per acre?—I would suggest that the lands of that nature should be sold to parties having irrigable lands contiguous thereto for grazing purposes. I estimate their value at from 25 cents to $1.50 per acre, according to their grazing qualities, location, and water facilities for stock.

19. How do you regard the withdrawal of all public land from settlement during the irrigation survey?—I regard that such action would be detrimental to the progress of the Territory, as it would practically prevent the settlement of all agricultural lands and put a stop to further irrigation enterprises.

20. Do you favor the donation of all irrigable public land to the Territory?—I would recommend that all agricultural and grazing lands be donated by the General Government to the Territory.

Name, **JOHN A. FISHER**; county, Albany; post-office, Laramie City.

1. How long have you resided in the Territory?—Nineteen years.

2. In what year did you begin farming?—I am not farming as yet.

3. How much land have you under ditch?—About 1,200 acres.

4. If obtained from the Government, state the filings which were made.—One-half section desert, part of a school section, and one-half section railroad land.

5. How many acres are now under cultivation?—[See answer to question 2 above.]

6. By what ditch or ditches is it watered?—By the Fisher ditch.

7. From what stream or streams is water taken?—From the Big Laramie River.

8. Give history of construction of ditch:

(*a*) Names of owners?—John A. Fisher.

(*b*) Date begun and time occupied in building?—It was begun in the month of May, 1884.

(*c*) Dimensions: length, miles, 75; depth, 2 feet; width, 9 feet.

(*d*) How many acres does it water?—Twelve hundred acres.

(*e*) What was the cost of construction?—About $5,000.

(*f*) What is the cost per year for management and repairs?—About $50.

9. Do you buy or sell water; if so, state price paid or received.—I do not.

10. Have you all the water needed; if not, state the reason.—I have.

11. What is the usual cost of bringing wild land under cultivation? This to include plowing, grubbing sage brush, fencing, etc.—Don't know as yet.

12. How many years' cultivation are required to bring wild land into proper condition for farming?—I can't tell.

13. What did it cost you to prove up and obtain title to your land and what was the length of time required? If any difficulties were encountered, state what they were.—I have not proved up as yet.

14. What has your cultivated land cost you per acre? This is to include cost of proving up, cost of ditches and laterals, expense of preparing land for cultivation, fencing, and all permanent improvements.—[No answer.]

15. What is its present market value per acre?—[No answer.]

16. Can you raise crops without irrigation? If so, state what they are and yields obtained.—No.

17. Do you think the present land laws are adapted to the conditions of this Territory? If not, what changes would you suggest?—[No answer.]

18. What should be done with grazing land which cannot be irrigated? What is its value per acre?—[No answer.]

19. How do you regard the withdrawal of all public land from settlement during the irrigation survey?—I do not believe in it.

20. Do you favor the donation of all irrigable public land to the Territory?—I do.

Name, **Luke Voorhees**; county, Laramie; post-office, Cheyenne.

1. How long have you resided in the Territory?—Fifteen years.
2. In what year did you begin farming?—1878 in a small way.
3. How much land have you under ditch?—About 4,000 acres.
4. If obtained from the Government, state the filings which were made.—Luke Voorhees, desert 640, October 10, 1880; George M. Drake, desert, September 15, 1880; George D. Jenks, desert 280, May 24, 1880; Florence L. Voorhees, desert 600, November 5, 1882; Am. Jenks, desert 640, June 19, 1883; William Jenks, desert 640, June 19, 1883; J. G. Huling, pre-emption 160, January 2, 1885; A. G. Lourey, pre-emption, November, 1883, 160.
5. How many acres are now under cultivation?—About 4,000 acres in hay land and other crops.
6. By what ditch or ditches is it watered—L. Z. ditch and Voorhees ditch.
7. From what stream or streams is water taken?—L. Z. ditch, Rawhide Creek; Voorhees, Niobrara Creek.
8. Give history of construction of ditch.—Commencement of ditches were in 1880, completed 1883.

(*a*) Names of owners, Luke Voorhees & Company.

(*b*) Date begun and time occupied in building?—1880, about three years in completing.

(*c*) Dimensions.—Voorhees, 4 feet on top, 3.6 on bottom; length, miles, 6½; depth, 2 feet average; width, 5.4 feet top, 3.6 bottom.

(*d*) How many acres does it water?—Four thousand acres.

(*e*) What was the cost of construction?—About——

(*f*) What is the cost per year for management and repairs?—Am not able to state now.

9. Do you buy or sell water; if so, state price paid or received.—Neither buy nor sell.
10. Have you all the water needed; if not, state the reasons.—Have sufficient water except in some very dry seasons.
11. What is the usual cost of bringing wild land under cultivation? This to include plowing, grubbing sage brush, fencing, etc.—From $7 to $25.
12. How many years' cultivation are required to bring wild land into proper condition for farming?—One to three years.
13. What did it cost you to prove up and obtain title to your land and what was the length of time required? If any difficulties were encountered state what they were.—From six months to three years in proving up. The usual difficulties of constructing ditches and other labor.
14. What has your cultivated land cost you per acre? This to include cost of proving up, cost of ditches and laterals, expense of preparing land for cultivation, fencing, and all permanent improvements?—About $23 per acre.
15. What is its present market value per acre?—Under the rulings of land commissioner for the five years from 1884 to the present time I can hardly say, as it has a market value, no titles.
16. Can you raise crops without irrigation? If so, state what they are and yields obtained.—Can raise no crop without irrigation.
17. Do you think the present land laws are adapted to the conditions of this Territory? If not, what changes would you suggest?—I can suggest no changes to the land laws that were passed prior to 1881. It is the rulings of land commissioners that are dangerous to settle.
18. What should be done with grazing land which can not be irrigated? What is its value per acre?—On an average not to exceed 10 cents per acre; should be donated to the State or Territory for schools and public buildings.
19. How do you regard the withdrawal of all public land from settlement during the irrigation survey?—I regard it as very dangerous and detrimental to the best interests of the citizens and Territory in general.
20. Do you favor the donation of all irrigable public land to the Territory?—I do. I believe it would be better for the General Government to donate to State or Territory.

Name, **Benj. F. Lowe**; county, Fremont; postoffice, Lander.

1. How long have you resided in the Territory?—Twenty-one years.
2. In what year did you begin farming?—1870.
3. How much land have you under ditch?—Thirty acres.
4. If obtained from the Government, state the filings which were made.—Cash entry for N.E. ¼, Sec. 18, Town. 33, Range 99 west Sixth principal meridian.
5. How many acres are now under cultivation?—About 30.
6. By what ditch or ditches is it watered?—By two ditches taken out of the Big Popoagie.

7. From what stream or streams is water taken?—The Big Popoagie River.

8. Give history of construction of ditch.—Were made by me in the year 1875.

(a) Names of owners.—Self.

(b) Date begun and time occupied in building.—Three or four days.

(c) Dimensions, 150 inches; length, one-half mile; depth, 10 inches; width, 18 inches.

(d) How many acres does it water?—Ten.

(e) What was the cost of construction?—Twenty dollars.

(f) What is the cost per year for management and repairs?—One dollar.

9. Do you buy or sell water; if so, state price paid on received.—Sell no water; buy none.

10. Have you all the water needed; if not, state the reason.—No; the Lander Mill Company has taken the water from its proper channel for their own use.

11. What is the usual cost of bringing wild land under cultivation? This to include plowing, grubbing sage brush, fencing, etc.—About $10 per acre.

12. How many years' cultivation are required to bring wild land into proper condition for farming?—Good as ever first year.

13. What did it cost you to prove up and obtain title to your land and what was the length of time required? If any difficulties were encountered, state what they were.—About $600. The town of Lander is located on N.E. ¼, Sec. 18. There were some persons other than myself living on the land, hence some additional cost. Time in obtaining title, sixteen months.

14. What has your cultivated land cost you per acre? This to include cost of proving up, cost of ditches and laterals, expense of preparing land for cultivation, fencing, and all permanent improvements.—About $2,000; 160 acres.

15. What is its present market value per acre?—From $50 to $500.

16. Can you raise crops without irrigation? If so, state what they are and yields obtained.—Some of the bottom land on the streams of Big Popoagie will produce average crop without irrigation; 95 per cent. of Wyoming requires water, more or less.

17. Do you think the present land laws are adapted to the conditions of this Territory? If not, what changes would you suggest?—The laws are all that could be asked as regards homesteads and desert entries; tree culture is a failure.

18. What should be done with grazing land which can not be irrigated? What is its value per acre?—They might be leased by stockmen; artesian wells put down at great expense would bring the lands up to a rate that would re-imburse the State.

19. How do you regard the withdrawal of all public land from settlement during the irrigation survey?—Do not think it necessary; new settlers will not be in the way.

20. Do you favor the donation of all irrigable public land to the Territory?—Yes.

Name, JOHN O. D. O'BRIEN; county, Converse; post-office, Douglas.

1. How long have you resided in the Territory?—Twenty-two years.

2. In what year did you begin farming?—1877.

3. How much land have you under ditch?—About 80 acres.

4. If obtained from the Government, state the filings which were made.—No filings made on account of Government survey of Fetterman Reservation, includes my claim, and no filing can be made until act of Congress is carried out.

5. How many acres are now under cultivation?—Fifteen acres.

6. By what ditch or ditches is it watered?—O'Brien's Ditch.

7. From what stream or streams is water taken?—La Prele Creek.

8. Give history of construction of ditch:

(a) Names of owners. O'Brien & Wallace, Burt Elder, and W. H. Powell.

(b) Date begun and time occupied in building.—November 11, 1887. One month.

(c) Dimensions, 4 feet; length, 3 miles; depth, 1 foot; width, 4 feet.

(d) How many acres does it water?—Two hundred and forty.

(e) What was the cost of construction?—About $1,000.

(f) What is the cost per year for management and repairs?—Forty to fifty dollars.

9. Do you buy or sell water; if so, state price paid or received?—No.

10. Have you all the water needed; if not state the reason?—Yes.

11. What is the usual cost of bringing wild land under cultivation? This to include plowing, grubbing sage brush, fencing, etc.—Ten dollars per acre.

12. How many years cultivation are required to bring wild land into proper condition for farming?—Three years.

13. What did it cost you to prove up and obtain title to your land and what was the length of time required? If any difficulties were encountered, state what they were?—Congress passed an act to sell the reservation of Fetterman, except what land was occupied by settlers, January 1, 1884, but it seems we are no nearer to-day to file than we were five years ago.

14. What has your cultivated land cost you per acre? This to include cost of ditches and laterals, expense of preparing land for cultivation, fencing, and all permanent improvements.—Ten dollars per acre.

15. What is its present market value per acre?—Nothing until patent is obtained, to which I should have been entitled at least eleven years ago.

16. Can you raise crops without irrigation? If so, state what they are and yields obtained?—No.

17. Do you think the present land laws are adapted to the conditions of this Territory? If not, what changes would you suggest?—No; an extra grant of, say, 160 acres of hilly land for pasture of grangers' cattle adjoining creek bottoms.

18. What should be done with grazing land which can not be irrigated? What is its value per acre?—Answered in question 17. Could not say; but very little.

19. How do you regard the withdrawal of all public land from settlement during the irrigation survey?—I hardly understand the question, but am not in favor of any public land being withdrawn, for it hinders settlement.

20. Do you favor the donation of all irrigable public land to the Territory?—No; the United States land laws are good enough for me.

Name, T. M. **Herrick**; county, Laramie; post-office, Goshen.

1. How long have you resided in the Territory?—Fourteen years.

2. In what year did you begin farming?—1885.

3. How much land have you under ditch?—Four hundred and fifty acres.

4. If obtained from the Government, state the filings which were made.—Desert.

5. How many acres are now under cultivation?—Two hundred in hay; forty plowed.

6. By what ditch or ditches is it watered?—Spy and Herrick and Bolcom.

7. From what stream or streams is water taken?—Big Horse Creek.

8. Give history of construction of ditch:

(*a*) Names of owners.—T. M. Herrick and wife.

(*b*) Date begun and time occupied in building.—Spy ditch, March, 1885; five months.

(*c*) Dimensions, Spy ditch, length, 1¼ miles; depth, 1 foot; width, 5 feet.

(*d*) How many acres does it water?—Three hundred.

(*e*) What was the cost of construction?—Eight hundred dollars.

(*f*) What is the cost per year for management and repairs?—Twenty-five dollars.

9. Do you buy or sell water? If so, state price paid or received.—In the Spy Ditch, no.

10. Have you all the water needed. If not, state the reason.—Because the water is taken out above me.

11. What is the usual cost of bringing wild land under cultivation; this to include plowing, grubbing sage brush, fencing, etc.?—Some $1; some $5.

12. How many years' cultivation are required to bring wild land into proper condition for farming?—Two.

13. What did it cost you to prove up and obtain title to your land, and what was the length of time required? If any difficulties were encountered, state what they were.—Four dollars per acre; two years.

14. What has your cultivated land cost you per acre; this to include cost of proving up; cost of ditches and laterals, expense of preparing land for cultivation, fencing, and all permanent improvements?—Six dollars.

15. What is its present market value per acre?—Nothing.

16. Can you raise crops without irrigation? If so, state what they are and yields obtained.—No.

17. Do you think the present land laws are adapted to the conditions of this Territory? If not, what changes would you suggest?—All but pre-emption and timber claims; they ought to be repealed.

18. What should be done with grazing land which can not be irrigated? What is its value per acre?—Sold in 1,000-acre lots; 50 cents per acre.

19. How do you regard the withdrawal of all public land from settlement during the irrigation survey?—It would ruin the Territory for the time continued.

20. Do you favor the donation of all irrigable public land to the Territory?—Yes.

Name, **Caleb M. La Grange**; county, Laramie; post-office, Goshen.

1. How long have you resided in the Territory?—Twenty-two years.

2. In what year did you begin farming?—1871.

3. How much land have you under ditch?—Eight hundred acres.

4. If obtained from the Government, state the filings which were made.—Under the desert land laws.

5. How many acres are now under cultivation?—Six hundred.

6. By what ditch or ditches is it watered?—Brown & La Grange Ditch.

7. From what stream or streams is water taken.—Horse Creek.

8. Give history of construction of ditch:

(*a*) Name of owners.—D. E. Brown, C. M. La Grange.

(*b*) Date begun and time occupied in building.—March 23, 1883; one year.

(*c*) Dimensions; length 4 miles; North Fork 2 miles; depth, 2 feet; width 13 feet on top and 6 feet on bottom.

(*d*) How many acres does it water?—Twenty-three hundred.

(*e*) What was the cost of construction?—Main ditch, $1,600; my own laterals $300.

(*f*) What is the cost per year for management and repairs?—$150.

9. Do you buy or sell water? If so, state price paid or received.—Do not buy or sell.

10. Have you all the water needed? If not, state the reason.—Have not; water taken by other ditches above.

11. What is the usual cost of bringing wild land under cultivation; this to include plowing, grubbing sage brush, fencing, etc.?—Four dollars.

12. How many years' cultivation are required to bring wild land into proper condition for farming?—Two.

13. What did it cost you to prove up and obtain title to your land and what was the length of time required? If any difficulties were encountered, state what they were.—Made proof in two years and six months after filing; cost $1,200.

14. What has your cultivated land cost you per acre; this to include cost of proving up, cost of ditches and laterals, expense of preparing land for cultivation, fencing and all permanent improvements?—6\frac{75}{100}$.

15. What is its present market value per acre?—From $5 to to $15.

16. Can you raise crops without irrigation? If so, state what they are and yields obtained.—No.

17. Do you think the present laws are adapted to the conditions of this Territory? If not, what changes would you suggest?—Free gift of 320 acres to every man or woman that will live on it for five years.

18. What should be done with grazing land which can not be irrigated? What is its value per acre?—Fifty cents. It should be sold to highest bidder, section at a time.

19. How do you regard the withdrawal of all public land from settlement during the irrigation survey?—It would act on the Territory like a wet blanket on a buffalo-chip fire.

20. Do you favor the donation of all irrigable public land to the Territory?—On condition, no.

Name, **Lionel Saratoris**; county, Albany; post-office, Laramie; manager of the Douglass, Willar and Saratoris Company.

1. How long have you resided in the Territory?—Seven years.

2. In what year did you begin farming?—1887.

3. How much land have you under ditch?—Twelve thousand acres irrigated, 25,000 acres under ditches not irrigated through scarcity of water.

4. If obtained from the Government, state the filings which were made?—About 8,000 obtained from Government, balance railroad land.

5. How many acres are now under cultivation?—Five hundred and fifty acres in oats and other grains, 800 acres in timothy hay, 3,000 native hay, balance of irrigated land as pasture.

6. By what ditch or ditches is it watered?—Snake Ditch and Taback Ditch and Sernatatle Snake Ditch.

7. From what stream or streams is water taken?—Little Laramie, Big Laramie, Mill and Dutton Creeks.

8. Give history of construction of ditch:

(*a*) Names of owners—Douglas, Willar, and Saratoris Company.

(*b*) Date begun and time occupied in building?—Snake Ditch, 1886; Taback Ditch, 1888.

(*c*) Dimensions: 6 miles, 14 miles; depth, 3 feet, 3½ feet; width, 8 feet, 12 feet.

(*d*) How many acres does it water?—See question 3.

(*e*) What was the cost of construction?—Taback $1,200 per mile, Snake $675.

(*f*) What is the cost per year for management and repairs?—About 3 per cent. original cost first year, afterwards 1 per cent.

9. Do you buy or sell water? If so, state price paid or received.—[No answer.]

10. Have you all the water needed? If not, state the reason.—Not for the last two years, on account of mild winters, when there is no snow on the mountains.

11. What is the usual cost of bringing wild land under cultivation? This to include plowing, grubbing sage brush, fencing, etc.—One hundred and twenty-five dol-

lars per mile. I have never grubbed sage-brush, as I have so much good land without any that it does not pay to grub the land.

12. How many years' cultivation are required to bring wild land into proper condition for farming?—Two years.

13. What did it cost you to prove up and obtain title to your land, and what was the length of time required? If any difficulties were encountered, state what they were.—Three dollars and fifty cents per acre to $4.50. Two years in most cases. No difficulties except gross ignorance on the part of the Cheyenne land office.

14. What has your cultivated land cost you per acre? This to include cost of proving up, cost of ditches and laterals, expense of preparing land for cultivation, fencing, and all permanent improvements.—A very hard question. I answer, about $9 to $15 per acre.

15. What is its present market value per acre?—I consider good meadow $15 per acre, cultivated land $35 per acre, with crop on land.

16. Can you raise crops without irrigation? If so, state what they are and yields obtained.—I am confident that crops can be raised without irrigation if land is plowed and allowed to fallow for one year, then to sow some quick-growing crop. Have it all so as to collect snow, and thus permanently loosen up the subsoil.

17. Do you think the present land laws are adapted to the conditions of this Territory? If not, what changes would you suggest?—All laws are satisfactory, but I think that people who control a large amount of land should be allowed to take up in some several sections of high land for purposes of pasture. I mean lands that are impossible to irrigate and that the "honest settler" has no use for. This will be better than the present unsatisfactory conditions of Government uplands. This quality of land is of no value except to large land-owners who have many cattle, and they should be allowed to control it either by lease or sale. These lands have always been the great impediment to Eastern capital coming into this Territory.

19. How do you regard the withdrawal of all public land from settlement during the irrigation survey?—I see no use for doing this.

20. Do you favor the donation of all irrigable public land to the Territory?—Yes; as long as the Territory is not allowed to put exorbitant prices on the uplands they should still in some way be controlled by Government, and county commissioners should have nothing to say in the matter of selling or trading these lands.

Name, **John R. Smith**; county, Johnson; post-office, Traburg.

1. How long have you been in the Territory?—Twenty-three years.

2. In what year did you begin farming?—1879.

3. How much land have you under ditch?—One thousand two hundred acres.

4. If obtained from the Government, state the filings which were made.—One homestead, one timber culture, two desert claims.

5. How many acres are now under cultivation?—About 800—400 pasture.

6. By what ditch or ditches is it watered?—The John R. Smith Ditch.

7. From what stream or streams is water taken?—Crazy Woman's Fork of Powder.

8. Give history of construction of ditch:

(*a*) Names of owners, John R. Smith, Agnes Smith.

(*b*) Date begun and time occupied in building?—10th day of April, 1879.

(*c*) Dimensions: Length, 6 miles; depth, 2 feet; width, 7 feet.

(*d*) How many acres does it water?—Ten thousand.

(*e*) What was the cost of construction?—Six hundred dollars.

(*f*) What is the cost per year for management and repairs?—On average, $75.

9. Do you buy or sell water? If so, state price paid or received.—[No answer.]

10. Have you all the water needed? If not, state the reason.—I have not this year; and 1886 and 1887 was short, caused by other ditches using it.

11. What is the usual cost of bringing wild land under cultivation? This to include plowing, grubbing sage-brush, fencing, etc.—Mine has cost me about $850, not including Government cost.

12. How many years' cultivation are required to bring wild land into proper condition for farming?—Two years.

13. What did it cost you to prove up and obtain title to your land, and what was the length of time required? If any difficulties were encountered, state what they were.—One thousand dollars on 640 acres; $350 on 240 acres; and $20 on 160; timber culture, not proved upon, 160 acres; three years and five years.

14. What has your cultivated land cost you per acre? This to include cost of proving up, cost of ditches and laterals, expense of preparing land for cultivation, fencing, and all permanent improvements.—Thirteen thousand and eighty-five dollars, in full.

15. What is its present market value per acre?—There is no land selling at any price.

16. Can you raise crops without irrigation? If so, state what they are and yields obtained.—You can not raise anything here without water to irrigate with.

17. Do you think the present land laws are adapted to the conditions of this Territory? If not, what changes would you suggest.—I do not think the Territory should own and control her own lands.

18. What should be done with grazing land which can not be irrigated? What is its value per acre?—Five to 20 cents per acre, sold to any one wishing to purchase.

19. How do you regard the withdrawal of all public land from settlement during the irrigation survey?—It will be an injustice to the public.

20. Do you favor the donation of all irrigable public land to the Territory?—I do; strongly.

Name, Gustave E. A. Moeler; county, Johnson; post-office, Buffalo.

1. How long have you resided in the Territory?—Twelve years.

2. In what year did you begin farming?—1879.

3. How much land have you under ditch?—One thousand two hundred and eighty acres.

4. If obtained from the Government, state the filings which were made?—Homestead, pre-emption, and two desert filings.

5. How many acres are now under cultivation?—About 800.

6. By what ditch or ditches is it watered?—North Fork and French Creek Ditch Company's ditch.

7. From what stream or streams is water taken?—North Fork of Clear Creek.

8. Give history of construction of ditch:

(a) Names of owners, North Fork and French Creek Ditch Company (a corporation).

(b) Date begun and time occupied in building?—January 3, 1886; five months.

(c) Dimensions, 112 square feet per section; length, 2 miles; depth, 3 feet; width, 7 feet.

(d) How many acres does it water?—Three thousand.

(e) What was the cost of construction?—Two thousand dollars.

(f) What is the cost per year for management and repairs?—Two hundred dollars.

9. Do you buy or sell water? If so, state price paid or received.—[No answer.]

10. Have you all the water needed? If not, state the reason—I have.

11. What is the usual cost of bringing wild land under cultivation? This to include plowing, grubbing sage-brush, fencing, etc.—The cost to me has been about $12 per acre.

12. How many years' cultivation are required to bring wild land into proper condition for farming?—Three years.

13. What did it cost you to prove up and obtain title to your land and what was the length of time required? If any difficulties were encountered, state what they were.—I paid the United States $1.25 per acre for 1,120 acres. It took nine years to get title to my homestead; six years for my desert. For 800 acres I have no title yet, although final proof has been made.

14. What has your cultivated land cost you per acre? This to include cost of proving up, cost of ditches and laterals, expense of preparing land for cultivation, fencing, and all permanent improvements.—Answered above.

15. What is its present market value per acre?—Ten to twelve dollars.

16. Can you raise crops without irrigation? If so, state what they are and yields obtained?—Not a spear of grass long enough to cut with a mower.

17. Do you think the present land laws are adapted to the conditions of this Territory? If not, what changes would you suggest?—I have none to suggest. Desert law ought not to be repealed.

18. What should be done with grazing land which can not be irrigated? What is its value per acre?—Might be sold without restriction as to quantity salable to one man. About 50 cents to $1.

19. How do you regard the withdrawal of all public land from settlement during the irrigation survey?—Might be a good plan to head off speculators.

20. Do you favor the donation of all irrigable public land to the Territory?—Yes.

Name, John Darbin; county, Carbon; post-office, Darbin.

1. How long have you resided in the Territory?—Twenty-one years.

2. In what year did you begin farming?—1875.

3. How much land have you under ditch?—The company in which I am interested has 400 acres.

4. If obtained from the Government, state the filings which were made?—Desert claim.

5. How many acres are now under cultivation?—One hundred.

6. By what ditch or ditches is it watered?—Darbin Nos. 1, 2, and 3.

7. From what stream or streams is water taken?—Muddy Creek.

8. Give history of construction of ditch:

(a) Name of owners, Darbin Cattle Company or Union Darbin Company.

(b) Date begun and time occupied in building?—[No answer.]

(c) Dimensions: Length, east, 2½ to 3 miles; depth, No. 1, 2 feet; No. 2, 2 feet; No. 3, 2 feet; width, No. 1, 5 feet; No. 2, 4 feet; No. 3, 4 feet.

(d) How many acres does it water?—Four hundred acres.

(e) What was the cost of construction?—Two thousand dollars.

(f) What is the cost per year for management and repairs?—Fifty dollars.

9. Do you buy or sell water. If so, state price paid or received.—Neither buy nor sell.

10. Have you all the water needed? If not, state the reason.—Have not. Failure of stream in summer is the cause.

11. What is the usual cost of bringing wild land under cultivation? This to include plowing, grubbing sage-brush, fencing, etc.—Eight to twelve dollars. Planting and grubbing sage-brush is alone worth $8 per acre.

12. How many years' cultivation are required to bring wild land into proper condition for farming?—Three to five years.

13. What did it cost you to prove up and obtain title to your land and what was the length of time required? If any difficulties were encountered, state what they were.—It was hard work to get the ditches completed within three years. The expense of getting witnesses to Cheyenne was also heavy.

14. What has your cultivated land cost you per acre? This to include cost of proving up, cost of ditches and laterals, expense of preparing land for cultivation, fencing, and all permanent improvements.—Fifteen dollars.

15. What is its present market value per acre?—[No answer.]

16. Can you raise crops without irrigation? If so, state what they are and yields obtained.—Can not raise anything.

17. Do you think the present land laws are adapted to the conditions of this Territory? If not, what change would you suggest?—More time should be given on the desert land proofs.

18. What should be done with grazing land which can not be irrigated? What is its value per acre?—I hardly know as to the first. Its value does not exceed 5 cents per acre.

19. How do you regard the withdrawal of all public land from settlement during the Irrigation Survey?—It would be detrimental.

20. Do you favor the donation of all irrigable public land to the Territory?—[No answer.]

Name, JOHN H. GORDON; county, Laramie; post-office, Little Horse Creek.

1. How long have you resided in the Territory?—Twelve years.

2. In what year did you begin farming?—1871, in Colorado.

3. How much land have you under ditch?—About 1,400 acres.

4. If obtained from the Government, state the filings which were made?—Most of the land I obtained by purchase which was taken up under the pre-emption, homestead, and desert act.

5. How many acres are now under cultivation?—About 1,000 acres.

6. By what ditch or ditches is it watered?—These lands are watered by nine ditches.

7. From what stream or streams is water taken?—Little Horse Creek Mills, Herrick Creeks, Mills Creek Ditch No. 1, and No. 2, and No. 3.

8. Give history of construction of ditch:

(a) Names of owners, Springdale Ditch Company, Herrick ditches No. 1 and No. 2.

(b) Date begun and time occupied in building?—The oldest, 1873; the balance since that time.

(c) Dimensions, from 2 to 8 feet wide; length, 1 to 5 miles; depth, about 18 inches; width, 2 to 8 feet wide.

(d) How many acres does it water?—About 1,000 acres.

(e) What was the cost of construction?—In the neighborhood of $7,000.

(f) What is the cost per year for management and repairs?—About $400.

9. Do you buy or sell water; if so, state price paid or received?—I neither buy nor sell water for the above lands.

10. Have you all the water needed? If not, state the reason.—No; the waters in this section not adjudicated yet.

11. What is the usual cost of bringing wild land under cultivation? This to include plowing, grubbing sage-brush, fencing, etc.—From $15 to $20 per acre.

12. How many years' cultivation are required to bring wild land into proper condition for farming?—Three years.

13. What did it cost you to prove up and obtain title to your land, and what was the length of time required? If any difficulties were encountered, state what they were.—As I said before, I purchased most of the above lands.

14. What has your cultivated land cost you per acre? This to include cost of proving up, cost of ditches and laterals, expense of preparing land for cultivation, fencing, and all permanent improvements.—About $20 per acre.

15. What is its present market value per acre?—About $15 per acre.

16. Can you raise crops without irrigation? If so, state what they are and yields obtained.—No.

17. Do you think the present land laws are adapted to the conditions of this Territory? If not, what changes would you suggest?—No; I should think the Territory ought to be allowed to make laws to govern the settlement of her lands.

18. What should be done with grazing land which cannot be irrigated? What is its value per acre?—It should be left as a common; but there is very little land which can not be irrigated.

19. How do you regard the withdrawal of all irrigable public land from settlement during the Irrigation Survey?—I think it would be a calamity to the Territory.

20. Do you favor the donation of all irrigable public land to the Territory?—Yes.

Name, D. E. Brown; county, Laramie; post-office, Goshen.

1. How long have you resided in the Territory?—Fifteen years.

2. In what year did you begin farming?—1885.

3. How much land have you under ditch?—About 1,400 acres.

4. If obtained from the Government, state the filings which were made?—Two desert, homestead, and tree claim.

5. How many acres are now under cultivation?—One hundred under plow.

6. By what ditch or ditches is it watered?—By Brown and La Grange ditches.

7. From what stream or streams is water taken?—Big Horse Creek.

8. Give history of construction of ditch:

(*a*) Name of owners—D. E. Brown and C. M. La Grange.

(*b*) Date begun and time occupied in building?—March, 1883; two years.

(*c*) Dimensions, 13 by 6 by 2; length, about 6 miles; depth, 2 feet; width, top 13 feet, bottom 6 feet.

(*d*) How many acres does it water?—About 1,800.

(*e*) What was the cost of construction?—My interest $2,000, on main line.

(*f*) What is the cost per year for management and repairs?—One hundred dollars will cover all repairs.

9. Do you buy or sell water? If so, state price paid or received.—No.

10. Have you all the water needed? If not, state the reason.—At all times, not. Because the water is used above us in the newer ditches that have been infringing on our priority of right.

11. What is the usual cost of bringing wild land under cultivation? This to include plowing, grubbing sage brush, fencing, etc.—From $4 to $6 per acre.

12. How many years cultivation are required to bring wild land into proper condition for farming?—For small grains, etc., just as soon as ditches are completed, with water ready for use.

13. What did it cost you to prove up and obtain title to your land and what was the length of time required? If any difficulties where encountered, state what they were.—The land cost me from the Government, including all expense in making final proof, about $1.50 per acre.

14. What has your cultivated land cost you per acre? This to include cost of proving up, cost of ditches and laterals, expense of preparing land for cultivation, fencing and all permanent improvements.—Nine dollars per acre.

15. What is the present market value per acre?—I value it at $15 per acre.

16. Can you raise crops without irrigation? If so, state what they are and yields obtained.—We can not raise crops without irrigation.

17. Do you think the present land laws are adapted to the conditions of this Territory? If not, what changes would you suggest?—I would suggest four years for making final proof on desert entries and that homesteaders be allowed 320 acres where they prove five years' continuous residence.

18. What should be done with grazing land which can not be irrigated? What is its value per acre?—Fifty cents per acre. I would favor its being leased subject to settlement.

19. How do you regard the withdrawal of all irrigable public land from settlement during the Irrigation Survey?—I do not approve of the withdrawal of all public lands during survey, only in sections where they are commencing to operate.

20. Do you favor the donation of all irrigable public land to the Territory?—On certain conditions, I do.

Name, A. M. McLaughtin; county, Laramie; post-office, Davis Ranch.

1. How long have you resided in the Territory?—Twelve years.

2. In what year did you begin farming?—1878.

3. How much land have you under ditch?—One hundred acres.

4. If obtained from the Government, state the filings which were made?—Homestead entry.

5. How many acres are now under cultivation?—One hundred.

6. By what ditch or ditches is it watered?—McLaughtin, Nos. 1, 2, and 6.

7. From what stream or streams is water taken?—North Horse Creek.

8. Give history of construction of ditch:

(*a*) Names of owners. A. and J. McLaughtin.

(*b*) Date begun and time occupied in building?—1874.

(*c*) Dimensions. Length, 2½ miles; depth, 15 inches; width, 2½ to 3 feet.

(*d*) How many acres does it water?—One hundred and sixty.

(*e*) What was the cost of construction?—One thousand dollars.

(*f*) What is the cost per year for management and repairs?—One hundred dollars.

9. Do you buy or sell water; if so, state price paid or received?—No.

10. Have you all the water needed; if not, state the reason?—Used to have water enough, but now failing on account of dry weather.

11. What is the usual cost of bringing wild land under cultivation? This to include plowing, grubbing sage brush, fencing, etc.—Eight to ten dollars per acre.

12. How many years cultivation are required to bring wild land into proper condition for farming?—Three years.

13. What did it cost you to prove up and obtain title to your land and what was the length of time required? If any difficulties were encountered, state what they were.—Five years time and cost of $1.25 per acre.

14. What has your cultivated land cost you per acre? This to include cost of proving up, cost of ditches and laterals, expense of preparing land for cultivation, fencing and all permanent improvements.—Twenty-two dollars per acre.

15. What is its present market value per acre?—Fifteen dollars per acre.

16. Can you raise crops without irrigation? If so, state what they are and yields obtained.—No.

17. Do you think the present land laws are adapted to the conditions of this Territory? If not, what changes would you suggest?—Government should give each man one section of land in fee simple, when he has reclaimed the same.

18. What should be done with grazing land which can not be irrigated? What is its value per acre?—Sell it in limited tracts at from 8 to 12 cents per acre.

19. How do you regard the withdrawal of all irrigable public land from settlement during the irrigation survey?—It would stop all settlement of the Territory.

20. Do you favor the donation of all irrigable public land to the Territory?—[No answer.]

Name, Emma M. Lathan; county, Laramie; post-office, Davis Ranch.

1. How long have you resided in the Territory?—Eighteen years.

2. In what year did you begin farming?—1873.

3. How much land have you under ditch?—Eighty acres.

4. If obtained from the Government, state the filings which were made.—Preemption.

5. How many acres are now under cultivation?—Eighty.

6. By what ditch or ditches is it watered?—Ditch not named.

7. From what stream or streams is water taken?—Spring Creek, a branch of Horse Creek.

8. Give history of construction of ditch:

(*a*) Names of owners.—Emma M. Lathan.

(*b*) Date begun and time occupied in building?—1879; about three years.

(*c*) Dimensions.—Length, 1 mile; depth, 8 inches; width, 3 feet.

(*d*) How many acres does it water?—Eighty.

(*e*) What was the cost of construction?—Two hundred and fifty dollars.

(*f*) What is the cost per year for management and repairs?—Fifty dollars.

9. Do you buy or sell water; if so, state price paid or received?—No.

10. Have you all the water needed; if not, state the reason?—No. Water was not in the creek.

11. What is the usual cost of bringing wild land under cultivation? This to include plowing, grubbing sage brush, fencing, etc.—From $7 to $10.

12. How many years cultivation are required to bring wild land into proper condition for farming?—Two to four years.

13. What did it cost you to prove up and obtain title to your land and what was the length of time required? If any difficulties were encountered, state what they

were.—Two dollars and twenty-five cents, and took about three years. A mistake of date was made by the land office and I had to offer proof a second time.

14. What has your cultivated land cost you per acre? This to include cost of proving up, cost of ditches and laterals, expense of preparing land for cultivation, fencing, and all permanent improvements.—Sixteen to twenty dollars.

15. What is its present market value per acre?—About $15.

16. Can you raise crops without irrigation? If so, state what they are and yields obtained.—No.

17. Do you think the present land laws are adapted to the conditions of this Territory? If not, what changes would you suggest?—I do not know, but I think every settler should have one section of land for reclaiming it.

18. What should be done with grazing land which can not be irrigated? What is its value per acre?—Should be sold at auction or at fixed value; 10 to 25 cents per acre.

19. How do you regard the withdrawal of all public land from settlement during the irrigation survey?—Unfavorably, for it would stop the settlement of the Territory.

20. Do you favor the donation of all irrigable public lands to the Territory?—I do.

Name, T. W. Rutledge; county, Laramie; post-office, Little Horse Creek.

1. How long have you resided in the Territory?—Twenty-two years.

2. In what year did you begin farming?—1883.

3. How much land have you under ditch?—Four thousand eight hundred acres.

4. If obtained from the Government, state the filings which were made?—Homestead, timber-culture, and mostly desert entries.

5. How many acres are now under cultivation?—One hundred and fifty plowed; 2,000 to hay.

6. By what ditch or ditches is it watered?—Rutledge and Hellman Ditch.

7. From what stream or streams is water taken?—Horse Creek.

8. Give history of construction of ditch:

(*a*) Names of owners.—Rutledge and Hellman.

(*b*) Date begun, and time occupied in building.—1883; and was three years in building.

(*c*) Dimensions.—Length, 50 miles; depth, 4 feet to 1 foot; width, 17 feet to 3 feet.

(*d*) How many acres does it water?—Three hundred acres really watered this year, 1889.

(*e*) What was the cost of construction?—Thirty thousand dollars.

(*f*) What is the cost per year for management and repairs?—One thousand dollars.

9. Do you buy or sell water; if so, state price paid or received?—No.

10. Have you all the water needed; if not, state the reason?—No, the last three seasons have been uncommonly dry, and we have no way of holding the water in time of a freshet.

11. What is the usual cost of bringing wild land under cultivation? This to include plowing, grubbing sage brush, fencing, etc.—Seven dollars and fifty cents per acre. No grubbing is necessary.

12. How many years cultivation are required to bring wild land into proper condition for farming?—Three to five years.

13. What did it cost you to prove up and obtain title to your land, and what was the length of time required? If any difficulties were encountered, state what they were.—One dollar and twenty-five cents for land, and $2.00 for each of the six entrymen on the land.

14. What has your cultivated land cost you per acre? This to include cost of proving up, cost of ditches and laterals, expense of preparing land for cultivation, fencing, and all permanent improvements.—Fifteen dollars per acre.

15. What is its present market value per acre?—Twenty-two dollars per acre, but can not sell for $12.

16. Can you raise crops without irrigation? If so, state what they are, and yields obtained.—No.

17. Do you think the present land laws are adapted to the conditions of this Territory? If not, what changes would you suggest?—No; any man that reclaims a section of land should have a free title, and be exempt from taxes for five years.

18. What should be done with grazing land which can not be irrigated? What is its value per acre?—Hold it as a public range; value, 25 cents per acre.

19. How do you regard the withdrawal of all public land from settlement during the irrigation survey?—As extremely detrimental to the Territory.

20. Do you favor the donation of all irrigable public land to the Territory?—I do.

Name, Jno. McLaughlin; county, Laramie; post-office, Davis Ranch.

1. How long have you resided in the Territory?—Twelve years.

2. In what year did you begin farming?—1878.

3. How much land have you under ditch?—Two hundred and forty acres.

4. If obtained from the Government, state the filings which were made?—Desert entry.

5. How many acres are now under cultivation?—Two hundred and forty acres.

6. By what ditch or ditches is it watered?—McLaughlin ditch, No. 5.

7. From what stream or streams is water taken?—North Horse Creek.

8. Give history of construction of ditch:

(a) Names of owners.—A. and J. McLaughlin.

(b) Date begun and time occupied in building?—1874; by Mr. Sanders, about eleven years.

(c) Dimensions. Length, 3¼ miles; depth, 1½ feet; width, 5 feet.

(d) How many acres does it water?—Six hundred.

(e) What was the cost of construction?—One thousand seven hundred dollars.

(f) What is the cost per year for management and repairs?—One hundred dollars.

9. Do you buy or sell water; if so, state price paid or received?—No.

10. Have you all the water needed; if not, state the reason?—Not for the last two seasons, as they have been exceedingly dry.

11. What is the usual cost of bringing wild land under cultivation? This to include plowing, grubbing sage brush, fencing, etc.—Eight dollars to ten dollars per acre.

12. How many years cultivation are required to bring wild land into proper condition for farming?—Three years.

13. What did it cost you to prove up and obtain title to your land, and what was the length of time required? If any difficulties were encountered, state what they were.—Three years time, at a cost of about $2.50 per acre.

14. What has your cultivated land cost you per acre? This to include cost of proving up, cost of ditches and laterals, expense of preparing land for cultivation, fencing and all permanent improvements. Fourteen dollars to fifteen dollars per acre.

15. What is its present market value per acre?—Ten dollars.

16. Can you raise crops without irrigation? If so, state what they are and yields obtained.—No.

17. Do you think the present land laws are adapted to the conditions of this Territory? If not, what changes would you suggest?—Any man that reclaims a section of land should have it in fee simple.

18. What should be done with grazing land which can not be irrigated? What is its value per acre?—Should be sold at 10 cents per acre, and no man or company to have over one section.

19. How do you regard the withdrawal of all irrigable public land from settlement during the irrigation survey?—I think it would stop the settlement of the country.

20. Do you favor the donation of all irrigable public land to the Territory?—[No answer.]

Name, Lizzie D. Johnston; county, Laramie; post-office, Little Horse Creek.

1. How long have you resided in the Territory?—Eight years.

2. In what year did you begin farming?—1881.

3. How much land have you under ditch?—Two hundred and forty acres.

4. If obtained from the Government, state the filings which were made?—Desert entry.

5. How many acres are now under cultivation?—About 200 acres.

6. By what ditch or ditches is it watered?—Johnston Ditch, No. 1.

7. From what stream or streams is water taken?—Little Horse Creek.

8. Give history of construction of ditch:

(a) Names of owners.—J. R. Johnston, Lizzie D. Johnston, Geo. D. Johnston.

(b) Date begun and time occupied in building?—Commenced 1882; about one year.

(c) Dimensions.—Length, 3¼ miles; depth, 18 inches; width, 3½ feet.

(d) How many acres does it water?—About 1,000 acres.

(e) What was the cost of construction?—About $3,000.

(f) What is the cost per year for managment and repairs?—Two hundred and dollars.

9. Do you buy or sell water. If so, state price paid or received.—No.

10. Have you all the water needed? If not, state the reason.—All that is needed.

11. What is the usual cost of bringing wild land under cultivation?—This to include plowing, grubbing sage brush, fencing, etc.—From $8 to $10.

12. How many years cultivation are required to bring wild land into proper condition for farming?—From one to four years.

13. What did it cost you to prove up and obtain title to your land and what was the length of time required? If any difficulties were encountered, state what they were.—Not less than $2 per acre. No difficulties, as I had fully complied with the law.

14. What has your cultivated land cost you per acre? This to include cost of proving up, cost of ditches and laterals, expense of preparing land for cultivation, fencing and all permanent improvements.—Ten dollars.

15. What is its present market value per acre?—Not over $3 per acre.

16. Can you raise crops without irrigation? If so, state what they are and yields obtained.—No.

17. Do you think the present land laws are adapted to the conditions of this Territory? If not, what changes would you suggest?—[No answer.]

18. What should be done with grazing land which can not be irrigated? What is its value per acre?—I do not know.

19. How do you regard the withdrawal of all irrigable public land from settlement during the irrigation survey?—Very unfavorably.

20. Do you favor the donation of all irrigable public land to the Territory?—No.

Name, **Donald Clark**; county, Laramie; post-office, Davis Ranch.

1. How long have you resided in the Territory?—Fifteen years.

2. In what year did you begin farming?—1874.

3. How much land have you under ditch?—One hundred acres.

4. If obtained from the Government, state the filings which were made?—Homestead.

5. How many acres are now under cultivation?—One hundred acres.

6. By what ditch or ditches is it watered?—Horse Creek Ditch, No. 8.

7. From what stream or streams is water taken?—Main fork of Horse Creek.

8. Give history of construction of ditch:

(a) Names of owners.—Donald Clark and Cheyenne Land and Live-stock Company.

(b) Date begun and time occupied in building?—1875; about two years.

(c) Dimensions.—Length, 2½ miles; depth, 1 foot; width, 3 feet.

(d) How many acres does it water?—One hundred.

(e) What was the cost of construction?—Five hundred dollars.

(f) What is the cost per year for management and repairs?—Seventy-five dollars.

9. Do you buy or sell water? If so, state price paid or received.—No.

10. Have you all the water needed; if not, state the reason?—Some seasons there is plenty, but the last two have been short on account of drought.

11. What is the usual cost of bringing wild land under cultivation? This to include plowing, grubbing sage brush, fencing, etc.—From $10 to $12 per acre.

12. How many years cultivation are required to bring wild land into proper condition for farming?—Four years.

13. What did it cost you to prove up and obtain title to your land and what was the length of time required? If any difficulties were encountered, state what they were.—Cost about $1 per acre and five years time.

14. What has your cultivated land cost you per acre? This to include cost of proving up, cost of ditches and laterals, expense of preparing land for cultivation, fencing, and all permanent improvements.—Not less than $14.

15. What is its present market value per acre?—From $8 to $10.

16. Can you raise crops without irrigation? If so, state what they are and yields obtained.—No.

17. Do you think the present land laws are adapted to the conditions of this Territory; if not, what changes would you suggest?—I do not know.

18. What should be done with grazing land which can not be irrigated? What is its value per acre?—From 10 to 25 cents per acre and limit the amount that each actual occupant shall be allowed to purchase not to exceed one section.

19. How do you regard the withdrawal of all irrigable public land from settlement during the irrigation survey?—Very unfavorably.

20. Do you favor the donation of all irrigable public land to the Territory?—I do.

Name, **R. P. Mull**; county of Laramie; post-office, Davis Ranch.

1. How long have you resided in the Territory?—Twenty years.

2. In what year did you begin farming?—1878.

3. How much land have you under ditch?—One hundred and twenty-five acres.

4. If obtained from the Government, state the filings which were made.—Homestead.

5. How many acres are now under cultivation?—One hundred and twenty-five.
6. By what ditch or ditches is it watered?—Mull Ditch, No. 1.
7. From what stream or streams is water taken?—Horse Creek.
8. Give history of construction of ditch:
(*a*) Names of owners.—B. P. and Mary Mull.
(*b*) Date begun and time occupied in building?—1879; three years.
(*c*) Dimensions; length?—1¾ miles; depth, 1 foot; width, 4½ feet.
(*d*) How many acres does it water?—One hundred and twenty-five.
(*e*) What was the cost of construction?—One thousand dollars.
(*f*) What is the cost per year for management and repairs?—One hundred dollars.
9. Do you buy or sell water; if so, state price paid or received?—No.
10. Have you all the water needed; if not, state the reason?—No; where my dam is there is so much sand that the water runs underground.
11. What is the usual cost of bringing wild land under cultivation? This to include plowing, grubbing sage brush, fencing, etc.?—Nine dollars per acre.
12. How many years cultivation are required to bring wild land into proper condition for farming?—Four to seven years.
13. What did it cost you to prove up and obtain title to your land, and what was the length of time required? If any difficulties were encountered, state what they were?—Twelve dollars per acre.
14. What has your cultivated land cost you per acre? This to include cost of proving up, cost of ditches and laterals, expense of preparing land for cultivation, fencing, and all permanent improvements.—Thirty-two dollars per acre.
15. What is its present market value per acre?—Twenty dollars per acre.
16. Can you raise crops without irrigation? If so, state what they are and yields obtained?—No.
17. Do you think the present land laws are adapted to the conditions of this Territory; if not, what changes would you suggest?—No; every citizen that reclaims the land should have, in fee simple, a title to one section of land.
18. What should be done with grazing land which can not be irrigated? What is its value per acre?—Should be sold at 8 to 10 cents per acre, and each person to have not over two sections.
19. How do you regard the withdrawal of all irrigable public land from settlement during the irrigation survey?—Unfavorably, as it would stop all settlement of the Territory.
20. Do you favor the donation of all irrigable public land to the Territory?—I do.

Name, AUGUSTUS TRABING; county, Albany; post-office, Laramie.
1. How long have you resided in the Territory?—Twenty-one years.
2. In what year did you begin farming?—1886.
3. How much land have you under ditch?—Sold out; had 800 acres.
4. If obtained from the Government, state the filings which were made?—I bought it from the Wyoming Central Land and Improvement Company.
5. How many acres are now under cultivation?—Twenty acres. Rest in grass.
6. By what ditch or ditches is it watered?—Pioneer Canal.
7. From what stream or streams is water taken?—Big Laramie River.
8. Give history of construction of ditch:
(*a*) Name of owners —Pioneer Canal Company.
(*b*) Date begun and time occupied in building?—Completed in 1886.
(*c*) Dimensions: Length, 35 miles; depth, 4 feet; width, 16 feet.
(*d*) How many acres does it water?—Twenty thousand.
(*e*) What was the cost of construction?—Fifty thousand dollars.
(*f*) What is the cost per year for management and repairs?—Twelve hundred dollars.
9. Do you buy or sell water; if so, state price paid or received?—Buy; 50 cents per acre.
10. Have you all the water needed; if not, state the reason?—Did have.
11. What is the usual cost of bringing wild land under cultivation? This to include plowing, grubbing sage brush, fencing, etc.—Five dollars per acre.
12. How many years cultivation are required to bring wild land into proper condition for farming?—Three.
13. What did it cost you to prove up and obtain title to your land, and what was the length of time required? If any difficulties were encountered, state what they were?—I paid $10 per acre, as it was only 2 miles from Laramie, Wyo.
14. What has your cultivated land cost you per acre? This to include cost of proving up, cost of ditches and laterals, expense of preparing land for cultivation, fencing, and all permanent improvements?—Twenty dollars, but I made extensive improvements.

15. What is its present market value per acre?—Sold for $40 last May, with all stock and improvements, net about $30 per acre.

16. Can you raise crops without irrigation? If so, state what they are and yields obtained?—No.

17. Do you think the present land laws are adapted to the conditions of this Territory? If not, what changes would you suggest?—No. Let each man have a section of desert-land for homestead on reclamation.

18. What should be done with grazing land which can not be irrigated? What is its value per acre?—Give it to Territory, value about 25 cents.

19. How do you regard the withdrawal of all public land from settlement during the irrigation survey?—A withdrawal for one year is all right.

20. Do you favor the donation of all irrigable public land to the Territory?—Yes.

Name, C. W. Holden; county, Uinta; post-office; Fontenelle.

1. How long have you resided in the Territory?—Nearly thirteen years.

2. In what year did you begin farming?—1877.

3. How much land have you under ditch?—About 800 acres.

4. If obtained from the Government, state the filings which were made?—Homestead and pre-emption, desert, and timber-culture, also lease of school land.

5. How many acres are now under cultivation?—About 800 acres.

6. By what ditch or ditches is it watered?—Nos. 1, 2, 3, and 4.

7. From what stream or streams is water taken?—Fontenello.

8. Give history of construction of ditch:

(a) Names of owners—C. W. Holden.

(b) Date begun and time occupied in building?—No. 1 was commenced in 1878.

(c) Dimensions: Length, 4 miles; depth, 1 to 2 feet; width, 4 to 6 feet.

(d) How many acres does it water?—About 800.

(e) What was the cost of construction?—About $1 per rod.

(f) What is the cost per year for management and repairs?—Not far from $200.

9. Do you buy or sell water; if so, state price paid or received?—No.

10. Have you all the water needed; if not, state the reason?—Yes. Have had so far.

11. What is the usual cost of bringing wild land under cultivation? This to include plowing, grubbing sage brush, fencing, etc?—About $10.

12. How many years cultivation are required to bring wild land into proper condition for farming?—About two.

13. What did it cost you to prove up and obtain title to your land and what was the length of time required? If any difficulties were encountered, state what they were.—My homestead cost two usual fees and about $50 for incidental expenses; have not final proof on the other entries.

14. What has your cultivated land cost you per acre? This to include cost of proving up, cost of ditches and laterals, expense of preparing land for cultivation, fencing, and all permanent improvements.—Twelve dollars to fifteen dollars.

15. What is its present market value per acre?—Don't know.

16. Can you raise crops without irrigation? If so, state what they are and yields obtained?—No.

17. Do you think the present land laws are adapted to the conditions of this Territory? If not, what changes would you suggest?—Give the desert land to the man who reclaims and reduces it to cultivation upon final proof that he has done so.

18. What should be done with grazing land which can not be irrigated? What is its value per acre?—Lands not susceptible of irrigation are of little value for any purpose; after the water-courses are all fenced.

19. How do you regard the withdrawal of all public land from settlement during the irrigation survey?—It would virtually stop immigration and could ouly benefit wealthy grazers.

20. Do you favor the donation of all irrigable public land to the Territory?—Yes.

Name, Edwin C. Smith; county, Converse; post-office, Douglas.

1. How long have you resided in the Territory?—Since April 4, 1873; sixteen years.

2. In what year did you begin farming?—1881.

3. How much land have you under ditch?—Three hundred and twenty acres.

4. If obtained from the Government, state the filings which were made.—One hundred and sixty homestead, 160 pre-emption.

5. How many acres are now under cultivation?—Thirty plow, 50 hay, balance pasture.

6. By what ditch or ditches is it watered?—My own ditch.
7. From what stream or streams is water taken?—Laprelle Creek.
8. Give history of construction of ditch:

(*a*) Names of owners—First ditch made by Joseph Hornbeck in 1887; I bought and reconstructed it.

(*b*) Date begun and time occupied in building?—1881; have forgotten exact date when finished.

(*c*) Dimensions: Length, 2 miles; depth, 1 foot; width, 5 feet.

(*d*) How many acres does it water?—About 100 acres.

(*e*) What was the cost of construction?—Five hundred dollars.

(*f*) What is the cost per year for management and repairs?—Can't state exactly.

9. Do you buy or sell water; if so, state price paid or received?—Do not sell.

10. Have you all the water needed; if not, state the reason?—Have when ditch is in good order, sometimes have breaks in ditch.

11. What is the usual cost of bringing wild land under cultivation? This to include plowing, grubbing sage brush, fencing, etc.—About $10.

12. How many years cultivation are required to bring wild land into proper condition for farming?—Three.

13. What did it cost you to prove up and obtain title to your land and what was the length of time required? If any difficulties were encountered state what they were.—Distance from land office when filings were made; received every courtesy from officials of land office.

14. What has your cultivated land cost you per acre? This to include cost of proving up, cost of ditches and laterals, expense of preparing land for cultivation, fencing, and all permanent improvements.—About $12.

15. What is its present market value per acre?—Can't state, as no sales are being made.

16. Can you raise crops without irrigation; if so, state what they are and yields obtained?—No; sometimes potatoes, but very seldom.

17. Do you think the present land laws are adapted to the conditions of this Territory; if not, what changes would you suggest?—Haven't any suggestion to make; am satisfied with the present land laws.

18. What should be done with grazing land which can not be irrigated? What is its value per acre?—Leave them, as they are a benefit to the settlers for grazing purposes.

19. How do you regard the withdrawal of all public land from settlement during the irrigation survey?—Favorable; don't exactly understand it.

20. Do you favor the donation of all irrigable public land to the Territory?—Can't say.

Name, A. L. SUTHERLAND; county, Albany; post-office, Sherman.

1. How long have you resided in the Territory?—Eleven years.
2. In what year did you begin farming?—In 1881.
3. How much land have you under ditch?—One hundred and twenty acres.
4. If obtained from the Government, state the filings which were made.—Homestead and also railroad lands.
5. How many acres now under cultivation?—One hundred and thirty-five.
6. By what ditch or ditches is it watered?—Private.
7. From what stream or streams is water taken?—Dale Creek, Pump Creek, and springs.
8. Give history of construction of ditch.—It was begun in 1872, and lengthened from time to time.

(*a*) Name of owner.—A. L. Sutherland.

(*b*) Date begun and time occupied in building.—1872, time of building not known.

(*c*) Dimensions.—Length, 3 miles; depth, 2 feet; width, 3 feet.

(*d*) How many acres does it water?—Forty.

(*e*) What was the cost of construction?—Six hundred dollars.

(*f*) What is the cost per year for management and repairs? [No answer.]

9. Do you buy or sell water. If so, state price paid or received.—Do not sell.

10. Have you all the water needed? If not, state the reason.—Have not, as those who have taken out ditches about me use all there is at times.

11. What is the usual cost of bringing wild land under cultivation? This to include plowing, grubbing sage brush, fencing, etc.—Ten dollars.

12. How many years cultivation are required to bring wild land into proper condition for farming?—Two.

13. What did it cost you to prove up and obtain title to your land, and what was the length of time required? If any difficulties were encountered, state what they were.—Cost $72.60. Had the best of proof, but patent is delayed over three years. Has not arrived yet.

14. What has your cultivated land cost you per acre? This to include cost of proving up, cost of ditches and laterals, expense of preparing land for cultivation, fencing, and all permanent improvements.—Twelve dollars.

15. What is its present market value per acre?—Twelve dollars.

16. Can you raise crops without irrigation? If so, state what they are and yields obtained?—Can not.

17. Do you think the present laws are adapted to the conditions of this Territory? If not, what changes would you suggest?—That patents should be issued within six months after final proof.

18. What should be done with grazing land which can not be irrigated? What is its value per acre?—One dollar and seventy-five cents. Thrown open to all not fenced in with railroad land.

19. How do you regard the withdrawal of all public land from settlement during the irrigation survey?—I think there should be restrictions on it.

20. Do you favor the donation of all irrigable public land to the territory?—I do.

Name, J. F. ROCHE; county, Laramie; post-office, Wendover.

1. How long have you resided in the Territory?—Three years.

2. In what year did you begin farming?—1886.

3. How much land have you under ditch?—Three hundred acres.

4. If obtained from the Government, state the filings which were made?—Homestead and desert.

5. How many acres are now under cultivation?—Fifty.

6. By what ditch or ditches is it watered?—Jumbo.

7. From what stream or streams is water taken?—Cottonwood Creek.

8. Give history of construction of ditch:

(*a*) Name of owner.—J. F. Roche.

(*b*) Date begun and time occupied in building.—September, 1886. Completed in 1887.

(*c*) Dimensions.—Length, 2½ miles; depth, from 1 to 8 feet; width, 8 feet.

(*d*) How many acres does it water?—Covers about 300 acres, but water is insufficient.

(*e*) What was the cost of construction?—Five hundred dollars.

(*f*) What is the cost per year for management and repairs?—Twenty-five dollars.

9. Do you buy or sell water? If so, state price paid or received.—No.

10. Have you all the water needed? If not, state the reason.—No water in the stream after about July 1.

11. What is the usual cost of bringing wild land under cultivation? This to include plowing, grubbing sage brush, fencing, etc.—Six dollars.

12. How many years cultivation are required to bring wild land into proper condition for farming?—Three years.

13. What did it cost you to prove up and obtain title to your land, and what was the length of time required? If any difficulties were encountered state what they were.—Not proved up.

14. What has your cultivated land cost you per acre? This to include cost of proving up, cost of ditches and laterals, expense of preparing land for cultivation, fencing, and all permanent improvements.—Six dollars.

15. What is the present market value per acre?—No fixed value.

16. Can you raise crops without irrigation? If so, state what they are and yields obtained.—Yes; have raised corn, wheat, oats, alfalfa, potatoes, and vegetables.

17. Do you think the present land laws are adapted to the conditions of this Territory? If not, what changes would you suggest?—No. I should suggest that all lands redeemable by irrigation should be given to parties redeeming the same without the necessary $1.25 per acre.

18. What should be done with grazing land which can not be irrigated? What is its value per acre?—Should be leased to settlers at nominal figures.

19. How do you regard the withdrawal of all public land from settlement during the irrigation survey?—Do not think it proper.

20. Do you favor the donation of all irrigable public land to the Territory?—Yes.

Name, HAINES BROS.; county, Carbon; post-office, Saratoga.

1. How long have you resided in the Territory?—Six years.

2. In what year did you begin farming?—1883.

3. How much land have you under ditch?—Two thousand five hundred acres.

4. If obtained from the Government, state the filings which were made?—Desert and pre-emption filings.

5. How many acres are now under cultivation?—About 250.

6. By what ditch or ditches is it watered?—Haines Ditch and other small ditches.

7. From what stream or streams is water taken?—North and South Spring Creek.

8. Give history of construction of ditch:

(*a*) Names of owners.—J. G. Haines, H. W. Haines, and M. Haines.

(*b*) Date begun and time occupied in building?—May 1, 1885; time, four months.

(*c*) Dimensions.—11 by 8 by 2; length, 11 miles; depth, 2 feet; width, 11 feet. Five miles of this ditch on a grade of 4 feet to the mile is of above dimensions; 3 miles natural water course; balance, owing to heavier grades, smaller.

(*d*) How many acres does it water?—Two thousand.

(*e*) What was the cost of construction?—Four thousand dollars.

(*f*) What is the cost per year for management and repairs?—Fifty dollars.

9. Do you buy or sell water? If so, state price paid or received.—No.

10. Have you all the water needed? If not, state the reason.—During high water have plenty, but last of the season not enough water in creek to fill ditch.

11. What is the usual cost of bringing wild land under cultivation? This to include plowing, grubbing sage brush, fencing, etc.—From $5 to $10 per acre.

12. How many years cultivation are required to bring wild land into proper condition for farming?—Most land a fair crop first year.

13. What did it cost you to prove up and obtain title to your land and what was the length of time required? If any difficulties were encountered, state what they were.—Cost, $1.25 per acre, with addition of advertising and agents' fees.

14. What has your cultivated land cost you per acre? This to include cost of proving up, cost of ditches and laterals, expense of preparing land for cultivation, fencing, and all permanent improvements.—Ten dollars per acre.

15. What is its present market value per acre?—Thirty dollars per acre.

16. Can you raise crops without irrigation? If so, state what they are and yields obtained.—No.

17. Do you think the present land laws are adapted to the conditions of this Territory? If not, what changes would you suggest?—Let them remain as they are.

18. What should be done with grazing land which can not be irrigated? What is its value per acre?—Left open to the public. Varies from nothing up.

19. How do you regard the withdrawal of all public land from settlement during the irrigation survey?—Do not regard it favorably.

20. Do you favor the donation of all irrigable public land to the Territory?—No.

Name, ED B. CHAPLIN; county, Johnson; post-office, Buffalo.

1. How long have you resided in the Territory?—At intervals since 1867. Continuously thirteen years.

2. In what year did you begin farming?—In Wyoming in 1879.

3. How much land have you under ditch?—About 200 acres, originally 320 acres.

4. If obtained from the Government, state the filings which were made.—Desert.

5. How many acres are now under cultivation?—One hundred and eighty nearly; garden 20, hay 160.

6. By what ditch or ditches is it watered?—Snider Ditch No's 1 and 2, Four Lakes and French Creek Ditches and Flume Company's.

7. From what stream or streams is water taken?—Clear fork of Powder River and French Creek.

8. Give history of construction of ditch:

(*a*) Names of owners, Snider Ditch No. 1, E. M. Snider and myself; Four Lakes and French Creek O. J. Wastman, R. S. Hopkins, H. R. Mann, F. Meyers, P. Georgen.

(*b*) Date begun and time occupied in building?—Three months; three and a half months.

(*c*) Dimensions: 5 feet, 10 feet; length, 3 miles, 1½ miles; depth, 2 feet, 2½ feet; width, top, 9 feet, top, 15 feet.

(*d*) How many acres does it water?—Seven hundred acres. Don't know how many acres Four Lakes and French Creek Ditch waters, but think about 5,000 acres.

(*e*) What was the cost of construction?—Snider No. 1, $600; Four Lakes and French Creek, about $1,000.

(*f*) What is the cost per year for management and repairs?—Snider No. 1, about $50; Four Lakes and French Creek, $350.

9. Do you buy or sell water; if so, state price paid or received?—[No answer.]

10. Have you all the water needed; if not, state the reason?—Have this season had all the water needed, but not in former years at times, because it was appropriated by parties above me, who had no right to it.

11. What is the usual cost of bringing wild land under cultivation? This to include plowing, grubbing sage brush, fencing, etc.—Ordinary hay land $12 to $25 per acre, garden $150 approximated.

12. How many years cultivation are required to bring wild land into proper condition for farming?—Three to five.

13. What did it cost you to prove up and obtain title to your land and what was the length of time required? If any difficulties were encountered, state what they were?—Actual cost was $550 to get final receipt. Have not received patent yet, although I proved in May, 1883.

14. What has your cultivated land cost you per acre? This to include proving up, cost of ditches and laterals, expense of preparing land for cultivation, fencing, and all permanent improvements.—Thirty-two dollars and sixty three cents per acre.

15. What is its present market value per acre?—About $50.

16. Can you raise crops without irrigation? If so, state what they are and yields obtained?—Nothing without water.

17. Do you think the present land laws are adapted to the conditions of this Territory? If not, what changes would you suggest?—[No answer.]

18. What should be done with grazing land which can not be irrigated? What is its value per acre?—Should lease to stockmen. It is very difficult to fix value.

19. How do you regard the withdrawal of all public land from settlement during the irrigation survey?—If the survey does not continue too long lands should be withdrawn to guard against speculation in reservoir sites

20. Do you favor the donation of all irrigable public land to the Territory?—I do.

Name, **Chas. A. Pollard**, county of Converse; post-office at Labonte.

1. How long have you resided in the Territory?—Twelve years.

2. In what year did you begin farming?—In 1878.

3. How much land have you under ditch?—Six hundred acres.

4. If obtained from the Government, state the filings which were made.—Pre-emption No. 1341, November 10, 1883; settlement made in spring of 1883, 160 acres; desert filing No. 633 in 1883; number of acres proved upon three years afterwards, in summer of 1886, 440 acres.

5. How many acres are now under cultivation?—About 400 acres.

6. By what ditch or ditches is it watered?—By Labonte Road Ranch Ditch No. 1 and Labonte Road Ranch Ditch No. 2.

7. From what stream is water taken?—From the main Labonte Creek.

8. Give history of construction of ditches.—Labonte Road Ranch Ditch No. 1 was begun in 1880 and partly completed and water run through it in the spring of 1883, but the ditch and ditch-head was very unsatisfactory at that time, owing to the fact that none of the excavation was "down to grade" and would only carry water during a "stage of high water." At this juncture my associate and myself purchased the ditch and entire ranch property and all improvements, paying $5,000 in cash for same. The parties we purchased from had made no land entries up to that time, but they were about to do so. Since the date of our purchase in 1883 we have enlarged No. 1 ditch, put it "down to grade," and kept it in constant repair at a very heavy annual cost, and it is now a permanent ditch, as all banks are grass grown.

Labonte Road Ranch Ditch No. 2 was commenced in the fall of 1883 and work has been done constantly upon it up to date, and the ditch has been in operation about one-half the time since the spring of 1885, and it is now in perfect order, but requires constant labor at a heavy expense to keep it in condition.

(*a*) Name of owners—Charles A. Pollard and Sophia E. Pollard.

(*b*) Date begun and time occupied in building—1880 and 1883. All of two years and three years.

(*c*) Dimensions—5 by 2 feet; length, about 12 miles; depth, 2 feet; width, 5 feet on bottom, 8 feet at top.

(*d*) How many acres does it water?—The two ditches will water more than 1,500 acres.

(*e*) What was the cost of construction?—The original cost per mile was over $250 per mile at a rate of 16 cents per cubic yard for earth; 25 cents per cubic yard for gravel; 35 cents per cubic yard for bowlders and all loose stone; $1 per cubic yard for all solid rock. Since the ditches were completed it has cost double the above amount to maintain them and to repair them.

(*f*) What is the cost per year for management and repair?—All the way from $50 to $150 per mile, according to the number of "water spouts" and "cloud bursts" that happen to strike the banks.

9. Do you buy or sell water? If so, state price paid or received.—We have sold some water at $1 per acre per annum for land actually irrigated during the season. We have also sold some other water at about the same rate.

10. Have you all the water needed?—Yes, during the irrigating season.

11. What is the usual cost of bringing wild lands under cultivation? This to include plowing, grubbing off sage brush, fencing, etc.—Anywhere from $10 to $25 per acre. Any kind of reclamation will cost $10 per acre.

12. How many years are required to bring "wild land" into a proper condition for farming?—From three to six years, according to the sage brush, alkali, prickly pear, and general character of the soil and "lay of the land." If very gravelly and sandy it requires time for the sediment or wash in the water each spring to flow out upon the sand and gravel and form a soil that can not be excelled by any known process of fertilization. Say six years for this latter kind of land, and after the six years I firmly believe the land could be successfully cropped to the same product each and every year forever, as the soil is constantly renewed by the rich sediment or wash that comes down the stream with the spring freshets.

13. What did it cost you to prove up and obtain title to your land and what was the length of time required? If any difficulties were encountered state what they were?—I made final proof upon my land entries under very great hardships, such as travel overland through heavy snows and storms more than 138 miles to the then nearest land office, viz, Cheyenne; at great expense for road ranch bills en route for myself and witnesses, and, as all the witnesses were taken from their daily labor at their homes, I naturally had to pay them for the time consumed going to and coming from Cheyenne land office. My pre-emption proof cost not less than $400, my desert proof cost not less than $640. This includes the money paid to Government and cost of time paid for, and cost of transportation of all witnesses to Cheyenne land office and return, and advertising land proof, and expense en route and at Cheyenne. I was also subject to a four days' delay at Cheyenne after we had supposed the officials were all through, by their demanding a "copy of my marriage certificate," which at that time was hard to procure. As yet I have no land title other than the final receipt. It took about three years.

14. What has your cultivated land cost you per acre?—Not less than $20 per acre for the best, and all of it has exceeded a cost of $10 per acre.

15. What is the present market value per acre?—No land in this part of the country having changed hands at any price for a long time, owing to the uncertainty of our ever seeming to be able to secure titles and a consequent depressed state of affairs with all land entry men, it is impossible for any one to state any price with any kind of certainty, but I should judge any land thoroughly reclaimed and under a ditch to be worth $30 to $40 per acre.

16. Can you raise crops without irrigation?—No, most assuredly. No one can raise a crop or anything like a crop without irrigation, and after a residence of twelve years I have yet to see the crop raised without irrigation any where in Wyoming, and I have tried each and every season for twelve seasons. The trouble with our fair Territory is, that all the reports about raising crops without irrigation are made by the ever increasing majority of new-comers who are always welcome to our arid land, but with them the wish is "father to the thought" or rather belief (for they honestly believe so), for about all sections of our Territory put on a "splendid mantle of green" along in April and May, each year, but in June and July it all turns to a "golden yellow" invariably long before maturity.

It can not be termed a drought for it is the rule and not the exception; perhaps once in five years or once in three years a few potatoes or a small garden can be grown or partly grown without irrigation along some mud bar or bank, too, or island in the stream, but all such crops or so-called crops are irrigatad naturally and not grown by rain-fall by any means. During the year 1883 a good crop could no doubt have been raised by rain-fall in certain parts of Wyoming. But as the farmer can not possibly tell in advance what the rain-fall for the coming season will be, and as whenever there is sufficient rain-fall it only happens once in five years, it is utterly impossible to depend upon anything other than artificial irrigation, except in some of the mountain parks where there are such heavy winter snows that they melt very late in the spring and the ground there stays moist until after the middle of July, but here the crops fail, too, as often as they succeed.

17. Do you think the present land laws adapted to the conditions of the Territory?—No, I certainly do not think the laws are adapted to the conditions of our Territory or to anything like it to a small degree.

Among the changes I would suggest are, to allow each individual, reclaiming land in a bona fide manner, to enter 2,000 acres or less. This amount should be so allowed him to secure the cost and maintenance of the ditches and as an incentive to build the ditches. In other words, give title to 2,000 acres or less of good irrigable land as a premium to any one reclaiming, in order to partly re-imburse the entry man for the extraordinary cost of, and what is more important the maintenance of the ditches in the future years.

Let the State or Government officials determine by actual survey all the worthless hill-tops and other lands lying too high and rough to ever have water conducted upon them by any means, and when this fact is positively ascertained allow the entry man as a free gift five acres (of all such worthless land and hill-tops lying adjoining to his good irrigable land) for each and every acre of land actually reclaimed, provided such worthless land must lie adjoining his 2,000 acres or less of irrigable land, on each side or along on one side and provided further, the entry man to pay Government the real cost of all such surveys. Also to allow all companies or corporations each alternate section of land (along under any ditch or canal) actually reclaimed by said company or corporation.

I am aware that the changes suggested by me as above will be looked upon with suspicion by some good people, but it must be remembered that these good people know nothing at all about what is really necessary to a successful reclamation of our arid Territory, and it is, to say the least, very unfair that they should have anything at all to say in the premises until after a residence of three to five years, engaged at an actual effort to cultivate the soil.

As the land is, in its natural state, it must lie forever worthless for ages. By a liberal policy, and allowing land enough to be entered to make it an inducement to capital to reclaim it, poor men will be constantly employed, and by their employment will be able to subsist and carry out in their turn their own plans and land entries on a smaller scale and in accordance with their means, whereas, as it now is, the poor man must obtain employment from some source or fail in his land entry entirely, as witness the many changes from one entry to another entry upon the same piece of land without attempting to prove up at all, thus exhausting two rights upon really one entry. And then, too, without any assurance that they will be any better able to prove up at the expiration of the second entry.

Allow no alien to enter any land until he has been a law-abiding citizen for five years, but allow any alien to acquire any lands by purchase from citizens, if he continues or keeps up the reclamation of such land by water.

Allow no contests for the right to enter lands or for the possession of title to same under any circumstances until three years after the original entry man had either failed to prove up or had really and actually abandoned his claim. Let all parties who have acquired a so-called title to land or any kind of a pretended possessory right whatever to improvements thereon or to the land or any part thereof "by contests" without first recognizing the original entry man, be forever barred and deprived of all their land rights as now existing or that may hereafter exist under the laws of our country.

I would modify the present land laws as they now stand by not requiring any actual residence upon any of them, but in lieu thereof insert a clause making the reclamation of all of the rights to lands by water compulsory, and not require any actual residence upon any of the claims where they had been honestly reclaimed with water. By honest reclamation of the land is meant the ownership by purchase or of appropriation of about 1 cubic foot flow of water per second of time for each 100 acres during the irrigating season, viz, during the months of May, June, and July, each year.

The central and best part of our Territory is traversed for its entire length by the "old Mormon trail," made when they left Nauvoo, Ill., more than forty-four years ago. Here, over the same old route, the California gold-hunters first traveled. Also the pony mail, and then the telegraph line to San Francisco, and afterwards Wells, Fargo & Co.'s overland stages.

The hundreds of mountain streams and small watering places, all crossed by this trail, all bear the plainest kind of evidence of having been quite thickly settled more than thirty years ago—old wells and old cabin foundations and stone chimneys all gone to decay, places where they had plowed for gardens and for grain, and some of the streams have from twenty-five to fifty graves scattered along their banks. There is almost any amount of evidence that Wyoming from the east to the west, through its entire length and best part, was all at one time fairly well settled upon its many streams more than thirty years ago. The question naturally arises why did not these old settlers stay upon their lands if crops can be grown without irrigation?

There are quite a number of people living in the Territory to-day who have been here from thirty to forty-five years, and it will be found upon investigation that all these old settlers have made their living in many other ways than by cultivating the soil. It is very doubtful if a resident of Wyoming can be found to-day who has, strictly speaking, taken his living from the soil for from three to five years, either with or without irrigation. They have all been trappers, hunters, employés of the Government, or had cattle, horses, or sheep, have been miners or freighters, any and everything other than tillers of the soil. The many hundreds of "deserted hearthstones" scattered all along the many water-courses of the Territory everywhere ought to convince the most skeptical that the desert-land entry man of to-day is right, and that our wise land-law-makers at Washington made no mistake on the side of liberality. The fact stands forth patent to all who are willing to make observations of the plainest character, that to remove our desert-land entry men and the cattle industry from our midst the Territory must go back and become comparatively deserted again by its people as it once was thirty or forty years ago.

Should the Government allow the entry man 2,000 acres of the best irrigable land at each filing, it is very doubtful then if the entry man would have anything like 500 acres of available land for cultivation. Will any one say it is right and justice to allow 480 acres of good agricultural land to be entered in the humid regions under the three old land rights of homestead, pre-emption, and timber-culture, and not allow an equal amount entered in the arid region? The entry man in Wyoming should have four times as much land as elsewhere.

18. What should be done with the grazing land which can not be irrigated; what is the value per acre?—All grazing lands and other worthless lands adjoining any good irrigable land actually reclaimed should be given to the land entry man adjoining at the rate of 5 acres of all such grazing land for each and every acre of irrigable land actually reclaimed by said entry man, provided the entry man pays the Government the actual cost of survey of such grazing land. The balance of the grazing lands that are left upon the hands of the Government should be leased to the highest bidder for cash for a period of five to ten years, with the privilege of a renewal of the lease at its expiration at the same rate if desired and there is no higher bid meantime. Grazing lands are worth from 5 to 50 cents per acre, and there are thousands of acres of such land that are entirely worthless and will probably always remain so, owing to their sterility and roughness.

19. How do you regard the withdrawal of all public lands from settlement during the irrigation survey?—If the lands can be restored to entry under our present land laws again after they are so withdrawn or after the irrigation surveys are completed I certainly should be very much in favor of withdrawing all lands from entry, or if the lands can be restored to entry under a more liberal system of laws than we now have, I certainly should favor the withdrawal. But if they can only be restored to entry under the homestead law, and that, too, with a new requisite for an actual residence of seven years, I certainly should think it unwise to add that increased hardship, and should not by any means favor their withdrawal in the last case. The desert-land law as it now stands is by far the wisest law ever passed by Congress, not excepting any of them, and it should not be touched at all unless to allow more access to the entry man and the land to conform in a body to the entry man's ditch as regards grade of ditch.

We have in the "far West" a very large class of migratory citizens who do nothing but travel overland from some of the older States to Washington Territory this year, and from there to Montana the second year, and from Montana to New Mexico the third year, and so on, the greater part of their lives. Constantly on the move, over thousands of miles of wagon-roads, and they subsist upon and live off the broad generosity of their settled countrymen generally. If they do happen to settle down upon a claim they do not as a rule stay longer than six months or a year. This class would certainly give the Irrigation Survey trouble if the lands were open to settlement by coming in by the thousands to get a location long before the Government was ready, and this is the class, too, that gives the honest entry man any amount of worry and vexation by always putting in an appearance and wanting no other land only such as has been filed upon in good faith, and also by writing constant complaints to the officials at Washington.

It is my belief that for every bona fide settler now occupying public lands there are twenty-five of this migratory traveling class, on the move. And if, as is said to be the case, the Eastern people generally are opposed to the rapid settling up of the West, I beg to respectfully call your attention to the state of affairs all over the far West.

In a country where less than seven years ago was an entire vast wilderness from old Mexico to the British possessions and from the Missouri River to the coast, with the exception of a narrow strip along the Northern Pacific Railway and small parts of Texas and Colorado. I repeat that a very short time ago all, or about all, of this vast stretch of country was uninhabited except by Indians and some military posts, and is now completely overrun with people and towns, cities, and villages, railroads, civilization, and the honest settler can be seen upon any stream, brook, and little spring of water, go where one may, all over this vast far West. Oklahoma is a case in point, viz, 10,000 settlers to 10,000 land entries.

Let me say that the land legislators of our beloved country at Washington have made no mistake in so far as they have got. They certainly "builded better than they knew," but as applied to this arid country they did not go far enough. They certainly were not liberal enough. In other words, the wise and liberal provisions of our generous land law-makers at Washington could hardly be broad enough and liberal enough, so long as the many wide gates of our Castle Garden stood for so many years wide open to all the world.

Let us shut them up tight before it is too late, and bar them shut, too, with the strong bars of protection, and remember the old principle of "first come, first served." If by any chance any of our land entry men should acquire too much land, the evil of it is imaginary, as it will cure itself if let alone, and as soon as they have acquired title they will dispose of it reclaimed. Unreclaimed, it will never be disposed of or benefit any one.

If the desert-land entry man made any mistake at all it was in not stopping to consider the value his capital and vast labor would give to a hitherto lot of worthless land, and consequently came a grand rush of people to all try and do the same thing in a country where for more than thirty years, the Government at Washington had asked the oft repeated question of what shall be done to cause the arid country to become an agricultural country, and at last, after many repeated inquiries and long years, the cattle industry has answered that question and answered it fully, and as a man naturally loves the country where he has succeeded in gaining a competence so the capital was forthcoming to build the irrigation ditches and canals. But it must not be forgotten that Bill Nye spoke the truth when he said, "It takes a great many acres of thin grass to make a fat beef steer," and it also requires large capital and any amount of the hardest kind of labor to reclaim desert land.

20. Do you favor the donation of all irrigable public land to the Territory?—Most assuredly I do favor the donation of all irrigable public land to the Territory, for then we should all stand some sort of a show of having justice done to a long-suffering and most patient lot of land-entry men the world has ever known. If the Territory owned all the lands the Territorial officials would (no matter of what political party or creed) be the judges of our wants and needs, and we should stand a fair show at least; whereas now the average man from any other section of our country knows nothing at all about our wants and seemingly can't be made to understand us, and really he can't be expected to help us until after a residence of from three to five years, trying to reclaim some of our arid lands and then, when he is won over (as they all are), his voice is drowned too by the ever-increasing majority of new-comers.

Incorporated Water Companies of Wyoming.

[Furnished by the secretary of the Territory.]

Name.	Principal office or place of business.	Date of incorporation.
The Wyoming Ditch and Water Company	Cheyenne	July 9, 1869
The Laramie Water and Ditch Company	Laramie	Mar. 27, 1871
Do	do	Sept. 12, 1874
The Albany County Ditch Company	do	Oct. 1, 1874
The Big Laramie River Water Company	do	Apr. 28, 1875
The Evanston Ditch and Water Company	Evanston	July 27, 1878
Pioneer Canal Company of Albany County, Wyo	Laramie	Apr. 22, 1879
Laramie River Ditch and Water Company, No. 1	do	June 19, 1879
The Rocky Mountain and Bear River Ditch Company	Almy	Aug. 19, 1879
Union Ditch and Water Company, of Albany County, Wyo	Cheyenne	Jan. 8, 1881
The Jack Creek Irrigating Company	Warm Springs	June 14, 1881
The Utah and Idaho Land and Irrigation Company	Evanston	Dec. 23, 1881
Hurlbut Creek Ditch Company	Johnson County	Jan. 25, 1882
The Upper Goose Creek Ditch and Irrigating Company	do	do
White and Jackson Creek Ditch Company	do	Mar. 8, 1882
Big Piney and Prairie Dog Ditch and Tunnel Company	do	Apr. 3, 1882
Trabing Creek Ditch Company	do	Aug. 14, 1882
North Piney and Prairie Dog Irrigating Canal and Tunnel Company	do	Aug. 21, 1883
The Wyoming Five-Mile Ditch Company	Bingham	Aug. 23, 1882
Upper East Side Goose Creek Ditch and Irrigating Company	Johnson County	Nov. 13, 1882
Chugwater Ditch Company	Cheyenne	Dec. 9, 1882
East Side Ditch and Irrigating Company	Johnson County	Dec. 11, 1882
Wyoming Development Company	Cheyenne	May 17, 1883
Helman Ditch and Irrigation Company	Laramie County	June 18, 1883
Wyoming Development Company	Cheyenne	Aug. 10, 1883
Rutledge and Hellman Ditch Company	do	Aug. 21, 1883
The North Platte Irrigation and Ditch Company	Fort Collins, Colo.	Sept. 22, 1883
Goshen Hole Ditch Company	Cheyenne	Oct. 3, 1883
The McKuen Ditch and Reservoir Company	do	Oct. 5, 1883
The North Platte Irrigation and Ditch Company	Fort Collins, Coloe	Oct. 12, 1883
Little Horse Creek Irrigating Company	Cheyenne	Nov. 1, 1883
Bordeaux Ditch Company	do	Dec. 29. 1883
The Deer Creek Canal and Improvement Company	Laramie	Jan. 15, 1884
Prairie Dog Water Supply Company	Sheridan	Jan. 19, 1884
The Sherman & Wood Ditch Company	Big Horn	Feb. 18, 1884
The Horse-shoe Creek No. 1 Ditch Company	Laramie County	Feb. 28, 1884
Springvale Ditch Company	Cheyenne	Mar. 10, 1884
The Lodge Pole Ditch and Reservoir Company	do	Mar. 22, 1884
The Gordon Ditch Company	do	Apr. 10, 1884
Clear Creek Land and Ditch Company	Buffalo	Apr. 22, 1884

Incorporated Water Companies of Wyoming—Continued.

Name.	Principal office or place of business.	Date of incorporation.
The Crow Creek Ditch and Reservoir Company	Cheyenne	Apr. 25, 1884
Gall and Culver Ditch Company	do	Apr. 26, 1884
The Phillips Ditch Company	do	May 9, 1884
The South Side Ditch and Reservoir Company	do	May 20, 1884
J. H. Gordon Ditch Company	do	Aug. 26, 1884
The Cloud Peak and French Creek Ditch Company	Johnson County	Aug. 30, 1884
Beaver Dam Ditch Company	Cheyenne	Oct. 1, 1884
The Organ Ditch Company	do	Oct. 4, 1884
Bear Creek Ditch Company	do	Oct. 13, 1884
The North Lodge Pole Ditch and Reservoir Company	do	Nov. 12, 1884
The Whitehead Ditch Company	do	Dec. 22, 1884
The North Platte Irrigation and Ditch Company	Fort Collins, Colo.	Jan. 23, 1885
The Rawhide Irrigation Company	Cheyenne	Feb. 14, 1885
Little Medicine Bow and Richard Creek Irrigating Ditch Company	do	Feb. 27, 1885
The Payson Hutchinson Ditch Company	do	Feb. 28, 1885
Mead Ditch Company	Big Horn	Mar. 10, 1885
The South Spring Creek Irrigation Company	Carbon County	Mar. 16, 1885
Ontario Water, Ditch and Irrigating Company	Cheyenne	Mar. 25, 1885
Goshen Hole Irrigation Company	do	Mar. 27, 1885
The Little North Fork Ditch Company	Buffalo	Mar. 28, 1885
South Clear Creek Ditch and Flume Company	do	Apr. 3, 1885
North Laramie Ditch Company	Cheyenne	Apr. 4, 1885
Big Goose and Soldier Creek Ditch Company	Johnson County	Apr. 9, 1885
Piney Prairie Dog and Mead Creek Irrigating Company	do	Apr. 11, 1885
North Crow Ditch Company	Cheyenne	Apr. 20, 1885
The Four Lakes and French Creek Ditch and Flume Company	Buffalo	May 8, 1885
The Lake DeSmet Ditch Company	do	May 28, 1885
The Central Ditch Company	do	June 18, 1885
The Willow Creek Ditch Company	Cheyenne	Aug. 5, 1885
Hillsdale Irrigating Company	do	do
Agricultural Ditch Company	do	Aug. 8, 1885
La Bonte Ditch Company	Albany	Aug. 31, 1885
Wagon Hound Ditch Company	Cheyenne	Sept. 1, 1885
Tongue River Ditch Company	Johnson County	Sept. 5, 1885
Muddy Creek Ditch Company	Cheyenne	Oct. 5, 1885
Hereford Home Ditch Company	do	Oct. 7, 1885
Bates Creek Irrigating Ditch Company	do	Oct. 12, 1885
The Bresnahen Ditch Company	do	do
La Prele Ditch Company	do	Oct. 13, 1885
Big Goose and Beaver Ditch Company	Sheridan	Oct. 16, 1885
The Maverick Ditch Company	Cheyenne	Oct. 17, 1885
Big Horn Ditch Company	do	Oct. 21, 1885
The Willow Creek Ditch Company	do	Oct. 29, 1885
The East Beaver Ditch Company	do	Oct. 30, 1885
The Blue Grass Ditch Company	do	Dec. 4, 1885
North Bear Ditch Company	do	Dec. 12, 1885
Colorado Colony Ditch Company	do	Dec. 29, 1885
Valley Ditch Company	do	Dec. 30, 1585
The North Fork and French Creek Ditch Company	Buffalo	Jan. 2, 1886
Fetterman Ditch Company	Cheyenne	Jan. 4, 1886
The McDonald Ditch and Irrigating Company	Chugwater	Jan. 25, 1886
Silver Crown Ditch Company	Cheyenne	Feb. 8, 1886
Muddy Creek Ditch Company	do	Feb. 26, 1886
The Butte Ditch Company	do	Mar. 6, 1886
Darlington Ditch Company	Fort Laramie	Mar. 10, 1886
Fetterman Ditch Company	Fort Fetterman	Apr. 6, 1886
The Forney Ditching Company	Saratoga	Apr. 6, 1886
Laramie Peak Ditch Company	Denver, Colo	June 5, 1886
Little Box Elder Ditch Company	Cheyenne	June 16, 1886
The Douglas Ditch and Water Company	Douglas	June 17, 1886
Colorado Ditch and Reservoir Company	Cheyenne	June 19, 1886
Niobrara Ditch Company	Lusk	July 2, 1886
Union Ditch Company	Cheyenne	July 14, 1886
The Big Sandy Colony and Canal Company	Green River	July 23, 1886
Home Irrigation Company	Cheyenne	Aug. 23, 1886
South Clear Creek Ditch and Flume Company	Buffalo	Aug. 31, 1886
The Piney Divide Ditch Company	Johnson County	Oct. 30, 1886
The Highland Ditch and Water Company	Dixon	Nov. 11, 1886
Enterprise Irrigating Company	Saratoga	Mar. 8, 1887
Rialto Ditch Company	Cheyenne	Mar. 12, 1887
The Moss Irrigating Canal Company	Dixon	Mar. 31, 1887
The Belle Fourche Irrigation Ditch Company	Sundance	June 20, 1887
The Fort Laramie Irrigating Canal Company	Fort Collins, Colo.	June 27, 1887
The Mead Ditch Company	Fort Laramie	Oct. 31, 1887
The Baggs Ditch Company	Baggs	Jan. 12, 1888
The Murphy-Collins Ditch Company	Laramie	Aug. 11, 1888
Glenrock Land and Canal Company	Glenrock	Mar. 20, 1889
The Crown Ditch Company	Buffalo	Apr. 5, 1889
The Mammoth Canal and Improvement Company	Green River	June 10, 1889

STATEMENT OF STEPHEN W. DOWNEY, OF LARAMIE.

With the mass of statistics before you, it is hardly necessary that I should dwell upon the practical benefits of irrigation, as that point has been fully examined by your committee; but I desire to suggest some plan of action in reclaiming the vast areas of sterile lands in the Rocky Mountain region and on the plains to the east of it.

Government land is becoming scarce, and it is a serious question what to do with our surplus population and how to preserve the equilibrium between the thinly and thickly settled portions of our common country. The nations of the Old World have been compelled to resort to vast and expensive schemes of colonization in order to provide for the excess of their population, and it will be but a short time, probably before the twentieth century arrives, when this question must be met by the Congress of the United States, as we have but little vent for our restless and enterprising population. The only solution is to render available the vast domain which at present lies sterile and useless to the home-seeker, who can not have means sufficient to secure water for the thirsty soil, which he could cultivate and upon which he could establish his home. I believe it to be the duty of Government to assist him and those who will accompany him in finding a home and in the consequent development of the country. There is surely sufficient warrant in this action, as Congress has for decades expended vast sums of money in the improvement of rivers and harbors, in protecting the lands adjacent to the Mississippi River from overflow, in providing for the reclamation of swamp-lands, and in a multitude of directions.

Either one of two plans should be adopted.

(1) Congress should appropriate yearly a considerable sum of money to the purpose of establishing reservoirs, diverting useless waters to streams where irrigation is practicable, and take upon itself the reclamation of the arid lands. Where the streams have deep beds and precipitous banks, and where the land through which they flow can not be made susceptible of irrigation, the waters should be diverted to streams and sections where the water can be made available for irrigation. If this plan be adopted, the Government could part with its lands at an enhanced price, covering the outlay and a reasonable compensation over the cost of constructing reservoirs and maintaining a system of reclamation, and thus recoup the amount expended.

(2) If this plan is not deemed feasible, the lands should be donated to the State, Territory, or county within whose limits the same are, for the purposes of reclamation, with authority to issue bonds for reclamation purposes, to be paid from the proceeds of the rental or sale of these lands, under a maximum and minimum price.

In either of these cases, so far as is possible, the purchase of lands by any one individual, association of persons, or corporation, should be limited in extent, and safeguards should be established, which shall prevent the absorption of these lands by speculators. This limit should not be less than one section of land for agricultural purposes, with a larger area for grazing purposes.

I can not imagine any other methods by which this great domain can be settled and its settlers made prosperous. There will always be a home market for the products of the soil, and with the increase of our population the surplus will all be needed at home.

The great stride in the right direction made by the passage of the homestead law would be supplemented by this step. We must do something to satisfy the land hunger of the people. It is conceded that the most intelligent, prosperous, and valuable portion of our communities is the farmers. What the peasantry is to France, its great conservative and moral class, the tillers of the soil are to this nation.

The rapid increase of population at our commercial centers, composed largely of wage-workers and those who are dependent upon the employment of others, creates a class which, being dependent, will be discontented and subject to the wind of doctrines and the appeals of doctrinaires, and the stability of our Government and the permanency of our institutions and the preservation of our Government must rest in the future, as it has in the past, with the agricultural classes of the country. While all branches of the industries have been protected by Congress and guarded to the utmost by the Government, the great farmer class of the country have received but little aid compared to the efforts which have been put forth on behalf of the commercial and manufacturing interests of the country.

The present time is most propitious for this undertaking on behalf of the Government, and it is but in harmony with the generosity of the Government towards the people of the Territories. A continuation of this policy would achieve grander results and afford an outlet to our rapidly-increasing numbers, increase our wealth and the prosperity of the country, and found in the shadows of the mountains a mighty empire, whose sons in time of war would defend their generous mother with their service, savings, and blood.

ADDITIONAL STATEMENT OF CHARLES H. BURRITT

[As corresponding secretary for Johnson County Mr. Burritt prepared the following for the Territorial Board of Immigration. It was submitted to the committee and ordered filed:]

Only a few years ago agriculture in Johnson County was not considered an industry worthy of consideration. This was the fact in 1881, as the following figures of assessed valuation for that year show:

Cattle in 1881	$1,047,688
Lands in 1881	34,485

The great distance from railroads and the demand for vegetables and grain for home consumption forced the people to experiment with crops. The result was startling, and the sequel was that the business of farming became a leading industry within the next five years. Land "proved up" in Johnson County is assessed for taxation at a value of $3 per acre, including improvements. It is easily worth an average of $10 per acre. The following table of values from the assessment roll of lands shows the increase from 1881 to 1887 in farming lands:

1881	$34,485	1885	$166,032
1882	51,195	1886	229,644
1883	66,160	1887	485,439
1884	147,785		

The real taxable value of this taxable land is at least three times this amount, or in 1887 $1,456,317, which is $408,649 more than the value of the cattle in 1881.

But one-fifth of the lands in Johnson County susceptible of irrigation have been artificially watered. The total area of irrigable lands is estimated at 953,000 acres, and at an average value of $10 an acre would be worth $9,530,000.

The county is in the northern part of Wyoming. Its elevation is only about 4,000 feet. Its streams are more frequent and available than any other portion of the Territory.

It is also one of the best watered counties in Wyoming, being well supplied with innumerable streams heading in the Big Horn Mountains and flowing generally to the northeast and northwest. The water along the foot-hills is clear, cold, sparkling, and soft. The soil is black and sandy loam, and appears to be capable of producing wonderful crops, with irrigation, of any thing that is planted in it.

AGRICULTURAL PRODUCTS.

The agricultural products of the county are wheat, oats, barley, corn, rye, hay, potatoes, vegetables, and fruits. The yields are: Wheat, 20 to 50 bushels per acre; oats, 25 to 75 bushels per acre; barley, 40 to 75 bushels per acre; rye, 20 to 40 bushels per acre; potatoes, 200 to 500 bushels per acre; hay, native blue stem, 1 to 2½ tons per acre; timothy, 2 to 3 tons per acre; alfalfa (lucern), 4 to 6 tons per acre.

The wild fruits are strawberries, raspberries, plums, choke cherries, service berries, wild currants, etc. Tame fruits are strawberries, raspberries, blackberries, currants, crab apples, etc. Strawberries especially grow to perfection. Wheat may be sown in March or April; even that sown in May fully matures three years out of four. In 1887 there were approximately 1,729 acres of wheat cultivated, and the total production was 38,000 bushels, or 2,228,000 pounds. The wheat raised is classed as A1. This cereal is being raised largely in Johnson County to fatten hogs, and even in this way is made to yield a good return. Barley, if sown in early April, can be raised on valley soil without irrigation and of the finest quality. Seventy-five bushels have been raised on an acre. The approximate number of acres in cultivation in the season of 1887 was 345, with a total production of 25,525 bushels, or 1,225,200 pounds. In 1888 a much larger crop was raised.

The malt used by the local breweries is made from home-grown barley and is fully equal to the eastern product. Oats are usually sown in April or May. Oats sown June 20 or 25 have returned fully matured crops of 50 to 60 bushels per acre. While the yield is, as usually, from 25 to 60 bushels per acre, as high as 95 and 105 bushels have been produced. The best crops of Johnson County in 1887, according to location as to valleys, were: Powder River, 37½ bushels per acre on 15 acres; Crazy Woman, 67 bushels per acre on 12 acres; Clear Creek, 65 bushels per acre on 10 acres; Piney, 60 bushels per acre on 25 acres; on French Creek, 75 bushels on 10 acres; on Rock Creek, 70 bushels on 100 acres. The approximate number of acres in cultivation in the year 1887 was 7,861; total production 234,475 bushels, or 8,441,130 pounds. The average weight of a bushel of oats is from 38 to 40 pounds. Corn was the last of the cereal crops introduced in the country. While not the most remunerative thus far it has been successfully grown. The Yellow Dent corn fully matures on our soil, and larger fields are planted every year. As this is the home of the solanum family of plants the potato grows to perfection; it is nothing uncommon to see potatoes weighing from 1 to 4 pounds, dry, mealy, and solid all through. The average yield of the tuber is about 200 bushels per acre; but under favorable conditions there have been 300, 400, and, on rare occasions, 600 bushels per acre raised on ground not manured.

Cabbage grows in very large size and the yield per acre is simply enormous. Heads of 25 and 30 pounds are common; 10 to 15 tons are often raised per acre. Cauliflower is also easily grown owing to the cool nights and the system of irrigation by which the plant can be watered at just the right time to perfect them in growth and development. Onions are an excellent crop, yielding from 300 to 500 bushels per acre of perfect bulbs. The celery raised here is pronounced to be superior in flavor to the famous celery of Kalamazoo, Mich. All other vegetables, such as beets, carrots, parsnips, etc., grow to a large size and yield immense crops. Melons, cucumbers, tomatoes, peppers, egg-plant, broom-corn, tobacco, sorgum-cane, beans, and many other vegetable productions are successfully grown in Johnson County. In 1888, according to thrashers' figures, the oat and wheat crop of Johnson County and Sheridan County was 400,000 bushels; estimated at 350,000 bushels of oats and 50,000 bushels of wheat, which would equal, oats 12,000,000 pounds and wheat 3,000,000 pounds; a total of 15,000,000 pounds or 700 car-loads. The oat and wheat crops of Johnson County alone will equal that amount in 1889. Johnson County can produce equally as good potatoes as Greeley, Colo.

As to the future: If one-third of the irrigated lands of this county were sown in wheat at at an average of 30 bushels per acre it would yield 2,340,000 bushels or 130,400,000 pounds, equal to 7,244 car-loads. If one-third of the area was sown to alfalfa it would produce 192,000 tons annually, and would fatten 58,400 steers, equal to 2,900 car-loads. Not more than one-fifth of the lands of Johnson County susceptible of irrigation have been watered. The possibilities that may be attained when development is complete become enormous. Johnson County will soon have railroads. For its agricultural products there is a ready market in the south.

STATEMENT OF H. B. PATTEN, ENGINEER OF THE WYOMING DIVISION, UNION PACIFIC RAILWAY.

In cases of aridity water is obtained by sinking wells, which, in some cases, are deep enough to be called artesian. Some wells supply large quantities and others only limited. Difficulty is to find water at all under ground; or, when found, to secure quality. Much that is found is extremely poor, being strongly alkaline.

Eighteen artesian wells have been driven, averaging 907 feet in depth. These vary in depth from 300 to 2,300 feet. They cost from $5 to $16 per foot, according to nature of boring, depth, and difficulties experienced, etc. Average cost of those driven is $6,700 per well, or per foot, $7.39.

Of those driven, a total of eighteen, nine are now furnishing fair to good supply for engine use. The other nine are either poor in quality or limited in quantity.

Do not know of any water storage system in use in this country.

Can furnish no direct observations for precipitation, etc., but can refer you to United States Signal Observatory at Cheyenne and to records of observations made at Rawlins by Union Pacific Railway. Subterranean water supply is of not infrequent occurrence. The dry beds of creeks usually have underground flow. The direct appropriation and immediate distribution of water from flowing streams in surface ditches for irrigation is the common and well-nigh only method used.

Irrigation enterprises are common. Large ditches are increasing in size and number. In Wyoming, what are generally known as the Sybille ditch, Pioneer Canal from Laramie River, and Bear River Canal are amongst the largest schemes.

For agricultural purposes water is essential. There are large tracts of land, of very fertile soil, which are now utterly non-producing. Water is the lacking element to the growth of large crops.

STATEMENT OF LOUIS BRECHEMIN, ASSISTANT SURGEON, U. S. ARMY, OF FORT LARAMIE.

For the eastern half of Wyoming Territory it may be stated that farming without irrigation can not be successful and can not be made fairly remunerative under the most favorable circumstances and with the best lands. In looking over this part of the Territory it is at once evident that but a small proportion of the land can receive by irrigation a supply of water sufficient for its needs owing to the fact that the streams are small, insufficient in number and capacity, and so situated that hardly a hundredth part of the land can be utilized. The valleys generally are narrow (the soil in many places sandy) and are surrounded by hills on each side. In order to irrigate successfully, that is, to get the water up on these high lands, it must be brought from a great distance and necessarily therefore at great expense. In consequence of this no combination of small farmers can afford to advance the large amounts required to construct these ditches and an association of capitalists for this purpose is imperative.

In examining the valley of the North Platte River, from the hills to the Nebraska line, it is seen that even in this valley, watered by the largest stream in the Territory, irrigation up to the verge of the banks of the river is necessary in all instances in order to raise crops. Occasionally the native grasses grow in spots, due to subirrigation from overflow of the river when it is high.

In rare instances, on second bench land where the prickly pear is plenty and where these are turned over thoroughly by the plow and left to remain under the fallow, not being disturbed by the harrow, there is moisture sufficient created by them to produce a medium crop. This is known as the sod crop and is always better than the second crop, unless the land is irrigated the second season.

When we take into consideration the high winds so prevalent in this county, the danger to ditches by occasional cloud-bursts, the extreme shortness of the season for anything but bulbous vegetation, &c., it may be stated with justice that the eastern portion of Wyoming is not an agricultural country.

These opinions are not altogether the result of personal experience, but have been formed and strengthened by inquiries made of those engaged in ranching in this section. One of my informants has had twenty-two years' experience and has expended large sums of money in experiments of various kinds during that period.

STATEMENT OF J. A. OLMSTED, CAPTAIN, NINTH CAVALRY, COMMANDING, OF FORT WASHAKIE.

From my experience in Texas, Utah, Kansas, New Mexico, and Wyoming I believe there is very little if any land in the United States that can not be profitably cultivated if water can be obtained to irrigate. When there is no surface water to be obtained wells, common or artesian, will always reach it. But the latter are too expensive for private individuals and will have to be made by the Genenal Government.

STATEMENT OF A. H. JACKSON, CAPTAIN, SEVENTH INFANTRY, U. S. ARMY, OF FORT WASHAKIE.

Information upon the subject of reclaiming waste lands by irrigation, derived from actual experiment and observation, extends little beyond the primitive cultivation of sage-brush lands employed by troops in the Northwest and ranche people in their vicinity.

Land of this character will usually produce good crops of grain and vegetables, with little expenditure of labor after that, of constructing the system of ditches for its irrigation.

In the selection of land, its adaptability to artificial irrigation is, of course, the first consideration. Sage-brush will soon disappear in the process of irrigation alone, which also serves in a large degree to relieve the soil from alkali deposit, provided there be a sufficient incline to carry it off.

A settler will do wisely, however, in avoiding land of the latter description altogether.

I have no practical knowledge of the larger systems of irrigation sometimes carried out in the Northwest at great expense and necessary in reclaiming the arid plains of the Southwest.

STATEMENT OF WILLIAM QUINTON, CAPTAIN, U. S. ARMY, FORT WASHAKIE.

Can only give the result of observation from the management of company gardens in Montana and Wyoming. The result of such observation is—

(1) No one single thing can be raised in the Territories referred to without irrigation.

(2) The soil is very rich, and although the growing season is rather shorter than the east, everything can be raised by means of irrigation.

(3) Ditches ought to be of sufficient depth to prevent the overflow of the soil intended to be irrigated—as the presence in the soil of large deposits of alkaline salts causes, from the action of the sun, over-hardening of the soil if overflowed. However, feeding the soil with a liberal supply of stable compost, coupled with frequent irrigation, will in the course of a few years' cultivation remove these salts.

WESTERN NEBRASKA DIVISION.

OGALALLA, NEBR., *September* 19, 1889.

The committee met pursuant to call of the chairman.

Present: Mr. Stewart, (chairman), also Director Powell.

STATEMENT OF ALFRED HOLLINGSWORTH, OF OGALALLA.

The CHAIRMAN. What is your occupation?

Mr. HOLLINGSWORTH. I am a physician and am engaged in farming.

The CHAIRMAN. How long have you resided here.

Mr. HOLLINGSWORTH. Since the spring of 1885.

The CHAIRMAN. What do you say as to the sufficiency of the rain-fall to produce regular crops here?

Mr. HOLLIGSWORTH. My experience has demonstrated to me that it is entirely insufficient.

The CHAIRMAN. You do occasionally raise crops here I suppose?

Mr. HOLLINGSWORTH. In certain localities, where local showers happen to come at the right time. But taking the amount of acres the country over in these parts, the crop is very light.

The CHAIRMAN. Can you mature all sorts of crops here?

Mr. HOLLINGSWORTH. As a usual thing the crop dries out and burns up for want of moisture before it comes to maturity.

The CHAIRMAN. Are you familiar with the State farther east?

Mr. HOLLINGSWORTH. I have seen people from the extreme eastern part of the State. I have traveled about a good deal by private conveyance and have always made inquiry about the crops.

The CHAIRMAN. How far east of here does this deficiency of rain-fall interfere with the regular production of crops.

Mr. HOLLINGSWORTH. I would place it about 100 miles east of here.

The CHAIRMAN. And they sometimes have failures east even of that?

Mr. HOLLINGSWORTH. Yes, two years ago they did have.

The CHAIRMAN. Have any measures been taken here to increase the moisture by irrigation or by the artificial storage of water?

Mr. HOLLINGSWORTH. There is an effort being made at the present time to do that.

The CHAIRMAN. Is there any land under irrigation here?

Mr. HOLLINGSWORTH. No, not in this county. There is irrigation in the western part of Lincoln County, the adjoining county on the east, on the Platte Valley.

The CHAIRMAN. Where do they get their water from?

Mr. HOLLINGSWORTH. From the North Platte River.

The CHAIRMAN. How far is it from here to the North Platte?

Mr. HOLLINGSWORTH. Six miles straight north.

The CHAIRMAN. Is there any irrigation on the North Platte opposite here?

Mr. HOLLINGSWORTH. No.

The **CHAIRMAN**. Nor west of here?

Mr. **HOLLINGSWORTH**. I think not. There is none that I know of.

The **CHAIRMAN**. Did you ever live in an irrigated country?

Mr. **HOLLINGSWORTH**. No; but I have been investigating the water supply for irrigating purposes for the last six weeks or two months.

The **CHAIRMAN**. You have seen no storage of water or any irrigated country yourself?

Mr. **HOLLINGSWORTH**. No.

The **CHAIRMAN**. How have you investigated the question of water supply?

Mr. **HOLLINGSWORTH**. We have been working up an irrigation scheme for the South Platte River here about twenty-five miles.

The **CHAIRMAN**. Is your engineer here?

Mr. **HOLLINGSWORTH**. Yes.

STATEMENT OF L. E. HICKS, OF LINCOLN.

The **CHAIRMAN**. What is your occupation?

Mr. **HICKS**. I am professor of geology in the Nebraska State University.

The **CHAIRMAN**. I presume you are pretty familiar with the State, and have given some attention to the subject of irrigation. We shall be glad to hear any statement on that subject which may be of use to us in our inquiry.

Mr. **HICKS**. I have given attention to the subject of irrigation ever since I came to reside in Nebraska. I have felt a deep interest in it, and have had and now have a very strong conviction of its necessity and importance.

There are certain things that I had prepared to say at Cheyenne, which I will say here, though I will not now say all that I intended to say there, because that place would have been appropriate for certain things which it is not necessary to say now. To a certain extent, however, the scope and direction of my remarks will be influenced by the fact that I prepared to speak at Cheyenne.

I have prepared hastily a map, which may be marked "Hicks, A." All that I did had to be done hastily because I had very short notice. I prepared this map as exhibiting the Platte River and its tributaries, as the main feature of the map, although it includes the whole of the State of Nebraska. The State boundaries are indicated by dotted lines to a portion of Kansas, a portion of Colorado, and a portion of Wyoming. The political divisions are not conspicuous upon the map and I did not intend to make them so.

The **CHAIRMAN**. You regard political and State lines as having nothing to do with irrigation?

Mr. **HICKS**. That is the point I wished to make by exhibiting this map of the State. Political boundaries should be non-existent so far as irrigation is concerned. I do not think I need to dwell upon that after simply stating it and calling attention to the physical features of this region, which emphasize the fact that State boundaries ought not to be considered as having anything to do with the question of where the water is to go or where it is to come from. We ought to consider a certain region (without regard to State boundaries) in its physical aspect as a hydrographic unit.

The Platte River is a remarkable stream in many respects. It is one of the large rivers of the world, considered with respect to its length.

The South Platte rises in the southern part of the Rocky Mountains, and the North Platte in the northern part. Each of those branches of the Platte is an important and valuable stream for irrigation. Not only so, but the numerous tributaries of the North Platte and the numerous tributaries of the South Platte are all valuable streams for irrigation.

I do not propose to speak at any length of the South Platte. We have a great interest in the South Platte, and the people of Ogalalla are particularly interested in it, but I propose to speak more particularly of the North Platte, because I think there is more value and more hope for Nebraska in the North Platte than in the South Platte. The State of Colorado includes a large portion of the South Platte. There are about 80 miles of the South Platte in Nebraska. I hope the committee will take a ride across the South Platte, and see it for themselves.

The CHAIRMAN. You may explain the condition and capacity of that stream.

Mr. HICKS. I have not proposed to say very much about the South Platte, as it would take me some time to say about it all that I should like. I should like to say why I believe that in the long run the use of the waters of the South Platte is going to benefit the people along here, because it will fill up, soak up, the lands in Colorado so that the lands themselves will become a great reservoir to gradually and constantly yield waters to fill the Platte along here and all the way down to its confluence with the North Platte and ultimately be beneficial. That, however, would take a long time. It will be hastened by the measures now being prosecuted under the authority of the General Government by the U. S. Geological Survey under the direction of Major Powell.

The taking out of the surface waters—the flowing waters—in the streams during irrigation season has deprived the people here on the South Platte of water, and has been an injury to them by taking the water which otherwise would flow through the South Platte. The beneficial result which is ultimately going to come from irrigation in Colorado will be hastened by this irrigation survey and by the construction of hydraulic works in the places which will be indicated by the survey. I understand that the survey conducted by Major Powell is not to construct anything but to indicate the places where reservoirs for the storage of storm waters may be advantageously placed, and how much it will cost to build the dams and make the reservoirs. I understand the intention is to furnish information so that individuals or companies may do the work.

The North Platte is a stream which has not yet been used up by irrigation in Wyoming as the South Platte has been in Colorado. The North Platte is a larger stream than the South Platte. It possesses many great advantages for irrigation. The whole Platte River in fact presents great advantages for irrigation; in one respect greater I think than any river of the same size in the world, namely its high gradient. For the size of the Platte River it is slow, the amount of fall in it is very remarkable. From Fort Steele away up in Wyoming—not at the head of the North Platte, but within 150 miles of the source of it—down to the mouth, the average fall for the whole distance is over 7 feet to the mile. If you carry the measurement up to the very sources of the Platte, of course it would be much greater, because the upper waters have a steep slope. The slope in different parts of the river vary a great deal, but it may be of interest to you to hear the details of the gradient of the Platte in different portions of it.

From Fort Steele to the Wyoming line the average gradient is 8.6 feet per mile; from the Wyoming line to the town of North Platte it is 7.4 feet per mile. I do not think you can find any other river of that size which has so high a gradient as the North Platte for so long a distance. That is certainly a very high gradient and, you know very well what that means in respect to its value for irrigation. If a stream has very low gradient and you take a ditch from it you have to go a long distance before you can get the water in. From North Platte to Kearney the grade is much less, being only 5.6 feet per mile and from Kearney to Fremont, singular to say, the grade is higher than it is from North Platte to Kearney, being 6 feet. The average for the whole distance from North Platte to Fremont is 5.8 feet.

There are many characteristics of this stream and of the country which it waters which I should like to point out in detail, but I think I have said enough to indicate what admirable provision nature has made for furnishing water to a very large piece of country, and it only needs the guiding hand of man to pour out its beneficent results on these plains to produce values in agriculture which can be expressed only by millions of dollars.

I shall return now for a moment to the subject of this map to illustrate the physical features of the Platte.

The CHAIRMAN. I should like you to state what the topography of the country is on each side of the river.

Mr. HICKS. I had intended to speak of that but do not want to make my remarks too long. If I speak of the lay of the land I shall be getting at that important point with respect to a very large section of Nebraska, and therefore it is perhaps as pertinent here as to speak of it in detail with regard to other streams.

The CHAIRMAN. I should like, if you are familiar with that stream, to have you state the elevations, and the opportunity for getting at the water also the extent of land that could be covered by it, commencing with the point at which you begin with the fall or grade of the river.

Mr. HICKS. With regard to that part of the river that is in the Territory of Wyoming you have had the facts from the engineer of that Territory, Mr. Mead.

The CHAIRMAN. That was as to the deep channel, but you commence where the channel is low.

Mr. HICKS. In the upper, or Wyoming, portion of the Platte a great deal of it flows through cañons, so that the taking out of the water would be difficult, but near the place where it crosses the west line of Nebraska (the Nebraska-Wyoming line) it comes out from the cañons and flows through a comparatively level country; in some places high banks on one side or the other, and on the whole, its valley is deep. The hills, when you get back to the crest, are high all along, but the slope is gradual, especially on the north side. It is no longer a cañon at that point, and therefore it can be taken out for irrigation in western Nebraska and to some extent in Wyoming, on the north side. On the south side there are bluffs all around here.

The CHAIRMAN. How far?

Mr. HICKS. To a distance of 30, 40, or perhaps 50 miles from the Nebraska line.

The CHAIRMAN. About midway between Platte and the Wyoming line?

Mr. HICKS. Yes; between North Platte and the Wyoming line the water can be taken out on the north side. There is one point to which I wish to call attention, which in the end may be a point of very great importance, although it will probably involve engineering operations and an expenditure of money on a very large scale.

Speaking of the facility of taking out the Platte, there are two theories of it. The question is whether it is easier to take it out in short ditches to water the lands that lie at a moderate elevation above the stream, or whether to take it out and carry its waters upon the high plateaus, upon the divides or table lands. If you take it out in the latter aspects, if it is proposed to carry the Platte upon the table-lands north of the Platte, you have to contemplate engineering operations upon a large scale—I will not say upon a vast scale, because in India they take out ditches as long as 500, 600, or 700 miles. To take out the waters of the Platte and spread them upon the table lands would require a ditch at least 150 miles in length, which is a great undertaking and would involve the expenditure of large sums of money, and it could only be done by a great corporation, or by national or State authority.

The CHAIRMAN. State which would be the most economical way in the end, per acre.

Mr. HICKS. To carry it out on the table-lands, or to use it in the valley?

The CHAIRMAN. Yes; which would be the most economical, taking into account the quantity of land that would be benefited?

Mr. HICKS. My conviction on that point is that the proper thing to do is take it out on the table-land.

The CHAIRMAN. Where would you take it out?

Mr. HICKS. I would go as far as the mouth of the cañon in Wyoming—the North Platte cañon, west of the Nebraska line.

The CHAIRMAN. If you had a ditch running out on the north side, explain where it would run?

Mr. HICKS. There is a vast body of table-lands between the Niobrara and the North Platte.

The CHAIRMAN. That river runs nearly parallel to that north line we call the Niobrara?

Mr. HICKS. Yes.

The CHAIRMAN. What is the average distance between the Niobrara and the North Platte, at about the one hundredth meridian?

Mr. HICKS. About 100 miles.

The CHAIRMAN. What length of ditch would it take to run it out at the mouth of the cañon and run it to the meridian?

Mr. HICKS. That would be well on to 200 miles.

The CHAIRMAN. And if you went down to the ninety-eighth meridian you would have something further to go?

Mr. HICKS. About, probably, 320 miles.

The CHAIRMAN. What is the character of the soil on that plateau?

Mr. HICKS. It is excellent. It is of the character which generally prevails upon the table-lands and in all this belt of country. The table-lands have a soil which is very rich in all the elements of fertility and has a subsoil compact enough to hold the water without being hard pan to prevent the water from entering it and being retained by it. It has the necessary porosity to have that quality to a useful extent, without having it to such an extent as to waste water. Therefore in every respect the table-lands are excellent for containing water and for its application to irrigation.

The CHAIRMAN. And for retaining water in the ditch?

Mr. HICKS. Yes.

The CHAIRMAN. They are better for retaining water in the ditch than the gravelly bottoms?

Mr. HICKS. Yes.

The CHAIRMAN. It would be an economical use of water to take it out there?

Mr. HICKS. Yes.

The CHAIRMAN. What do you say as to the quantity of water in the North Platte to supply such a ditch?

Mr. HICKS. I have never gauged the North Platte, and can not speak with any positiveness as to that. Major Powell could inform you better than I can on that subject.

The CHAIRMAN. Have you ever seen the North Platte in flood time?

Mr. HICKS. Yes.

The CHAIRMAN. Is it a large stream, then?

Mr. HICKS. It is an immense stream.

The CHAIRMAN. What would be the opportunity of storing the water to supply such a ditch?

Mr. HICKS. There are good places for storage basins to contain the flood water.

The CHAIRMAN. Suppose you have it on the summit of a ridge, would you be able to make reservoirs to catch the water in flood time as you followed the Niobrara on one side and the Platte on the other?

Mr. HICKS. Yes; there are such places.

The CHAIRMAN. So that you could enlarge the quantity?

Mr. HICKS. You could enlarge the quantity by retaining the waters that fell along the course of the ditch.

The CHAIRMAN. What do you say of the flood waters with which you could augment the stream between the Niobrara and the Platte? Do the rains fall there to a considerable extent?

Mr. HICKS. The rain-fall has never been carefully investigated in that region. The stations for the investigation of rain-fall are none of them so situated as to do that, and it is impossible to say with positiveness what the rain-fall is, but I am safe in declaring that it is certainly 15 inches or over. With that amount of rain-fall you can form an idea of the amount of the flood waters which might be saved.

The CHAIRMAN. What is the character of the surface—has it got basins and ravines and unevenness enough to find storage places or places to catch water?

Mr. HICKS. The topography is extremely favorable for storage. I might perhaps qualify that word "extremely." It is favorable. It is certainly as favorable as the average conditions over the county, if not more so.

The CHAIRMAN. I observe by that map that between the two rivers you have other streams marked.

Mr. HICKS. Yes. Those are the Loup rivers and their tributaries—the whole being tributary to the Platte.

The CHAIRMAN. Have you got on the map all the rivers and ravines that are between those rivers?

Mr. HICKS. No. This map was hastily constructed to bring out certain points especially the point that State lines ought not to come into account. There are many streams that are not on the map. I have not put in any tributaries of the Niobrara River.

The CHAIRMAN. Independently of taking the water from the Platte, which of course must ultimately be done (that would be a great enterprise), what are the opportunities for storing the storm water, to begin with?

Mr. HICKS. Do you mean over the surface generally?

The CHAIRMAN. Over the surface generally.

Mr. HICKS. In my belief the opportunities are good.

Director POWELL. Will you please state a little more fully the advantage of taking the North Platte out upon the divide between the Niobrara and the Platte itself—the advantage of taking it out upon a high line to the region between that high line and the Platte itself?

Mr. J. J. MCINTOSH (of Sidney, Nebr.). I would suggest that the examination be confined to the country west of the one hundredth meridian, as east of that line it is not claimed that it is necessary to have irrigation.

The CHAIRMAN. I think that irrigation is not confined to that meridian any more than it is to State lines. Let us have the facts.

Mr. HICKS. I am going to answer the question, but I wish to get at it by a circuit. The proposition I have made about taking out the North Platte may seem to be a rather startling proposition because of its magnitude, but if it can be shown that there are certain great advantages that can not be secured in any other way, then we will contemplate that proposition.

In answer to a suggestion of Major Powell's, I will bring out one of the things which constitutes a great argument for attempting work on a large scale like that. It is that by taking out these waters upon the high divide here you have them at an elevation above the stream, and with a slope between the main ditch and the stream, which includes a vast body of land—land that is well suited for irrigation, almost every acre of it, and which lies upon this slope between that main ditch and the Platte in such a way as that when you have used the water up here next to the ditch, upon the highest part of that divide, and irrigated your fields there, the same water will come on down and irrigate the fields which lie a little lower, nearer the Platte. Then, after irrigating those fields you take it again and irrigate other fields, and so on, using the water of that main ditch over and over again. That is one of the great advantages of attempting things on a large scale.

The CHAIRMAN. If you had the ditch, need it necessarily be on a very large scale to irrigate some lands?

Mr. HICKS. No.

The CHAIRMAN. And as you extended it along here you would cover a great deal of land with every mile, would you not?

Mr. HICKS. Yes.

The CHAIRMAN. The work done would be a great deal larger as you went along. When you irrigated this land along the ditch and filled it with water, would not that filling of water work along down and fill the land towards the river, saving the water all the time?

Mr. HICKS. Yes.

The CHAIRMAN. And go of itself down towards the river?

Mr. HICKS. Yes.

The CHAIRMAN. And if you were up here on the high divides could you not start your ditches and make reservoirs below it, to save your surplus water and do a good deal more work with it than if you took it out on the low beds; would it not get right back into the river there?

Mr. HICKS. Yes, and there are other reasons why it is not so good. I may introduce some qualifications here. Job said, "Oh * * * that mine adversary had written a book." I wrote a pamphlet about this subject once. I contemplated taking out the North Platte and am in a measure going back on my record.

The CHAIRMAN. Are you familiar with the facts as to how far east the water would be useful if that ditch was extended? I am not putting it at the bare point of necessity where you could eke out life on that land, but how far would it be useful to extend that ditch?

Mr. HICKS. If I should answer that question just as it lies in my mind I should take it out clear to the Missouri River. I maintain that the use of water in irrigation would be advantageous on account of its increasing the yield and making the yield certain, giving you the opportunity to put the water on the land just when it needed it, instead of waiting for the clouds to pour it on. They do not always bring it when it is needed. Therefore, on account of the certainty of the results and of the increased yield of the fields, I say that water for irrigation could be profitably used all over the State of Nebraska, but I do not believe you intended the question exactly in that sense.

The CHAIRMAN. I wanted to know fully where it would be useful.

Mr. HICKS. I will answer it now in another way: "What is the eastern limit of the arid region?"

The CHAIRMAN. What I want to know is where the division line is, if there be one, between poverty and comfort, without irrigation?

Mr. HICKS. I would rather answer it in the form in which I put it, "What is the eastern limit of the arid region?" My conviction is that so far as you can define the eastern limit of the arid region by mathematical lines the boundary is the one hundredth meridian.

The CHAIRMAN. In Nebraska?

Mr. HICKS. Yes, in Nebraska. I would limit it a little more yet. I would say in central Nebraska. In central Nebraska the one hundredth meridian is the limit. For instance, in Custer County the one hundredth meridian runs right through the western part of that county. Good crops can be raised in central Nebraska up to the one hundredth meridian, and very fair crops in some districts even west of the meridian. Custer County is crossed by the one hundredth meridian, cutting off about two tiers of townships from the west line.

The CHAIRMAN. To what meridian does Custer County extend eastward?

Mr. HICKS. It extends east to about 99° 30′, and that county which lies there mainly between the ninety-ninth and the one hundredth meridian extending over west of the one hundredth meridian took the first premium for county exhibits at the State Fair of Nebraska which has just closed.

The CHAIRMAN. Do you know where those exhibits were obtained; in what portion of the county?

Mr. HICKS. Somebody here will be better able to give you that information, but I will say that in regard to the character of Custer County it is in the Loup River country. Several Loup rivers pass through it, and along those rivers the bottom-lands generally are sandy and poor. The good land is on the divides between the rivers. These divides or table-lands between the rivers occupy by far the greater portion of the county. It was on these divides that the crops were raised that took first premium and therefore upon land which is the prevailing and characteristic land of Custer County and not upon select patches of remarkable fertility, or upon land any more fertile than the rest of the county. So that it is not like the case of crops raised in some particular portion of the county which was a great deal more fertile than the rest.

The CHAIRMAN. Do you know whether that county has had uniform crops for a series of years?

Mr. HICKS. Custer County is new; the oldest lands in that county (those that have been plowed the longest) have probably not been plowed more than five years, and during that time the yield has been uniformly good. The first plowing of those lands does not yield the best crops as it does in other parts of the country.

The CHAIRMAN. Are you familiar with Brown County? If so, what can you say as to the land there?

Mr. HICKS. The land in Brown County is not very good.

The CHAIRMAN. How is it situated as to rain-fall?

Mr. HICKS. The rain-fall is not perhaps quite so great, because the lines of greatest rain-fall do not pursue mathematically straight courses, but make curves. The line of greatest rain-fall would be something like this [indicating upon the map].

The CHAIRMAN. Commencing at the southeast corner of Harlan County?

Mr. HICKS. Yes, and passing out here to the one hundredth meridian and curving off.

The CHAIRMAN. Commencing at the southeast corner of Harlan and then going in a northwesterly direction, crossing the Platte River at the western part of Dawson, and then continuing north to Custer and Brown about on the one hundredth meridian, and when it strikes Brown it would then be a sharp angle to the east through the corner of Brown and Holt up into Knox County and to the Missouri River. That would be about the line of equal precipitation, according to your observation?

Mr. HICKS. Yes; and therefore the boundary of the arid region would not be the mathematical line of the one hundredth meridian according to my opinion, but the line of equal precipitation would be a curve and not a straight line. Westward of that line irrigation is needed.

The CHAIRMAN. Is it a necessity?

Mr. HICKS. It is not an absolute necessity in many portions.

The CHAIRMAN. Is it a necessity to general prosperity?

Mr. HICKS. Yes; it is a necessity to general prosperity and highly advantageous for the certainty and the greatness of the yield which would result from irrigation—the certainty of a production of a fair crop and a greatly increased yield per acre.

The CHAIRMAN. About what proportion of the State would that take—about one-half of it?

Mr. HICKS. Something more than one-half.

The CHAIRMAN. Then something more than one-half is in the arid belt?

Mr. HICKS. Yes; about one twenty-fifth of the whole arid region of the United States is in Nebraska. I want to emphasize that fact to this committee, that Nebraska is entitled to attention in this matter, and we are very glad that you came here to Nebraska to look into the subject.

The CHAIRMAN. In addition to the large ditch that you have suggested, what other modes would you suggest for supplying this arid region with water?

Mr. HICKS. Before leaving the question of the large ditch north of the North Platte I want to say that the water can be taken out on the divide south of the North Platte also. I say that particularly for the benefit of people who are interested on the south side of the North Platte rather than on the north side. Your inquiry now is with respect to additional methods.

The CHAIRMAN. What other streams or means beside the North Platte could be used for irrigation?

Mr. HICKS. It would take me a long while to detail them.

The **CHAIRMAN.** I do not want them in detail. How is it in regard to the Niobrara; is that useful?

Mr. **HICKS.** Yes; I will speak somewhat fully of the Niobrara with your permission, and then more briefly as to the other streams, because what I say of the Niobrara will apply to many others. The Niobrara River carries quite a large volume of water. I never gauged it low down, but away up here in this region—in the northwest corner of the State—I found about 125 cubic feet per second.

The **CHAIRMAN.** At what season of the year?

Mr. **HICKS.** About this time of the year two years ago, at nearly the driest part of the year.

The **CHAIRMAN.** How is it about the wettest parts of the year?

Mr. **HICKS.** I never gauged it then, but I know it carries an immense volume of water.

The **CHAIRMAN.** Has it been utilized at all for irrigation?

Mr. **HICKS.** Not to my knowledge.

The **CHAIRMAN.** What is the character of the country along the Niobrara on both sides? That river would irrigate some lands in Dakota, would it not?

Mr. **HICKS.** Near the north part of Cherry County it might possibly be used in Dakota, but there is a great body of land which might be irrigated by the Niobrara River in Nebraska—in that portion of it which lies in Cherry, Sheridan, Dawson, and Sioux Counties. Below that, for instance in Brown County, the Niobrara River flows in a cañon, and can not be used.

The **CHAIRMAN.** You would have to rely on the Platte and the smaller streams.

Mr. **HICKS.** Yes, but below the Platte the facilities of the Niobrara River are excellent.

The **CHAIRMAN.** What is the character of the land and the topography?

Mr. **HICKS.** The land there lies sloping up with a gradual slope from the Niobrara River on both sides all through the counties I name, so that the water taken up by ditch upon that slope could be used between the ditch and the river with the greatest possible efficacy.

The **CHAIRMAN.** What is the grade or fall of the river?

Mr. **HICKS.** The Niobrara has a much steeper grade than the Platte. It is a smaller river, and would be expected to have a steeper grade. The characteristic of the Platte River is its remarkable gradient. For a medium sized or small stream the Niobrara River is remarkable for having a high gradient. I will remind you of the French name of the Niobrara River as you have seen it on the old maps, *L'eau qui cour*, the water that runs. The swiftness of the stream so impressed itself upon the French *voyageurs* that they called it "The water that runs." That of course depends on the grade. It has a high gradient and low banks. The water can be easily taken out. The land lies favorably, and in every respect it is an excellent stream for irrigation.

The **CHAIRMAN.** In addition to that, the different forks of the Loup extend up into Brown, Cherry, and Holt. Can the waters of the Loup be utilized?

Mr. **HICKS.** Undoubtedly. They are good streams for irrigation.

The **CHAIRMAN.** Into what does the White River discharge its water?

Mr. **HICKS.** Into the Missouri in Dakota.

The **CHAIRMAN.** What kind of a stream is it?

Mr. **HICKS.** The White River is not so good in irrigation time as the

Niobrara. Some of its tributaries for small streams are excellent. The White River, however, in the main stream is not so good a stream for irrigation. But on the whole, taking the Upper White River and the tributaries of the White, there is a large body of land in upper Nebraska which could be irrigated. A stream which is one of the very best in the State of Nebraska for irrigation is the Republican River and its tributaries.

The CHAIRMAN. Where is that?

Mr. HICKS. In the southwestern part of Nebraska. As far east as irrigation is needed the Republican River is a source of much water for irrigation.

The CHAIRMAN. In what State does the Republican River rise?

Mr. HICKS. In Colorado, but very near the State line. It flows into Kansas. The Republican, therefore, is a Nebraska river. It is not a mountain stream. It rises on the plains not far from the Nebraska line in Colorado.

The CHAIRMAN. Does it carry water in the dry season?

Mr. HICKS. A great volume of it. I gauged it in Furnas County and found 570 cubic feet.

The CHAIRMAN. What is your theory as to the remarkable supply of water in the Republican—it does not come from the immediate rain-fall does it?

Mr. HICKS. I am not able to say with any positiveness that there is any other important source.

The CHAIRMAN. I have heard it suggested that it was probably supplied from underground water; water that was passing through Colorado under ground.

Mr. HICKS. I think it is probable. Observe what I said, that I am not able with any positiveness to ascribe any other source for the water of the Republican but the rain-fall of the region which it drains. I know that the rain-fall on the Republican basin furnishes most of the water that runs into the Republican. Whether there is any other source of any considerable importance (while I think it highly probable) I do not know any facts that would give me any means of making a positive statement.

The CHAIRMAN. A considerable country could be irrigated by that?

Mr. HICKS. A very great area could be irrigated by the Republican and its tributaries. While I described the land along the Niobrara as lying favorably for irrigation, I think that I could speak with more emphasis still of the land of the Republican. It lies admirably to receive the water.

The CHAIRMAN. As to the South Platte; you have about 80 miles of that in Nebraska. Can a supply be obtained from that; and, if so, how? You have already explained that, by natural process, if the water is stored above, so that it will fill the soil, it will naturally work along down and finally benefit Nebraska; but, not waiting for that, is it possible to take out the water from the South Fork?

Mr. HICKS. I do not want to monopolize the business of giving information to this committee; and, while I might have something to say on that point, the engineer who is now constructing a ditch to take out the water of the South Platte, in this immediate locality is here, and I should like you to ask him that question.

The CHAIRMAN. I wish you would speak at greater length of the storm-water and the facilities for utilizing it in Nebraska generally, according to your observation, by reservoirs?

Mr. HICKS. Do you mean the flood-waters of the streams, or the precipitation upon the general surface?

The CHAIRMAN. Upon the general surface, in the ravines and small streams in the highest portion of the State—anywhere where it could be done without regard to streams. How much of an aid will that storm-water, kept in small ponds and reservoirs, be?

Mr. HICKS. In my judgment it will be of the utmost value; while, compared with many parts of the earth the rain-fall over this region is what you would call light, still, the aggregate of water falling on say a square mile of land in this region, supposing the rain-fall to be 15 inches, can be easily computed; and any one who makes the computation will be astonished at the amount of rain-fall that reaches the land. If the waters that fall on the surface here were collected in small reservoirs, such as might be constructed at moderate expense by individual owners on their own lands, and for the construction of which the topography is favorable, an immense area might be irrigated from these storm-waters.

The CHAIRMAN. How much water do you require in addition to the rain-fall generally in western Nebraska to produce all-around crops? Have you given that particular subject any consideration?

Mr. HICKS. I am not prepared to answer that question definitely as to quantity. I could, however, make an estimate in general terms.

The CHAIRMAN. Do so.

Mr. HICKS. In my judgment, through a large part of the area west of the curve which I have already indicated, the rain-fall and the climatic conditions generally are such that the amount of the artificial aid required from irrigation is comparatively small. For instance, in Colorado it requires 12 inches of water each year on the irrigated fields to produce crops, while, I should say, that in some parts of Nebraska, 2 inches ould be enough, in other parts 3, and in other parts 5, and so on, according to the proximity to this line that I have indicated. Further west, you must have a greater number of inches and during a greater length of time. In many parts west of the line I indicated, if water could be put upon the land only for a few days at a critical time, it would save the crop and make a good crop. So that the amount required varies with the location, and with many local conditions and circumstances. But generally my answer would be, that the amount required is not more than one-third of full irrigation in a great part of this region.

The CHAIRMAN. What effect in Nebraska does thorough cultivation have upon the moisture?

Mr. HICKS. It has the effect of retaining that which falls from the heavens, and of attracting more moisture from the atmosphere in the form of dews, and also probably, locally, in the form of rain. I do not consider it an established fact that the rain-fall of Nebraska is increasing.

The CHAIRMAN. Is it generally supposed that rain-fall is increasing?

Mr. HICKS. Yes; it is generally supposed that it is, and that the rain-fall is traveling westward. As I say, I do not regard that as an established fact; but, owing to the conservation of the moisture in the soil, resulting from cultivation and the protection of the surface by the vegetation that grows upon it, its protection from the heat of the sun's rays, so that it does not become so intensely hot, and so that it does not immediately discharge the water put upon it, the effect of cultivation is manifest. As to the increase of moisture, it comes principally in the form of dew. In the great plains it was often stated and believed by many that there was no dew. In all this region, wherever crops are cultivated, if you go into a field of wheat, oats, barley, or tall grass in the evening you will get your feet wet, and you will find plenty of dew, Where the soil is cultivated and where vegetation is growing there is dew. The reason why there was no dew before cultivation is that the surface, baked by the sun's rays during the day, becomes so intensely hot that at no hour of the night did it become much colder than the air; and the precipitation of dew depends on the condition of a difference between the temperature of the objects which receive the dew (the lower temperature of the earth or of the plants on which the dew collects), than the temperature of the surrounding air. When the surface is protected by vegetation the earth itself does not become so hot—is not so intensely heated by the rays of the sun—and the plants stretching up into the air from the surface of the earth are so situated as to lose their heat rapidly by radiation. As soon as the sun goes down in the evening they begin to cool off, and speedily become colder than the circumambient atmosphere, and in that way form dew. Thus, without any increase in rain-fall, but by the increase in the dew-fall, or the conservation of dew, we have, as a practical result of breaking the surface of the soil, what is the same in effect as if there had been an increase in rain-fall.

The CHAIRMAN. There is another question which I wish to ask you: It has been suggested that by the cultivation of the soil and the production of vegetation over a large surface the rain-fall is equalized and is not so spasmodic and erratic so far as concerns its falling all in a body in a single place as in the case of a cloud-burst. Have you observed in Nebraska any effect of that kind?

Mr. HICKS. Nebraska at present is not afflicted with sudden bursts like that.

The CHAIRMAN. That is, the cultivated portion of it?

Mr. HICKS. The cultivated portion of it. Whether that is due to the cultivation, and whether storms were formerly more spamodic here I am not prepared to answer.

The CHAIRMAN. You have not lived here long enough and observed the changes so that you could not say whether that is a fact or not?

Mr. HICKS. I could not say personally whether it is or not.

The CHAIRMAN. How are rains in this part of Nebraska; do they form cloud-bursts in places, or do they fall pretty evenly over the whole surface?

Mr. HICKS. There are not many "cloud bursts," but there are many local storms.

Director POWELL. What would you suggest as the line of investigation for the arid region of Nebraska?

Mr. HICKS. I believe that the scientific study of the special characteristics of this whole region, pursued long enough and thoroughly enough to give systematic and tolerably complete results, is the proper method of procedure, and in fact the only method, regarding this region as a whole, and that may be done most economically under the authority of the General Government. If it is not so done it must be done at the expense of communities, corporations, or individuals, in a spasmodic, irregular, incomplete, and often inaccurate and inadequate manner; whereas a general survey of this whole region would be in the hands of the most skillful engineers who would present the subject in its completeness and in all its connections, and would be far more valuable in any given locality, so far as it pertains to that locality than if the most thorough survey of that locality had been made by itself.

As to the method of doing that, it seems to me that this region demands a line of investigation different from any other. And when I speak of this region I do not simply mean this portion of Nebraska, or this county, or even this belt of Nebraska in which we now are, or of which I have been speaking, but the whole belt that lies approximately in the same meridian—a belt of one, two or three hundred miles in width, which lies upon the margin of the arid regions, where physical conditions are so different from those which prevail in the mountainous districts that a different line of investigation must be pursued, and a line of investigation which in some respects must be more costly and elaborate than would be required in the mountain regions. There ought to be a great deal of attention given to this region in this Irrigation Survey, and money ought to be expended upon it without stint, all that is necessary to bring out the best possible results.

The reason why it is going to be a more costly survey in this region than in some other parts of the arid regions, is that the streams are inadequate to water this region. While I have described a number of streams for irrigation, I believe I have said nothing beyond what the facts will bear out in regard to the value of those streams; yet, taking them altogether, they are inadequate to the demands of this region for irrigation. You can not get the water out of all the streams in Nebraska to water all the lands that need water here. Nebraska is so happily situated, and its physical condition is so happily adjusted in respect to the character of the surface, that there are very few acres of all this region that are not good arable land. Of all this region that needs irrigation the percentage of it which would not kindly respond to the efforts of the irrigator and farmer is very small, indeed—remarkably so as compared with other regions. We have no mountain ranges. We have a few sand-hills and other places that can not be irrigated. But I suppose the amount of arable land in Nebraska is one-half the land of the State; that is, we will say in round numbers, 40,000 square miles. There is, I should say, not more than 5,000 square miles of that that would not respond to operations to redeem it. We will say there are 35,000 square miles, then, that are suitable to receive the water.

The water of the storms is insufficient to supply that body of land, and therefore the storm waters must be stored in numerous little reservoirs all over the country. To find the places for these numerous little reservoirs, to ascertain the configuration of the surface, and to "place" those reservoirs will take careful and accurate work. In my judgment, the Irrigation Survey should proceed upon those lines in this region to indicate by their careful work where those reservoirs can be constructed, not only how the streams may be used, but how the storm-waters which fall upon the general surface of the country and run off can be saved up and made to water the largest amount of land. In general, that would be my notion of what an Irrigation Survey ought to be for this belt.

The CHAIRMAN. Have you any artesian water any where in the State?

Mr. HICKS. Yes.

The CHAIRMAN. You are aware of the existence of a belt of artesian water in the two Dakotas. Is the artesian water of Nebraska good water?

Mr. HICKS. Yes; the best I ever saw. The belt runs somewhat west of north. That belt strikes Nebraska. In Knox County there is excellent artesian water to be found and at very moderate expense, but it is not in the belt that needs it. That artesian water is going to be of great value for power, if for nothing else. You can get a great water-power by boring into the earth. In the western region, where irrigation is most needed, the results of exploration for deep artesian waters have so far been negative.

The CHAIRMAN. How deep have they bored in any one place in the western part of the State?

Mr. HICKS. I do not know exactly as to that. No very deep wells have been bored in this region.

The CHAIRMAN. Have any of them kept a record of the conformation in the case of those wells that have been found?

Mr. HICKS. I have no record of wells in this region of greater depth than 500 feet.

The CHAIRMAN. Are there any portions of Nebraska where the water is near enough to the surface to make the use of pumping machinery cheap enough to be practiced to any extent?

Mr. HICKS. I think there are.

The CHAIRMAN. In what portions of the State is the water near the surface?

Mr. HICKS. I might adduce the facts that have come to your own notice as we traveled along this section. The water is standing on the surface in some places as we came along, and I have been informed that here at Ogallalla the water is only three feet from the surface.

Near the headwaters of the Loup River the water lies very near the surface. In many parts there are salt lakes. The water collects in the depressions and makes little salt lakes. In the sand-hills (all things considered the least valuable of all), there are small lakes and the water generally lies near the surface (I do not mean the summit of a sharp peak of a sand-hill), but you can get water and it is remarkable how near the surface you can get it. Wherever there are depressions the water lies very near the surface for wells.

The CHAIRMAN. May not the fact that the water lies near the surface on the Loup and other rivers have something to do with the production of crops there and with extending the belt?

Mr. HICKS. That is an explanation of the productiveness of that region but you would have to go farther to show that the water is there.

The CHAIRMAN. The water is there. It would be increased by additional rain-fall but the water is on the surface. What is the price of coal in this town?

Mr. HICKS. Some gentlemen living in Ogallalla can tell that better than I.

Mr. NEEVES. We do not get it very cheap. We pay $7 a ton for it.

STATEMENT OF ROBERT B. HOWELL, OF OMAHA.

The CHAIRMAN. What is your occupation?

Mr. HOWELL. I practice engineering.

The CHAIRMAN. In what engineering enterprise are you now engaged?

Mr. HOWELL. In hydraulic engineering. We are considering the construction of a canal here in Ogallala.

The CHAIRMAN. From what stream and to cover what land?

Mr. HOWELL. From the South Platte River to cover the land lying between the town of Brewell, about 10 miles above here, and this town.

The CHAIRMAN. How do you expect to get the water out of the Platte?

Mr. HOWELL. By seepage from the sand.

The CHAIRMAN. How are you going to get seepage?

Mr. HOWELL. Either by digging a drainage ditch or by means of galleries.

The **CHAIRMAN**. Explain how you would do it.

Mr. **HOWELL**. The gallery would be a wooden structure made of wood scantling and made in the rectangular form, and placed on the hard pan to form a sort of sewer as it were to carry off the drainage of the sand. This would be laid down and the water led off the pipe. The river falls at the rate of 8 feet to the mile. The pipe would be laid out about 2 feet to the mile.

The **CHAIRMAN** You would go into the sands and sink these galleries to form a body of water, and you would draw that water off by means of pipes and by gravitation with sufficient grade until you got it so that you could turn it into a ditch?

Mr. **HOWELL**. Yes.

The **CHAIRMAN**. Have you prospected the river to find out how much water there is below the surface? What means have you taken to ascertain that?

Mr. **HOWELL**. No means. We have examined and know that the stratum is about 18 feet. By digging anywhere from 6 to 18 inches below the surface the water fills up the cavity.

The **CHAIRMAN**. How wide does the water flow near the surface?

Mr. **HOWELL**. At this point it flows across the whole surface of the river.

The **CHAIRMAN**. About how wide is that?

Mr. **HOWELL**. About 3,000 feet at some places.

The **CHAIRMAN**. Does it also flow beneath the surface in the low bottoms?

Mr. **HOWELL**. Yes. The water seems to be higher in borings that are made below the river bank than in the river itself.

The **CHAIRMAN**. For some distance from the river on either side this water is as wide as the river bed?

Mr. **HOWELL**. Yes, it seems to be a little wider.

The **CHAIRMAN**. How wide at this place is the bottom where you can get the water?

Mr. **HOWELL**. For three-quarters of a mile on each side of the river you could get water for a distance of about 30 miles, I should think, at the highest point.

The **CHAIRMAN**. Is it not best to make a ditch deep in proportion to the width?

Mr. **HOWELL**. Yes, the theoretical form for a ditch is a deep ditch.

The **CHAIRMAN**. The practice in Colorado and this country seems to be to make a shallow ditch. Do you agree with that practice as to the economical preservation of the water?

Mr. **HOWELL**. No; I think a deeper ditch would be the best, but deeper ditches are more expensive, and it is only in cases of high water that they would carry a maximum amount.

The **CHAIRMAN**. How far up the river are you going to take out this ditch?

Mr. **HOWELL**. About 12 miles.

The **CHAIRMAN**. Are you going to continue it a considerable way down.

Mr. **HOWELL**. No, we are going to stop at this point.

The **CHAIRMAN**. There is land below to which it may be carried down if you should wish, is there not?

Mr. **HOWELL**. Yes.

The **CHAIRMAN**. Is it possible to get the water of the South Platte, commencing in Nebraska, onto the table-land?

Mr. **HOWELL**. Yes, that can be done.

The CHAIRMAN. Beginning in Nebraska and extending up and down?

Mr. HOWELL. Yes, I think it can, without doubt.

The CHAIRMAN. Are there any places in the river between here and the mountains where there is rock formation to bring the water to the surface?

Mr. HOWELL. Yes; there is one place that I know of.

The CHAIRNAN. How far up is that?

Mr. HOWELL. Near Fort Morgan.

The CHAIRMAN. How much water runs in the river at that point?

Mr. HOWELL. About 122 cubic feet per second, but the rock is only exposed on one side. Over that rocky place there are 122 cubic feet per second running.

The CHAIRMAN. You do not know what the inclination of the rock is on the other side of the river?

Mr. HOWELL. No.

The CHAIRMAN. Or whether the rock rises again so as to form a dam—that has not been prospected?

Mr. HOWELL. No. In Colorado they are constructing a canal to take the water out, and there is a point above where a dam has been constructed across the river, from bed-rock to the surface, to force the water in the river to the surface.

The CHAIRMAN. It follows the bed-rock?

Mr. HOWELL. Yes.

The CHAIRMAN. How much water does that force to the surface in ordinary times?

Mr. HOWELL. The gentleman who constructed it calculated that it was 100 cubic feet per second that was running through the canal, but there was some being lost at the same time going down the river.

The CHAIRMAN. The dam did not stop it all?

Mr. HOWELL. No. The dam was just up to the surface of the sand

The CHAIRMAN. How far is that from the State line?

Mr. HOWELL. That was at Fort Morgan. I do not know exactly where it is. It is beyond Sterling.

The CHAIRMAN. How long a ditch have they run from that down?

Mr. HOWELL. I think it is about the neighborhood of 64 miles altogether.

The CHAIRMAN. It is getting down pretty well to the State line?

Mr. HOWELL. No. The main or supply ditch follows the contour of the surface and there is a lateral. Altogether, I think, it is 64 miles long.

The CHAIRMAN. On which side of the river is it taken out?

Mr. HOWELL. On the south side.

The CHAIRMAN. Why would it not be a good plan to unite with those people and take out all the water and bring it down as far as it will come?

Mr. HOWELL. Because 122 feet per second would be insufficient.

The CHAIRMAN. But in flood-time there is a good deal more?

Mr. HOWELL. Yes; but they have not practiced much the saving of water in winter.

The CHAIRMAN. Water saved in winter is just as good as that saved at any other time, is it not?

Mr. HOWELL. Yes.

The CHAIRMAN. Suppose you make reservoirs along on the highest points, could you not irrigate a good deal of your land in that way?

Mr. HOWELL. Yes; not only there, but upon the tables. There are many natural reservoirs where water might be stored, and, although it could not be used for irrigating, it could be left there to temper the winds.

The **CHAIRMAN.** But it could be stored and used for irrigation when wanted.

Mr. **HOWELL.** It might. If you could not get the water on the land to irrigate, it would be good to let it stand around in small lakes.

The **CHAIRMAN.** Taking the river out at the point where the rocks appear, what would be the lay of the land, of the topography, from there down?

Mr. **HOWELL.** There is a gradual slope to the river. The slope ends at the table-land above.

The **CHAIRMAN.** How does the land on the South Platte along here by Fort Morgan and Sterling compare with the land on the other side as regards its natural fertility?

Mr. **HOWELL.** The soil seems to be sandy about Fort Morgan.

The **CHAIRMAN.** On which side?

Mr. **HOWELL.** On the south side.

The **CHAIRMAN.** Much more so than on the north side?

Mr. **HOWELL.** Yes.

The **CHAIRMAN.** Is that true all along for a considerable distance that this is really somewhat of a sand-hill region on the south side?

Mr. **HOWELL.** I think it is.

The **CHAIRMAN.** Are there any other views you wish to present?

Mr. **HOWELL.** There is one point which I think is a good one, that is, to make a series of reservoirs or lakes on the table-lands, using the spring water. Although the water can not in many cases be used to irrigate land, at the same time it would be making innumerable lakes which would increase evaporation and dew. Whether it would have any effect on the rain-fall is uncertain.

The **CHAIRMAN.** Can you get reservoirs and use the storm water?

Mr. **HOWELL.** I think the storm water is all held there now. I think there is only one draw that extends up to the table-land between here and Grant, about twenty miles south of this. It does not seem that any great quantity of water ever passes at that draw.

The **CHAIRMAN.** Is there a lake there?

Mr. **HOWELL.** No. There is sort of dry lake but the water is stored in the shallow lakes until about this time. Then evaporation takes the greater portion of it. There are wells there 200 feet deep and the strata there are ordinarily pervious to a great extent.

STATEMENT OF C. H. BROWN, OF KEITH COUNTY.

The **CHAIRMAN.** How far from this town is your county?

Mr. **BROWN.** Seven miles southeast.

The **CHAIRMAN.** What is the character of the county on the other side of the river?

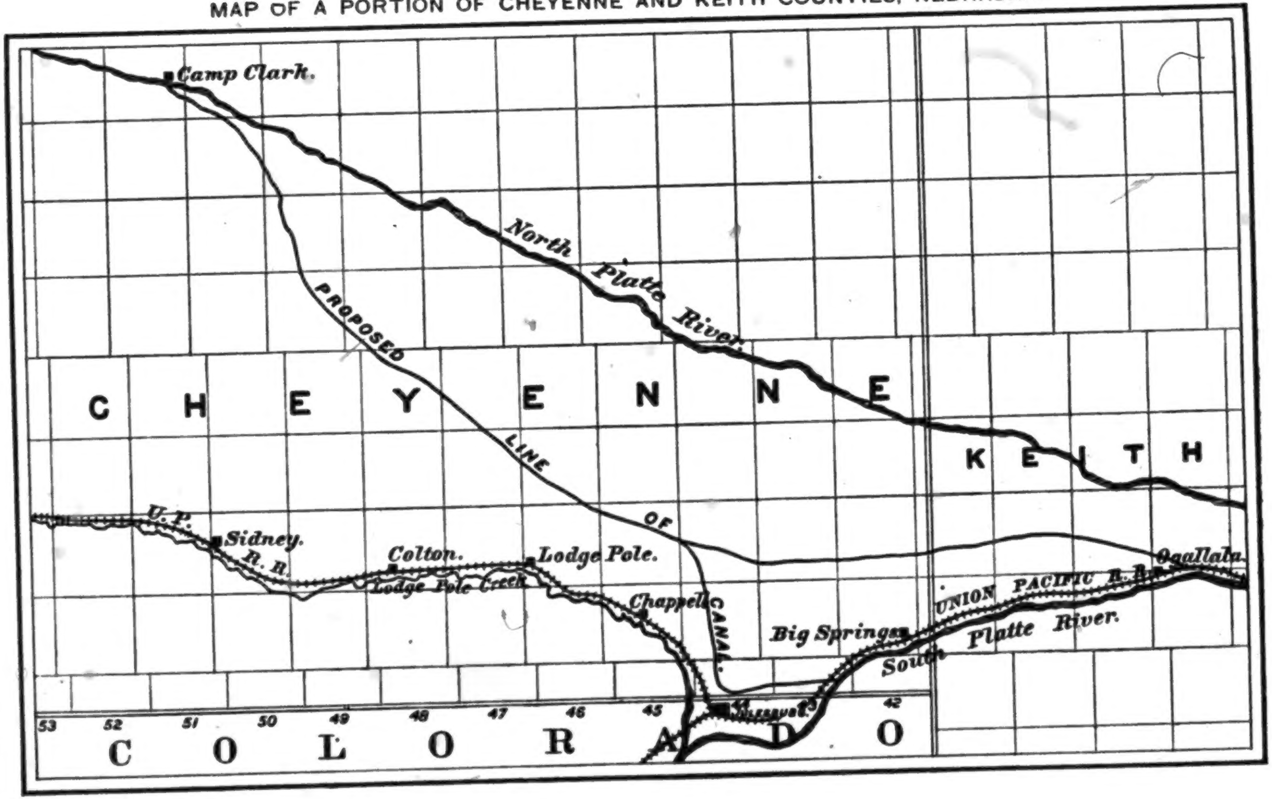
Mr. **BROWN.** It is very level and smooth. It has a fine soil. It is also indented with what are called in this country lagoons. You will find a lagoon on an average to a quarter section and from that more. Those lagoons in extent will run up from 4 acres to 160.

The **CHAIRMAN.** Does much water collect in those during the storms?

Mr. **BROWN.** Some seasons they have been partly filled with water but never full.

The **CHAIRMAN.** Do they discharge the water into the Platte?

MAP OF A PORTION OF CHEYENNE AND KEITH COUNTIES, NEBRASKA.


Camp Clark.
North Platte River.
PROPOSED LINE OF CANAL.
CHEYENNE
KEITH
U. P. R. R.
Sidney.
Colton.
Lodge Pole.
Lodge Pole Creek
Chappell
Big Springs
UNION PACIFIC R. R.
Ogallala.
South Platte River.
53
52
51
50
49
48
47
46
45
44
43
42
COLORADO

Report on Irrigation.

Mr. Brown. But very little.

The CHAIRMAN. They have no outlet?

Mr. BROWN. No.

The CHAIRMAN. There are depressions in the earth.

Mr. BROWN. Yes. There is not water enough falling to overrun these lagoons at any time.

The CHAIRMAN. Can you not build a dam across them and make a pond?

Mr. BROWN. There are already ponds.

The CHAIRMAN. But you say they are so low that you can not get the water to use?

Mr. BROWN. In some places. Some of them are too low, and you can not drain them on to the land, but others on the high points could be used for irrigation. There are several ridges of land that are a little higher than the balance, and those ridges generally have the most lagoons.

The CHAIRMAN. The lagoons are almost too large to make ponds of, are they not? You do not have water enough to fill them?

Mr. BROWN. We never have had them all filled in the six years that I have been here.

The CHAIRMAN. Could you not make ponds or small lakes and fill them?

Mr. BROWN. We could if we had the water.

The CHAIRMAN. Some water comes down I suppose?

Mr. BROWN. Yes.

The CHAIRMAN. How is the lay of the land between the Republican River and the Platte?

Mr. BROWN. There is a natural fall to the south.

The CHAIRMAN. And there are table-lands extending along between the Republican and the Platte, are there?

Mr. BROWN. Yes.

The CHAIRMAN. About what elevation is there above the Platte?

Mr. BROWN. About 200 feet from the water-bed. That is about the depth of our wells—from 150 to 200 feet.

The CHAIRMAN. Is it good land?

Mr. BROWN. The nicest I ever saw.

The CHAIRMAN. Do you raise regular crops there without irrigation?

Mr. BROWN. No.

The CHAIRMAN. Can a farmer prosper there without irrigation?

Mr. BROWN. No.

The CHAIRMAN. It is not a good place for homes, then, without irrigation?

Mr. BROWN. No.

The CHAIRMAN. Have you tried it thoroughly to ascertain?

Mr. BROWN. I have tried it for six years.

The CHAIRMAN. Do you know anybody who knows it any longer than you do?

Mr. BROWN. No. I plowed the first acre of land that was plowed in this country.

The CHAIRMAN. And during the six years' experience you have come to the conclusion that it will not do to try to farm without irrigation?

Mr. BROWN. I have.

The CHAIRMAN. Is that the experience of your neighbors?

Mr. HOWELL. Yes, as far as I know.

The CHAIRMAN. You came here under the expectation that you could do it?

Mr. **BROWN.** Yes.

The **CHAIRMAN.** And you have been disappointed?

Mr. **BROWN.** Yes. Some years we have raised a particularly good crop and some years nothing. This year we have nothing at all as far as corn goes, though we have a middling fair crop of wheat and a partial crop of rye.

STATEMENT OF W. L. GOULD, OF OGALALLA.

The **CHAIRMAN.** How long have you resided here?

Mr. **GOULD.** About three years.

The **CHAIRMAN.** You may state anything that occurs to you in reference to storm-water and other water for irrigation.

Mr. **GOULD.** My experience has been this, that when we have abundance of rain through the winter, enough to soak up the ground well, there is no trouble about certain classes of crops growing; but if we have a dry winter we are apt to have a dry spring following, and not sufficient rains to grow crops. I know this, that in these table lands between the two rivers nature has provided a number of places, if utilized, to fill up with an abundance of water during the winter, which could be utilized during the summer. I have driven extensively over the country.

The **CHAIRMAN.** You think reservoirs would be filled if they were made?

Mr. **GOULD.** Yes.

The **CHAIRMAN.** Have there been any experiments made here to show what reservoirs can do?

Mr. **GOULD.** We have seen farmers who have built dams on small streams and have used that water for irrigation on whatever surface was below, and with good results.

STATEMENT OF FRANCIS M. SMITH, OF OGALALLA.

The **CHAIRMAN.** Where do you reside?

Mr. **SMITH.** In Ogalalla.

The **CHAIRMAN.** Are you a farmer?

Mr. **SMITH.** I have had experience in farming this season.

The **CHAIRMAN.** Have you ever constructed a reservoir here to save water?

Mr. **SMITH.** Yes, we constructed an irrigating ditch, and have been using the water this season, and it has been successful.

The **CHAIRMAN.** Give us some information as to it.

Mr. **SMITH.** We have our farm over on the north side of the North Platte River, about 15 miles northwest of this. There is a small stream called Sand Creek running a couple of miles on our property. My experience is that, in this section of country, farming is unsuccessful. I have never seen a full crop grown yet for the three years that I have been here. We went to work and constructed a dam across this stream and put in a canal for a distance of about 3 miles (myself and my neighbor), and we have been using the water on 40 acres of ground that we broke this spring. We put that to corn, and it is a very heavy piece of corn. We consider it a full crop. My neighbor also uses it on 40 or 50 acres, and he got a good crop. Where the water failed to reach the crop the corn was a failure.

The **CHAIRMAN**. How much water did you store by your dam?

Mr. **SMITH**. I think we have about 1,400 cubic inches.

The **CHAIRMAN**. Per second or what?

Mr. **SMITH**. All the time.

The **CHAIRMAN**. Does the stream furnish that, or did you increase it by your dam?

Mr. **SMITH**. We increased it by the dam. We turned the stream.

The **CHAIRMAN**. Did you make a lake?

Mr. **SMITH**. No, we did not mean to make a lake. We live on the bottom, on the north side of the river, in the valley, and we constructed a dam there and turned the stream simply.

The **CHAIRMAN**. How is that stream in winter?

Mr. **SMITH**. There appears to be just as much water there in winter as in summer.

The **CHAIRMAN**. If you had a reservoir in there, so that you could save that water the year round, you could do a good deal more, could you not?

Mr. **SMITH**. Perhaps so, but we use it as it is to irrigate about 80 acres.

Director **POWELL**. What did you mean by 1,400 inches of water?

Mr. **SMITH**. That would mean 1,400 inches of solid water; what the ditch would carry.

Director **POWELL**. In how much time?

Mr. **SMITH**. It would carry that by the minute or second, just as it would run.

Director **POWELL**. Have you ever mined?

Mr. **SMITH**. No, I never did mine.

Director **POWELL**. You do not know what a miner's inch is?

Mr. **SMITH**. No.

Director **POWELL**. How wide is your ditch?

Mr. **SMITH**. I think it is about 3 feet in the bottom.

Director **POWELL**. And how deep does the water run?

Mr. **SMITH**. I hardly know the depth. We have never measured it, but when we filed our right under the irrigating law there were men who appeared to understand the nature of irrigation that we consulted, and they said that there were about 1,400 cubic inches of water in that stream.

STATEMENT OF J. J. McINTOSH, OF SIDNEY.

The **CHAIRMAN**. Do you require to irrigate your land in order to produce crops?

Mr. **McINTOSH**. We irrigate there as much as we can. Irrigation is not carried on there, however, to any very great extent.

The **CHAIRMAN**. Could you produce crops there without irrigation?

Mr. **McINTOSH**. No, not a full crop.

The **CHAIRMAN**. What efforts have been made to irrigate there, and what are the chances to irrigate?

Mr. **McINTOSH**. The chances are good to irrigate there, as stated by Professor Hicks. There was no attempt to do any farming there until the year 1884. The people that came there to settle came with the understanding that irrigation was not required, and it was not expected at all that people would have to irrigate. They supposed that there was sufficient rain-fall to produce a fair crop after the land was properly tilled. But many settlers came in and many went away, and at no time since then have they succeeded in raising a full crop of anything. That is about the truth of the matter in few words. I have lived in that county on and off since 1870.

The **CHAIRMAN.** They have irrigated some in your county, have they not?

Mr. **McINTOSH.** They have irrigated some along the Lodge Pole.

The **CHAIRMAN.** What have been the results of irrigation there?

Mr. **McINTOSH.** When they have irrigated the results have been very satisfactory.

The **CHAIRMAN.** What are the facilities for irrigation?

Mr. **McINTOSH.** The facilities are good there.

The **CHAIRMAN.** The Lodge Pole furnishes some water, I suppose.

Mr. **McINTOSH.** Yes.

The **CHAIRMAN.** Does it have floods?

Mr. **McINTOSH.** We have heavy rain-falls there. Our rain-falls are more spasmodic than the rain-falls in the center or eastern part of the State.

The **CHAIRMAN.** The water runs to waste then considerably, does it?

Mr. **McINTOSH.** Yes.

The **CHAIRMAN.** If that water was stored in proper places would the Lodge Pole furnish any considerable amount of water for irrigating the land?

Mr. **McINTOSH.** It would furnish enough water to irrigate the valley in which it is. My idea about irrigating the table land between the Lodge Pole and the North Platte River would be to take the water from the North Platte River at some point in Wyoming. Then it can be stored in ravines so as to be used in the valley if necessary.

The **CHAIRMAN.** Are you familiar with the North Platte?

Mr. **McINTOSH.** No.

The **CHAIRMAN.** You do not know how much of an undertaking that would be?

Mr. **McINTOSH.** No; but I have been informed by a practical engineer who went out there about ten days ago, that it is perfectly practicable to take the water out of the North Platte River on to the table land.

The **CHAIRMAN.** If that were done and the flood waters were saved you could irrigate considerably?

Mr. **McINTOSH.** We could irrigate the whole divide.

The **CHAIRMAN.** What are the opportunities on the divide for storing storm water in the ravines?

Mr. **McINTOSH.** There are a number of natural basins on the table-land where water stands the whole season round. I have been all over the table land there.

The **CHAIRMAN.** These natural basins are not always the best places. Sometimes you could save water better by making your own basin in the ravine. They are apt to have underground communication and leak badly. Besides, you would need to make the places deep or the evaporation would be bad. Are there opportunities to make ponds there so as to have water?

Mr. **McINTOSH.** Yes.

The **CHAIRMAN.** How deep is the water under the surface?

Mr. **McINTOSH.** On the table land it varies. It runs from 75 feet to 250.

The **CHAIRMAN.** How deep is it in the Lodge Pole Valley?

Mr. **McINTOSH.** Twenty-three feet in the center of the valley and then as you go back toward the table land the depth is greater.

The **CHAIRMAN.** Is there much of a flow of the underground water in the Lodge Pole at 23 feet?

Mr. **McIntosh.** Yes, the wells are inexhaustible.

The **Chairman.** Something might be done, perhaps, by pumping there?

Mr. **McIntosh.** Yes, I think so.

STATEMENT OF THEODORE MENGES, OF KIMBALL.

The **Chairman.** On what stream do you reside?

Mr. **Menges.** On the Lodge Pole.

The **Chairman.** Has there been any irrigation from the Lodge Pole in your vicinity?

Mr. **Menges.** Yes, to some extent.

The **Chairman.** With what success?

Mr. **Menges.** With the best of success. They have gardened some. They have farmed barley and some oats (60 bushels to the acre). The barley was 35 bushels to the acre. They have got excellent corn and all kinds of vegetables in great abundance.

The **Chairman.** What are the opportunities for irrigating on the Lodge Pole in your neighborhood?

Mr. **Menges.** They are good.

The **Chairman.** How can they be utilized?

Mr. **Menges.** By damming the valley.

The **Chairman.** Does much water flow in the Lodge Pole at any season of the year?

Mr. **Menges.** An average of about 12 cubic feet per second flows on the surface. At Kimball we have been at considerable expense to make surveys to find out how much water we have there, expecting to construct a dam and create a water power. It was estimated by an engineer we had there that we had five times as much water flowing on the surface as flood in the stream itself.

The **Chairman.** Is there any opportunity to get that water to the surface?

Mr. **Menges.** We have made soundings across the valley, a distance of about 400 feet, and we find that the distance to rock bottom varies from 11 to 17 feet. About from 2 to 3 feet beneath the surface of the soil we come into water, and from there all the way down into the rock. To bring that water to the surface is very desirable, and we believe it can be done by putting down a dam of some sort on this rock bottom and building it up.

The **Chairman.** They have not resorted to pumping there at all?

Mr. **Menges.** No. We do not know how it is possible even to get down to that rock-bottom. We have sounded with augers but we need to get down so as to make a larger excavation.

The **Chairman.** Is there any other possible water supply for you except the Lodge Pole?

Mr. **Menges.** That is all, excepting the storm waters. With reference to those storm waters we find these lagoons on the divide, and, as stated by yourself and others, I think they are not the best places for catching these waters. Take the whole of Kimball County and you will find it more or less rolling. We have "draws" there in places varying from 20 to 500 feet. They will sometimes have enough water during these storms to swim a horse across them. I know that passing my house and passing the ranch in which I live there is a place that looks perfectly dry generally. It drains a distance of two miles. We have our heavy freshets in July and August and the water was five and six feet deep towards the end of July and first of August. Take the town of Kimball and for two or three hours after a heavy storm you could row a boat through its streets. Kimball drains a body of land of two or three townships, I should say, and when the heavy floods come it makes the whole town practically a lake.

The **CHAIRMAN.** If that water was stored it would do considerable good.

Mr. **MENGES.** Yes, an immense amount of good.

The **CHAIRMAN.** Would you regard surveys and examinations as to the best points for designation for reservoirs as desirable?

Mr. **MENGES.** Very desirable and exceedingly valuable to the people.

The **CHAIRMAN.** We want to know whether money spent in that way will be useful.

Mr. **MENGES.** Very useful and it will be very highly appreciated. In the town of Kimball we have been attempting to develop a water-power and have been at an expense of $500 or $600, which demonstrates the desire of the people to have better water facilities.

The **CHAIRMAN.** What is the fall of the stream?

Mr. **MENGES.** It is 14.4 feet to the mile.

The **CHAIRMAN.** Then a mile of a channel or cut would bring you to the level of the bottom of it, will it not?

Mr. **MENGES.** Yes.

The **CHAIRMAN.** Then you would not have to build the dam so high?

Mr. **MENGES.** No, although we get power of course in proportion as we raise the dam. We have made an examination 10 miles westward from the town of Kimball, and we find that the average will be 15 feet to the mile. In some places the fall would be greater than at others. We had intended to take out a canal, and went up 10 miles and found it 15 feet to the mile on an average. Then we made accurate measurement for 5 miles and for that distance it was 14.4 feet to the mile.

The **CHAIRMAN.** In a couple of miles you would get to bed-rock?

Mr. **MENGES.** Yes. Immediately west of the town of Kimball you will find the bed-rock and all water flows over the rock itself.

The **CHAIRMAN.** Why would that not be a good point?

Mr. **MENGES.** It would be an excellent point, but it would not be at the place where the town wants it.

The **CHAIRMAN.** Suppose you built your dam there and brought the water through the town by a flume or pipe?

Mr. **MENGES.** That would do. We want it to make a lake near the town, however, and were willing to put in a little extra expense. In that stream we have 12 to 14 cubic feet to the second. It is supposed that we can have about 25 to 30 by putting this dam down to bed-rock, and possibly more than that. One estimate was that we could have about 60 by putting it down to bed-rock.. If we could save the flood water we would have all the water we wanted for the whole valley and a portion for the divide.

The **CHAIRMAN.** You could build a dam and save the water by that means. I should build a dam where the rock is and I should have a pipe at the bottom—an iron pipe—cemented in so that you could draw the water out and irrigate a great deal of the land. You would want to draw water off in the summer, would you not, for irrigating purposes?

Mr. **MENGES.** I think you would not want it all. By taking the North Platte and going 20 or 30 miles into Wyoming, that is a magnificent divide lying between the Lodge Pole and the North Platte. There are 1,500,000 acres that could be utilized and utilized well. There is practically no waste land at all.

The CHAIRMAN. The Platte River is a large river.

Mr. MENGES. Very large.

The CHAIRMAN. A great deal of it runs to waste.

Mr. MENGES. Yes; a great deal of it. In the spring as much as 1½ to 4 feet in depth over a half to three-quarters of a mile was flowing down.

STATEMENT OF J. A. PHILLIPS, OF GRANT.

The CHAIRMAN. Is there any stream of water in your county?

Mr. PHILLIPS. No; the nearest stream of water we have is 20 miles away. I live 20 miles south of this.

The CHAIRMAN. How would you suggest that this section might be redeemed by irrigation?

Mr. PHILLIPS. We would like to have a ditch commence in Colorado, 20 miles from the Nebraska line.

The CHAIRMAN. Is there any place at which you could get the water out?

Mr. PHILLIPS. There is such a fall that it will come along.

The CHAIRMAN. Suppose you went still farther up?

Mr. PHILLIPS. There is a sand region farther up that would make it difficult to get the water through?

The CHAIRMAN. You want to get below the sand?

Mr. PHILLIPS. We will have to do that, we think.

The CHAIRMAN. You can not raise crops in your vicinity without irrigation?

Mr. PHILLIPS. We can not raise corn.

The CHAIRMAN. Can you raise any other kind?

Mr. PHILLIPS. We can raise wheat, rye, and a half a crop of oats.

The CHAIRMAN. How much wheat?

Mr. PHILLIPS. Eight to 18 bushels per acre, but there is more of it at 3 and 5 bushels per acre than there is at 8.

The CHAIRMAN. How deep is it to water where you are?

Mr. PHILLIPS. One hundred and eighty-five feet.

The CHAIRMAN. You have not tried artesian water?

Mr. PHILLIPS. No.

The CHAIRMAN. Is there an abundance of water when you get down 185 feet?

Mr. PHILLIPS. Yes; we can run a wind-mill constantly with a 2-inch pipe and can not exhaust the supply of water at the bottom of the pipe.

The CHAIRMAN. Have you irrigated any land with wind-mills?

Mr. PHILLIPS. Not to any great extent?

The CHAIRMAN. Have you irrigated gardens?

Mr. PHILLIPS. People have irrigated their gardens that way. In the south part of the county there is a kind of surface spring water, and they had some little crops there. In the eastern part of the county it is lower and they have some better crops there. We do not see our way to farming there unless we can see our way to water.

The CHAIRMAN. Is there any way to store storm water there?

Mr. PHILLIPS. Yes; there are natural reservoirs all over there.

The CHAIRMAN. In these large natural depressions the water evaporates. You would have to find smaller ones.

Mr. PHILLIPS. We could get them of any size.

The CHAIRMAN. You have not tried to make ponds?

Mr. PHILLIPS. I have a small pond which is used somewhat for a fish pond.

The **Chairman**. If it would do for fish it would do for irrigation.

Mr. **Phillips**. Certainly. We can pump water into it.

The **Chairman**. You can not fill it from storm water, then.

Mr. **Phillips**. No. Our rains in the spring are heavy. From January to June we have had for three years past plenty of rain and after that time we have had scarcely any rain. If we had reservoirs prepared we would be able to store that early spring water.

The **Chairman**. And irrigation at the critical time would enable you to raise crops?

Mr. **Phillips**. Yes, without any trouble.

The **Chairman**. If that section were surveyed carefully and places for reservoirs located by scientific men of experience would it be useful to you?

Mr. **Phillips**. I think it would. The majority of our farmers now think that the only thing to be done is to store the storm water.

STATEMENT OF JAMES ROBSON, OF JULESBURG, COLO.

The **Chairman**. What is your occupation?

Mr. **Robson**. I am in the banking business there.

The **Chairman**. Has your attention been called to the deficiency of moisture here for the purposes of growth of crops.

Mr. **Robson**. It has.

The **Chairman**. How long have you been here?

Mr. **Robson**. About two and a half years.

The **Chairman**. Have you looked over the country to see what the conditions were by which farming might be improved and moisture obtained?

Mr. **Robson**. Yes.

The **Chairman**. We shall be glad to have any statements you think proper to make in regard to the matter.

Mr. **Robson**. The land I speak of is between the North Platte and the Lodge Pole Creek, and between the one hundred and second and the one hundred and fourth meridians. From the time I have been in this country I have become convinced that to make a success of corn it is necessary to have more moisture. We have for that purpose, in our town, discussed the matter in our board of trade. There was a committee formed to investigate it and see whether there was any possibility of irrigating the region which I have mentioned, from Julesburg west and northwest. The committee engaged the services of an engineer of Denver, named Wilson, to go across this country and see whether there was any possibility of taking the water from the North Platte and bringing it over toward Julesburg and irrigating there. To make my remarks shorter, I will read a short paper that the committee prepared yesterday, after they learned that your committee was to meet here.

The paper is as follows:

> Our object in laying this scheme before the committee is to call your attention to it, and give it prominence and recognition as an undertaking of great importance and value to a large number of people in one of the most fertile regions of western Nebraska. The practicability of ditching from the North Platte River, at a point northwest of Julesburg about 100 miles, across the table-land, has been established by a preliminary survey. The proposed route is from a point on the North Platte River, near Camp Clark, on to the table-land, and in a southeast direction to Julesburg.
>
> In regard to the quality of the section of country to be irrigated, we would say that we believe that no stretch of country approaching this to any degree in scope and richness has been irrigated in the West.

The soil is first-class; no sand or gravel to be found in the entire distance except in the river bottom.

From the point where the projected route strikes the table land to the terminus there is not one acre of inferior land, and no area can be found that will irrigate to better advantage.

A ridge or divide extends almost the entire route, thus allowing the water to be conducted both ways for many miles. The river bluffs are composed of soil and soft rock. The river bottom contains some sand, the same as is found all along either valley of the Plattes. The survey, which was made by Mr. C. A. Wilson, a civil engineer of Denver, found the fall of the North Platte River to be 10 feet to the mile, and the height of the bluffs about 350 feet. The fall of the table-land is about 7 feet to the mile, the general trend being to the southeast from the starting point. The scope to be irrigated is on an average about 25 miles in width; beautiful, level-lying land, with a ridge running along the center, this making it easy to irrigate the whole scope.

The committee believe that this project bids fair to open up the richest part of the West, and make the whole tract embraced within the scope of the ditch a perfect garden, and the people a rich and prosperous community.

That no ditch in the West would be more profitable to its constructors and satisfactory to its operators.

Mr. ROBSON. I would say in regard to the water supply that the North Platte has always afforded an abundance of water, and that the engineer at the time he was there, just about a year ago, said that there was then an abundance of water for the supply of three or four or half a dozen such ditches as would be necessary to irrigate that region, probably, at that time. The inhabitants around the river there have been there for a great number of years; they said they never knew the river to be so low, although it is probably lower now than it has ever been. Still, if the river did not afford enough surplus water running, I think the possibility of obtaining water enough by creating dams in the gravel is very great, and would be successful. All through this whole region of country there is an underlying stratum of water that is practically inexhaustible. That has been demonstrated without any dispute. It is necessary that dams should be built if anything is to be made out of that country in the way of agriculture. I think that by building dams and running down into this gravel-bed a water supply can be obtained. It may be expensive, but the water is there.

The CHAIRMAN. Do you think an investigation by the Government as to the best mode of doing it, and where the water can be obtained and estimates of cost and reservations made for reservoir sites would be valuable to the people here?

Mr. ROBSON. Very valuable, indeed.

STATEMENT OF C. A. WALKER, OF OGALALLA:

The CHAIRMAN. What is your occupation?

Mr. WALKER. I am county surveyor of this county.

The CHAIRMAN. You are familiar, I suppose, with the water supply about here?

Mr. WALKER. Yes.

The CHAIRMAN. Have you made any surveys in reference to irrigation?

Mr. WALKER. Yes.

The CHAIRMAN. You may state, in your own way, what you have done, and give us your views with regard to irrigation.

Mr. WALKER. I made one preliminary survey on the south side of the South Platte River, beginning at the Colorado line and extending it about 23 miles east. From what I have done I should think a water-supply could be easily obtained at that point, and a ditch could be built at very little expense. There are about 30,000 or 40,000 acres of land that could be put under ditch.

The CHAIRMAN. If a ditch were commenced at that point would it get onto the table-lands?

Mr. WALKER. Not so far down as I came. I should think it would take 30 or 35 miles to do that.

The CHAIRMAN. Can you not go up higher to better advantage, and get a ditch on to the table-lands, or are you in the sand belt?

Mr. WALKER. No. I could have gone 30 or 35 miles further up the river, and by that means it would get to the table-land.

The CHAIRMAN. Would not that be a better place?

Mr. WALKER. I think likely it would.

The CHAIRMAN. How would you get the water from the river?

Mr. WALKER. By means of a gallery going down into the gravel bed.

The CHAIRMAN. Is that ditch going to be constructed?

Mr. WALKER. I do not know.

The CHAIRMAN. What chance is there for storing storm-water on the south side of the river?

Mr. WALKER. There are very good chances. On the south side—in fact, on both sides—of each of the rivers, the North and South Plattes, there are lagoons, the lower parts of which could be dammed up, and I think a great deal of storm-water could be saved.

The following papers were received and filed. The committee then adjourned, to meet at Washington, D. C., on the call of the chairman:

STATMENT OF A. D. SCHERMERHORN, ENGINEER NEBRASKA DIVISION OF THE UNION PACIFIC RAILWAY.

The main line of the Union Pacific Railway, from the one hundredth meridian west to Cheyenne, passes through the western part of Nebraska and eastern part of Wyoming. Along this line the water supply of the road is, with two exceptions, derived entirely from wells, which give a supply ample for all uses of the company. The road lies along the South Platte River and Lodge Pole Creek, and the wells are sunk on this line, varying in depth from 12 to 30 feet east of Potter Station, and west of there from 35 to 120 feet deep. In sinking these wells trouble was often had on account of quicksand.

Following is a list of wells along the above line, with depth, quantity, and quality of water, etc.:

Station.	Depth.	Diameter.	Quantity.	Quality.
	Feet.	*Feet.*		
Willow Island	12½	12½	Ample	Fair.
Brady Island	12	12	do	do.
Maxwell	10	12	do	do.
North Platte	70	*	Limited	Good.
O'Fallon's	15	9½	do	do.
Paxton	19	12	Ample	do.
Ogallala	10	12	do	do.
Julesburg	18	12	do	do.
Weir	17	9½	Limited	do.
Lodge Pole	17	9½	do	do.
Sidney	35	12	Ample	do.
Potter	30	9½	do	do.
Bushnell	40	9½	Limited	do.
Pine Bluffs	40	9½	Ample	do.
Egbert	35	9½	do	do.
Hillsdale	60	9	Limited	do.
Atkins	120	12	do	Fair.

* Four 3-inch pipes.

More or less alkali is found in the water of all the above wells. At Big Springs the supply is derived from a spring on the hill, from which a pipe line is laid to the tank, it being a gravity supply. The water is of good quality, but the supply is limited. At Kimball the water is pumped from Lodge Pole Creek, about 1 mile from the road, direct into the tank. The supply is ample and the quality good.

No storage system in use on the road. No record has been kept by this department of the rain-fall in this part of the State. The rain-fall is light, and what there is generally occurs between the months of January and July.

There are no irrigation enterprises in successful operation, though several plans for the same have been talked of.

At Kearney there is a canal running from the Platte River, which furnishes water power, but is not used for irrigation purposes.

STATEMENT OF ABBEN WOODCOCK, GENERAL LAND COMMISSIONER OF THE UNION PACIFIC RAILWAY COMPANY.

The Union Pacific Company has never made any surveys relative to irrigating its lands. Neither has it at any time published maps or reports on the subject of irrigation. We have nothing in print relative to the matter.

The subject of irrigation is a very important one. The solution of the problem, "How can the millions of acres of our arid lands be irrigated?" may well engage the best minds of our country, and especially enlist the attention of Congress.

There is no more beautiful country in the world than that which lies between the Missouri River and the Rockies, "The great divide of our continent." Richer land the sun does not shine on. The west third of this lovely country is mostly unproductive for the want of water. Where water has been applied to its soil vegetation springs up like magic and grows and blooms with all the luxuriance of a flower garden. Its yield of vegetables, the cereals, and of fruits is very prolific, and the quality is of the very best.

In Colorado, the land to yield must be irrigated. This is also true of Wyoming, Idaho, Utah, Arizona, New Mexico, Nevada, and the south of California.

In Colorado, east of the mountains, the rivers and streams are already tapped by irrigating ditches; and in the driest part of the season hardly furnish sufficient water to irrigate the lands that are already under cultivation. The South Platte, in its meandering course through Nebraska, is but a bed of sand, the water having been taken from it in Colorado. The same may be said of other streams that have their source in the Rockies. In the dry season but little water through these channels reaches the Missouri.

It is supposed that if the few floods that swell those streams in summer were gathered into reservoirs, sufficient water would be furnished to irrigate the lands which are now under cultivation. At present this is not the case. But how can water be procured to irrigate the millions of acres in Colorado that are yet uncultivated and can be used only for grazing land?

In the spring-time of the year the melting snows of the mountains come thundering down the rocky defiles of the mountains in cascades, and the rain-storms at times pour in torrents. These swell the creeks and streams to overflowing, but soon are carried away in swiftly-running currents and are lost in the great rivers on their way to the sea. How can the priceless waters of these spring floods be saved to the parched up and thirsty country? By collecting them into numerous and extensive reservoirs throughout the country. These reservoirs must be strongly and scientifically built. Large canals and ditches must be so constructed that the waters in flood time may be carried from the creeks and rivers at a high elevation into these reservoirs. No water of flood-time must be allowed to escape as long as there may be room in the reservoirs.

There would, of course, be a constant loss of water from the reservoirs by seepage into and through the ground. The water that would escape by seepage would again appear to the surface in the form of springs and little rivulets. These would break out in low depressions of the ground, in ravines, and small valleys.

These springs and rivulets would be utilized by the farmer in watering his stock or in irrigating his orchards and garden.

Reservoirs might be made in the creeks and rivers themselves by building good and substantial drains at certain available places along their courses.

Mr. Gilmore, general manager of the Platte Land Company, Denver (who, by the way, has studied this subject for years), says that in Colorado they estimate that a stream of water equal to 1 cubic foot per second of time is sufficient for irrigating 50 acres. It is believed that could the vast amount of water that falls in spring and occasionally at intervals during the year be saved for irrigation, it would be amply sufficient to make the States and Territories above named bloom like a rose agriculturally. The cost of the construction of such reservoirs, canals, and ditches would be so great, that capitalists, as yet, have not dared to undertake the enterprise. Should our General Government lead off in this great enterprise by making the required surveys in the different States and Territories where irrigation is a necessity, and inaugurate that great work, capitalists, and the people generally, would enthusiastically join in and give every aid in their power.

THE LANDS OF THE UNION PACIFIC RAILWAY COMPANY.

Nebraska.—As far west as North Platte, on the Union Division of the Union Pacific Railway, the country is agriculturally rich and most prolific in crops, and for some distance beyond Julesburg crops are raised successfully without irrigation. In the extreme western part of the State "dry farming" (as cultivation without irrigation is called) has not thus far been entirely successful. Good crops, however, at some seasons in the western part have been raised. The settlers have confidence and believe that ere long in the future the rain-fall will be amply sufficient. The amount of rain-fall from year to year has gradually increased. The rain-fall this year has been abundant and the prospects for an abundant crop are splendid. The company has practically sold its lands in Nebraska. It has but few pieces unsold. Irrigation I do not think is needed in any part of Nebraska.

Wyoming.—The company has sold all its land in this Territory as far west as Fort Steele, with the exception of a few sections. The land was sold for grazing purposes, with few exceptions, to men engaged in raising cattle. We have yet a large body of land in the western part of the Territory, at least 2,500,000 acres, lying on either side of Green River. I have no doubt that a great portion of this land lying west of Green River can be made highly productive and capable of sustaining thousands of people by constructing a canal that will tap the river high up towards its source, by means of which at least two-thirds of the company's as well as the Government's lands can be successfully irrigated. I ask that your committee investigate this subject when in Wyoming. There is no question about the richness of the soil; even that upon which the station of Green River is situated, which seems so sterile. When at that station, please look at the little inclosure of a Mr. Johnson, just south of our track. It is as green and beautiful as a Washington City park—the effects of irrigation. Owing to the high altitude of Wyoming, Indian corn can not probably be raised, but other crops will be a success. Eastern Wyoming is very similar to western Nebraska, and but little irrigation will be necessary. I am of the opinion that the North Platte, flowing through the southeast of this Territory, can be made to yield its waters to portions of land in that part of the Territory. The same may be said of Bear River, in the western part of the Territory. The unsold Wyoming land has up to this date been a source of outgo to the company in the shape of fees paid for obtaining patents and the yearly taxes, and has furnished no income. It now seems probable that these payments will have amounted to so much by the time this land is sold as to largely reduce the net revenue of the company from this portion of its grant.

Colorado.—The company has over 2,500,000 acres of land in this State. The greater portion can be used alone for grazing purposes unless irrigated. In the extreme eastern part of the State settlers on quite a large area adjoining Kansas and Nebraska have been trying farming, but with varying success. To insure crops even here irrigation is necessary. I have written more fully of this State in the commencement of this letter.

Idaho.—The company had no land grant in this Territory, but owing to its Oregon Short Line, and Utah and Northern Railway, it has great interest in the Territory. The land is very rich. The Snake River, having its source in our National Park, and meandering through the central and west portion of the Territory, is capable of irrigating millions of acres, and of making the south half of this Territory as productive and rich as any part of our country. The climate is admirable, and when water touches its soil vegetation seems to spring up spontaneously.

Utah.—The company has a little over 400,000 acres of land in Utah. The greater part of this land is situated in the eastern part of the Territory, adjacent to Wyoming, and is very broken and mountainous. At present the greater portion of it is fit only for grazing purposes. The land in Utah, without exception, must be irrigated to produce agriculturally. The surface of the country is broken into high hills and mountains, very rich valleys intervening. Much of the land can never be reached with water, but many valleys can be irrigated by the outlay of capital, and when irrigated will become surpassingly beautiful like that of Salt Lake. As is well known, the climate of this Territory is superb, and in salubrity can not be excelled. A great many of the valleys are well settled, but there is a large body of land in nearly all of these which can not be farmed either because water is scarce, or can not be got upon it from the streams. A system of water supply from Utah for irrigating purposes would unquestionably open up large and fertile areas in many of the very productive valleys in which the Territory abounds, and be the means of adding a large population to a country blessed with an invigorating and healthful climate and a capacity for producing many and varied crops, not the least of which are fruits of the best quality known.

Kansas.—The company has sold a vast amount of land in Kansas, there remaining yet unsold upwards of 700,000 acres. This land is first class, and lies in the western part of the State. Here irrigation is not needed. The maturing crops at this season of the year were never better, and there is every indication of a very abundant harvest. The air is pure and bracing and the climate healthful.

I am well aware that I have not treated this subject in the manner you wish. What you desire is succinct and definite information as to the practicability and feasability of irrigation in these different States and Territories. As I said, this department has never made any surveys or studied the subject relative to irrigating the company's lands. I am therefore unable to treat the subject in the practical manner it should be.

STATEMENT OF AUGUST V. KAUTZ, COLONEL EIGHTH INFANTRY, COMMANDING AT FORT NIOBRARA.

The Niobrara River flows near the northern line of the State almost its entire length from west to east. The current is very rapid and the volume of water may be roughly calculated by assuming an average depth of 2 feet and an average width of 150 feet. It is a remarkably constant stream, subject neither to droughts or floods. In the past two years it has not varied more than 2 feet between the highest and lowest water. A large portion of the country through which the river flows is sandy and subject to drought, and its value would be vastly increased if the land north and south of the river could be irrigated. The highest areas are not more than 200 feet above the stream, but many large areas are not half so high. The fall of the river is so great that it would seem highly probably that much if not all the land in the vicinity of the river could be reclaimed.

The constant character of the river is due to the fact that it is supplied entirely by springs. The country is underlaid by an impervious strata which forces the surface water it has passed through the sand that overlies it to drain into the river through the springs, thus making the water supply constant and unvarying. The river-bed has cut down into this strata about 100 feet in the cicinity of this post. Beyond this fact the thickness of the strata is not known. Its impervious character, however, suggests the great probability that artesian water could be obtained by boring through it. The material of the strata is a white earth, alkaline, and sufficiently firm to present a perpendicular wall along a great portion of the river, but as far as known it can be bored as easily as chalk. The nearest flowing well to this point is at Fort Randall, on the Missouri River, about 125 miles east of this post. Its depth is said to be something over 600 feet. If the fact could be demonstrated that artesian water could be obtained within 1,000 feet of the surface it would be of incalculable value to this portion of the State.

STATEMENT OF J. S. POLAND, LIEUTENANT-COLONEL TWENTY-FIRST INFANTRY, U. S. ARMY, OF FORT SIDNEY.

My experience in this department is not extensive enough for me to make any valuable suggestions, but I wish to remark that while stationed at Fort Bridger it occurred to me that portions of the country near that post could be made fertile by raising water from an unfailing stream, the Black Fork of Green River, into reservoirs at suitable places along its banks, as can be determined by barometric survey, and large portions of the country reclaimed by irrigating ditches. The soil is fertile and needs only proper moisture to produce anything. I am not prepared to confirm the assertion of a prominent geologist that the plains of southwest Wyoming may yet furnish a valuable fertilizing soil for worn-out districts.

STATEMENT OF E. W. STONE, CAPTAIN COMPANY A, TWENTY-FIRST INFANTRY, U. S. ARMY, OF FORT SIDNEY.

My experience in irrigation has been such only as applies to the cultivation of a company garden. For the successful cultivation of a garden, growing of trees, in fact any product of the earth, on the plains, and I might say through the entire West, irrigation to a certain extent is necessary. In the few places that have come under my observation no organized system has been adopted. Generally streams of water have been tapped, and water, without regard to quantity required, allowed to flow over the surface without means being provided for conducting that not required back to the stream, thus allowing great waste which, as the country settles, causes a scarcity, and in many cases trouble.

In many sections irrigation by flooding the surface is common, which, in my opinion, is injurious. When the flow of water is stopped, the heat and dry atmosphere converts the surface into a hard crust, thus preventing the air from penetrating to the roots of the plants, etc., which is essential to a healthy growth. I have met with the best success in irrigation by means of narrow trenches leading from a main ditch, whereby the water is absorbed in the earth around the roots of the plants and the surface left free and opened.

At this post means of irrigation are furnished from Lodge Pole Creek, the water of which is conducted to the post by a military ditch tapping the creek about a mile and a half above the post, by which means 20 acres in vegetables are successfully cultivated; fine grass plats and a luxurious growth of trees are maintained about the garrison. In this section, as settlers increase, additional acreage comes under cultivation, and timber claims planted, the rain-fall sensibly increases ever year, thus decreasing the demands for irrigation.

At the fair of the County Agricultural Society held at Sidney last year many fine specimens of vegetables and small grains, raised without irrigation, were exhibited. Prizes are only offered for such exhibits as are raised without irrigation in this county.

STATEMENT OF H. L. BAILEY, FIRST LIEUTENANT AND REGIMENTAL QUARTERMASTER TWENTY-FIRST INFANTRY, U. S. ARMY, OF FORT SIDNEY.

Observed the system and results of irrigation over wide tracts of dry deserts in Oregon, Washington, Idaho, Utah, and elsewhere. In Utah, lately, capitalists are forming companies to construct and control great ditches or canals, which will give them power to heavily tax thousands of farmers. Such projects are in contemplation, I believe, in this vicinity of Nebraska. The South Platte River throughout this State is destitute of water in summer in consequence of the use of its water in irrigation in Colorado. The taking of the water should be regulated by law. The soil of these deserts I have mentioned is very rich in agricultural ingredients, and needs only water. The North Platte, 70 miles north of this place, could, I doubt not, be made to irrigate many thousands of acres of Wyoming and Nebraska. I have not been over the ground personally, but I think it would be easy to conduct its waters to these little valleys along the Union Pacific Railway. The benefit of such spread of the water would extend beyond mere wetting of the soil, as the effect of the moisture and resulting vegetation would in time so modify the climate as to produce more rain and dew.

SESSIONS OF THE COMMITTEE.

Page.
El Paso, Tex., September 6, 1889 5
Santa Fé, N. Mex., September 7, 1889 59
On train at Las Cruces, N. Mex., September 8, 1889 88
On train at Pecos, Tex., September 9, 1889 101
On train at Colorado, Tex., September 9, 1889 102
On train from Midland, Tex., September 9, 1889 108
Toyah Tex., September 9, 1889 110
Fort Worth, Tex., September 11, 1889 112
On train near Dodge City, Kans., September 11, 1889 145
Dodge City, Kans., September 12, 1889 147
Garden City, Kans., September 13, 1889 158
Pueblo, Colo., September 14, 1889 261
Colorado Springs, Colo., September 14, 1889 275
Denver, Colo., September 16, 1889 285
Fort Collins, Colo., September 17, 1889 379
Greeley, Colo., September 17, 1889 383
Cheyenne, Wyo., September 17, 1889 439
Ogalalla, Nebr., September 19, 1889 537

INDEX.

A.

Page.

- Agricultural features and resources 46, 130, 534, 535
- Altitudes, in and Region:
  - Abilene 106
  - Baird 106
  - Bear River, near 453
  - Big Horn Valley 459
  - Brazos River, changes westward from 106
    - at the Texas and Pacific railroad crossing 118
    - Texas 21
    - crossing 106
  - Breathing Well in Texas 108
  - Clyde 106
  - Colorado River crossing, Texas 104, 106
  - Deeming, New Mexico 65
  - Doña Aña, New Mexico 85
  - Douro Station, Texas 118
  - Eastland, Texas 106
  - Fort Collins, Colorado, near 307
  - Gordon 106
  - Jornado del Muerto, New Mexico 89
  - Lamber, at 106
  - Laramie and plains, at 106, 439
  - Marienfeld, at 118
  - Merkel, at 106
  - Midland, at 118
  - Midland County, in 124
  - Monahans, Texas 119
  - Mountains of, extreme 65
  - Northern New Mexico, in 39
  - Odessa, Texas 118
  - Panhandle, Texas 104
  - Panhandle region 138
  - Pecos, Texas 56
  - Pecos Valley, Texas 132
  - Ranger 106
  - Rio Grande, above the 27
  - San Luis Valley, Colorado 326
  - Southern Colorado 39
  - Staked Plain, Texas 105, 137
  - Strawn 106
  - Sweetwater 106
  - Texas, various parts of 104
  - Trent 106
  - Warfield 118

B.

- Basins, relating to:
  - Ancient lake, known as the "White Sand Hills" 119
  - Big Horn 447
  - Cache la Poudre, the 408, 456, 457
  - Catchment, Rio Pecos, of 100
  - Denver 365
  - Land-locked 124

Basins, relating to—Continued. Page.
Natural
Natural storage, the 42, 134, 445, 454, 467, 468, 558
Paris and London 99
Storage 365
Tennessee, of 542
Black Hills 288
440

C.

California big trees
Camps, U. S.: 281
Pina
Rice 54
Canals for irrigation, and relating to: 34
American and Mexican irrigation
Bear River 50
Cache la Poudre 535
Casa Grande, at 389
Construction of 62
about Socorro 128, 129
Del Norte, map of the 59
Eureka 328
Grand Valley 161, 216
High-line 377
Irrigating 47, 48
Lariet 24, 27, 30, 39, 41, 55, 60, 129
Larimer and Weld 304
La Tempe 392, 405
Lincoln County, in 62
Main 60
Miles of 30, 55
Natural, relating to 314, 315, 325
Northern, the 148, 149
Pecos Investment Company 8, 100
Pioneer, Texas 55, 110
Platte, rules for employés on the 56, 535
Reeves County, in 374, 375
Rio Grande 55
Rio Grande Valley, in the 325
Southern, the 54
System of 100
Union Colony 7, 8, 84
Cañons 393
Animas, the 34, 45, 46, 66, 70, 138, 268
Cherry Creek 82
Colorado River, on the 353
Cuchillo Negra, the 37
Delaware 82
Fraser 103
Fort McCrea 53
Langtry 82
Las Vegas Hot Springs, 4 miles above 36
Lympia 91
Northern New Mexico 53
North Platte 7
Nueces River 541
Olympia 8
Palmas, the 103, 115
Perches, the 82
Quitman 82
Red River 6
Regions of 72
Rosebud 18
Sandia Mountains 53
Staked Plain 87
Vermejo 116
Yellow Horse 98
Chalk Bluffs 20
Chesapeake Bay 402
64

Page.
Cities and towns:
Abilene, Kansas 117, 308, 312
Adelaide 70
Albuquerque 5, 6, 42, 75, 80, 81, 86, 87, 88, 90
Aleman 88
Artesian City 166
Austin 102, 107, 115, 134
Baird 140
Bernalillo 81, 87
Big Spring 119
Bird City 249
Boston 73
Boswell 97
Brazoo 117
Breckinridge 261
Brewell 551
Brighton 403
Buffalo 456, 458, 526
Cañon City 263, 265, 267, 269, 286, 288, 289
Cerrillos 96
Chamberino 30
Cheyenne 443, 460, 461, 538, 564
Cimarron, Kansas 185
Cisco 139
Ciudad Juarez 51
Cokeville 453
Colorado City 19, 121, 275
Coolidge 173, 174, 197
Coronado 62
Cumming City 442
Dallas 21, 55, 118, 121, 124, 128
Darbin 515, 564
Dawson 545
De Dios 30
Del Rio 36, 51, 52, 54
Deming 63, 64, 82, 90, 95
Denver 33, 265, 274, 276, 289, 290, 341, 342, 344, 345, 346, 351, 353, 365, 372, 374, 379, 383, 397, 404, 454, 562
De San Lorenzo 30
Dodge City 147, 149, 152, 154, 157, 184, 209, 212
Dolores 54
Douglas 523
Douro 119, 142
Dryden 112
Eaton 391, 402, 405
Eddy 110
El Canton del Bravo 48
El Paso 5, 6, 9, 12, 13, 15, 21, 26, 28, 29, 32, 34, 38, 40, 41, 42, 44, 46, 48, 49, 50, 75, 83, 89, 90, 115, 116, 122, 141
El Rato 87
El Real 30
Epernay, France 137
Epworth 138
Espanola 75
Estacado 138
Evans 388, 403
Evanston 452, 453
Fabens 34, 37, 48
Fontenelle 523
Fremont 540
Fruita 379
Garden City 181, 183, 186, 187, 190, 191, 200, 210, 215
Germania 119
Golden 366
Goshen 517
Grand Junction 326, 377, 378, 379
Grant 554, 561
Granite 267
Great Bend 153

Cities and towns—Continued. Page.
- Greeley, Colo, 228, 355, 381, 385, 388, 394, 395, 396, 398, 402, 403, 405
- Guadalupe, 26, 49
- Hartford, 73
- Hillsboro, 82
- Ignacio, 372
- Ingalls, 161, 208
- Jetmore, 154
- Juarez, 30, 41, 44, 47, 48
- Julesburg, 562
- Junction City, 210, 229
- Kansas City, 183
- Kearney, 540, 565
- Kimball, 559, 560, 565
- Kingsley, 145, 146, 207, 208
- Labonte, 527
- La Junta, 184, 185, 309
- Lake, 205
- Lamar, 185, 309
- Lander, 459
- La Massila, 30
- La Mesa, 30
- Laramie, 439, 448, 454, 463, 464, 465, 509, 513, 533
- Larned, 171
- Las Amoles, 30
- Las Animas, Colorado, 185
- Las Cruces, 6, 30, 32, 59, 63, 81, 87, 88, 111
- Las Vegas, 72, 91
- La Union, 30
- Leadville, 261, 267, 286, 287, 344, 354
- Lincoln, 538
- Littleton, 344
- London, 365
- Los Angeles, 17
- Lubbock, 113
- Manhattan, Kansas, 247
- Mansfield, 113
- Marfee, 37, 53
- Marienfeld, 119, 121, 134, 135, 136, 137
- Mariposa, 54
- McKinney, 132
- Meade Center, 154
- Merkel, 133, 134
- Mesilla, 6, 64
- Mexico City, 8, 24, 40, 43, 44
- Midlands, 23
- Midland, 109, 117, 118, 119, 121, 122
- Miles City, 26
- Mineola, 107
- Minneapolis, 458
- Montagu, 33
- Murphyville, 37
- Naples, 79
- New York City, 17, 73
- Nombre, 30
- Oberly, 208
- Odessa, 113, 117, 119, 122, 132
- Ogalalla, 537, 539, 551, 556, 563
- Oklahoma, 12
- Paris, 365
- Paso del Norte, 26, 30, 31, 32, 47
- Pecos City, 8, 55, 56, 57, 97, 101, 112, 117, 132
- Pena Blanca, 75
- Philadelphia, 73
- Platteville, 397, 403
- Pueblo, 261, 263, 265, 267, 268, 269, 270, 273, 354, 355
- Quitman, 6
- Raton, 97
- Richville, 170

Page.

Cities and towns—Continued.
- Roswell ... 96, 100, 110
- Salt Lake City ... 208
- San Angela ... 21
- San Angelo ... 113, 130, 132
- San Antonio ... 8, 17, 35, 51, 104, 134
- San Francisco ... 67
- San Ignacio ... 49
- San Marcial ... 6, 75, 88
- San Pedro ... 96
- San Saba ... 126
- Santa Fé ... 65, 66, 68, 75, 78, 94, 96, 100, 176
- Santiago ... 20
- Saratoga ... 449
- Scott Center ... 205
- Scott City ... 179, 185, 186
- Seni Cu ... 30
- Sherman ... 446, 455, 524
- Sidney ... 557
- Socorro ... 28, 75
- Spearville ... 209
- Speerville ... 149
- Springer ... 98
- Sterling ... 292, 403, 458, 553, 554
- St. Paul ... 458
- Syracuse ... 173, 197, 189, 199, 212
- Traburg ... 514
- Tres Jacales ... 30
- Topeka ... 241, 256, 310
- Toyah ... 113
- Trinidad ... 355
- Ulysses ... 196
- Valley ... 205
- Victoria ... 53
- Waco ... 137
- Washburn ... 113
- Washington ... 38, 39, 50, 117, 279, 285, 286, 462, 564
- Weatherford ... 106, 107
- Wendover ... 525
- West Las Animas ... 268
- Wichita ... 250
- Worcester ... 39
- Zaragoza ... 49

Climate ... 44, 69, 70, 98, 99, 132, 139, 152, 199, 208
- Dry ... 70, 116
- Extreme heat ... 43
- Humid region ... 105, 120
- Moist ... 135
- Semi-arid in Texas ... 104
- Sub-humid region ... 104, 105, 107, 133
- Temperate ... 262
- Warm ... 42
- Water, effect of on ... 18
- Winter of ... 56, 89

Colony:
- Lumia ... 18
- Quacker the ... 138

Colorado forest legislation and suggestions ... 284

Constitutional provisions:
- Colorado, State of ... 410, 411
- New Mexico, proposed ... 94
- Wyoming, proposed ... 482

Counties:
- Albany ... 462, 463, 464, 465, 513, 522, 524
- Andrew ... 134
- Andrews ... 21
- Arapahoe ... 404
- Barton ... 153
- Bent ... 264

Page.

Counties—Continued.
  Bernalillo....80, 81, 86, 87
  Brown....545, 546
  Callahan....106, 107, 140
  Carbon....449, 515
  Cherry....546
  Cheyenne....249
  Colfax....71, 72
  Conejos....404
  Concho....130
  Converse....462, 523, 527
  Costilla....404
  Coulees in....123
  Cowley....170
  Crane....119
  Crook....461
  Crockett....35, 112, 119
  Crosby....113, 138
  Custer....544
  Dawson....546
  Dickens....119, 138
  Dona Ana....59, 83, 85
  Douglas....353
  Eastland....106, 107, 139
  Eddy....111
  Edwards....145, 207
  El Paso....22, 28, 35, 48, 84, 104, 105, 106, 108, 112, 116
  Finney....158, 199, 206, 209
  Floyd....138
  Fremont....459, 461, 510
  Furnas....547
  Gaines....134, 136, 137
  Garza....138
  Grant....196, 206
  Gray....159, 160, 161, 165, 167, 172, 174
  Greeley....179
  Hale....113, 138
  Harlan....545
  Hamilton....113, 173, 197, 198
  Hansford....104
  Haskell....176, 177, 178, 184
  Hockley....112
  Holt....545
  Howard....21, 102, 118, 119, 139
  Huerfano....404
  Jefferson....364, 404
  Joacum....137
  Johnson....446, 456, 457, 458, 461, 514, 515, 526, 534
  Kearney....194
  Keith....554
  Kimball....559
  Kinney....54
  Knox....545, 550
  Llano....117
  Laramie....460, 462, 465, 516, 517, 518, 519, 520, 521, 525
  Larimer....340
  Las Animas....264, 404
  Lincoln....60, 83, 110, 537
  Lubbock....138
  Martin....21, 22, 103, 119, 134, 135, 136, 137
  Meade....161, 211, 212
  Mesa....378
  Midland....124
  Mitchell....104, 106, 114, 119, 140, 141
  Montague....104
  Montgomery....193
  Morton....170, 212
  Motley....138
  Navarro....114

Page.
Counties—Continued.
Nolan 140
Pan Handle 128
Pecos 55, 112
Rains 22
Reeves 22, 57, 102, 112
Rio Grande 404
Routt 397
Saguache 404
San Saba 126, 127
Scott 179, 180, 184, 193, 200, 204, 205
Shackelford 107
Sheridan 446, 456, 457, 458, 461, 546
Sierra 85
Sioux 546
Socorro 78, 81
Stevens 167, 168
Sweetwater 451
Taos 77
Taylor 117, 118, 133, 134
Terry 137
Tom Green 201, 104, 112, 113, 116, 130
Uintah 452, 523
Valencia 62, 81
Ward 57
Weld 340
West Las Animas 266
Wichita 179
Countries:
Africa 80
Arabia 95
Asia 95
Australia 69, 70
China 70
Chickasaw Nation 11
Egypt 80
England 365
Europe 70
France 79, 137, 365
Germany 281
India 70, 80, 365
Italy 137
Japan 70
Mexico 9, 12, 14, 15, 16, 17, 20, 24, 29, 30, 33, 38, 40, 42, 44, 46, 50, 51, 84, 122, 139, 328
Persia 95
Spain 25, 69
United States 6, 17, 20, 29, 38, 40, 42, 44, 46, 47, 48, 49, 50, 54, 63, 69, 78, 104, 107, 120, 139, 140, 178, 187, 189, 190, 200, 281, 388, 449, 466, 485, 545

Creeks:
Beals 140, 141
Bear 196, 197, 206, 344, 460
Beaver 263, 269
Big Beaver 403
Big Crow 403
Bijou 403
Bitter 451
Box Elder 140
Camp 140
Champlins 140, 144
Cherokee 126
Cherry 345, 353, 403
Clear 315, 316
Clear Fork 143
Coal 315, 317
Cold 366
Comanche 20
Coon 145
Crazy Woman 458
Crooked 160, 162, 165

Page.

Creeks—Continued.
Crow 99, 396, 403, 460
Dale 460
Deep 141
Dove 53, 127, 130
Dugent 140
Escordido 119
Four Mile 442
Hackberry 140, 141
Horse 460
Kannah 378
Kiowa 403
Labonte 527
Las Moras 54
Lewis 403
Limpia 119
Little Beaver 403
Little Crow 403
Little Horse 516, 519
Lodge Pole 558, 559, 560, 562, 564, 565, 568
Lone Tree 403
Lone Wolf 140, 144
Lost 403
Mexia 143
Monument 288
Morgan 140, 141, 144
Mud 54
Olympia 115
Palo Pinto 143, 144
Palo Pinto (north fork) 144
Palo Pinto (south fork) 144
Pawnee 403
Pinto 54
Prairie Dog 456, 458
Pole 460
Rainbow 54
Ralston 364
Rendrebrook 140
Richland 127
Rock 442
Sand 309, 403, 440, 451, 556
San Juan 86
Seven Mile 442
Scurry 141
Silver 141
Spring 53, 127, 130, 211
Sweetwater 143
Sybille 460
Toyah 22, 55, 56, 119
Willow Creek 140
Wild Cat 403

Crops:
Mention of 12, 20, 21, 23, 24, 27, 30, 49, 51, 55, 61, 63, 65, 66, 68, 69, 72, 77, 78, 79, 80, 81, 82, 83, 86, 87, 88, 91, 96, 99, 104, 106, 108, 109, 111, 116, 118, 120, 121, 122, 123, 126, 127, 131, 134, 137, 138, 145, 146, 147, 151, 152, 153, 154, 155, 157, 158, 160, 163, 164, 165, 168, 169, 170, 171, 172, 182, 189, 193, 195, 196, 198, 201, 204, 206, 207, 208, 211, 213, 261, 262, 266, 271, 272, 273, 277, 292, 293, 294, 307, 327, 340, 341, 343, 346, 347, 352, 363, 379, 380, 382, 387, 390, 397, 444, 446, 453, 458, 465, 537, 544, 556, 562
Alfalfa 55, 56, 57, 61, 63, 79, 82, 84, 99, 117, 119, 131, 135, 174, 193, 196, 207, 341, 342, 343, 353, 379, 382, 384, 385, 388, 390, 391, 403, 440, 452, 460, 463
Barley 6, 8, 56, 63, 66, 72, 79, 131, 133, 147, 352, 448, 454, 458, 463, 466, 534, 548, 559
Beets 55, 132, 384
Broom corn 177
Cabbage 166, 208, 342, 384, 439, 535
Cereals 448, 466
Corn 6, 8, 9, 12, 21, 27, 28, 51, 63, 66, 68, 69, 72, 81, 82, 86, 105, 106, 107, 108, 111, 116, 119, 127, 131, 133, 135, 140, 145, 146, 166, 174, 175, 177, 182, 193, 196, 201, 205, 206, 208, 383, 384, 386, 448, 463, 466, 534, 556, 559, 561, 562

Page.

Crops—Continued.
  Corn, Indian 55, 56, 141, 169
  Corn, for cattle 177, 182, 193, 196
  Forage 138, 141
  Grains 52, 55, 56, 70, 99, 132, 133, 145, 174, 200, 277, 342
  Grains, small 6, 21, 72, 107, 131, 446, 450, 453, 459, 464
  Grasses 51, 52, 55, 131, 132, 137, 140, 278, 340, 440, 444, 451, 456, 468, 548
  Grasses, blue stem 175, 440
  Grasses, buffalo 138, 154, 164, 175, 178
  Grasses, gramma 64, 89, 100, 106, 112
  Hay 108, 138, 140, 180, 277, 288, 446, 453, 458, 461, 464, 534
  Johnson grass 119, 140, 177
  Mesquite grass 106, 112, 124, 138
  Native grass 120
  Natural grass 68, 79
  Red Top grass 440, 553, 460
  Sedge grass 106
  Timothy grass 440, 452, 453, 460
  Wild rye grass 180
  Maize 211
  Millet 55, 56, 119, 138, 140, 174, 177, 182
  Oats 56, 63, 68, 69, 79, 106, 107, 118, 119, 127, 131, 133, 140, 147, 156, 160, 163, 169, 193, 196, 205, 211, 277, 340, 343, 352, 384, 439, 448, 450, 453, 454, 456, 458, 460, 463, 466, 534, 548, 559, 561
  Onions 69, 122, 134, 182, 439
  Potatoes 63, 66, 95, 96, 111, 119, 131, 132, 133, 134, 141, 146, 156, 157, 161, 166, 168, 169, 182, 193, 383, 384, 385, 386, 387, 388, 398, 403, 439, 448, 450, 454, 455, 456, 460, 463, 466, 534
  Rye 56, 63, 66, 80, 83, 119, 131, 134, 135, 158, 166, 169, 182, 193
  Vegetables, general mention of 21, 43, 47, 55, 79, 82, 85, 90, 95, 99, 107, 109, 112, 121, 131, 132, 134, 135, 136, 137, 138, 140, 145, 146, 147, 154, 161, 200, 277, 341, 380, 382, 448, 450, 454, 459, 464, 466, 554, 556, 559, 561
  Rhubarb 95
  Tomatoes 134
  Turnips 55
  Wheat 6, 8, 21, 56, 63, 66, 68, 69, 80, 81, 82, 86, 106, 107, 108, 111, 116, 119, 127, 131, 133, 139, 142, 146, 147, 160, 163, 166, 169, 170, 171, 177, 193, 199, 205, 208, 209, 210, 211, 277, 278, 340, [illegible], 343, 352, 384, 385, 387, 388, 390, 439, 446, 448, 449, 450, 453, 454, 455, 458, 460, 463, 466, 468, 534, 548, 556, 561

D

Dams, for irrigation purposes 9, 22, 32, 43
  Bowlder stone 47
  Brush 27
  Coffer 46
  Construction of 48
  Curvilinear 46
  Earth of 53
  Fort Selden, site at 16, 28
  French, Algiers in 25, 26
  General outline, International, Rio Grande, El Paso, near 39-42
  Location for a 14, 15, 16
  Masonry, in Spain 25
  Memorandum on the general character of the project (dam at North Pass) 19
  Mexican 14, 46
  Necessity for 19
  Paso Del Norte, above 31
  Pena Blanca 86
  Proposed, International, Rio Grande on 9, 13, 14, 15, 16, 17, 18, 19, 24, 28, 29, 30, 38, 41, 44, 45
  Relative merit of sites 46
  Rio Colorado, Yuma at 44
  Rio Perches, on the 85
  Scouring galleries, description of 25
  System of 20, 132
  Willow 40
Ditches, names and relating to:
  Abstract from records of Fremont and Carbon Counties 507
  Agricultural 290

Page.

- Ditches, names and relating to—Continued.
  - Amazon 193
  - Area of land under 296, 313, 458
  - Bessemer 268
  - Blanks and forms used in management of 374, 375, 376, 377
  - Cache La Poudre 392, 410
  - Cañon City, line of 271
  - Colorado of 9, 47, 178, 201, 202
  - Concho County, in 130
  - Construction of 129, 128
  - Construction of, cost 393
  - Del Rio, near 54
  - Distributing 98
  - Dove Creek on 130
  - Grand River 379
  - High-line 46, 48, 356
  - Ileff 292
  - Irrigating 53, 60, 126, 127, 173, 186, 203, 308
  - Laboute Road ranch 527
  - Lariet 304
  - Larimer County, in 392
  - Laterals 203, 204, 269
  - Lines of 10
  - Lower Pecos, at 7
  - Main 51, 52, 53, 54
  - Mileage of 313, 325
  - Mesilla Valley in 61
  - Mexican system of 52
  - Miller 55
  - Monte Vista 328
  - Murphy 55
  - North Concho River on 130
  - North High-line 98
  - Partial list of the principal irrigation 130
  - Pecos Valley in 142
  - Pioneer Company's report 22
  - Pony 291
  - Proposed 149
  - Record of, Colorado Water Districts No. (1) 489, 490
    - (2) 490, 491
    - (3) 491, 492
    - (4) 493
    - (5) 493, 494, 495
    - (6) 495
    - (7) 496
    - (8) 497
    - (9) 498
  - Rio Grande, from the 32
  - Rooney 55
  - San Felipe 51
  - San Luis Valley, in 6
  - Saragosa Manufacturing and Irrigating Company's 55
  - Secondary 51, 54
  - Seepage 405
  - Soule 208
  - South Concho River, on 130
  - Spring Creek, on 130
  - Statistics 503
  - Style 55
  - Sybille 535
  - System of 61, 71. 96, 468
  - Union 303
  - Victoria, at 53
  - Water, capacity of 201, 360
- Ditch owners:
  - Cochran & Wynn 130
  - De Long Bros 130
  - Gardner, A 130
  - Foulkes, J 130

Page.

- Ditch owners—Continued.
  - Lee, P. C 130
  - Locky, William 130
  - Miles, Jonathan 130
  - Middle Conche River 130
  - Metcalf, C. B. 130
  - Morris, P. H 130
  - McLane, J. T 130
  - McDonald, T 130
  - Nasworthy, J. R 130
  - Neill, James 130
  - Phelan & Glenn 130
  - Sims, W 130
  - Scott & Ryan 130
  - Stilson, E 130
  - Tankersby, R. F 130

E.

- El Paso:
  - Proposed dam at, Mexican testimony 49, 50, 51
  - Report on, Major Mills, extracts from 42, 44, 45, 46, 47, 48
- Engineers, mention of:
  - Follet, W. M 14, 44
  - Garfias, Senor 43, 44, 48
  - Hinton, R. J 15, 79, 97, 103, 124
  - Humphrey, J. S 185, 186, 217
  - Nettleton, Edwin S 7, 44, 276, 359
  - Stewart, Henry 214
  - Trull, W. E 186, 217
  - Wilson, C. A 562, 563
  - Wood, Mr 111

F.

- Flumes 26, 55, 98, 99, 114, 119, 128, 129, 195, 196, 204, 309, 311
  - Wooden 121
- Forts, United States:
  - Bascom 72
  - Bliss 13, 33, 38, 46, 52
  - Brown 53
  - Bridger 567
  - Clark 54
  - Collins 291, 294, 306, 379, 382, 385, 389, 408, 410, 468
  - Concho 53, 104, 130
  - Crawford 371, 372
  - Davis 11, 20, 53, 115
  - Hancock 24, 26, 34, 37, 48
  - Keogh 26
  - Laramie 535
  - Leavenworth 244
  - Lewis 369, 370
  - Lupton 403
  - Lyon 371
  - Marcy 96
  - McCrea 82
  - Morgan 291, 553, 554
  - Niobrara 567
  - Quitman 18, 25, 28, 31, 34, 36, 39
  - Riley 244
  - Ringgold 53
  - Selden 16, 28, 29, 33, 89, 90
  - Sidney 567, 568
  - Stanton 96, 97
  - Steele 539, 540
  - Stockton 8, 20, 57
  - Sumner 7
  - Sumpner 100
  - Supply 245
  - Washakie 536

Page.

Forts, United States—Continued.
  Worth 108, 112, 113, 121, 144
  Yuma 30
Fremont, John C. 370
Fruits, small, mention of 82, 455, 456, 458
  Blackberries 133, 139, 456, 534
  Cherries 132, 133, 139, 145
  Currants 133, 138, 534
  Gooseberries 133, 139
  Melons 55, 132, 138, 141, 169
  Raisins 21, 57, 80, 121
  Raspberries 133, 139, 456, 534
  Strawberries 133, 456, 534
Fruit trees, under irrigation 8, 12, 21, 22, 49, 52, 55, 57, 61, 63, 65, 68, 72, 78, 79, 82, 85, 89, 90, 95, 96, 99, 106, 107, 109, 111, 116, 120, 121, 131, 133, 134, 135, 136, 137, 139, 141, 142, 145, 147, 277, 341
  Almond 55, 57, 132, 139
  Apple 8, 28, 63, 68, 90, 121, 133, 138, 139, 140, 145, 384, 456, 458
  Apricot 8, 63, 90, 132, 133, 139
  Banana 133
  Date 63
  Fig 8, 90, 133, 139
  Lemon 109
  Mulberry 70
  Nectarine 63, 90, 133, 139
  Olive 8
  Orange 8, 133
  Peach 28, 63, 64, 90, 96, 109, 121, 132, 133, 135, 138, 139, 140, 145, 384
  Pear 28, 63, 64, 68, 90, 109, 121, 133, 138, 139, 140
  Pecan 130
  Persimmon 133
  Plum 68, 90, 109, 121, 132. 133, 138, 139, 140
  Pomegranate 63, 133
  Prune 55, 57, 63, 120, 121, 132
  Quince 63, 139
  Walnut, Black 95
  Walnut, English 55, 57

G.

Government aid to irrigation 41, 92, 349
  General 29, 31, 33, 49, 55, 122, 360
  Mexican 13, 24, 29, 43, 44, 48, 49, 50
  Spanish 52
Gulch, McNulty's 262
Gulf of Mexico 39, 40, 42, 48, 53, 104, 107, 118, 313, 314

H.

Head-gates 25, 26, 41, 55, 100, 268, 292, 309, 348, 410
  Flap 98
  Flood 52
  Iron valve 98
  Pecos River, on 57
  Ripples at 57
  Sluice-gates 185
  Valves 19
  Waste 53, 287

I.

Indian Reservations:
  Southern Utes 372
  Wind River 461
Irrigation, character and effects of 122, 134, 183, 188, 498, 502
  Acequia, by 54
  Acres under 54
  Act to encourage 128
  Advantages of 51, 259, 260
  Agriculture by 63
  Arkansas Valley in 185

Page.

Irrigation—Continued.
  Amount of land under 263
  Ancient works 62
  Arid lands of 9
  Artesian water, value of, for 213
  Artificial 83, 147
  Bed work 51
  Clear Fork of the Brazos, on the 117
  Colorado, in 291
  Commission 50
  Cost per acre 51, 52
  Dams by 35
  Decadence or loss of 30
  Del Rio, at 52
  Districts 323
  Ditches, system of 54
  Divisions 313, 314
  Dry Creek, on 346
  Effect of upon Crops 117
  Enterprises 130
  Facilities for 21, 30, 103, 139, 558
  Farming without .... 11[illegible], 158
  Flooding, by 368, 568
  Furrows, by 131
  Future development of 488
  Government aid in 203
  Idaho, in 246
  Kansas, S. W., in 250
  Kern County, Cal., effects of on 364
  Lands subject to 195
  Local 164, 212
  Maxwell grant in northern Mexico, development of 7
  Means of 145
  Method of 130
  Mexicans, depend on 78
  Moisture gained by 200
  Necessity for 32, 145, 174, 199, 200, 201, 207
  New Mexico, in 5, 7
  Observation as to 176
  On public lands and canal constructions 498, 499, 500, 501, 502
  Over-irrigation, effect of 363, 364
  Particular streams that would furnish water for 11
  Pecos Valley, in 54, 132
  Period of 293
  Plan for using the river underflow in Kansas. 256, 257, 258, 259, 260, 261, 262, 263, 264
  Possibilities of 10, 44
  Preferred to dry culture 135
  Regions, Colorado, map of 296
  Reservoirs 20, 139
  Resolution of State of Texas 101
  Results of 189, 369, 374, 378
  Rio Grande, valley in 38, 39, 80
  San Angelo, Tom Green County, near 113
  Small orchards and vineyards 138
  Staked plains, Texas, on 23, 104, 118, 124
  Sub-irrigation 109, 372, 368
  Summary of, district development in Wyoming. 488, 489, 490, 491, 492, 493, 494, 495, 496, 497, 498
  Supply of water for 211, 264
  Surface 53, 109, 141
  Systems of 51, 71, 98, 180, 186
  Systems of, on Maxwell grant 97
  Table showing extent of, in Wyoming 504
  Texas, in 8, 11, 34, 115, 126
  Underground, system of 141, 209
  United States Senate, committee on 44, 97, 134
  Upper and lower Rio Grande, effect on 31
  Wasteful method of 131
  Water used for 41, 120, 134, 171, 273
  Wells, by 116, 128, 129, 131, 134, 135, 136, 138, 139

Irrigation—Continued. Page
- Western Texas, in 35
- Works 487
- Wyoming, in 486

Irrigation companies, name of 49, 50, 73
- Arkansas River, Land, Reservoir and Canal 297, 308
- Arkansas Valley 303
- Atchison, Topeka and Santa Fé Railroad 222, 267
- Aztec Irrigation 56
- Berrendo stock 130
- Denver Reservoir and Canal 353
- Ditch (New Mexico) list of 94, 95
- Fort Morgan Land and Canal 337
- Incorporated, Wyoming of 531, 532
- Incorporated 54
- Ingalls, ditch 209
- Jornado and El Paso Canal and Reservoir 90
- Kansas Water Works 152
- Land Grant 60
- Larimer and Weld 303, 392
- Marienfeld Fruit-growing, Gardening, and 21, 102, 121
- Marienfeld Fruit 132
- Maxwell Land Grant 97
- Mineral Land 364
- Northern Colorado 374, 376
- North Poudre Land and Canal 306, 307
- Pecos 61
- Pecos River 57
- Pecos Valley Irrigation and Investment 7
- Pioneer Canal 54, 55, 57, 102, 132, 142
- San José Irrigation and Power 130
- Sante Fé Railroad 157
- South Dodge Canal 255
- Southern Pacific Railroad 64

L.

Lagoons 554, 555, 559, 564

Lakes, names and mention of—
- Ancient beds 72, 179
- Artificial 92, 127
- Beaver 35
- Boyds 386, 389
- Chamber's 390
- Cooper 442
- Hattie 442
- James 442
- Moccasin 98
- Natural 98, 191, 192, 447
- Old beds between mountains 11
- Salt 124, 135, 447
- Seven 269
- Subterranean 96
- Tulare 404
- Twin 267, 286, 287
- Underground 138
- Utah 404

Lands—
- Acreage of, tillable in Mexico 6
- Acreage of, under cultivation in New Mexico 76
- Acres of, actually irrigated 313
- Acres of, under canals and ditches 314, 315
- Acres of, under canals 325
- Acres of, irrigated and cultivated 50
- Acres of, actually irrigated by canals and ditches .... 31[illegible], 315
- Agricultural 100, 280, 296, 313, 340, 404
- Alkali 35
- Arable 138, 271, 383, 462, 550
- Arable, susceptible of irrigation 197
- Area of, irrigated 51

Page.

Lands—Continued.
  Arid 19, 80, 91, 120, 388, 449, 469
  Arid, total area of 313
  Arid, of Colorado 98
  Arid and semi-arid 190
  Arid regions in 89
  Arid belt in 341
  Arkansas Valley 265
  Artesian City, irrigated at 166
  Barren 83
  Bench 459
  Bench, cultivated without irrigation 76
  Black and chocolate colored stuff 56
  Bottom 17, 39, 54, 91, 100, 197, 203, 263, 404, 454, 459, 544
  Brown County in 545
  Buffalo 170
  Buffalo sod 167
  Character of, on the Pecos in New Mexico and Texas 111
  Chocolate-colored 57
  Clay 384
  Colorado 49
  Crow Flats, Little 403
  Cultivated, in El Paso County 28
  Cultivated 343
  Cultivation, under 52, 59, 139
  Cultivation, formerly under 31
  Desert 350
  Desert, Yuma 44
  Donations of 54
  Dry 340
  Dry farming 131
  Eagle Flat 108
  Elevated 135
  Enriched, by irrigation 83
  Examination of 44
  Expenses of reclaiming 487
  Farm 21, 452
  Farming 10, 86
  Farming, on the Platte 352
  Fertile 91
  Fertile and productive 271
  Flooded 290
  Foot-hills 366, 402, 408, 453
  Francisco Garcia Grant 14, 19
  Fruit 56, 84
  Government 19, 74, 75, 76, 78, 80, 82, 85, 92, 440
  Grand Valley, area in 328
  Granted free by the Spanish Government 52
  Grazing 98, 509, 530
  Hay 450
  High 53, 187, 202, 291, 389
  Higher 149
  Higher lying 138
  High table 140
  Improved 52
  Irrigable 11, 26, 28, 53, 127, 263, 288
  Irrigated 52, 61, 191, 277, 279, 367
  Irrigated, acres of 126
  Irrigated, at foot of mountains 66
  Irrigation, cultivated by 61
  Irrigation, under 132
  Irrigated, value and rental of 131
  Jornado del, Muerto, on 59, 72, 82, 85, 88
  Laramie Plains 439, 440, 444, 446, 454, 455
  Laramie County, actually under cultivation 460
  Lower mountains and foot-hills 65
  Lipan Flat 128
  Low-lands 47, 66
  Made, wash from the foot-hills 384
  Maxwell grant 60, 71, 79

Lands—Continued. Page.
Maynard Flats 403
Melgas 131
Meadow 453
Mesa 20, 28, 35, 66, 81, 82, 83, 86, 87, 88, 89, 90, 100, 105, 116, 126, 263, 270, 343, 458
Mesquite Flats, uplands on 106
Midland and odessa, estimates on 121
Mississippi Basin 120
Mountain and prairie 97
Non-irrigated, loans on 340
Outlying 275
Owners 203, 303, 311, 357, 358, 359, 365
Pan Handle region 11, 20, 72, 73, 116, 117, 138
Plateau of salt 153
Platte Valley, under ditch in 296, 450
Ponce de Leon, tract of 15
Prairie 98, 154
Price of, in Pecos Valley 56
Private 41, 76, 129, 278, 288, 326, 365
Private owners, Spanish and Mexican grants of 74
Productiveness of 52
Public 73, 76, 83, 84, 278, 326, 350, 467
Public, of Texas 49
Public timber 279, 280, 281, 312
Public, on Jornado del Muerto 90
Quality, in Ward County, Tex 57
Railroad 56
Railroad, Atchison, Topeka and Santa Fé 87
Railroad companies 355
Refugio Colony, Spanish grant 14, 19
Rich 157
River bottom 51, 130
Rolling 150
Rolling and hilly 106
Roswell, near 96
Sage brush 453, 458, 536
Sand-bars 18, 83
Sandy 170, 208
Sand-hills 550, 551, 554
Sandy loam 167
Santa Fé, near 96
Segregation of 368
Settlement of unoccupied 91
Shin oak 106
Spanish, grants of 14
Springer 98
State 326
State school 19
Staked plains 18, 21, 22, 100, 103, 105, 119, 121, 122, 124, 127, 128, 130, 132, 133, 135, 137, 142, 178, 181
Sterile 533
Streams on tributary to the Rio Grande in Taos County 77
Submerging 41
Swamp 198, 350
Tables, of 19, 64, 141, 195, 198, 202, 455, 541, 544, 552, 554, 555, 556, 558, 562, 564
Table of Great Plain 118
Tartary, plains of 95
Texas, reclaimable in 7
Tillable 204
on the Rio Puerco 86
Uintah County, acres under ditch in 452
Unappropriated 44
Union Pacific Railway, of 566, 567
Unreclaimed 349
Uplands 66, 200
Upland Plains 95
Upper 17, 359
Valley 48, 200
Value of 54
Value of increased by cultivation 79

Page.

- Lands—Continued.
  - Value of increased by irrigation 20,51,52
  - Value of before irrigation 51,53
  - Valueless without water 59
  - Valueless, by being submerged 48
  - Waste 404
  - Water facilities, with good 79
  - Water, investment in 75
  - Water, under 54
  - Wild 311
- Larned District 187
- Laws, references to—
  - Ante alien act 74
  - Contract labor act 48
  - Desert-land act 312
  - Homestead law 10, 154, 280, 311, 349, 352
  - Spanish water laws and customs 61
  - Timber culture law 312
- Laws on irrigation, Colorado, statutes of 410–438
  - Abuse and mismanagement of ditches, punishment for 432
  - Appeals from referee provided for 418
  - Appropriation of water regulated 411
  - Arbitration provided for 415
  - Arid lands only for those who construct ditches 431
  - Assessment on stockholders 429
  - Charges for water regulated 425
  - Claims, filing of regulated 418
  - Collecting damages provided for 423
  - Commissioners of water, how appointed 427
  - Commissioners, their pay and duty 427
  - Compensation for private property provided for 411
  - Condemnation of right of way 421
  - Compensation of referee provided for 420
  - Corporations compelled to furnish water 425
  - Court, its power to make just rules 418
  - Court proceedings defined 426
  - Damage by canals prohibited 437
  - Damages for bursting reservoirs 422
  - Damages to ditches from floating timber, and its regulation 425
  - Damages, liability for 422
  - Distribution of water regulated 434
  - Ditch companies, their right to condemn real estate 421
  - Engineers, duty and pay 428
  - Evidence defined 416
  - Exemption of ditches from taxation 411
  - Governor, power of appointment, removal, etc 428
  - Highways protected 422
  - Incorporation of irrigation company provided for 413
  - Jurisdiction of courts defined 413
    - of justice of peace 424
  - Land owners near stream, their right of way 421
  - Limitations for suits 420
  - Malicious mischief defined 425
  - Meadows provided for 413
  - Measurement of water 429
  - Mill owner's rights defined 411
  - Numbering of ditches by the court 415
  - Owners, duty of 423
  - Owners of ditches, liabilities for neglect and refusal 424
  - Penal statutes in regard to water 432
  - Polluting stream or ditch, penalty for 425
  - Price of water regulated 431
  - Priority rights provided for 411
  - Private property may be condemned for public irrigation use 411
  - Purification of water provided for 431
  - Rates for water provided for 411, 431
  - Referees, duties and powers 417
  - Report, annual, when to be made 428
  - Reservoirs provided for 422
  - Rights to purchase water 426

Laws on irrigation—Continued. Page.
  Rights of parties against referee for neglect and oppression ... 418
  Right of way for ditches, etc ... 411
  Riparian rights defined ... 411
  Sheriff's and clerk's fees defined ... 420
  duy of ... 420
  Superintendents of irrigation provided for ... 435
  Supreme court jurisdiction ... 419
  Taxation, free from, when ... 411
  Unappropriated water, the right to divert and use, never denied ... 410
  Waste of water to be prevented ... 423
  Water declared public property ... 410
  Water for domestic purposes, the preference over ... 410
  Witness fees provided for ... 417
Laws on irrigation—Texas ... 128–130
  Appropriation of water for irrigation provided for ... 128
  Incorporation of ditch companies provided for ... 128
  Incorporations authorized to borrow money ... 129
  Right of way for ditches provided for ... 129
  Trespass on canals declared a misdemeanor ... 129
Laws on irrigation—Wyoming, statutes of ... 470–481
  Adjudication provided for ... 480
  Agriculture to have preference of water over manufacturing ... 481
  Appeals from arbitration ... 471
  Appropriation of water ... 474
  Arbitration provided for ... 471
  City rights to water protected ... 478
  Compensation for damages provided ... 470
  Commissioners of irrigation provided for ... 473
  Commissioners' duties defined ... 474
  Damages for leakage, etc ... 477
  Districts provided for ... 472
  Domestic use of water to have preference ... 481
  Engineer for the Territory provided for and duties defined ... 478
  Fish to be protected ... 478
  Incorporation provided for ... 480
  Jurisdiction of courts ... 477
  Land and water rights defined ... 470
  Prior rights guarantied ... 481
  Prior rights protected ... 471
  Rights of way for ditches defined ... 470
  Surplus water to be sold ... 481
  Water declared public property ... 480
  Witness fees, mileage, etc ... 477
Laws on irrigation—New Mexico, statutes of ... 92–94
  Apportionment of labor on ditches ... 93
  County and district jurisdiction regulated ... 92
  Cactus ... 112
  Canaigre plant ... 95
  Election of directors of ditches provided for ... 93
  overseers of water provided for ... 92
  Fibers, cotton ... 20, 83, 106, 107, 108, 116, 127, 131, 140, 141, 142
  Forage plants ... 119
  Freedom of water for travelers ... 93
  Impediments to irrigation prohibited ... 92
  Manner of appropriating land for ditches ... 93
  Majority rights guarantied ... 92
  Overseers of ditches to prosecute trespassers ... 93
  Prior rights guarantied by constitution ... 94
  Pueblos of Indians regulated ... 93
  Right of way for canals ... 92
  Yucca or amoil ... 95

M.

Mountains, mention and names of—
  Big Horn ... 445, 446, 456, 457, 459, 534
  Black range ... 85
  Blue range ... 8
  Bross (Mount) ... 262
  Caballo ... 89

Page.

Mountains, mention and names of—Continued. 100
- Capitan 119
- Castle 456, 457
- Cloud's Peak 64
- Cook's Peak 89
- Crestobal 89
- Dona Ana 96
- El Capitan 105
- El Paso 307
- Foot-hills 263
- Greenhorn range 100
- Guadalupe 86
- Jaemos range 465
- Laramie range 261, 262
- Lincoln (Mount) 454
- Medicine Bow range 105, 118
- New Mexico 83, 89, 90
- Oregon 289
- Pike's Peak 115
- Quitman. 265
- Raton 86
- Rio Puerco 40, 53, 82, 88, 97, 181, 183, 214, 264, 326, 533, 539, 565
- Rocky 83, 100
- Sacramento 89
- San Andreas 87
- Sandia 86
- San Juan 35
- San Marcial 11, 100
- Sierra Blanca 442
- Snowy range 87
- Tajaemos 208
- Wasatch 83
- White

N.

Newspapers: 341
- Colorado Farmer 388
- New York Tribune

O.

49, 53, 55, 68, 84, 111, 132, 133, 138, 200, 342

Orchards, reference to 72
- Apple 120
- Established at Odessa and Marienfeld 379
- Peach 68
- Trees

P.

54

Pass, Eagle 13
- North

Ponds: 143
- Abilene, at 191, 192
- Artificial 143
- Baird, at 143
- Delmar 143
- Westbrook 5, 20, 29,

Powell, John W., Director U. S. Geological Survey
38, 39, 42, 43, 59, 87, 88, 101, 102, 108, 110, 112, 147, 158, 182, 183, 190, 261,
262, 275, 285, 325, 379, 383, 409, 410, 439, 451, 462, 537, 539, 542, 543, 549, 557

Pumps, for irrigation: 136
- Chain and bucket 49
- Public 23, 145, 169
- Steam 395, 396, 397, 398, 401, 402
- Steam vacuum 122, 124
- Knowles steam

R.

Page

Ranches, mention of—
Davis ....
Five Well 518, 520, 521
Mallet 136
Slaughter, C. C., of 136
Railroads: 103
Atchison, Topeka and Santa Fé ....
Atlantic and Pacific 14, 15, 42, 69, 89, 90
Chicago, Kansas and Western 76
Denver and Fort Worth 223
Denver and Rio Grande 113
Galveston 286
Kansas Pacific 16
Memphis, El Paso and Pacific 185
Mexican Central 40
Northern Pacific 53
Santa Fé 530
Santa Fé, reconstruction of 12, 16, 40, 46, 78, 184
Southern Pacific 19
Texas and Pacific 14, 15, 20, 35, 36, 37, 40, 44, 46, 47, 53, 90, 112
Topeka and Santa Fé 8, 21, 22, 34, 55, 102, 106, 116, 118, 142, 143
Union Pacific 14
Rain-fall 222, 248, 289, 310, 372, 508, 535, 564, 565, 566, 567
.... 21, 23, 39, 56, 65, 73, 78, 79, 80, 81, 98, 99, 103,
104, 106, 113, 115, 116, 119, 120, 124, 132, 137, 138, 139, 145, 146,
147, 160, 163, 164, 168, 170, 175, 178, 202, 204, 212, 213, 257, 266,
275, 277, 282, 288, 289, 312, 329, 341, 349, 358, 359, 363, 367, 369,
372, 380, 467, 468, 537, 542, 545, 547, 549, 551, 554, 557, 558, 565
Annual ....
Average 39, 53, 56, 69
Average, on mesa lands 104
Baird, Callahan County, at 105
Black Wax Belt of Texas, at 104, 140
Brackettville, Kinney County, at 107
Coleman, Coleman County, at 104
Decatur, Wise County, at 104
Denver, at 104
Distribution of 294
Dodge City, at 294
Easter, Kans., at 211
El Paso, at 211
Fort Concho, Tom Green County, at 122
Fort Davis, annual, at 104
Fort Elliot, Wheeler County, at 11
Fort Griffin, Shackelford County 104
Fort McKavett, Minard County 104
Fort Wallace, at 104
Gauge of 211
Graham, Young County, at 23, 62
Henrietta, Clay County, at 104
Insufficient 104
Increase of 20, 128, 198
Jacksborough, Jack County, at 134
Light 104
Local 84, 201
Marienfeld, annual, at 22, 43, 45, 107, 118
Martin County, on Stalked Plain 122
Midsummer 137
Mountains, on the 133
Natural 19
Nebraska, at 131
Plain, of the 548
Precipitation 119
Precipitation, annual 233
Precipitation, average 58, 130
Precipitation, irregular 193
Precipitation in —— and dew 119
Precipitation in Texas 43
Recapitulation of 104
.... 137

Page.

- Rain-fall—Continued.
  - Rio Grande Valley, average, in 88
  - San Martin Station, annual 142
  - Santa Fé 177
  - Southwest Kansas 250
  - Spring 133
  - Storage of 193
  - Subhumid regions 104
  - Summer 105
  - Taylor County, of 133
  - Texas, in 21, 104, 105
  - Texas, Eastern and Southern 106
- Ravines, mention of 20, 45, 53, 70, 96, 99, 149, 150, 170, 184, 195, 198, 202, 272, 362, 363, 396, 542, 558
  - Damming, for water storage 139
  - Draws, known as 119, 123, 137, 149, 150, 172, 194, 208, 559
  - In valleys 11
  - Irrigated, and growing trees 161
  - Sulphur, draw 118
  - Western Kansas 156
  - Western Texas 161
- Reports, special—
  - Military officers, from, on western Texas 51, 52, 53, 54
  - Northwest Kansas, on 229, 230, 231, 232, 233, 234
  - Southwest Kansas, on 234, 235, 236, 237, 238, 239
  - Territorial engineer of Wyoming to governor 502, 503, 504, 505, 506, 507
- Rivers, names, and references to—
  - Alamosa 85
  - Arkansas 145, 147, 150, 153, 154, 156, 159, 160, 165, 166, 173, 174, 176, 177, 179, 180, 181, 182, 183, 186, 193, 194, 195, 196, 197, 199, 200, 201, 203, 206, 207, 209, 211, 212, 213, 214, 218, 261, 262, 263, 264, 266, 267, 268, 269, 270, 271, 274, 276, 285, 286, 309, 313, 314, 344, 345, 352, 355, 362, 404
  - Bear 206, 397, 447, 453
  - Beaver 181, 291
  - Berendas 97, 100
  - Big Horn 446, 447, 459, 461
  - Big Laramie 439, 441, 443, 445, 454
  - Big Thompson 402
  - Boulder 276
  - Brazos 11, 21, 106, 107, 118, 133, 138, 140, 142, 144
  - Cache La Poudre 294, 295, 402, 405, 406, 469
  - Colorado 9, 10, 11, 12, 20, 21, 22, 24, 103, 106, 107, 114, 116, 119, 127, 130, 133, 140, 141, 142, 144, 262, 308
  - Concho 21, 22, 47, 50, 107, 116, 117, 118, 127, 130, 132, 133
  - Cuchilla Negra 85
  - Danube 69
  - Canadian 66, 73, 181
  - Cimarron 71, 98, 99, 165, 170, 172, 173, 177, 181, 196, 211
  - Clear Fork 117
  - Clear Fork, Brazos River 144
  - Clear Fork, Poudre River 457
  - Clear Fork of Trinity River 144
  - Devils 35, 36
  - Encarnacion 53
  - Fontenelle 452, 453
  - Fountain 275, 286, 289
  - Gallinas 91, 92
  - Gila 76
  - Grand 261, 328, 330
  - Great Bend 155
  - Greene 447, 451, 452, 461
  - Guadalupe 10, 22, 118
  - Hondo 100, 110
  - Laguna Madre 98
  - Lampasas 126
  - Laramie 439, 440, 442, 445, 460, 465
  - Llano 11
  - Little Laramie 439, 441, 442, 445, 454, 463
  - Lower Pecos River 70

Page.

Rivers, names, and reference to—Continued.
- Loup 542, 544, 546, 551
- Lower Rio Grande 5, 70
- Marquis 10
- Middle Concho 21, 53, 130
- Mississippi 92, 118, 466
- Missouri 66, 181, 183, 381, 446, 530, 544, 545, 546, 565
- Monument 275, 286, 289
- Mustang 21
- Nile 69
- Niobrara 212, 541, 542, 543, 546, 547
- Nueces 8, 9, 10, 11, 118
- North Concho 21, 53, 127, 130
- North Platte 292, 308. 313, 314, 440, 465, 536, 537, 539, 540, 541, 542, 543, 545, 556, 558, 560, 562, 563, 564
- North Poudre 292
- North Spring 96, 100
- Palomas 76
- Pecos 7, 8, 10, 11, 22, 24, 34, 35, 36, 47, 54, 55, 56, 57, 66, 69, 73, 76, 77, 83, 96, 103, 104, 105, 107, 110, 112, 116, 117, 118, 119, 122, 132, 137, 142, 144
- Pinto 54
- Platte 276, 291, 343, 344, 345, 352, 355, 361, 396, 297, 440, 444, 445, 449, 450, 460, 469, 538, 541, 543, 544, 545, 546, 561
- Popo Agie 459
- Poudre 379, 387, 391, 393, 405, 455, 456, 457, 468
- Puerco 83, 86
- Red 72, 76, 98, 106, 107, 118, 181
- Red Fork of the Colorado 117
- Republican 181, 211, 292, 547, 555
- Rio Grande 5, 6, 7, 11, 12, 13, 17, 24, 26, 27, 28, 29, 30, 38, 39, 40, 41, 42, 47, 48, 49, 51, 52, 53, 54, 59, 60, 62, 65, 66, 75, 76, 77, 78, 82. 84, 85, 86, 89, 90, 96, 100, 103, 104, 115, 116, 118, 122, 142, 313, 314, 325, 359, 403, 404
- Rio Las Animas 85
- Rio Pecos 100, 403
- Rio Polomas 85
- Sabine 107
- Sabinal 118
- Saline 211
- San Antonio 10, 11, 22, 36, 118
- San Cruces 10
- Santa Cruz 370
- San Marcos 118
- San Pedro 22
- San Saba 11, 117, 126
- Santa Fé 70, 74, 75. 96
- Seven 100
- Smoky Hill 181, 211
- Snake 447
- Solomon 211
- South Concho 53, 127, 128, 130
- South Platte 5, 292, 308, 313, 314, 402, 403, 404, 538, 539, 547, 551, 554, 564, 565
- South Spring River 97, 100
- St. Charles 368
- Sweetwater 445
- Tennessee Fork, Arkansas 286
- Ten Mile Creek or Blue 261, 262
- Thompson 387
- Town 455
- Trinity, South Fork of 144
- Underground 22, 103, 108, 119, 124, 148, 156
- Vermejo 98, 99
- Washita 12
- White 546, 547
- Yellow Fork 20
- Yellowstone 181, 446

Rocks, mention of
- Bed-rock 11, 14, 40, 43 45, 46, 163, 345, 359, 402, 403, 450, 465, 553, 560
- Bituminous 114
- Bottom 25, 36, 559

Page.
Rocks, mention of—Continued. 9
Dikes of 136
Flint 53
Formation 110, 127
Limestone 112
Pecos County in 33
Trap 10, 11, 13, 15, 18, 19, 25, 34, 42, 43, 44, 48, 59, 65, 66, 71, 72,
Reservoir sites 78, 81, 82, 83, 85, 89, 90, 91, 98, 102, 103, 111, 115, 122, 126, 127, 128, 129,
131, 150, 151, 164, 173, 190, 195, 196, 199, 202, 203, 207, 208, 210, 271,
277, 278, 28[illegible], 289, 290, 325, 326, 344, 345, 346, 353, 354, 369, 452, 454, 563
292
Arkansas Valley in 19
Capacity of 286, 287
Clear Lake
Cold Creek, at
Cranes 10
Estimates of cost of 308
Fort Collins, north of 286, 287
Hayden 100
Hondo, on the 90
International 309
King 288
Leadville 172
Local 10, 389
Mountains in 70, 71, 78, 91, 96, 152, 206, 267, 309, 344, 554, 561
Natural 286
Old Glacial Period, of the 364
Ralston Creek, on 7, 9, 10, 69, 70, 73, 74, 75, 77, 84, 86, 88, 90, 96,
Storage, for 116, 120, 124, 129, 138, 184, 193, 197, 206, 213, 215, 256, 263, 264, 266, 268,
272, 274, 275, 282, 306, 307, 328, 354, 355, 371, 378, 442, 445, 453, 457, 464
355
Storm-water 286, 287
Sugar Loaf 194
Surface 318, 319, 320, 321, 322
Tabulated statement of, Colorado 23, 103, 149
Tanks 21, 134, 135, 136
Earth 142
San Martin 121, 138, 142
Storage 114
Wooden 286, 287
Tennessee 142
Texas Salt Company, at the works of 287
Twin Lake

S.

43, 45, 60, 68, 70, 108, 117
Seasons and aridity 131
Average precipitation of moisture, of 85
Clear water, Rio Grande, of 96
Critical 66
Crop 5, 22, 39, 47,
Droughts 49, 52, 62, 84, 98, 100, 106, 107, 118, 120, 124, 135, 139, 146, 163, 170, 346
12, 15, 53, 62,
Dry 131, 133, 135, 148, 155, 157, 192, 196, 262, 281, 291, 352, 364, 367, 406, 547
89
Farming 286
Field 32, 39, 52, 155, 164, 264, 265, 267, 380, 387, 463
Flood 195, 207
Growing 311, 390
Harvest 15, 75, 269
High water 43, 75, 99, 100, 264, 273, 294, 295, 306, 309,
Irrigation 310, 316, 317, 329, 344, 359, 380, 381, 383, 396, 409, 441, 445, 448, 466, 539
46, 329, 450
Low water 359
Non-irrigating 9, 20, 53, 64, 71, 77, 83, 87, 96, 127, 133, 139
Rainy 55, 63, 66, 71, 77, 79, 105, 122, 130, 151, 454
Spring 110, 149, 150
Storm 130
Summer 275
Tillage

Page.

Seasons and aridity—Continued.
  Torrential 20
  Wet 116, 133
  Winter 70, 73, 87, 133
Senators, United States, special mention of—
  Jones, J. K. (Arkansas) 145, 158, 163, 164, 165, 168, 169, 170, 178, 192, 196, 203, 203, 204, 205, 261, 263, 264, 265, 266, 267, 268, 272, 275, 276, 277, 278, 281, 282, 285, 286, 288, 289, 290, 291, 294, 295, 296, 297, 303, 305, 307, 308, 309, 310, 312, 313, 316, 317, 323, 324, 328, 329, 330, 346, 348, 349, 351, 353, 354, 358, 359, 360, 361, 368, 369, 376, 381, 382, 383, 388, 391, 392, 393, 394, 395, 397, 439, 440, 441, 442, 443, 444, 447, 448, 449, 451, 453, 455, 458, 468, 469, 484, 485
  Plumb, P. B. (Kansas) 151, 159, 160, 161, 162, 165, 167, 168, 170, 171, 172, 173, 174, 175, 176, 177, 179, 180, 181, 187, 188, 189, 190, 191, 192, 193, 194, 195, 196, 197, 198, 199, 200, 201, 202, 203, 204, 205, 206, 207, 208, 209, 210, 211, 214, 215
  Reagan, John H. (Texas)....................5, 10, 11, 13, 18, 19, 20, 27, 30, 31, 32, 33, 35, 59, 73, 88, 101, 102, 108, 110, 112, 113, 116, 117, 118
  Teller, Henry M. (Colorado) 369, 393, 394, 396, 397, 405
  Stewart, William M. (Nevada) 5, 19, 59, 88, 101, 102, 108, 110, 112, 145, 147, 158, 261, 275, 285, 379, 383, 439, 537
Silk culture.................... 70, 79
Small farms 61, 99
Snow-fall....................39, 62, 66, 77, 99, 195, 289, 329, 389, 445, 454, 457
  Defective supply of.................... 201
  Kansas, in.................... 105
  Melting, spring in 71, 77, 96
  Melting, Rocky Mountains, in.................... 88
  Mountains, in.................... 173
  Mountain (New Mexico and western Texas) of.................... 118
  Mountain-side, on the.................... 105
Staked plain, on.................... 105
Soils, reference to 16, 18, 42, 43, 51, 65, 69, 78, 96, 98, 122, 123, 126, 127, 132, 137, 164, 172, 180, 198, 206, 209, 211, 272, 273, 278, 282326, 327, 357, 363, 367, 368, 405, 406, 408, 536, 541, 563
  Adobe 290
  Alkaline.................... 112
  Alluvial 53, 57, 80, 82, 95, 132
  Aluminous shale 276
  Analysis of, Pecos Valley.................... 56
  Black sandy loam....................57, 106, 126, 458
  Black river-bottom.................... 106
  Black waxy.................... 140
  Bluish clay 212
  Character of, Kansas in.................... 150
  Chocolate loam....................106, 124, 130, 137, 141, 142
  Clay 53, 99, 112, 124, 130, 134
    carboniferous formation of 127
    joint.................... 119
    waterproof.................... 124
    yellow.................... 124
  Cultivation of 51
  East, of the.................... 73
  Examination of.................... 23
  Fertile 120, 154, 160, 171, 182, 203
  Gravel 53, 112, 130, 183, 396, 397
  Howard County, of.................... 139
  Lake bottoms, on.................... 116
  Light, sandy alluvium 39
  Limestone 8, 22, 100, 111, 118, 119, 123, 124, 126, 127. 130
  Loam.................... 459
  Loose red.................... 8
  Mexican 43, 46
  Mineral matter.................... 341
  Natural 53
  New Mexico of.................... 73
  Productiveness of....................89, 90, 369, 454
  Pecos Valley, of the.................... 56
  Quicksand....................40, 45, 47, 123, 145, 153, 403, 564

Page.

- Soils, reference to—Continued.
  - Red clay ... 110, 116, 124, 138, 141
  - Red sand, known as shinneries ... 106
  - Red, sandy ... 96, 133, 137
  - Rich ... 65, 152
  - Sand ... 46, 53, 112, 114, 148, 168, 183, 184, 195, 384, 403, 406, 459, 554
  - Sandy loam ... 8, 56, 106, 138, 463
  - Sandstone ... 53, 124, 136, 138
  - San Luis Valley, condition and character of ... 325
  - Silica and lime, contained in ... 56
  - Subsoil ... 124, 126, 200, 367, 395
  - Surface ... 124
  - Texas, western in ... 11
  - Triassic strata ... 213
  - Uplands or table lands, on ... 106
  - Virgin ... 69
  - Volcanic ash ... 79
  - Water-bearing sand ... 186
  - Western Kansas, in ... 154, 170
  - Whitish loam ... 56
  - White sand ... 80, 124
  - Sorghum ... 55, 56, 119, 131, 132, 134, 135, 136, 138, 140, 141, 147, 158, 174, 177, 182, 196
- Springs:
  - Antelope ... 142
  - Apache ... 142
  - Big ... 139, 142, 564
  - Caballo Mt ... 89
  - Cherokee ... 126
  - Clear Water Fork ... 11
  - Colorado ... 279, 286, 288
  - Comanche ... 119
  - Flemming ... 126
  - Hubbard ... 126
  - Lampasas ... 126
  - Las Vegas Hot ... 91
  - Live Oak ... 8
  - Lower Pecos ... 7
  - Oss Denaio ... 89
  - Reck ... 124
  - Permanent, of great volume ... 100
  - Richland ... 127
  - Rock ... 451
  - San Felipe ... 36, 52
  - San Saba, Texas ... 126, 127
  - Soda ... 136
  - Staked Plains ... 119, 130
- States, references to—
  - Arkansas ... 72
  - California ... 8, 17, 21, 22, 61, 70, 90, 114, 120, 134, 135, 139, 175, 364, 565
  - Chihuahua, Mexico ... 84
  - Colorada ... 5, 7, 9, 13, 27, 32, 39, 47, 48, 49, 54, 66, 69, 71, 88, 89, 9, 98, 104, 108, 109, 110, 140, 141, 172, 174, 178, 179, 180, 184, 185, 186, 187, 200, 206, 208, 210, 212, 213, 261, 262, 264, 265, 270, 274, 275, 277, 278, 279, 281, 283, 288, 308, 312, 323, 325, 341, 342, 343, 344, 345, 347, 348, 351, 355, 357, 362, 365, 367, 372, 383, 384, 391, 395, 396, 402, 404, 440, 442, 445, 447, 465, 468, 484, 530, 538, 539, 547, 552, 553, 561, 562, 563, 565, 566
  - Dakota ... 178, 187, 546
  - Illinois ... 159, 352, 449, 453, 455
  - Indiana ... 167, 173, 199, 455
  - Iowa ... 112, 446, 449
  - Kansas ... 79, 104, 105, 145, 146, 150, 151, 155, 157, 163, 165, 166, 176, 178, 181, 184, 185, 191, 193, 194, 198, 206, 210, 212, 228, 261, 266, 274, 277, 288, 292, 308, 310, 345, 354, 355, 359, 362, 368, 386, 397, 446, 538, 547, 567
  - Louisiana ... 79, 107
  - Maine ... 178
  - Massachusetts ... 39, 170, 305
  - Michigan ... 352
  - Minnesota ... 65

Page.

- States, references to—Continued.
  - Missouri 197
  - Montana 26, 280, 281, 397, 455, 459, 466
  - Nebraska 104, 105, 112, 212, 292, 362, 386, 396, 397, 445, 460, 466, 469, 535, 536, 537, 538, 539, 540, 541, 544, 545, 546, 547, 548, 549, 550, 551, 552, 553, 561, 562, 564, 566
  - Nevada 125, 565
  - New York 25, 65
  - Ohio 165, 199
  - Oregon 135
  - Pennsylvania 355
  - Texas 5, 7, 8, 9, 10, 11, 14, 15, 19, 20, 21, 24, 26, 29, 32, 34, 35, 38, 39, 40, 42, 46, 47, 49, 50, 51, 52, 53, 54, 55, 56, 57, 72, 73, 85, 88, 89, 90, 100, 101, 103, 106, 107, 108, 111, 112, 117, 118, 122, 124, 126, 128, 130, 132, 133, 134, 135, 136, 137, 138, 139, 142, 148, 164, 397, 530
  - Washington 135, 281
  - Wisconsin 350
- Stock-raising 96, 112, 115, 120, 122, 128, 135, 138, 461
  - Cattle ranges 52, 64
  - Horses, raising 120, 132, 461
  - Sheep raising 97, 120, 132, 391
- Streams, names and mention of:
  - Badger 366
  - Beaver 179
  - Bijou 291
  - Bijo 366
  - Brazos (upper) 11
  - Cache laPoudre 355, 362, 380, 301, 388
  - Colfax County, in 70
  - Double Mountain Fork 11
  - List of, on Texas and Pacific Railroad 144
  - Llano 117
  - Main 54
  - Mora 92
  - Mountain 66
  - Natural 402
  - Natural, in portion of Texas 128
  - Natural, flow of 102
  - Nueces 8, 9
  - Pecos City, at 8
  - Perennial streams 53
  - Plains of New Mexico, on 91
  - Roswell, near 96
  - Running water of 119
  - Salt Fork at, charged with brine 11
  - Santa Fé, at north and east of city 75
  - Sapello 92
  - Seepage, from 405
  - Shook's Run 279
  - Southern Texas, in 22
  - Subterranean 131
  - Tom Green County, in 116
  - Underground 138
  - Upper Rio Grande, along 92
  - Vermejo 71
  - White Woman 179
  - Wild Horse 140
  - Yellowstone 455
- Surveys for irrigation, etc 33, 37, 43, 44, 50, 87, 98
  - Ancient river-beds worthy of 103
  - Arkansas River, about Lamar, Colo 176
  - Concho River, headwaters of the 132
  - El Cantilo 39
  - Fountain River 288
  - Government 10, 67, 83, 84, 187, 326, 327, 354, 358
  - Land 39, 40
  - Land, Government 355
  - Marshall Pass, through 267
  - Pecos, of the 37

Page

- **Surveys for irrigations, etc.—Continued.**
  - Platte River, on the ... 563
  - Preliminary ... 45, 96
  - Railroad ... 56, 267
  - Rio Grande, of the ... 48, 60, 81
  - Santa Fé River, for storage reservoirs ... 74
  - United States geological ... 33, 38, 42, 43, 44, 50, 90, 122, 123, 214, 329, 367, 369, 539
  - United States irrigation ... 44, 111, 362, 550

T.

- **Territories:**
  - Arizona ... 62, 65, 80, 126, 379, 565
  - Idaho ... 61, 281, 447, 453, 565, 566
  - Indian ... 12, 245
  - New Mexico ... 5, 7, 9, 13, 15, 19, 21, 22, 24, 27, 28, 29, 30, 32, 33, 39, 47, 48, 49, 55, 59, 60, 62, 63, 65, 67, 69, 73, 74, 78, 80, 87, 88, 90, 91, 94, 96, 97, 100, 101, 104, 105, 107, 108, 110, 111, 126, 136, 359, 397, 404, 555
  - Utah ... 61, 98, 161, 213, 326, 328, 397, 450, 565, 566
  - Wyoming ... 351, 439, 443, 447, 456, 458, 461, 462, 465, 466, 468, 469, 508, 534, 538, 540, 541, 558, 560, 564, 565, 566
- **Tobacco** ... 83, 136
- **Topography, in connection with irrigation** ... 137, 140, 197, 270, 288, 344, 354, 540, 542, 546, 548, 554
  - Colorado, of ... 269
  - Country, of a ... 21, 149, 194, 205, 232
  - Mitchell County, of ... 140
  - Nueces, the ... 9
  - Rio Grande, sources of ... 7
  - Subhumid regions, of ... 106
  - Western Texas, of ... 10, 35, 115, 135
  - Treaty of Guadeloupe Hidalgo ... 29, 30
- **Trees** ... 49, 95, 121, 138, 139
  - Ash ... 27
  - Black Jack ... 53
  - Brush ... 53
  - Cedar ... 97, 107
  - Chittim ... 106
  - Cottonwood ... 95, 106, 109
  - Elm ... 106, 130
  - Greasewood ... 100
  - Hackberry ... 106
  - Live oak ... 106, 130, 133
  - Mesquite ... 23, 51, 106, 133, 404
  - Pecan ... 106
  - Pine ... 97, 99
  - Pinon ... 97
  - Post ... 106
  - Red oak ... 106
  - Shin oak ... 106
  - Spruce ... 97
  - Timber growth ... 89, 95, 97, 106, 129, 132, 250, 280, 281, 312, 464
  - Wild China ... 106

V.

- **Valleys:**
  - Arkansas ... 145, 147, 148, 166, 173, 184, 187, 194, 265, 266, 270, 274, 288, 343, 354, 403
  - Beaver ... 187
  - Brazos ... 142
  - Cache la Poudre ... 296, 402
  - Cimarron ... 172, 187
  - Crooked Creek ... 212
  - El Canutilo ... 39
  - Grand ... 326
  - Green ... 326
  - Green River ... 451
  - Laramie ... 444, 448
  - Las Cruces ... 6
  - Lodge Pole ... 558

Page.
Valleys—Continued.
Mesa 65
Mesilla 59, 60, 61, 81, 82, 83, 85, 88, 89, 90, 91, 122, 181
Mountain 122
Paul's 11
Pecos 56, 60, 118, 132, 142
Platte 190, 292, 342, 362, 266, 537
Red River 98
Republican 397
Rio Grande 5, 6, 11, 12, 28, 38, 52, 66, 72, 75, 78, 79, 80, 81, 82, 85, 88, 328
Salt River 62
San Bernardino 366
San Juan 264
San Luis 5, 6, 7, 296, 303, 304, 325, 326, 327, 328, 330, 340, 342, 359, 363, 366
San Martine 142
San Marcial 7
Santa Fé River 70
South Platte 403
Village:
Granite, of 286
Indian 47, 87
Marfa, of 53
Vineyards 12, 19, 33, 63, 64, 80, 82, 106, 121, 122, 133, 137
Grape of 8, 21, 28, 55, 57, 63, 64, 66, 68, 79, 80, 81, 90, 110,
111, 120, 121, 122, 131, 132, 133, 134, 135, 136, 137, 138, 139, 140, 141, 142
Hops of 107, 241

W

Water supply, reference to:
Abundance of 6, 7, 27, 31, 61, 63, 113, 118, 136, 210, 563
Acre, system of 129
Alkali 11, 119, 273, 564
Ample, of 44, 141, 165, 459
Amount of, required for ditches 297
Amount of, thrown out by wells 109
Analysis of, Pecos River 56
Annual rent of 100
Appropriator of, protection to the 55, 504, 505, 506
Arkansas River, quantity of 270, 273
to irrigate with 149
Arkansas water division, Colorado 313, 315
Artesian 108, 132, 140, 156, 166, 168,
171, 173, 174, 175, 177, 178, 180, 194, 196, 205, 212, 214, 255, 365, 550, 561
Batavia, supplied with 365
belt of 56
flow at Larned 213
in the San Luis Valley 326
Artificial supply of 171,
181, 183, 191, 193, 194, 196, 197, 199, 201, 204, 205, 206, 207, 275, 587
Average flow of 39
Average, line of the 124, 125
Brazos, at silt in 142
Capacity of 316
Carrizo Pass, at 142
Catchment areas 53
Clear and fresh 29, 42
Cloud-bursts 282, 549
Coleman, at 117
Colorado, of 368
Commissioner 291, 343, 362
Consumption of, for crops 259
Contract for 303, 361
Control of 44, 346, 347, 349
Courses 53, 60, 98, 106, 123, 133, 138, 196
Decreed, amount 323, 324
Deep 181, 366
Demand for 40
Depth required to sink for 145
Devastating floods of 92
flow of 41

Page.
Water supply—Continued.
  Disappears, how it 62, 206, 291
  Distribution of 100, 142, 278, 304, 342, 343, 348, 363
  Distribution of, in valley of Rio Grande 13, 67
  Districts in Colorado 313, 314, 348, 451, 507
  Diversions of, in Colorado 62
  Diverted 50
  Divisions in Colorado, No. 1 ..... 296, 313, 315
  Drainage of 39, 53, 243, 273, 275, 363, 364, 368, 395, 406
    area of 100, 288
    basins or surface lakes 113
    Crooked Creek 236
    east slopes of Capitan 100
    farm on, by ditching and tiling 107
    Kansas of, natural 244
    North Fork of the Cimarron 237
    Republican and Smoky Rivers 230
    Salt Fork of the Arkansas 239
    surface 241
    underground 113, 118, 123
  Division No. 3, Rio Grande (San Luis Valley) 313, 315
  Dry, courses 122, 404
  Duty of 67, 71, 99, 131, 313, 314, 315, 316, 327, 342, 348, 367, 379, 382, 384, 385, 393, 405
  Economy in 67, 102, 206, 269, 316, 348, 408, 409, 542
  Evaporation of 39, 44, 43, 83, 91, 96, 203, 113, 124, 134, 150, 155, 180, 190, 202, 203, 211, 213, 271, 273, 275, 290, 292, 309, 317, 352, 365, 386, 409, 554, 558, 561
    Water-course, from dry 105
    Measuring of 19, 39, 45
    Total 293, 294
  Evaporating, pans 45
  Experiments for, by boring wells 124
  Facilities of 277
  Falls, during summer 275
  Fall of 365
  Famine, a 47, 96
  Fertilization of lands by 49
  "Fills" built to retain 306, 307
  Flood 37, 46, 47, 48, 64, 69, 99, 100, 111, 131, 273, 325, 328, 346, 353, 362, 386, 409, 448, 460, 542, 553, 558, 559, 560
    annual in Rio Grande 42, 72
    annual 39
    control of 39
    height of Rio Grande 88
    in the Mesilla Valley in spring 82
    saving of early season 89
    time, amount of 8, 29, 31, 33, 60, 344
    time at Pecos 36
    annual period of 41
  Flow of 43, 47, 70, 71, 126, 128, 141, 148, 155, 160, 161, 176, 305, 346, 365, 366
    annual 40, 41, 42, 45, 46, 131, 132, 295
  Flowing to waste 60
    Pecos City, at 112
    Sandy Mountain, out of 87
    Near Gomez, Tex. 142
  Forms of Colorado water contracts 300, 302, 330, 339
  Forests, largely to conserve the 279
  Freshet of 53, 208
  Gauging station 43, 45
  Gauging station at Denver 314
  Graves' spill-box for measuring 304
  Head of 72, 97, 114, 130, 140, 142, 180, 281, 447, 469, 551
    Arkansas, of 262
    Colorado, of 118
    Rio Grande, of 62
  High 45, 91, 98, 267, 272, 288
  Highland, depressions on 199
  How obtained 218, 219

Water supply—Continued. Page.
- How water runs up-hill 220
- Iron 366
- Lack of 30, 49, 86
- Late 394
- Lateral system of 99
- Leakage of 131
- Liberal supply of 107
- Line 179
- Limestone, found resting on 138
- List incorporations, New Mexico 94
- Location and distribution of 486, 497
- Local flood of 317
- Local spout 317
- Low stage of 39, 62
- Marienfeld, at 134
- Measurement of 124, 125, 304, 305, 315, 367, 368
    - by boxes 304
    - by Weir method 305, 306
- Means of obtaining 32
- Means of restoring, suggested 13
- Mechanical power in elevating 404
- Mexican system of 5
- Miles of ways 57
- Mode of distributing 407
- Moisture economy 80, 241, 244
- Mountains 107, 292
- Natural basins for, Grant County 206
- Natural flow of 115, 130, 131, 194, 275, 344
- Necessity for 11, 24
- Obtained by irrigating ditches 96
- Occupation of 50
- Overflow of 39, 40, 41, 53, 96, 173, 172, 199, 202, 366, 389, 390
    - annual 39
    - lands by 19
- Owners of 311
- Passes into cañon 72
- Paso Del Norte, insufficiency of, at 31
- Pecos, of the 100
- Percolation of 119, 268, 276, 363, 365, 366
- Pepetual, right in 340
- Pioneer canal, permanent right of 56
- Pipes for saving 77, 368
- Pipes of wood 99
- Plan of disposing of 61
- Platte, of the 276
- Ponds of, Mitchell County 114
- Power of 17, 27, 29, 31, 41, 42, 46
- Precipitation of 39, 195, 197, 202, 209
- Pressure of 26
- Price of 188, 485
- Prior right to 48, 328
- Prior appropriation of 55, 323
- Privileges of 51
- Proximity to 51
- Questions of supply 49, 120
- Quantity needed for irrigation 51, 121, 122, 123, 128, 129, 150, 349, 359
- Railroad on 222, 223, 224
- Rain 135
- Rentals of 311
- Removed by pumping 53
- Reserve of 41
- Rights 13, 17, 32, 33, 46, 56, 57, 61, 71, 74, 91, 94, 128, 129, 131, 203, 290, 303, 310, 311, 327, 329, 341, 348, 351, 352, 354, 356, 360, 361, 365, 392
    - ancient 32
    - form of agreement for 297, 300
    - price of 100
- Rio Grande, of 28, 48, 49
- Riparian rights in 40, 69, 126, 127, 142
- Riparian laws 47

Page.

- Water supply—Continued.
  - Running wild over the sod 98
  - Salt 171
  - Samples of 45
  - San Saba, of the 127
  - Saving flood, Rio Grande, of the 90
  - Search for 123, 124
  - Scarcity of 27, 31, 32
  - Sedimentary deposit of 15, 19, 25, 39, 42, 43, 45, 52, 84, 85, 148, 202, 203, 272
  - Seepage of 77, 103, 114, 119, 124, 148, 151, 201, 202, 203, 204, 269, 292, 307, 309, 314, 317, 346, 359, 362, 363, 368, 381, 384, 386, 390, 395, 402, 406, 465, 551
  - Service of 56
  - Shallow pools of 238
  - Sheds 130, 262, 266, 267, 270, 290, 292, 308, 354, 408, 444
    - Arkansas and Cimarron 238
    - Platte, of the 343
    - Smoky Hill 194
  - Sheet 183, 185, 194, 202, 217, 270
  - Shortage of 393, 394, 404
  - Sinks into sand 5, 270
  - Small pools of 45
  - Snow 5
  - Source of, supply 30, 32, 51, 77, 126, 180, 197, 199, 200, 207, 263, 269, 276
    - re-issue of 346
    - Jornado del Muerto 89
    - New Mexico, in 74
    - Rio Grande, valley of 88
  - Spouts 328
  - Spring 5, 100, 554, 562
  - Springer system of 98
  - Staked Plains, amount needed on 120
  - Stations, experimental, suggested 23, 223, 224, 373
    - Dodge City and Cañon City, between 223
    - Texas and Pacific, on 143, 144
    - Agua Zarca, at 224
    - Benson, at 224
    - Brooklyn, in 224
    - Caibo, at 224
    - Caddoa, at 223
    - Calatasas, at 224
    - Car, at 403
    - Carlin, at 223
    - Castle Rock, at 223
    - Cimarron, at 223
    - Clear Creek, at 223
    - Clelland, at 223
    - Clyde, at 106
    - Codman, at 223
    - Coolidge, at 223
    - Colorado Springs, at 223
    - Crittenden, at 224
    - Denver, at 223
    - Dodge City, at 223
    - Dromo, at 116
    - Elgin, at 224
    - El Paso, at 39
    - Fountain, at 223
    - Garfield, at 208
    - Granada, at 223
    - Hermosillo, at 224
    - Imuris, at 224
    - Kendall, at 233
    - Kent, at 142
    - La Junta, at 223
    - Lakin, at 223
    - Lamar, at 223
    - Las Animas, at 223
    - Llano, at 224
    - Lava, at 224
    - Magdalena, at 224

Water supply—Continued. . Page.
  Stations—Continued.
    Miami, at
    Nepesta, at 223
    Nogales, at 223
    Pan Handle City, at 224
    Pesqueira, at 223
    Pierceville, at 224
    Pinon, at 223
    Potter, at 223
    Pring, at 564
    Prowers, at 223
    Pueblo, at 223
    Rincon, at 223
    Salton, at 89
    San Martine, at 44
    Sedalia, at 142
    Sherlock, at 223
    Syracuse, at 223
    Taylor, at 223
    Upham, at 223
  Statutory inch, sold by 224
  Stealing of 327
  Stock 347, 353
  Storm 349, 351
  7, 53, 69, 88, 89, 149, 151, 175, 177, 215, 216, 272, 343, 344, 355, 363, 539, 550, 554, 556, 559, 561, 562, 564
  Storm, storage of 150, 170, 318, 352, 362
  Strata of 22, 34, 64, 121, 185, 186, 402, 403
    Dacota formation in 212
    limestone in 123
    sand in 162
    sand or gravel in 124, 185
    tertiary grit in 211, 212
    white gravel in 110
  Storage, mention of. . 7, 8, 9, 15, 19, 39, 40, 41, 44, 57, 59, 60, 83, 84, 85, 86, 96, 98, 111, 125, 127, 133, 138, 139, 173, 194, 195, 202, 262, 274, 277, 279, 283, 284, 290, 292, 294, 309, 328, 344, 386, 408, 442, 463, 466, 467
    Albany County, in 464, 465
    Capacity for 41, 45
    Dams in 66
    Facilities for, Jornada del Muerto 82
    Flood water, of 82, 152, 153, 155, 175, 209, 316
    Natural 202
    Pecos, on the 34
    Ravines in 146
    Reservoirs in 380, 301
    Sink-holes or sand beds, for 276
    Springs in 210
    Subhumid region, capacity for 107
    Surplus of 70, 131
  Subterranean 81, 186, 209, 228, 397, 402
  Supply of 5, 7, 8, 22, 26, 36, 40, 49, 52, 53, 59, 67, 73, 90, 96, 98, 99, 103, 106, 108, 112, 115, 116, 119, 121, 122, 124, 127, 133, 134, 135, 141, 147, 148, 158, 162, 166, 167, 168, 170, 171, 172, 173, 174, 176, 182, 184, 185, 190, 195, 202, 214, 215, 216, 217, 222, 223, 224, 245, 258, 261, 264, 266, 273, 277, 289, 291, 292, 296, 310, 318, 325, 326, 328, 347, 349, 350, 359, 396, 403, 404, 405, 440, 445, 456, 460, 462, 465, 483, 486, 559, 561, 563, 564
  Supply, Arkansas Valley in 185
    damming at 64
    description of 222
    El Paso at 83
    Government aid for 189
    gradually increasing supply 342
    how to increase 240, 241
    increased by storage 102
    Rio Grande, from 59, 88
    Santa Fé River, from 75
    source of 35, 143
    Sterling, at 291
    Wells, from 222

Page.

Water supply—Continued.
  Surface........ 43, 55, 78, 119, 133, 172, 539, 561
  Surplus of........ 27, 69, 127, 129, 181, 295, 310, 385, 469, 543, 563
  Supply of, in Arkansas River........ 202
  System by gravity........ 54
  System, Western Texas, in........ 20
  Tanks........ 53, 113
  Tenure of property in........ 297
  Tidal flow of........ 40, 41, 130
  Tub, exhausted in........ 98
  Unappropriated........ 128
  Unburdened by silt........ 47
  Underflow, the........ 119, 148, 149, 152, 183, 187, 208, 210, 398, 404, 465, 547, 558
      chief domain of........ 221
      Upper Arkansas........ 255, 256
  Under-ground channels........ 107
      reservoir of........ 403
      supply of........ 107, 119, 122, 186, 190, 228, 229
      supply from sandstone strata........ 229
  Underlying bottom-lands........ 197
  Under limestone strata........ 118
  Use of........ 55, 324
  Use of interstate streams........ 101, 102
  Users of........ 350
  Utilized in arroyos for power........ 100
  Utilized for irrigation purposes........ 126
  Utilizing the natural supply........ 126, 184
  Vast power of........ 47
  Velocity of........ 274
  Vermejo, system of........ 98
  Vested rights in........ 19, 47, 84
  Volume of........ 26, 27, 28, 29, 45, 60, 66, 75, 86, 96, 111, 138, 140, 141, 153, 174, 295, 359, 469, 546
      Pecos, in the........ 73
      Platte, in the........ 366
  Want of........ 39, 49
  Waste of........ 6, 7, 27, 28, 41, 69, 75, 77, 82, 83, 86, 91, 124, 126, 129, 131, 175, 194, 200, 201, 261, 262, 264, 269, 275, 278, 288, 290, 291, 316, 317, 345, 351, 363, 381, 383, 386, 407, 408, 450, 454, 463, 558, 561
      In floods........ 90
      Ways........ 20, 179, 287
  Ways of getting........ 202
  Wells, raised by........ 34, 138, 149, 142, 176
  Works........ 22, 34, 75, 126, 141, 186, 210, 465
      at Atlanta, Ga........ 53
      Croton, New York........ 25
      hydraulic........ 74
      Lone Star salt........ 141

Wells:
  Artesian, reference to........ 10, 52, 53, 96, 97, 102, 135, 140, 162, 166, 167, 170, 173, 176, 184, 193, 194, 196, 214, 329, 365, 366, 372, 373, 374, 465, 535
      Artesian City, at........ 165, 175
      Coolidge, at........ 174, 197, 212
      Colorado, at........ 143
      flowing........ 56
      Fort Worth, at........ 143
      Great Bend, at........ 213
      Laramie Plains, in the........ 449
      Pecos, at........ 142, 143
      Richfield, at........ 212
      southwestern Kansas, in........ 250, 251, 252, 253
      Toyah, an abandoned artesian, flowing........ 142
      Van Horn, at........ 143
  Albert Howard, the........ 397
  Aledo, at........ 143
  Aleman or Martin's........ 89
  Atchison, Topeka, and Santa Fé Railway, on........ 226, 227
  Barn-yard, in........ 108
  Beeler, at........ 223

INDEX.

Wells—Continued. Page.

- Boring for
- Boring, proposed experiments in ... 21, 23, 134, 135, 141
- Breathing, Eagle Flat, at ... 124
- Clyde, at ... 108
- Colony Fork, at ... 143
- Colorado, at ... 143
- Concho County, in ... 141, 142
- Crisley, at ... 131
- Crooked Creek, on ... 223
- Denver Pacific district, in ... 162
- Diagram of proposed ... 373
- Dighton, at ... 126
- Description of between Wakeeney and Denver ... 223
- Dug ... 222
- Dug or bored into underground water ... 136
- Existing ... 119
- Flowing ... 122
  - in Hockley County ... 366
  - in Meade County ... 113
  - at Washburn ... 161
- Garden City water-works, at ... 22
- Glazier, at ... 185, 186, 217
- Hale County, in ... 223
- Hancock, failing about ... 113
- Haas Farm, on the ... 47
- Hungary, in ... 126
- Iowa, in ... 135
- Jim Crow ... 113
- La Junta ... 23
- Leon ... 185
- Lorraine, at ... 119
- Marienfeld, at ... 143
- Mallet Ranch, on ... 143
- Martin County, in ... 136
- Meade County, in ... 136
- Merkle, at ... 213
- Midland, at ... 134, 143
- Modoc, at ... 109
- Monohans, at ... 223
- Mustang Draw, in ... 142, 143
- North of Dryden, on Pecos ... 136
- Railway, at Monahans ... 112
- Union Pacific, on ... 119
- Rock Creek, at ... 373, 374, 564
- Servia, in ... 143
- Size and capacity of ... 135
- Shallow, change of formation in ... 121
- Slaughter, C. C., belonging to ... 112
- Staked Plain, on ... 136
- Steely, B. E., owned by ... 110
- Stevens County, in ... 168
- Strawn, at ... 167
- Sulphur Draw, on ... 143
- Surface, a few of the ... 136
- System of ... 119
- Van Horn, at ... 20
- Weirs ... 142

Winds:

- Blizzard ... 19, 41, 98
- Dry ... 56
- Gulf ... 133
- High ... 105
- Hot ... 43
- Local ... 152, 154, 164, 178, 211, 213
- Northers ... 105
- Prevailing, the ... 56, 234
- South ... 104

Wind-break ... 234

... 65

Page.

- Windmills, 21, 23, 107, 108, 112, 113, 114, 120, 121, 134, 141, 158, 166, 168, 169, 561
  - At Bird, 135
  - At Challenge, 134, 135, 136
  - At Deeming, 64
  - At Eclipse, 136
  - Grist, a, 27
  - At Halladay, 134, 135, 136
  - Iron turbine, with, 135, 136
  - José Caribal's, at, 31
  - Juan Gilas, at, 31
  - Kirkwood, at, 136
  - Midland, at, 109, 113
  - Montoyas, at, 31
  - Star, the, 136
  - Vacante Provencios, by, 31
- Witnesses' names:
  - Allen, G. H, 170, 171, 172, 173
  - Alford, N. C, 379
  - Allen, Martin, 240, 241
  - Amies, F. J, 382
  - Alexander, W. E, 353, 354
  - Ameson, J, 136
  - Arnold, Joseph, 136
  - Ashton, William, 372
  - Bailey, H. L, 568
  - Bailey, L. D, 181, 182, 183
  - Baker, S, 370, 371
  - Balwin, Noyes, 459, 460
  - Bartlett, Robert, 135
  - Bauer George, 139
  - Baxter, O. H. V, 269, 270
  - Bell, George, 136
  - Bell, D. J, 206, 207
  - Bellamy, Charles, 439, 440, 441, 442, 443
  - Bodfish, Sumner H, 285, 286, 287, 288, 289
  - Borden, W. C, 51
  - Booth, Levi, 345
  - Bowman, John B, 88, 89, 90, 91
  - Boyd, David, 391
  - Boyle, Arthur, 68, 69, 70
  - Brackett, A. G, 54
  - Brant, R. K, 101, 102
  - Braul, B. K, 54, 57
  - Brechemin, Louis, 535, 536
  - Bristol, Warren, 63, 64, 65, 80
  - Briggs, George E, 109
  - Bronson, Edgar B, 5, 6, 7, 8, 9, 10, 13, 19, 20, 28
  - Brown, M. C, 448, 449
  - Brown, Fred, 206
  - Brown, C. H, 554, 555, 556
  - Bryant, Willis, 193, 194
  - Burdick, Charles W, 449, 450
  - Burton, J. R, 308, 312
  - Burritt, Charles H, 456, 457, 458, 534, 535
  - Byers, W. N, 283, 284
  - Campbell, Joseph, 136
  - Carey, Joseph M, 461, 462
  - Carpenter, Louis G, 291, 295, 296
  - Catron, T. B, 65, 66, 67, 68, 70, 84
  - Chamberlin, H. B, 289
  - Churches, John, 364, 365
  - Clark, R. J, 159, 164
  - Clark, E. J, 172, 175
  - Clark, J. Max, 385
  - Cloud, H. H, 110, 111
  - Cochrane, A. B, 204, 205
  - Coffeen, H. A, 455, 456
  - Conyers, G. W, 158, 159
  - Crosby, J. F, 26, 27, 28, 29

Witnesses' names—Continued. Page.

Crowley, A. F .....
Cruse, Thomas 136
Cummins, W. F 96, 97
De Witt, P. M 126, 127. 128
Dill, Robert G 135
Downey, Stephen W 354, 355
Dumble, E. T 533
Dunbar, Thomas P 115, 116, 117
Earnest, C. H 340, 341
Eaton, Benjamin H 140
Emigh, A. L 388, 389, 390, 391, 405
Ensign, Edgar T 382, 383
Escobar, Senor J 279, 280, 281
Estes, T. C 12
Eubank, J. W 136
Follett, W. W 34
Fountain, Albert J 33, 34
French, W. H 81
Fugate, J. C 207, 208
Gardener, Isaac 210
Garfias, C. I 135
Gettinger, Joseph 24
Gilbert, J. W 134
Gilchrist, Andrew 147–152
Gildersleeve, Charles H 460
Grace, W. R 73, 74, 75, 76
Grant, M. M 210
Grant, James B 464, 465
Graves, Walter H 344
Greene, J. S 325, 326, 327, 328, 329
Gregory, J. W 367, 368, 369
..... 183,
184, 185, 186, 187 188, 189, 190, 191, 214, 215, 216, 217, 218, 219, 220
Grierson, Henry F .....
Griswold, John S 78, 79, 80
Gould, W. L 371
Guy, J. C 556
Hall, E. D 197, 198
Hare, L. R 199, 200
..... 244
Hay, Robert 210, 211, 212, 213, 214, 229, 230, 231, 232, 233, 234
Heldt, Ludwig .....
Helm, Jos. C 35
..... 323. 324
Hicks, L. E 538, 539, 540, 541, 542, 543, 544, 545, 546, 547, 548, 549, 550, 551
Hills, Victor G .....
Hilton, H. R 261, 263, 264
Hobart, Edward F 241, 242, 243. 244
Hobson, W P 91, 92
Holbrook, Henry R 270, 271, 272, 273
Holden, C. W 264, 265, 266, 267, 268, 269
Hollingsworth, Alfred 452, 453, 454
Hopkins, Mark 537, 538
Howell, Robert R 451, 452
Hoyt, John W 551–554
Hughes, Cyrus L 454, 455
Hutchinson, W. E 379
Jackson, A. H 196, 197
James, R. O 536
Jarvis, N. S 167, 168, 169, 170
Johnston, J. A 370
Jones, R. O 465
Jones, T. J 175
Karl, Joseph 200, 201, 202, 203, 204
Kautz, August V 135
Kellog, Geo W 567
Kellog, E. H 95
Kelly, J. H 97
Kirkpatrick, E. W 165, 166, 167
Kochs, Louis 132
Kouz, J. B 135
..... 134

Page
Witnesses' names—Continued.
La Grange, B. S........ 295, 405-410
Lacey, F. E........ 371
Landerdale, J. V........ 53
Lester, H. K........ 198, 199
Llewellyn, W. H........ 58, 59, 60, 61, 62, 63, 64, 65, 66, 67
Livingston. James K........ 87
Logan, Thomas H........ 24, 25, 26
Lowry, Austin P........ 249, 250
Luce, J. E........ 139
Magoffin, Joseph........ 32, 33
Malrany, A. D........ 379
Maltby, W. J........ 140
Mankart, Charles........ 223
Marshall, W. S........ 112, 113, 114
Matzec, George........ 135
Maxwell, J. P........ 312, 313, 314, 315, 316, 317, 318, 319, 320, 321, 322
McCaw, Walter D........ 372
McCune, A. J........ 377, 378
McCunniff, Thomas........ 372
McIntosh, J. J........ 557, 558, 559
Mead, Elwood........ 443, 447, 483, 486, 502, 508
Menges, Theodore........ 559, 560, 561
Mills, Anson........ 6, 9, 13, 19, 24, 25, 29, 38, 39, 42, 44, 52, 53
Moller, L. N........ 131, 135
Mohler, M........ 229
Moon, A. T........ 191, 192
Morgan, George H........ 54
Morton, Charles........ 54
Nettleton, Edwin S........ 362, 363
Newsom, John Q. A........ 170, 180, 181
Nichols, J. Clayton........ 379
Olmsted, J. A........ 536
Otero, M. S........ 86, 87
Pagendarm, John........ 136
Parsons, George H........ 281, 282
Patten, H. B........ 535
Poland, J. S........ 567
Powell, J. L........ 245, 246, 247
Phillips, J. A........ 561, 562
Pratt, Charles E........ 117, 118
Prince, I. Bradford........ 92
Provencio, E........ 30, 31
Quebedeaux, W. A........ 136
Quinton, William........ 536
Randall, E. M........ 53
Rawlins, A........ 135
Ritch, William G........ 77, 78
Robertson, J. B........ 134
Roesler, F. E........ 21, 22, 23, 102, 108, 118, 124, 126, 128, 134
Robson, James........ 562, 563
Roof, Stephen........ 209
Rogers, Platt........ 355, 356, 357, 358, 359, 360, 361
Routt, John L........ 383
Rumbough, D. J........ 51
Rynerson, W. L........ 84
Sartoris, Lionel........ 463
Schermerhorn, A. D........ 564, 565
Schmitz, N. S........ 134, 137
Seymour, G. H........ 135
Sheldon, A. Z........ 275, 278
Shelton, F. M........ 247, 248, 249
Shrophire, R. W........ 378
Sidlow, John W........ 157
Sloan, William B........ 76, 77
Sloan, J. M........ 173, 174, 175
Smith, James........ 136
Smith, Francis M........ 556
Smith, H. D. W........ 142

Page.

- Witnesses' names—Continued.
  - Sommers, Frederick ... 135
  - Southworth, Royal A ... 351, 352
  - Springer Frank ... 70, 71, 72, 73
  - Stanger, J. S ... 341, 342, 343
  - Stanton, Irving W ... 273, 274
  - Steffes, John G ... 250, 251, 252, 253, 254, 255, 256
  - St. John, O ... 234, 235, 236, 237, 238, 239
  - Steele, C. W ... 378
  - Steernwitz, W. H ... 10, 11, 12
  - Stone, E. W ... 567, 568
  - Stover, E. S ... 80, 84
  - Stubbs, A. W ... 176, 177, 178, 179
  - Sulton, M. W ... 152
  - Swink, Geo. M ... 138
  - Symington, John ... 96
  - Taylor, Edward D ... 145, 146
  - Towle, Geo. F ... 53
  - Trimble, L. S ... 87
  - Tweedy, Joseph ... 130
  - Tweeddale, C. E ... 256, 257, 258, 259, 260
  - Ulrich, J. C ... 306, 307, 308
  - Van Diett, P. H ... 365, 366
  - Vaughan, J. L ... 133
  - Walker, C. A ... 563, 564
  - Warren, Francis E ... 466, 467, 468, 469, 470
  - Warwick, O. B ... 371
  - West, George H ... 228, 395, 396, 397, 398, 404
  - Wheeler, Byron S ... 346
  - White R. N ... 85
  - Wilcox, E. T ... 369, 370
  - Williams, B. F ... 108, 109
  - Wilson, J. A ... 194, 195, 196
  - Woodcock, Abden ... 565, 567
  - Woodward, Alfred A ... 244
  - Wright, R. M ... 154, 155, 156, 157
- Wyoming local reports by—
  - Brown, E. D ... 517
  - Chaplin, Ed B ... 526, 527
  - Clark, Donald ... 521
  - Darbin, John ... 515, 516
  - Fisher, John A ... 509
  - Gilchrist, Andrew ... 508, 509
  - Gordon, John H ... 516, 517
  - Haines Bros ... 525, 526
  - Herrick, T. M ... 512
  - Holden, C. W ... 523
  - Johnston, Lizzie D ... 520, 521
  - La Grange, Caleb M ... 512, 513
  - Lathan, Emma M ... 518, 519
  - Lowe, Benjamin F ... 510, 511
  - McLaughlin, John ... 520
  - McLaughlin, A. M ... 518
  - Moeler, Gustave E. A ... 515
  - Mull, N. P ... 521, 522
  - Obrien, John O. D ... 511, 512
  - Pollard, Charles A ... 527-531
  - Rock, J. F ... 525
  - Rutledge, T. M ... 519
  - Sartoris, Leonel ... 513, 514
  - Smith, Edwin C ... 523, 524
  - Smith, John R ... 514, 515
  - Sutherland, A. L ... 524, 525
  - Trabing, Augustus ... 522, 523
  - Voorhees, Luke ... 510

○

REPORT

OF THE

SPECIAL COMMITTEE

OF THE

UNITED STATES SENATE

ON THE

IRRIGATION AND RECLAMATION OF ARID LANDS.

VOL. IV.—STATEMENTS BY DIRECTOR POWELL AND OTHER OFFICERS
OF THE U. S. GEOLOGICAL SURVEY.
CONSULAR REPORTS.
GENERAL REPORT ON IRRIGATION IN UNITED STATES.
MISCELLANEOUS PAPERS.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1890.

VOL. IV.

STATEMENTS BY DIRECTOR POWELL AND OTHER OFFICERS OF THE U. S. GEOLOGICAL SURVEY.

REPORTS OF UNITED STATES CONSULS IN COUNTRIES USING IRRIGATION.

MISCELLANEOUS PAPERS ON SUBJECT OF RECLAMATION.

HINTON'S REPORT ON "IRRIGATION IN THE UNITED STATES." RE-EDITED BY ORDER OF THE COMMITTEE.

WASHINGTON DIVISION.

WASHINGTON, D. C., *January* 17, 1890.

The committee met pursuant to the call of the chairman.

Present, Mr. Stewart (chairman), Mr. Plumb, Mr. Casey, Mr. Moody, Mr. Reagan, and Mr. Jones of Arkansas.

STATEMENT OF J. W. POWELL. DIRECTOR OF THE GEOLOGICAL SURVEY.

Director **POWELL**. Mr. Chairman and gentlemen of the committee, since the return of the committee from the West, having ascertained special questions in which the members of the committee were interested, I have devoted almost all my time to the collection of the data which they seemed to require, and to assembling those data in such manner as to present to the committee a body of material that should as far as possible be a repository of facts in relation to arid lands. For this purpose I have not only devoted most of my own time but have employed from five to twenty-five men in the office of the Geological Survey getting together the facts.

I now present before the committe a map of the arid region exhibiting the distribution of the land already irrigated. The committee will see on this map a red line along the eastern border.

The **CHAIRMAN**. How is that map entitled?

Director **POWELL**. It is entitled, "Map showing the irrigated areas of the United States."

Senator **PLUMB**. That corresponds to the line drawn on other public maps, I suppose; for instance, the one at the White House, separating the arid from the subarid regions?

Director **POWELL**. That map at the White House I made some fifteen years ago. I have more complete data now.

Senator **PLUMB**. Do the lines run to the same places?

Director **POWELL**. Not quite.

Senator **CASEY**. Is that line drawn at about the one hundredth meridian?

Director **POWELL**. It is very near to it, but not exactly at the one hundredth meridian. There is a border zone along the eastern side of the line—a doubtful region—the region in which at some times rain falls in quantities sufficient for agriculture and at other times in quantities not sufficient for that purpose. The line itself is drawn conservatively, so as to include only those areas now generally, perhaps universally, recognized as being arid to such an extent as to require irrigation from year to year.

The greatest change I have made since the old maps were constructed is in the western border. We are able to trace out more accurately the lines on the western border where irrigation is necessary. I have also left out the northern portion of the valley of California in which irrigation is not absolutely necessary.

The CHAIRMAN. In the northern Sacramento Valley?

Director POWELL. Yes.

The CHAIRMAN. Irrigation districts are being rapidly organized there.

Director POWELL. Yes, but I have only indicated here the area where irrigation is absolutely necessary. The total area of the regions thus embraced within the two lines is about 1,340,000 square miles. If we include the subhumid zones on either side, where irrigation must be practiced some years to secure crops, the total area will be about one-half of the United States exclusive of Alaska.

A glance at the map will exhibit the districts of country where irrigation is now in progress. From the data we have collected we find that about 8,000,000 acres of land have been irrigated and are under cultivation, and that a little more than 10,000,000 acres of land are under ditch. I have that all plotted on the map, except some few places yet to be completed—little outlying districts where 10, 20, or 30 acres are irrigated by little springs, etc.—a few in Nevada, Idaho, and Oregon, and some in Wyoming. They will very soon be completed.

I here present a table by States, setting this forth:

IRRIGATED AREAS—TOTALS.

States and Territories.	Under ditches constructed or projected.	Irrigated and under ditch.	Percentage irrigated to total area of State.	Authority.
	Acres.	*Acres.*		
Arizona	455,600	175,000	0.2	T. E. Farish.
California	6,000,000	3,000,000	3.0	R. J. Hinton.*
Colorado	....	2,250,000	3.0	Do.*
Idaho	740,000	400,000	0.7	J. C. Straughn.
Montana	....	†348,000	0.3	R. S. Tarr.
Nevada	....	75,000	0.1	R. J. Hinton.*
New Mexico	1,360,000	638,000	0.8	T. B. Mills.
Oregon	191,000	119,000	0.2	W. G. Steel.
Utah	....	802,000	1.5	F. H. Newell.
Wyoming	1,227,819	†500,000	0.8	E. Mead.
Total	....	8,307,000	....	

*Mr. Hinton's estimates are based on various reports and figures, the details of which are not now accessible.

†Including large areas of hay lands in Wyoming, probably 90 per cent. meadow.

The figures above are not comparable among themselves, as they are derived from many sources and made by various persons, each having different purposes and ideas as to what constitutes irrigation.

NOTE.—Mr. Hinton's figures are those of his report on "Irrigation in the United States" made in 1885-'86 and published in 1887 by order of the United States Senate.

ARIZONA.

The estimates for Arizona are based on the report of Mr. T. E. Farish, Commissioner of Immigration, bearing date May 25, 1889. Following is a summary of his figures:

County.	Reclaimable.	Under ditch.	Cultivated	(Newell) estimated under irrigation.
	Acres.	*Acres.*	*Acres.*	*Acres.*
Mohave	....	....	1,000	1,000
Yavapai	....	....	11,680	10,000
Apache	....	....	9,000	9,000
Graham	....	47,000	....	10,000
Gila	....	....	6,600	5,000
Pinal	....	71,600	12,000	10,000
Maricopa	1,250,000	300,000	132,800	100,000
Yuma	....	30,000	5,000	5,000
Pima	300,000	7,000	5,000	5,000
Cochise	100,000	....	20,000	20,000
Total	1,650,000	455.600	203,080	175,000

COLORADO.—PARTIAL STATEMENT.

District.	Under ditch	Irrigated.	District.	Under ditch	Irrigated.
	Acres.	*Acres.*		*Acres.*	*Acres.*
1, State engineer's report, 1888	150,000	39,720	15	2,771	4,544
2, State engineer's report, 1888	....	46,150	16	32,623	12,713
3	....	108,900	20	396,360	100,610
4	....	69,910	21	57,920	45,183
5	....	86,655	22	46,211	33,855
6	....	50,000	41 and 60, Montrose County	....	*5,000
7	98,558	68,905	40, Delta County	....	*2,000
8	....	3,000	42 and 63, Mesa County	....	10,390
9	6,915	3,740	43, Garfield County	....	1,000
14	13,694	7,264	Total	....	699,539

* Assessor.

The above comprises all the figures, official or otherwise, that are at present in this office. It is evident, on inspection, that these estimates are very incomplete, far below the actual irrigated acreage even in the districts given, while many districts are not mentioned.

IDAHO.

[From the report of the governor, 1889.]

Counties.	Approximate area.	Irrigated and in process as reported.	Irrigable as reported.	The irrigable land now irrigated.	Total area reclaimable.
	Sq. miles.	*Acres.*	*Acres.*	*Per cent.*	*Per cent.*
Ada	2,424	60,000	900,000	6.25	62
Alturas *	2,100	14,500	268,000	5.13	21
Bear Lake	†1,300	21,500	40,000	35.5	74
Bingham ‡	12,364	284,750	2,503,500	10.5	35.5
Boisé	3,024	83,500	262,000	24	18
Cassia	5,100	82,000	655,000	11.1	22.5
Custer	4,350	24,000	446,000	5.1	17
Elmore	2,700	10,000	230,000	4.2	14
Lemhi	4,300	10,000	600,000	1.64	22.2
Logan	5,200	50,000	1,250,000	2.6	39
Oneida	2,600	38,800	148,000	20.8	11.2
Owyhee	7,812	21,300	248,500	8	42
Washington	2,900	40,000	500,000	7.4	29
Total	56,174	§740,350	8,051,000	9.2	24

* Much on Lost River and lava bed. † This area includes the lake. ‡ Much of this is "in process."

§ The land actually under ditch at present can not be much over one-half of this amount—evident from the amount of water known to be used in certain counties. Estimated 400,000 acres now under ditch.

MONTANA.

[From assessor's returns.*]

County.	Cultivated.	County.	Cultivated.
	Acres.		*Acres.*
Deer Lodge	49, 875	Fergus	12, 696
Gallatin	47, 330	Cascade	9, 020
Madison	44, 204	Yellowstone	7, 357
Jefferson	37, 000	Park	6, 759
Meagher	32, 300	Silver Bow	4, 461
Lewis and Clarke	25, 968	Dawson	109
Custer	21, 812	Choteau	14, 378
Beaver Head	20, 971		
Missoula	13, 862	Total	348, 102

*As the statements upon which this table is based were made by an assessor, and were to form the basis of taxation, it is probable that they are considerably under-estimated. I think that it is safe to say that in 1888 there were 500,000 acres of land under cultivation, and the amount is probably not much greater the present year. (Report of R. S. Tarr, June 21, 1889.)

It should be noted that this estimate is based on the assessor's returns of all lands under cultivation.

The largest item of this is 209,000 acres of meadow.

Total acreage of crops (nearly all irrigated)	348,000
Total acreage of meadow	209,000
	139,000

This gives 139,000 acres of small grains and vegetables. This latter figure should be taken in comparison with other States and Territories, since in these latter meadow or grazing lands form but a small item.

NEW MEXICO.

[Estimate of land and ditches by T. B. Mills, June 24, 1889.]

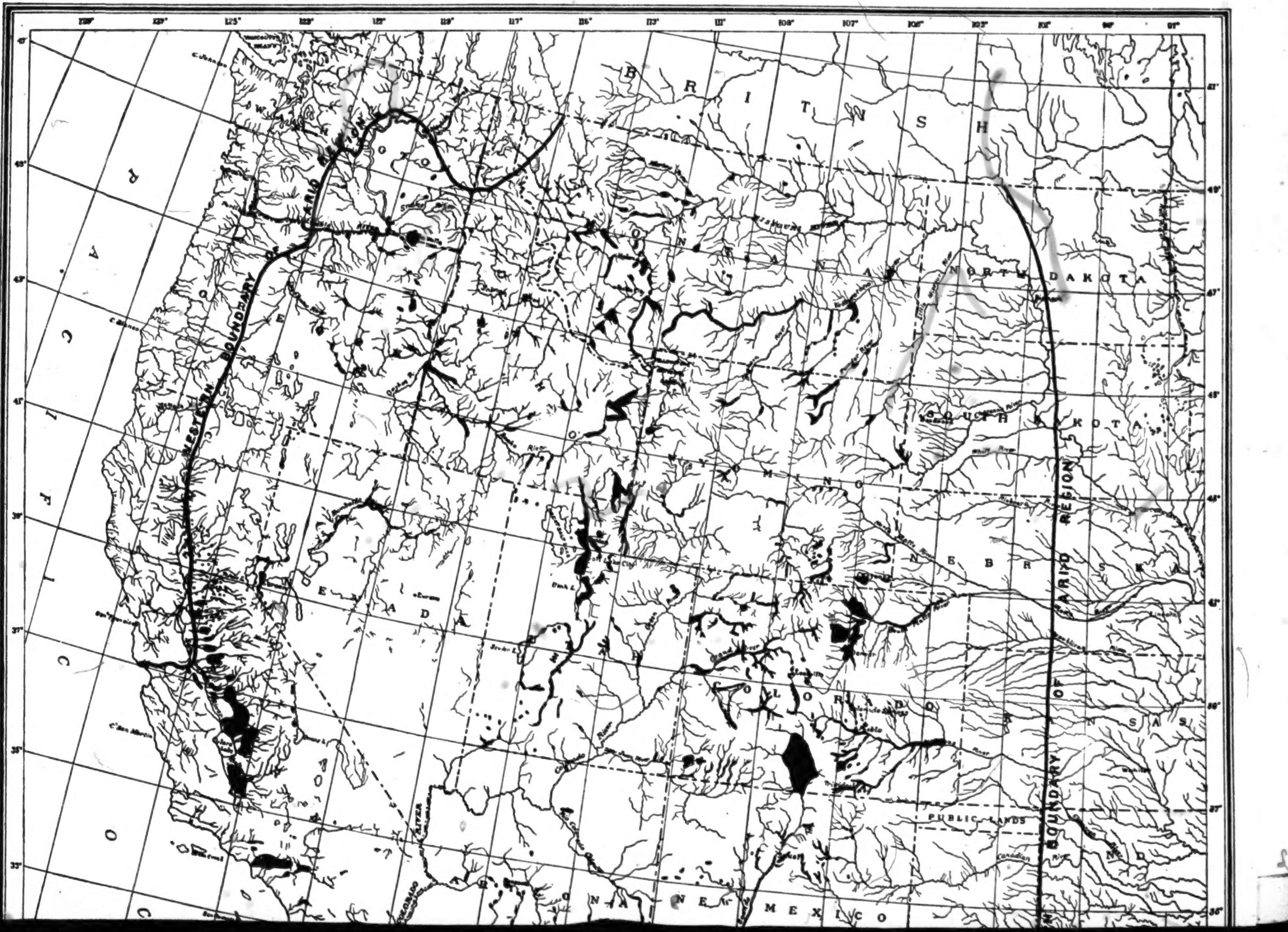
County.	Under ditch.	County.	Under ditch.
	Acres.		*Acres.*
Bernalillo	12, 421	Santa Fé	9, 830
Colfax	13[illegible], 400	Sierra	8, 673
Doña Aña	37, 621	San Juan	20, 000
Grant	8, 721	Socorro	73, 464
Lincoln	100, 000	Taos	88, 763
Mora	51, 279	Valencia	26, 429
Rio Arriba	29, 623		
San Miguel	38, 241	Total	638, 455

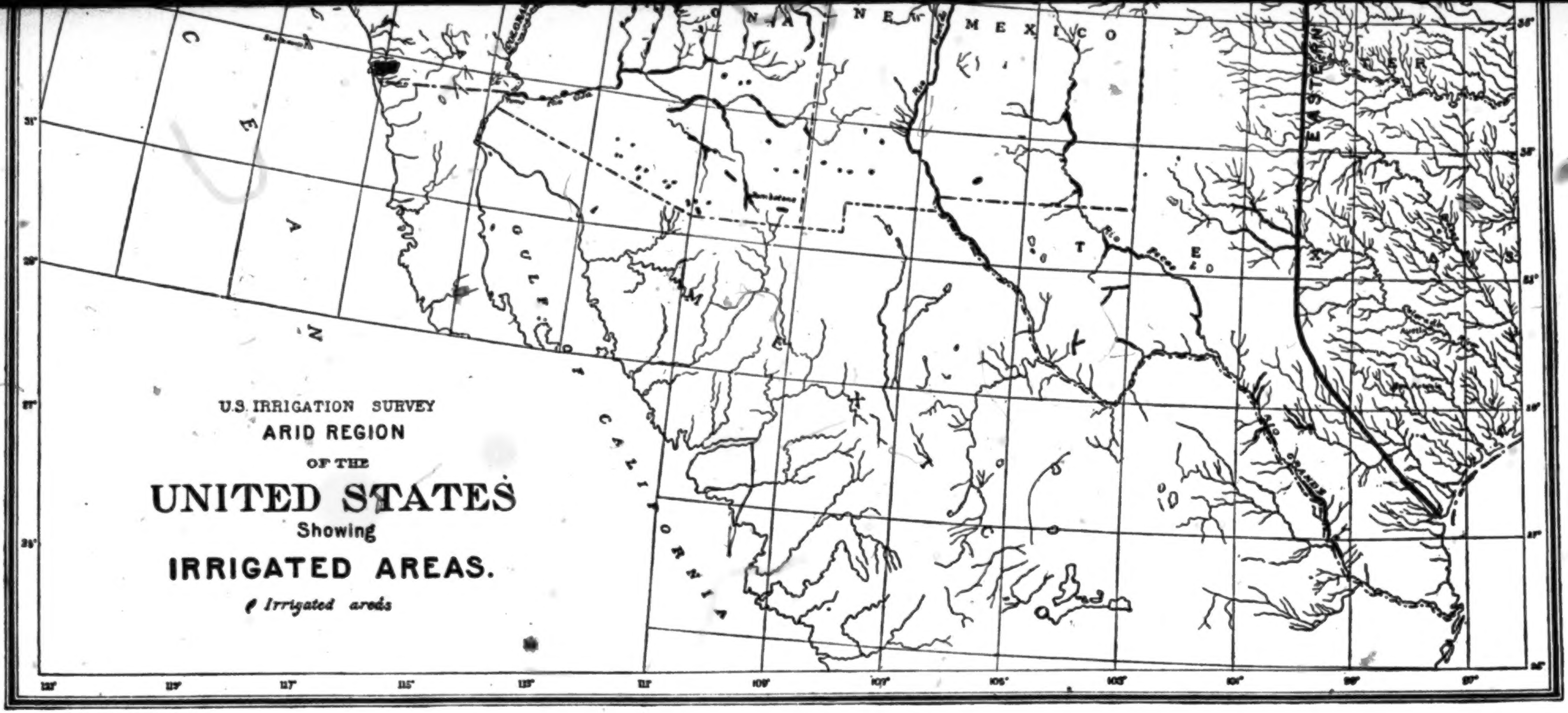
Projected ditches and ditches under construction will serve in addition, 722,000 acres.

OREGON.

[Report of W. G. Steel, June 27, 1889.]

County.	Irrigated.	Irrigable under ditches.	County.	Irrigated.	Irrigable under ditches.
	Acres.	*Acres.*		*Acres.*	*Acres.*
Baker	5, 000	10, 000	Lake	5, 000	5, 000
Crook	8, 000	8, 000	Malheur	40, 000	60, 000
Gilliam	3, 000	5, 000	Morrow	6, 000	18, 500
Grant	10, 000	10, 000	Umatilla	5, 000	7, 000
Harney	20, 000	20, 000	Union	5, 000	8, 000
Klamath	5, 000	30, 000	Wallowa	7, 000	10, 000
			Total	119, 000	191, 500

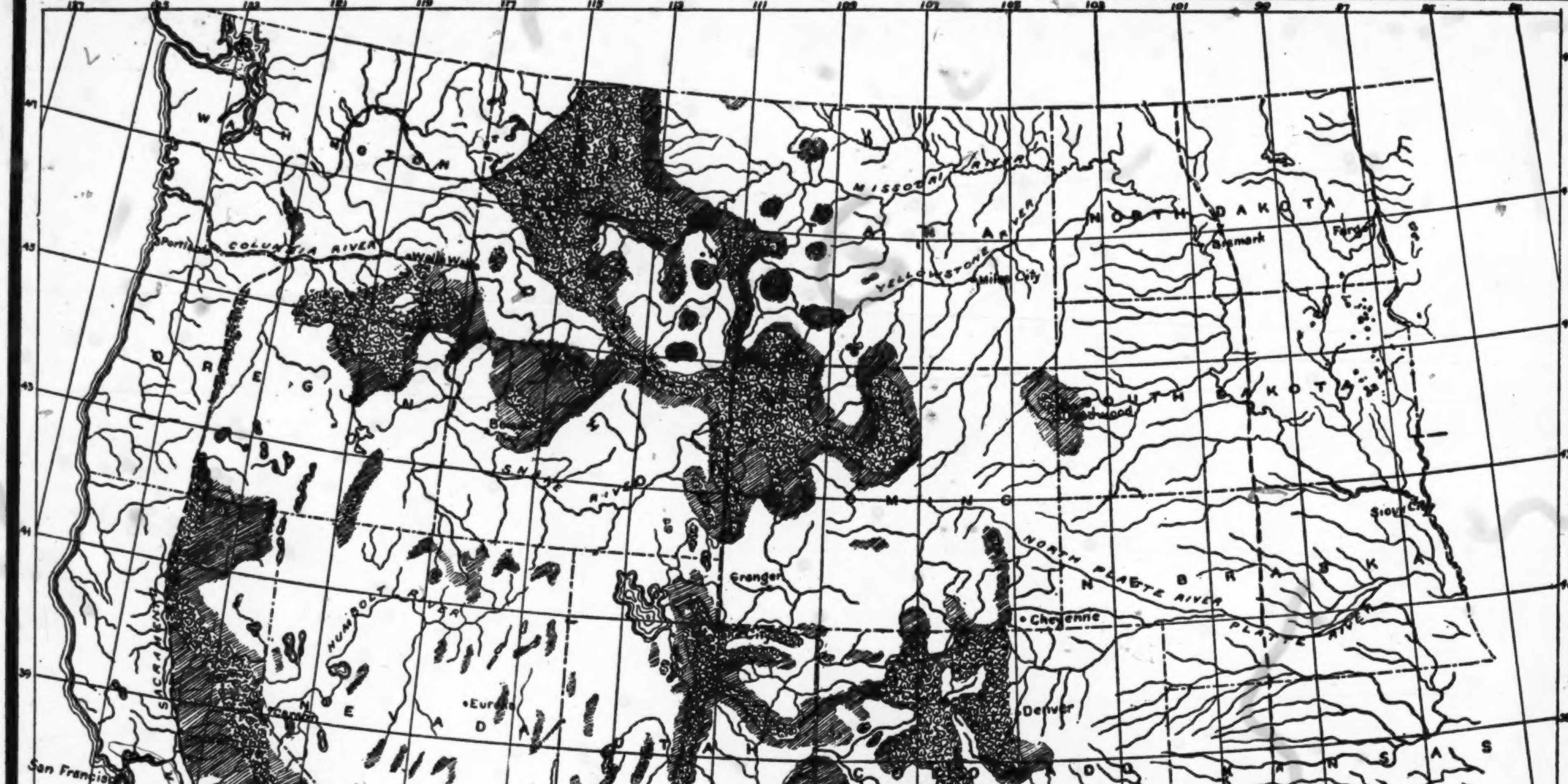

BRITISH
WASHINGTON
OREGON
IDAHO
MONTANA
NORTH DAKOTA
SOUTH DAKOTA
WYOMING
NEBRASKA
KANSAS
COLORADO
UTAH
NEVADA
ARIZONA
NEW MEXICO
PACIFIC OCEAN
WESTERN BOUNDARY
ARID REGION
BOUNDARY OF ARID REGION
PUBLIC LANDS
COLORADO
Canadian River
White River
Salt Lake City
Grand River
123°
125°
121°
119°
117°
115°
113°
111°
109°
107°
105°
103°
101°
99°
97°
49°
47°
45°
43°
41°
39°
37°
35°
33°

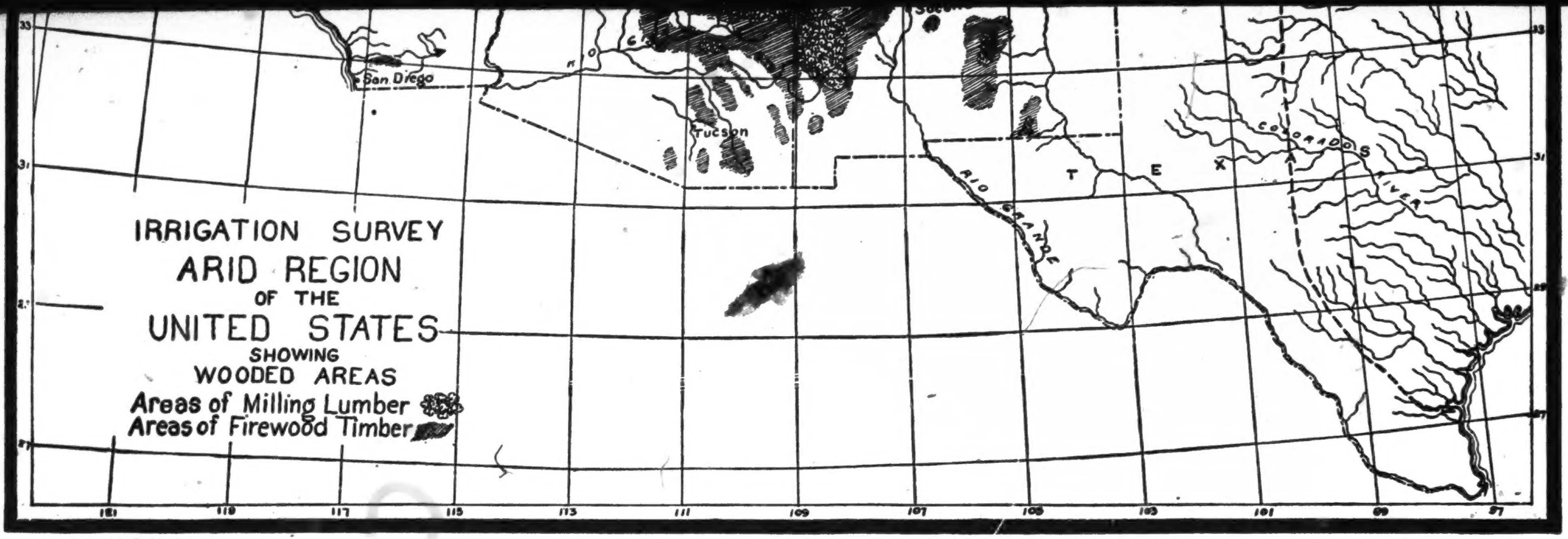


U.S. IRRIGATION SURVEY
ARID REGION
OF THE
UNITED STATES
Showing
IRRIGATED AREAS.

Irrigated areas
NEW MEXICO
TEXAS
MEXICO
GULF OF CALIFORNIA
OCEAN
Rio Grande
Rio Pecos
31°
29°
27°
25°
121°
119°
117°
115°
113°
111°
109°
107°
105°
103°
101°
99°
97°

Report on Irrigation.


COLUMBIA RIVER
Portland
Walla Walla
MISSOURI RIVER
YELLOWSTONE RIVER
Miles City
NORTH DAKOTA
Bismark
Fargo
SOUTH DAKOTA
Deadwood
OREGON
Boise
SNAKE RIVER
NORTH PLATTE RIVER
NEBRASKA
Sioux City
Granger
Cheyenne
PLATTE RIVER
HUMBOLDT RIVER
NEVADA
Eureka
UTAH
Denver
KANSAS
Pueblo
ARKANSAS RIVER
Wichita
San Francisco
SACRAMENTO
Escalante
CANADIAN RIVER
NEW MEXICO
Socorro


IRRIGATION SURVEY
ARID REGION
OF THE
UNITED STATES
SHOWING
WOODED AREAS
Areas of Milling Lumber
Areas of Firewood Timber
San Diego
Tucson
RIO GRANDE
COLORADO RIVER
T E X
33
31
29
27
121
119
117
115
113
111
109
107
105
103
101
99
97

Report on Irrigation.

UTAH.*

County.	Land under irrigation.	1880 actually irrigated.	Dry farming.	Arable land not irrigated.
	Acres.	*Acres.*	*Acres.*	*Acres.*
Beaver	14,670	7,450	4	48,690
Box Elder	88,695	11,740	24,090	159.046
Cache	89,025	53,489	18,653	68,917
Emery	44,140	22,406	....	298,680
Iron	9,107	6,937	100	56,206
Garfield	13,365	7,635	....	33,046
Juab	9,000	5,300	400	33,000
Kane (county survey)	1,625	....	....	1,756
Millard	104,428	11,150	450	488,772
Morgan	8,804	6,687	624	2,822
Pi Ute	29,080	15,285	....	22,264
Rich (county court)	40,811	....	....	44,748
Salt Lake (partial)	44,489	22,082	6,875	89,027
San Juan	770	500	....	750,000
San Pete	*45,506	24,014	1,250	68,606
Sevier	32,874	24,914	....	30,150
Summit	24,115	20,825	800	14,950
Tooele	6,122	4,080	1,340	120,342
Uintah	33,750	18,816	....	12,810
Utah	96,097	60,520	6,910	112,680
Wasatch	21,500	15,200	10	21,000
Washington	7,433	6,235	10	22,250
Weber	37,048	25,270	4.465	26,265
Total (except Davis County)	802,456	371,437	66,191	2,525,403

* Statistics derived from Mormon Church records.

WYOMING.

[From Meade's letter of May 9, 1889.]

Statement.—November 1, 1888, amount of land under ditch, 1,227,819 acres (1,918 square miles). "Probably below the truth."

Actually irrigated (including hay lands), 500,000 acres; (agricultural, 50,000acres).

Duty, 1 section foot to 80 acres.

Director POWELL (continuing). Do the Senators wish to ask any questions in relation to any special districts? I thought I could assemble on a map a large amount of information and save much oral description. I have had this map engraved. The plates on copper are now in the Geological Survey, and, if desired by the committee, the maps which I present can be incorporated in their report, so that the whole matter may be presented in one body. (See map.)

I have also prepared a map entitled "A map showing the wooded area of the arid region," in which I have delineated in two colors all the forest areas of the region, and it is done with some minuteness and care. The dark green represents all the areas the forests of which are valuable for timber for commercial purposes. Those forests are composed of pines, spruces, hemlocks, firs, and sequoias. (See map.)

The area covered by forests in this manner in that region is less than one-tenth of the arid region, that is to say, one-tenth is covered with forests of commercial value. It must be understood that these forests are all at a great elevation. They are all on the mountains or very high plateaus. The forests grow invariably in regions either where agriculture is impossible or where agriculture pays but very poorly. They are in regions where snow accumulates through many months of the winter, and where frosts may be expected in almost any month of the summer. For that reason the regions where merchantable and valuable timber grows, such as I have been speaking of, have not lands that are susceptible of practical agriculture. They will grow some grains, it may be, and some potatoes, some rye, and a few other things, but in the main, agriculture is impossible there, and the crops which can be cultivated are few. The growth would compare with that of Norway and of southern Alaska.

The **CHAIRMAN**. What is the altitude?

Director **POWELL**. It varies. In the north the lower margin is about 5,000 feet, and that margin rises southward to about 7,500 feet, while the upper margin is about 9,000 feet at the north and about 11,000 feet at the south. It is about at that elevation that the timber is found. This timber, in the main, however, is scant. There are some places where the forests are dense. Usually, the pine and fir and sequoia forests are open. The trees are scattered and the forests are interspersed with glades and prairies in such manner that all the timber could grow advantageously on one fourth of the area they now occupy, and still the ground would not be crowded—the trees would be scant.

Not only are those forests interspersed with prairies and with naked glades and "parks," as they are very often called in that country, but the forest area being, in the main, mountainous area, there are many cliffs, crags, and mountain sides of naked rocks which are not covered with timber. So that on the map an amount of forest area appears much larger than it actually is. On this scale it is impossible to exclude these small tracts which are treeless.

In addition to the forests of commercial value, forests composed in the main of piñons or nut-pines, of cedars, and of small oaks are found in California. These trees are valueless for ordinary commercial purposes. That is, they can not be cut into timber; they are too small for that purpose, but they have great value for fire-wood, fencing, and many domestic purposes. These lie much below the pine forests. These piñon and cedar forests are on the low plateaus and on the rocky hills. In addition to those along some of the streams, as on the Upper Missouri, the Yellowstone, and other streams, down on the bottoms are found forests of cottonwood. Of these all that are worth mentioning are delineated on the map.

The area covered with forests of this class, where the trees are valuable only for fire-wood and other domestic purposes, is slightly greater than the other. A little over one-tenth of the area is covered with forests of this character. Some of the lands covered with this description of forest are valuable for agricultural purposes, but not all. Some are high, others are on rocky hills, and in situations where they can not be used for agriculture.

I wish to incorporate the following table showing by States and Territories the area and character of these forests.

Approximate area in square miles of timbered lands in the arid region.

State.	Fire-wood.	Merchantable timber.
	Sq. miles.	*Sq. miles.*
Washington	1,050	1,080
Idaho	8,600	9,800
Montana	6,500	21,000
Oregon	3,500	8,700
Wyoming	7,300	15,700
South Dakota	2,400	400
North Dakota (river bottoms)	200	....
California	20,300	11,000
Nevada	5,400	700
Arizona	26,510	11,700
New Mexico	21,540	14,490
Colorado	15,000	23,500
Utah	14,000	7,700
Total	132,300	125,970 132,300
		258,270
Total area of arid region, square miles		1,335,126

Senator **REAGAN**. Did you extend your information down to the Texas territory?

Director **POWELL**. I have not hitherto done so. I have only a small portion of the information, such as I gathered this summer, but I have been for twenty years gathering these data in the other regions.

I wish now to say a word or two with regard to the preservation of forests.

The forests are destroyed frequently by fire. The amount of timber used by man is comparatively inconsiderable. I witnessed one fire twenty years ago in Colorado which destroyed more timber than the people of Colorado have used since the settlement of that country, and I have myself witnessed five or six fires in Colorado of equal magnitude. I have witnessed elsewhere in the mountains very great fires. They are well known. As some of you will remember, during the journey of the committee this past season we passed through the mountainous region of Montana, eastern Washington, eastern Oregon, Idaho, and down into Utah before a mountain was seen, because the whole country was enveloped in smoke as in a dense fog.

These fires are exceedingly destructive. I have with me a map of Utah which will show how destructive they are. This map was made twelve or fifteen years ago and shows simply the areas which were destroyed by fire at that time. I will present it to you for a moment so that you may see how it looks. (See map.)

The blue represents the standing timber at that time—twelve years ago. The brown represents the burned timber at that time. I have no doubt that if a map were made to-day of that same region it would show that much of that blue area has been destroyed in twelve years. The green exhibits the irrigable areas as determined at that time. The forests are chiefly coniferous and needle-bearing, and are charged highly with resin, and so exceedingly inflammable; and for this reason fires are greatly destructive. Then, since the white man has come into the country, the forests have not been annually burned. In old times, when the Indians occupied that country, they systematically burned the forests every fall. By so doing they unconsciously, though not for that purpose perhaps, prevented the total destruction of those forests.

If a forest of coniferous trees is protected from fire for a series of years until the ground is covered with an accumulation of cones, needles, twigs, and brush, then the fires have something on which they may feed. If then, by accident or design, a fire is kindled in such a forest it sweeps through and destroys it. So the forests are being destroyed not for want of protection, but because they are protected from fires. The only proper preservation of those forests consists in a systematic annual burning. If this burning is accomplished at a season of the year when the ground is not too dry the whole accumulation on the surface of the ground may be burned up and destroyed and the trees remain.

Senator **JONES**. Do you think it would now be practicable (with the accumulation of underbrush that years have produced) to burn any of those forests without destroying the timber?

Director **POWELL**. Yes; if burned in seasons of dampness, when the forests are not too dry. Fires are destructive in seasons of great dryness or aridity.

Senator **JONES**. Then, in the districts where the forests have been destroyed by fire, the annual burnings would have to be dispensed with until the young trees got sufficiently large to be safe from destruction by fire?

Director POWELL. If the burning were done at a dry time the smaller trees would be burned; but if the fires were set at a comparatively wet and moist time, and systematically, and if small areas were burned, and burned out, and started again when not too dry, they could be burned without destroying the small trees. In this matter I have had some experience, for I was a farmer's boy in a prairie region and have taken part in such matters. I have burned forests for their protection many times in my life.

The arid region, as I have shown, has already been developed to a great extent for agricultural purposes. In that region there are mines of gold, silver, lead, iron, coal, and so forth, so that a great deal of the country is being settled and in some places it is comparatively densely settled, so that population is now distributed in every valley of importance throughout the region.

In the progress of irrigation and development of that country by which 10,000,000 acres of land have been put under canals, and provision made for the irrigation of that quantity, a large experience has accrued, so that the problems involved—scientific, industrial, and political—have been pretty well developed.

I now show you a map of the arid region exhibiting the areas underlaid by coal, so far as the coal of that country has been determined.

You will observe that in the northeast there is a very great area, in the Dakotas and Montana, but that these areas decrease elsewhere in size, and that in Nevada and the western part of the arid region the coal areas, so far as they are known, are small. You will see them scattered about in various places on the map. (See map.)

This coal is all of a comparatively late age; that is, it is of a late age as compared with the coal of the eastern part of the United States. The coal of the East is of the Carboniferous age. The coal of the West is of the Cretaceous and Tertiary ages, but it varies in character very much. It varies from a brown, soft, friable lignite, found in many places, to the most valuable, dense, hard, anthracite.

Senator CASEY. Where are the anthracite fields?

Director POWELL. In Colorado, Arizona, and New Mexico, so far as I yet know. They may be elsewhere, but we do not know of them elsewhere at present.

All these coals are valuable for domestic purposes. They are all valuable for the creation of power by steam. A large part of them are valuable for metallurgical purposes. In this connection it must be understood that all coals, wherever found, present in each case a distinct problem for their utilization. When a new coal-field is discovered it is never known to what extent it may be used for metallurgical processes until experiments are made and a new method of coking is devised. A new method has to be invented for every new coal-field. A slight variation in the constant part, such as the bituminous or other quality, compels a change in the processes, and when a new region is discovered it is not known whether it is valuable for metallurgical purposes or not. This knowledge has been gathered now in the arid region. Ten years ago it was supposed there was only one field of coking coal in the West. One after another, however, the fields have been brought in as new methods were invented. I have no doubt that ultimately, as new methods are discovered by chemists and others, the fields of coal will one after another be brought in. In addition to that the fields of anthracite coal are being multiplied by discovery from year to year.

Senator CASEY. The gray lignites may be coked to advantage, may they not?

Director **Powell**. Many of them may be. We have not discovered that all can be; but probably experience will prove that processes will be discovered for the coking of all gray lignites. It is doubtful about the brown lignites, however.

These coal-fields are very rich. They usually have from two to twenty and in some places even fifty beds of coal in one field. These vary in thickness from a few inches to 20, 30, 40, 50, and even 100 feet in some places. So that the coals are, for all practical purposes for our present civilization, inexhaustible.

These areas are such as, it is found by geological examination, are coal-bearing; but they do not always have the coal lying near the surface. In Dakota and Montana part of this coal-field is near the surface and part of it is deeper down at a depth of 2,000, 3,000, 4,000, or 5,000 feet, so that under present conditions not all of that coal area is available. The expense of getting at the deep coal is too great under present conditions in this country. But, notwithstanding all this, there is enough coal shown to exist near the surface in the hills, foot-hills, and mountains to give an ample supply for this country for many centuries.

The **Chairman**. They have some coal supply in the new State of Washington, west of the arid region, have they not?

Director **Powell**. Yes, but you will notice that in these maps I have nothing to do with the humid region at all. There is a very valuable lot of coal in this space that I now indicate [indicating]. The red spots over the blue indicate the more important places where coal is mined; I could not get them all on this map.

Senator **Reagan**. There are coal-fields in the Indian Territory and in northern Texas which are not shown on that map; but that is explained, I presume, by the fact that that region is outside of the line.

Director **Powell**. Yes.

Senator **Moody**. Have you had your attention called to the recent developments of those coal-fields lying west of what is known as the Black Hills?

Director **Powell**. Yes; we are annually collecting the statistics of the coal mines. We have a corps of men engaged on that work.

Senator **Moody**. Are you acquainted with the bed of coal that the Burlington and Missouri River Railroad people have been developing recently?

Director **Powell**. Not from personal observation. I know it only by description.

Senator **Moody**. Have any of your force examined it?

Director **Powell**. Yes; they have analyzed it.

Senator **Moody**. Is that what you call an upper bed, or is it a lower bed?

Director **Powell**. The terms "upper bed" and "lower bed," as used by miners, have no special significance. The coal is Lower Cretaceous coal, but beds are tilted and brought up to the surface in various ways. In one district beds which are geologically low will lie high in the mountains, and beds a few miles away which are geologically high will appear in valleys, because the dipping of the rocks has so placed it.

Senator **Moody**. You are aware, I suppose, that there is a very great difference between those strata of coal?

Director **Powell**. Very great; but the difference does not in the least depend upon the geological horizon of the coal. The coals at Rock Springs, in Wyoming, belong high in the Cretaceous age and are very fine coals. The coals of the Sulphur Creek, 25 or 30 miles away, belong 5,000 feet lower in the geological series, and are not quite so good. In other districts it will be *vice versa*, varying in character, and that variation is owing to the manner in which the coal beds are accumulated in basins.

Senator REAGAN. What are the brown spots indicated on the map?

Director POWELL. Those brown spots indicate the regions where coal is mined in large quantities for commercial purposes. I could not put all of them on the map. They are multifarious, but I put the most important mines in by dots on the map. (See map.)

Senator CASEY. Are there not extensive mining operations in Montana farther north than your map indicates?

Director POWELL. Perhaps there are, but the facts come to my office only once a year.

The CHAIRMAN. These coal areas may be found, on further development, to be larger than are indicated on the map?

Director POWELL. Yes. These that I show are the coal areas as they are known.

The map which I now place before you represents the drainage basins of the arid regions, and indicates to the committee the more important problems which have arisen in each one of these drainage basins represented on the map. For this purpose I will commence with the Arkansas basin, that is, I will set forth some of the more important problems that have arisen in the utilization of the Arkansas and its tributaries. (See map.)

This [indicating] is the basin as outlined on the map. The Arkansas River heads in the great mountains of central Colorado, in regions of perpetual snow, and flows down through the mountains until it debouches into the plains and runs through a great valley across the State of Colorado into Kansas and across a corner of Kansas down into the State of Arkansas.

The mountain region above is cold and inhospitable by reason of its great altitude. Great bodies of snow accumulate there during the winter and frosts may occur during any month of the summer. When it leaves the mountains and strikes the plains a warmer and more beautiful region is reached. In this upper region there are many beautiful valleys, valuable especially for pasturing purposes, and the mountains and hills on either side are covered with valuable forests. But when it reaches the plains it has a broad open valley for its course, and it is below where the waters are chiefly used for irrigation.

During the season of irrigation and in years of scarcity of water and small accumulation of snow, the entire volume of the Arkansas is now utilized. Any increase of irrigation on the Arkansas River hereafter must arise from the storage of the waters which now run to waste from nine to ten months of the year. The great body of the irrigable lands under canal ——

The CHAIRMAN. Let me interpose at this point just one question. Does not a large portion of the water run under ground in the sand?

Director POWELL. Yes. I will come to that point in a moment, if the Senator please.

Senator PLUMB. Speaking of the storage of water there, what is the actual average evaporation in that area each year?

Director POWELL. From standing bodies of water it will vary from 56 to 82 inches per annum, depending upon exposure to winds and upon altitude.

Senator PLUMB. What is the difference between the altitudes in that matter? Is there a greater evaporation in the lower altitudes?

Director POWELL. The higher the altitude the less the evaporation;

the greater the exposure to wind the greater the evaporation, and so on.

The Arkansas has irrigable lands, then, in the mountain region, but they are valuable chiefly for grasses. Below, on the Arkansas and on its tributaries—and what I say in relation to the Arkansas itself is practically true of most of its tributaries—the lands are situated somewhat lower than the land now irrigated in the State of Colorado from this river and its tributaries.

There is a very important and interesting condition which must be explained at this point, for it is a governing condition in the utilization of the waters of most of the rivers of the West. I wish to set it forth somewhat in full that it may be clearly understood. The waters of the West usually head in the mountains. The mountain streams are clear and deep, and in the main run in cañons. When the streams leave the mountains, and reach the plains or valleys below, their character is suddenly changed. The dry plains on either side are covered with dust, and the winds and storm waters blow and wash this dust into the stream. Thereupon, the river or creek immediately changes its character. While above, it was clear and deep and swift, below it becomes broad, shallow, and muddy. You are all familiar with the Platte River and know what the waters of that river are. It is a thin sheet of tawny mud, rolling down to the Missouri. Sometimes it is only 10 to 20 inches in depth, varying in places as you cross it. Nearly all the rivers of that country thus change their character when they leave the mountains, but there are important exceptions.

The point where this transformation occurs in the character of the streams is a critical and important point in the utilization of these waters. If the waters are taken out above this point they are used on land of less value by reason of climatic conditions, as already explained. If they are taken out below this point they are charged with silt and mud, and under these conditions they rapidly silt the ground and injure the lands on which they are placed, and they are especially bad in destroying the irrigation works. Water can not be taken out below this point because in some places the reservoirs will be filled up and the canals choked, and in other places they will be eroded and cut so that they are practically destroyed by the presence of the silt.

Senator CASEY. That is a matter of practical experience?

Director POWELL. Yes. So that it is always highly advantageous to take the water out of the stream at this critical point.

But, more than that; when the waters come down to this point they spread in valleys, like the Arkansas, 1, 2, 3, 4, 5, or 10 miles in width. A low sandy valley is found with a wide channel running through it; a low sandy "bench" on either side. Out into the sands on either side the water runs for miles and is rapidly evaporated, so that in a dry season no waters are used in irrigation. A large stream may come from the mountains of Colorado which may be lost before it reaches the Colorado-Kansas line, and no water whatever pass beyond that line.

In general there is a vast waste of the water in these sands. Only a part, however, of this water in the sands is evaporated; the other part remains in the sands. These sands can be tapped by wells and other methods and the water brought out on the surface, so that it is not all lost in this manner, although the larger part is lost by evaporation.

In the valley of the Arkansas irrigation commenced in the State of Colorado. The people of that region are anxious to increase the area of irrigation, and settlers are going into the upper creeks and into the mountains and upper valleys, and are taking out the water in those upper valleys, to be used in the irrigation, in part, of hay-fields, and are raising some few other crops that may be grown in that cold climate.

Senator CASEY. Some wheat included?

Director POWELL. Not much wheat; the climate is almost too cold for that. There are some valleys where wheat may be grown, but not very many. The use of water in these upper regions is a great waste of the water, because of the climatic conditions, as I have explained. But a man may go on a stream above, and another farther up, and cut off the water from where it is used in the region below. It is a difficult matter, under the present laws of Colorado, to correct that condition of affairs, because it is difficult for the farmer in one county to enjoin by law the farmer above him in another county from using the water. How is he to say to the court that the water which the man above has taken is part of the water which he, below, should get for the use of his farm? Both are using the water that flows in the same stream. To identify the water used on a farm below is a very difficult matter. So that, at present, the tendency is to settle the mountain valleys, and thus to drive the agriculture of Colorado into the mountains, and away from the sunny valleys below. That tendency has only begun in Colorado; but elsewhere the evil is of great magnitude, and is accounted a matter of exceedingly great importance, and will, within the next five or ten years, become a matter of still greater importance to Colorado. The result is the driving of the people into the snowy mountains to live, instead of permitting them to live in the sunny plains below.

These problems that I have mentioned are inter-county, inter-community, and inter-farm problems. A new set of problems arises from the fact that the Arkansas passes the Colorado line into Kansas, and in Kansas the people have to resort to some extent to irrigation. In the past year they have developed some irrigation in that region. The water which they use flows from mountains far away; and the people of Kansas desire that the water shall be allowed to flow in its natural channel until it reaches their State, while the people of Colorado insist that they themselves have a right to the water in their State. This brings up an inter-state problem which has come to be a serious one.

Works have been constructed in Colorado, near the line of Kansas, and across the line in the State of Kansas, to irrigate lands to the amount of over 100,000 acres, and works are projected to be constructed this season, and are in part now constructed, to irrigate four or five times that amount. Should there be one, two, or three wet seasons on the upper Arkansas, and the present season is one of great snow-fall up to the present time, the river will supply water to those lands, but only on condition that it is not used above in Colorado. In this State, however, they are constructing works on a very much larger scale, and if these works are finished the waters of even a season of great precipitation will be used in Colorado, and no supply will be afforded to Kansas, except such waters as are taken from the sands of the valley.

Passing from the Arkansas to the Pecos we find problems of the same character. The Pecos rises in New Mexico and flows through a portion of Texas until it reaches the Rio Grande. This is the drainage basin of the Pecos, as shown on the map. The waters of the Pecos are now, and have for years been, used in New Mexico, in part, and to some extent in Texas. Within the last eighteen months or two years the development of irrigation on the Pecos, in New Mexico, has very greatly increased. There has been some increase of irrigation development in Texas, as the maps I have presented will show. There are companies at work this winter, with sufficient capital, engaged in the construction of canals in

New Mexico, and of dams, and to some extent of reservoirs, which, when completed, will take the waters of the Pecos, in New Mexico, and cut off the entire supply from Texas, and as the matter now stands all irrigation, ancient and modern, on the Pecos, will be swept out of existence in two years, unless some supply is provided other than that of the Pecos during the season of irrigation. It is, therefore, an inter-state problem. (See map.)

I will proceed to explain some of the problems which have arisen on the Rio Grande. For two or three centuries the Spanish people who settled on the Rio Grande have been irrigating the soil of that valley, and there are many Spanish or Mexican settlements scattered along its course. The Rio Grande heads in Colorado. It passes into New Mexico and runs southward across that State until ultimately it becomes the boundary line between Texas and the Republic of Mexico. It is in New Mexico, in Texas, and in old Mexico that this ancient irrigation is found. In modern times, or within the last five years, the waters of the Rio Grande have been taken out, and are now being taken out, in Colorado.

I am informed by the engineer of that region, who has just come here, and who has general charge of those works, that it is proposed, before the end of another season, to have canals and works ready for the irrigation of 1,500,000 acres, and that already works are prepared for the irrigation of more than 1,000,000 acres. The irrigation of that region and the waters of that region, in the main, are under the control of an insurance company, which goes into that region, takes out the water, establishes rights to the waters of the country, and sells those rights to the people and in part buys up the land, so that the company owns not only the water and distributes it to the people, but it in part owns also the land.

Passing into New Mexico, then, the water that practically heads in the high mountains of Colorado is largely, almost wholly, cut off from the Rio Grande, so that no portion of the water that heads in these mountains where there is a great precipitation will cross the line into New Mexico. Already the effect of that is seen in Mexico along the lower Rio Grande. During the past season the Rio Grande was dry for many miles below El Paso, which is situated near the line of New Mexico, Texas, and the Republic of Mexico. The Rio Grande was dry there, and dry for 360 miles above that point; so that the people of the lower valley of the Rio Grande in New Mexico, and the people of Texas below, and the people of the Republic of Mexico, had no water. The sand was blowing across the channel of the river, and instead of the space being covered by waves of water it was, when I saw it last, filled with sand dunes.

Senator PLUMB. Was not that due more to the absence of snow in the upper mountains at the head of the stream than to the taking out of the water from the upper stream?

Director POWELL. It is a complex problem. It is due in part to that.

Senator PLUMB. Has there not been a lack of snow during the last year, compared with former years?

Director POWELL. There has not been as much snow as usual.

Senator JONES. Is the Gila a tributary of the Colorado?

Director POWELL. It is a tributary of the Colorado.

The taking out of the water in Colorado subtracts from the river the volume of water which might come from those mountains. In a wet season there is water enough for all, as irrigation is developed to-day, alike in Colorado, New Mexico, Texas, and the Republic of Mexico. But in a dry season the supply is entirely insufficient for all the lands now under canals. If in such seasons the water is used in Colorado and in upper New Mexico it is entirely cut off from lower New Mexico and from the valley of the Rio Grande immediately below El Paso. In a dry season nothing can be raised in the lower region, and sometimes dry seasons come two or three together. One dry season when lands are dependent upon irrigation is disastrous, because fruit trees, vineyards, and all perennial plants are killed. One or two such destructive seasons drives all the people away from the country.

Senator PLUMB. Is any part of that water returned to the river by seepage?

Director POWELL. Yes.

Senator PLUMB. What proportion do you know?

Director POWELL. About 50 per cent.

Senator PLUMB. About 50 per cent. taken from the canal would be returned to the river in the seepage?

Director POWELL. Yes, in careless irrigation. In careful irrigation, like that practiced in southern California, a much smaller amount is returned. With the best irrigation, none is returned.

Senator REAGAN. I put questions to some witnesses with regard to that return of water. It was stated that no provision of law had been made to compel persons taking the water for irrigation to return it to the river.

Senator PLUMB. The question I asked Major Powell was on a somewhat different line. I referred to the return of water by seepage, what would be returned to the river by soaking through the ground into the subterranean channels and be then returned to the river.

The CHAIRMAN. That water does not return or reach the river for the first year or two.

Director POWELL. Being asked by a committee of the Senate to investigate that subject I have for the last eighteen months been investigating it, and I have some facts to set before you in their order when I come to them.

Irrigation has also been greatly developed in New Mexico. The tributaries of the Rio Grande are being taken out in many places. Many streams are being taken out and the water spread upon the land. The Rio Grande is a clear stream until it passes Embudo Cañon, in northern New Mexico. From the mouth of the Chama downward it is a river of mud like the Platte, the Chama being also a river of mud.

Senator CASEY. Will you indicate on the map just about where that occurs?

Director POWELL. There [indicating on the map] is Embudo Cañon. It is a clear stream above that point; it is a river of mud below that. It is suddenly transformed, like the Platte, the Arkansas, and many other streams in the West. (See map).

Senator CASEY. That is after it has left the mountains?

Director POWELL. Below where it leaves the Embudo Cañon and receives the Chama. The water of the upper valley is being used to such an extent that the water of the lower valleys is being taken away from those who have been using it.

As long as no water is being stored in lakes, natural or artificial, or in reservoirs, irrigation in any district depends upon the flow of water through the season of irrigation. That season varies in different portions of the United States from a little less than two months to a little more than three months. Perhaps on the Lower Colorado it will be five months, but in general it varies from two to three months. The irrigation practiced in this manner has a practical limit placed upon it by the dry season. For if in seasons of greater humidity larger areas are brought under ditches, when seasons of greater dryness or aridity come the farmers depending on such waters are destroyed. The trees and vines that are growing become dried up and the seeds go to waste and the canals are filled with sand by the winds. The limit of agriculture is set by the dry season. Hence it may happen, and will happen on the Rio Grande and elsewhere, that in seasons of great humidity there will be sufficient water flowing during the season of irrigation to supply the wants of all the people now engaged in irrigation there and of the people who will want water under the works projected during the past year. But during the season of drought the amount of water is insufficient to serve the land already provided with canals.

A part of the waters that are spread upon the land are returned to the rivers, as shown by the investigations that your committee have been making this year. We have in Colorado and elsewhere studied certain streams that were all taken out and spread upon the land. We have measured the waters thus spread upon the land while being spread. We have then gone below, where these waters have been recovered—where the waters flowing from the irrigated land have been used again—and we have measured the waters thus used again, and have found that the conditions for the recovery of the water vary greatly; that they vary greatly for very important reasons; that in extreme cases 70 per cent. of the water returns to channels immediately below the place where it is used, and 30 per cent. only is evaporated. But that is under conditions where an excessive amount is put on the lands by the farmers.

Growing plants evaporate three hundred times their own weight of growth annually. Whatever the crop may be, whether corn, grass, or wheat, that grows in one year, it will evaporate into the heavens three hundred times its own weight of water. If, then, a crop is raised on a field which is irrigated, and a farmer is careless to such an extent that the field is covered not only with the corn or other crop he desires to raise, but also with a dense growth of weeds, the evaporation from that surface will be enormous. But if his field of corn is well cultivated, and if speedily after each irrigation he turns, with a harrow or raking tool, the ground between the rows, so as to have the ground mulched with a thin surface of soil, the evaporation is at a minimum. The great duty of water which they have secured in Southern California is secured by perfect cultivation, but when the cultivation is bad it requires two or three times the amount of water that is required when the cultivation is good.

There are some other conditions affecting the return of the water besides the two mentioned. Something in the nature of the soil and something in the condition of the slopes determine how much of this water can be recovered, but under the most favorable conditions we find that about 70 per cent. can be recovered to be used again. Under some conditions, however, only 30 per cent. can be recovered. That depends in part on the condition of the slope, in part on the subsoil itself, and in part on the condition of the soil, as well as on the conditions of the channels below in which it may be gathered. Under the best conditions and with thorough cultivation nothing is returned.

The CHAIRMAN. Is there not another condition—the condition of time when getting the ground saturated in the first instance?

Director POWELL. Yes.

The **Chairman**. We had an illustration of that at Fresno and other places.

Director **Powell**. Yes; and it is universal. It will be noticed all over the country, where it is properly studied. A very large amount of water is necessary to saturate the soil the first year. The maximum duty of water is not reached until two, three, four, or five years of cultivation have been had. So that the claims which the people set up to the amount of land which can ultimately be redeemed by the irrigating works already constructed are well maintained by the fact, because although to-day the water may be used to the utmost extent, next year larger areas can be irrigated, and the year after still larger areas, and this for a term of years will increase until after a few years the whole duty of water can be secured. When the whole duty of water is secured, the land well cultivated and economically irrigated, but little will return to the streams.

In the valley of the Rio Grande the greater portion of the water during the season of irrigation is lost in the sands, as in the valley of the Arkansas. If the water of the Rio Grande is compelled to flow across the line from Colorado into New Mexico, it will destroy from 1,000,000 to 1,500,000 acres of agriculture above, in order to save 200,000 or 300,000 acres in the valley below. The water can not be used below for the benefit of the greatest number of people. It is important that irrigation in Colorado which is already established and in progress of establishment should proceed.

But what remedy have the people below to save their property from destruction? The lateral streams which come in are being taken out above in the same manner. Some provision ought to be made by which the waters of these lateral streams, and the waters which flow into the Rio Grande below the Colorado line, should be made first to serve the irrigation already established. As the matter now goes on the new irrigation is destroying the old. When we come down to El Paso we find mountains in that neighborhood the waters of which are competent to serve all the lands on the Texas side and on the Mexican side if they can be utilized—if they can be stored. The waters which can be stored in that region are ample for that purpose, but all the storm waters of the immediate region must be stored.

The **Chairman**. You would add to that the flood waters that come down every winter?

Director **Powell**. I am supposing that there will be no flood waters in dry seasons when the water is properly used above. The people will become better skilled in using the water and there will not be so much waste of the flood waters.

The **Chairman**. Do you think it would be a possibility to use all the flood waters?

Director **Powell**, I think ultimately it would be possible to use all the flood waters. I think the waters which flow from the mountains of New Mexico are ample to supply the irrigation already established and much more.

Senator **Plumb**. What is the valley area of the Rio Grande above this cañon which was spoken of a while ago?

Director **Powell**. The Embudo Cañon?

Senator **Plumb**. Yes; give us a rough calculation as to that.

Director **Powell**. Roughly speaking it would be 5,000,000 acres above Embudo Cañon, good and bad. It is estimated by an engineer of skill and ability that about 1,500,000 acres can be redeemed by irrigation there.

Senator CASEY. The conditions are such as you spoke of a while ago—the land not being adaptable, you think, to cereals.

Director POWELL. Oats and wheat can be raised there but not corn. It happens to be just in the border region between the upper and the lower climates.

Senator PLUMB. Then your opinion is that all the waters that originate either by creeks or otherwise and all the storm waters of that area will be used within the area when this maximum of irrigation is reached.

Director POWELL. That is my judgment.

Senator PLUMB. And then that there will be no water to be utilized in the lower Rio Grande.

Director POWELL. None from this source.

Senator CASEY. Especially if they raise wheat.

Senator PLUMB. They can raise fine potatoes in that country too.

Senator CASEY. There is not the same salability for potatoes.

Director POWELL. Serious troubles are arising in the Rio Grande Valley now and the valley is all aflame. The people are petitioning the Secretary of the Interior and the Secretary of War for troops to protect the old rights from invasion by those who are developing new systems in that country. The difficulty is that at present there is no way by which any court or authoritative officer can say whether a canal shall or shall not be constructed. There is at present no determination of specific waters to specific lands and the area which it is possible to irrigate is six or twelve times as great as the waters will ever serve. What is needed is something by which somebody may be able to say that the waters shall be used on particular lands, so that the valley shall not be left open for anybody to construct a ditch above that of his neighbor and take away from him the water that he has been using. That is the same problem that has arisen on the Pecos.

The CHAIRMAN. What would be your suggestion as to saving the lower waters for the benefit of those people in the Republic of Mexico and in Texas?

Director POWELL. I think a reservoir can be constructed at El Paso. I have had a reservoir planned, and have had the surveys begun in that region, so as to discover the areas that would drain into it, the amount of water in the catchment area, and the amount that would accumulate in the immediate region if it were all cut off above. I find already that there is a large flow into the river in the immediate neighborhood sufficient to fill a great reservoir there which, I believe, would support all the irrigation which has been already developed along the lower river. The catchment area is not fully surveyed; its extent and the character of its slopes are not fully determined; and I can not yet say how much water can be caught.

The CHAIRMAN. Would it be enough for an addition of some new land on the Texas side?

Director POWELL. I believe it would.

The CHAIRMAN. You have stated that it was difficult to have reservoirs on the lower levels. How would you free that reservoir from silt? Would that be practicable? Have you considered that question?

Director POWELL. Yes, I have considered that question with great care. That seemed to be a serious problem. If the reservior is to depend on the bed of the river it is one problem; if on the mountains adjacent it is another problem. If it is to take all the silt of the river, and the waters are not cut off by irrigation above, it will fill in about one hundred years if the flow of the river should be continued for the future as it has been in the past. We have measured the silt of the river from day to day for some months so as to determine that question. There is another source of débris in the hills and mountains that stand about the reservoir sites, the amount of which is yet undetermined, and can not be until the topographic survey is completed.

The CHAIRMAN. Has any method been discovered or devised whereby to free the reservoirs from silt?

Director POWELL. Yes; but nothing that is not somewhat problematical as yet. If filled by the brooks and creeks that flow from the adjacent mountains it can be constructed with dikes or wings on either side so that every stream can be checked on the bench above before it is turned into the reservoir and its flow turned around a long course, and it may be thus forced to deposit its silt on the benches above so that the water can come into the reservoir itself comparatively pure. The reservoir under those conditions would be comparatively permanent. It would last two or three hundred years if the silt above were cut off.

The CHAIRMAN. What would be the probable cost of that?

Director POWELL. I have not the figures before me at the moment and I dare not speak from memory. I have the figures at my office. The construction of the reservoir might be the minor cost. The right of way might be the major cost, because two railroads run across the site.

Senator REAGAN. Regarding the exhaustion of the waters of the Rio Grande, the people tell me that during the flood season the Rio Grande is very great in size.

Director POWELL. It is.

Senator REAGAN. And that it carries a great volume of water. Is it likely that that water could be so stored that it would not flood the country?

Director POWELL. In my judgment it is likely that that can be done in time. It is my belief that it is possible to store all the waters of the Rio Grande in lakes; cut off all the tributaries from Colorado down to the Texas line; and if all the tributaries are cut off and the water of every tributary is stored there is very little water for the valley of drifting sands. But that will not be done to-day or next year. It may be twenty years before all the water is stored. If, however, irrigation should develop for twenty years as it has developed for the past two years in that country the water will all be cut off in less time, that is, all the flood waters of the dry season.

Senator REAGAN. If storage would do they might get the waters of the wet season and hold them over for the dry season.

Director POWELL. Yes, that will ultimately be done, to some extent.

Senator PLUMB. When you say "season" do you mean "year?"

Director POWELL. Yes, I mean the dry year. I think the waters will be ultimately stored in that region. They are already in that region providing reservoirs to store the water and hold it over from the wet year to the dry year.

Senator CASEY. Have you formed any estimate as to the number of dry years in a number of given years?

Director POWELL. They will come pretty evenly. There will be two or three or four years dry, and two or three or four years wet; not invariably so, but frequently so.

I place before you to-day a map of the Rio Grande, including all the area drained by that stream north of the Texas line. There are some important facts relating to the utilization of the arid lands which can be well elucidated by considering that region of country, and I present the map again for that reason. In talking to you about the irrigation problems presented in the valley of the Arkansas, I called your attention to the fact that that valley could be divided into districts, each one an independent unit. The whole arid region may be divided in like manner into natural districts or drainage basins, each one of which has its problems so interwoven that the entire district must be so considered in planning its system of irrigation works, but which is practically independent of all other districts. These hydrographic basins, as I call them, are of three classes, viz, headwater districts, river-trunk districts, and lost-stream districts. The headwater districts commence in the mountains and extend down the streams far enough to include catchment areas and farming areas. These headwater districts are not only found on the main streams, but on all perennial laterals or tributaries. Usually each lateral or tributary forms a natural district by itself. But the great rivers flow on across the plains and down the great valleys, and their trunks must be divided into districts, each one of which presents an independent system of works. These I call river-trunk districts. Then in the arid lands there are many streams which do not flow into great rivers and ultimately to the sea, their waters being lost in the sands or emptying into salt lakes. These I call lost-stream districts. All of these classes are represented in the Rio Grande region, the map of which is before you.

In considering this subject and planning the work of the Irrigation Survey, it has been found that a natural district or hydrographic basin must be considered as a unit in which all the problems must be solved. In order to report upon the district and recommend a plan of works, we must know in such a district how much water will be supplied for irrigation where the diverting dam sites, reservoir sites, and canal sites are situate and where the lands to be irrigated lie. And it has been found, after a careful examination and from the best data we have on hand, that there will be two or three hundred such districts in the arid region, and that if the survey is carried out it will need a separate report on each. I have therefore found it necessary, for the administration of the Survey, to consider these hydrographic basins, and have been studying them for some time—in fact for years before the survey was organized, for I early recognized that ultimately these natural features would present conditions which would control the engineering problems of irrigation and which would ultimately control the institutional or legal problems. The study which I have made in the survey in this direction of course can not be considered final. An actual survey on the ground is necessary to define the limits of each basin, and a very careful survey is especially necessary to define the limits of the trunk districts. The headwater districts, or those of the first class, and the lost-stream districts, or those of the third class, are quite easily discovered; but the districts of the second class require very careful study for their determination. The meaning of this will more fully appear from the illustrations which I am able to present to you to-day in considering the Rio Grande Valley.

First, we have the Saguache River, a river with tributaries—a number of beautiful creeks. The river flows into a sink, and the drainage is lost in the sands. Now, the utilization of that water affects that valley only. It is independent of all the other regions of country. The region of country at the sink is one of sand, and it sinks in these sands and is evaporated. It is only on very rare occasions, many years apart, that there will be a great flood which will cause it to overflow and open a channel to the Rio Grande. In all ordinary years all the water which is used must be in the valley here [indicating], hence it is an independent basin. This is what I call a district of the third class, a lost-river district. It will be noticed that in this district the people who engage in agriculture here can not possibly have any conflict about water rights with the people of any other district. They may use all of this element which they can catch and spread it upon their lands, and nothing will be cut off from any other district; nor can they obtain water from any other district to put upon their lands. And they are interested not only in the water; they and they only are interested in the forests about the fountains whence their waters come, and they are the people who should be interested in the grasses which grow in the valleys and on the hills and mountain slopes.

The Saguache district, therefore, is clearly defined in nature. Its boundary is marked everywhere by the parting of the waters.

Passing over to the Rio Grande proper, we have the San Luis district, which is also a headwater district. The San Luis park is a beautiful tract of land, and high mountains stand around it and gather great quantities of water. This is a region lately redeemed for agriculture, but already all the flow of critical years with extreme dry seasons is used in agriculture, and the companies that are specially interested in these water rights are preparing to store and use all its waters which flow through this season. It may be possible that they can use all and that the area of good land to be cultivated will be sufficient. We do not yet know the amount of water that flows in the streams, nor do we know the amount of good available land. Be that as it may, we are able to state that this great district is a unit, and that it must be considered as such in planning the proper system of irrigation works, and that its people will be as a body interested in the management of its waters, its forests, and its pastures. And they are the only people to be interested except to this extent, that if the waters are not used here they will flow into trunk districts below, to be used there. If the people of the districts below, in New Mexico, could lay an embargo upon irrigation in the San Luis Valley, larger areas in New Mexico could be cultivated, but the loss of water on the way would be such that they would not equal in area the lands that could be irrigated in Colorado. It is therefore manifest that it is to the advantage of the agricultural interests of the country that the people of Colorado who live in the San Luis Valley should be permitted to develop their agriculture to the utmost, and use all the waters that they can put upon good agricultural lands.

The Rio Grande, in crossing the line between Colorado and New Mexico, enters a cañon and flows for about 50 miles through the gorge, and its waters can not be taken out along this stretch. This cañon ends where Taos River, coming from the east, joins the Rio Grande. The Taos is a beautiful stream and all of its waters can be used in its own valley. All that run during the season of irrigation and all that run throughout the year can be stored, so that the waters of the Taos may ultimately be cut off from the Rio Grande.

The region of country on either side of the cañon of which I have made mention—Embudo Cañon—has lava-fields and is not agricultural; but some fair timber grows there and much water comes down into the cañon, so that when the river emerges into the valley at the foot of Embudo Cañon it is a fine stream, and must always be so whatever water is taken out in Colorado above. Some 40 or 50 miles below the river enters another cañon. Between these two cañons lies the valley of San

Ildefonso, into which come some small creeks from the east, and the water of the Rio Grande can be taken out at the foot of Embudo Cañon and spread over the San Ildefonso Valley and make here a river trunk district; or district of the second class. This is a district also well defined in nature. Its catchment area is lava-fields above and mountains on every hand, and its irrigable or farming area is the low valley stretching back from the Rio Grande on either side.

Near the foot of San Ildefonso the Chama enters from the west. The Chama is a large river for that country, and its smaller tributaries drain great mountains, and there are many beautiful valleys scattered about through the region. The lower portion of the Chama runs through a sand plain, and these sands are volcanic ashes which drift and blow into the river and fill it with sediment. The Rio Grande above the mouth of the Chama is a clear, beautiful river, but at the mouth of the Chama it is transformed by the mud of the Chama itself. It then becomes a river of mud and continues such to the Gulf, as it takes up sands along its way. The Chama Basin is another natural basin, having timber lands, pasturage lands, and agricultural lands.

At the foot of San Ildefonso Valley the Rio Grande enters White Rock Cañon and continues its course through a deep gorge for 40 or 50 miles. Along this course its waters can not be used for irrigation. The cañon walls are hundreds of feet, and in some places more than a thousand feet, above the waters. But the high volcanic plateau on the east furnishes a notable amount of water to this stream, and on the west there is a group of great volcanoes from which many beautiful streams flow; so that if all the water should be cut off at the head of White Rock Cañon, there would still come into the Rio Grande, through the course of this gorge, a vast body of water to be used below—water which can not be used elsewhere, as none of the streams above on either side of the cañon have agricultural lands along their courses. But they have great forests. Here some of the finest forests of New Mexico are found. This is the great catchment area for the valley below White Rock Cañon.

Some flood waters will always come down the Rio Grande from San Ildefonso Valley, however thoroughly the country may be utilized, and additional water will be caught in the cañon itself, and so the valley below will have a good supply. White Rock Cañon empties below into a valley which I shall call the Albuquerque Valley. In it lie Bernalillo, Albuquerque, Los Lunas, Socorro, and other towns. Now, all the water that comes out of White Rock Cañon can be used in the Albuquerque Valley, as it may be diverted below the White Rock Cañon and carried out and stored on the flanks of the valley. There is now much agriculture in this valley, and some of it is very ancient. Including the catchment area about White Rock Cañon and the hills and mountains on either side, and the valley where agriculture can be carried on, we have another natural district or hydrographic basin—a district of the second class, or stream-trunk district. Now, it will be seen that all the water to be used in this great valley comes from the mouth of White Rock Cañon. Whoever has control of that point owns that dam site and has the right to take the water out of its natural channel and carry it into canals—has command of all the agriculture of that great district.

I wish to explain further that the people who have settled here have taken out the waters of the Rio Grande and utilized them during the season of irrigation, but they have not yet resorted to storage and the waters which they use are used to very poor advantage. The flood plain or strip of country next to the river which is sometimes overflowed is broad and sandy; the river itself is shallow and is a river of mud, and it is very wide; so it flows into these sands and is evaporated to a very large extent and thus lost to agriculture. Then the people have constructed low-lying ditches near to the Rio Grande and take out the water by a system which is exceedingly wasteful and which is destroyed more or less with every flood. Ultimately they will find it to their advantage to take the water higher up, near the mouth of White Rock Cañon, and carry it out by high line canals and store the surplus in the lateral valleys. By this means the area of agriculture in the valley can be increased five or ten fold.

It is possible to take all the water of the Rio Grande there during the season of irrigation. It is also possible to take out all the water there during the non-irrigating season. If the water for the non-irrigating season is to be stored, you are compelled to take it out there. You can not take it out by the present ditches, for they do not flow on high enough ground; but if a canal is constructed from the mouth of White Rock Cañon, and a diverting dam built there and lakes made—there are good places—all the water could be used in the valley. So, not only is it necessary to take the water out at that one point and utilize the entire flow during the season of irrigation, but it is also necessary to take it out at that point in order to store the water which now runs to waste. So that if the water is taken out at this one point of which I speak altogether, the area of irrigation will be multiplied ten times. But that can not be done without considering the rights of the people who now use some of the water by improvident and obstructive dams.

Off to the east here, as you see on the map, is the Santa Fé Creek, on which the city of Santa Fé is situated. It also constitutes a distinct basin with irrigable lands, timber lands, and pasturage lands, and all its waters can be caught and used in the Santa Fé Valley, so that no considerable amount will ultimately flow from the Santa Fé Creek into the Rio Grande.

On the west we have the Jemez River, where another natural district of the first class is found. The Jemez River drains the Tewan Mountains and plateau. The catchment area is well wooded. Fine forests are found and great mountain meadows are seen, but the land above is cold and is not valuable for agriculture, except for pasturage, and perhaps a little hay may be cut with advantage. The many streams which head in the Tewan Mountains and plateau find their way into deep cañons. On leaving the mountains nearer Jemez Pueblo the whole body of the stream can be taken out and put on the mesa above Albuquerque, or west of Albuquerque and Bernalillo. It is another natural hydrographic basin of the first class.

Below Albuquerque we have the Rio Puerco. All of its waters can be used in the upper portion of its valley, and there is much more land than the water will serve. Very little water ever runs into the Rio Grande from the Puerco, and that comes only at flood-time. It is a hydrographic district of the third class, with irrigable timber and pasturage lands, and with many fine sites for reservoirs.

Where the Albuquerque district should end and the next district embracing the Mesilla Valley and the El Paso Valley should begin, I am not able to state, but from such information as I have been able to collect, I believe that below Socorro a new natural division can be made.

Let us go on to consider the region of the Rio Grande below, from Socorro to a point on the river 30 or 40 miles below El Paso. Here there are two valleys, Mesilla Valley above El Paso and the valley below, a part of which is in the Republic of Mexico and a part in Texas. Now it is possible to cut off from these two valleys all of the waters which flow during the season of irrigation in critical years and destroy all the agriculture in those two valleys unless the waters of the non-irrigation season are stored. During the non-irrigating season large bodies of water come into the Rio Grande from the mountains on either side. There are high mountains to the west and high mountains to the east, but there are few perennial streams, and they are only small creeks. The principal body of the water comes in as storm water. But the area is pretty large and its waters can be stored immediately above El Paso and at the head and along the flanks of the Mesilla Valley. At the Point of Rocks, at the head of Mesilla Valley, all of the waters of the Rio Grande can be captured again and they can be taken out into the Mesilla Valley and used once more.

The waters of the non-irrigating season can be stored on the flanks of the valley, and there is more land than all the waters will serve. Still there is a mountain catchment area on either side of the Mesilla Valley, the waters of which will flow through the valley at El Paso at flood times, and these waters can be stored to be used in the valley below in Texas and Old Mexico. But I do not think there is enough of these waters to support all the agriculture now developed if the waters of the Rio Grande are all taken out at the Point of Rocks. To maintain the irrigation now developed in the El Paso and Mesilla Valleys, some division of the waters must be here made. The catch from Socorro down, coming from the mountains on either side, and the surplus which may come down in great floods from the Rio Grande above, must be divided between the Mesilla Valley and the El Paso Valley to maintain the agriculture already established and to give some development to the same. Just how this can be done to advantage is not known; the topographic survey has not proceeded far enough. We know where the waters can be stored for the El Paso Valley, and I have already explained that to the committee some days ago. We can create a great reservoir with reasonable economy immediately above El Paso; we can also create a reservoir, or series of reservoirs, in the Mesilla Valley; but how much water can be caught and held in these reservoirs we do not know, and can not know until the topographic survey is completed, for on that we depend to determine the water supply.

It is safe to say, however, that the reservoir at El Paso may be constructed, and I incline to think that the rights to the present irrigation in the Mesilla Valley may be maintained, the rights in the El Paso Valley maintained, and that irrigation in both districts may be increased—but to what extent and to what size these reservoirs should be constructed is yet unknown. It will require another year's survey to determine these facts. This, however, is certain, that there can be no development of irrigation in these valleys through the use of the waters of the irrigating season only; in fact the present agriculture can not be maintained unless the waters are stored. The irrigation already developed in Colorado and the upper valleys of New Mexico is destroying the agriculture here. Two more years of development will cut it all off when dry seasons come. The only hope for these valleys is through storage, and how the entire problem is to be solved by storage is not yet known. Nor can it be done without some interference on the part of the United States. If the General Government does not step in and by definite legislation assign specific waters to El Paso and the Mesilla, the El Paso Valley will surely be destroyed, and the Mesilla Valley can be almost ruined by the people of the Albuquerque

Valley. What is needed is the construction of storage reservoirs and their protection, and the assignment of specific catchment areas to those reservoirs. The Government must say that a certain catchment area can be used for the Mesilla Valley and that the remaining catchment area can be used for the Albuquerque Valley.

A State, a Territory, and a foreign country are involved, and they can not settle the problem for themselves. There is only one way to protect this ancient irrigation in the El Paso and Mesilla Valleys and their right to use the water of the irrigating season, and to proceed as they have heretofore done without storage, and that is to destroy all irrigation in Colorado and all of the lately developed irrigation in the valley of the Rio Grande in New Mexico above, and to prohibit forever the use of the waters there; and this would mean that to maintain seventy-five to one hundred thousand acres of agriculture, several million acres of development must be stopped. Of course this can not be done. They must resort to storage, and somehow storage rights must be fixed and maintained.

The area drained by the Rio Grande above El Paso is a little more than 23,500,000 acres, or about 37,000 square miles. But much of the region is mountainous. Even if there was water enough it would not be possible to irrigate one-half of the land; of the arable lands only a portion are irrigable, from the fact that there is not water to supply them all. It may be that when all the waters of the Rio Grande are used in Colorado and New Mexico and in the valley of El Paso, in Texas, and the Republic of Mexico, from three to four million acres can be cultivated; but this can be done only by using all of the waters and storing all those that now run to waste. And then the irrigable lands must be properly selected, so that the waters can be used to the best advantage. That none may be wasted they must be stored where there is the least evaporation, and the lands must be selected near where they are stored, and the waters must not be permitted to run through sand valleys, where they are evaporated. They must be taken out from the streams and stored to the best advantage and used without waste. Then it may be possible to irrigate from three to four million acres. Of course the estimate is rough, because the surveys have not been perfected, and it may be too great; I do not think it is too small. Now the problem which you ask me to solve is this: How can these waters be used to the best advantage; how can they be divided among the best lands; and how can the rights of the present irrigators be maintained? I shall try to answer these questions, and certain collateral problems that are involved; and to do so, shall go over the the ground again, district by district.

Commencing then at the head of the Rio Grande Valley, we first meet with the Saguache. This river sinks in the sands; except in very great floods it discharges no water into the Rio Grande. Its valley therefore is an independent district, one of the minor class; all that can be done in the Saguache district is to select the best irrigable lands and provide that the waters shall not be used where they will be largely wasted.

Then we have a district drained by the headwaters of the Rio Grande—a district of the first class. All or nearly all of its waters can be used within the district on good lands, but they must be selected or the waters will be wasted. The district lies wholly within the State of Colorado.

The next district below on the river is the San Ildefonso. This is a trunk district and thus belongs to the second class. For 60 miles down below the Colorado line the river can not be taken out, as it runs in a cañon. The lands on either side are of little value and should be used only for pasturage and forest purposes. This upper portion of the San Ildefonso Valley is naturally the catchment area for the waters to be used in the valley below the mouth of Embudo Cañon. There are some creeks that come into this valley from the mountains on the east. This district, therefore, has a great catchment area which will supply a large quantity of water, which should be dedicated to the use of the farmers of the valley below. But they should understand that they can not maintain rights to use water coming from the San Luis district; that they should develop their agriculture wholly from the supply of their own catchment area. The best lands lie on either side of the river in the valley below Embudo Cañon and along sections of the eastern tributaries. These lands should be selected in sufficient amount to use all the water for irrigation, then there could be no controversy about the water rights in the district. Settlers could not go upon the non-irrigable lands and illegally take the water; farming could be developed in the valley to the greatest extent and on the best lands, and the farmers would be secure from depredation by other farmers going above them and pirating the water—to use a term common in the western country.

Midway in this district, and at the head of the irrigable lands, the Taos joins the Grande. It is a fine stream and its drainage basin constitutes a district of the first class. All the waters of the Taos can be used in its own valley, and it should be established that the people of that district have a right to use all of those waters, and that the people in the San Ildefonso Valley below can never maintain the right to have those waters flow down to their valley; that the Taos Valley is not a part of the catchment area of the San Ildefonso Valley.

In the lower part of the San Ildefonso Valley the Chama joins the Rio Grande. The basin drained by this river constitutes a district of the first class. All its waters can be used at home, and it should be established that the people have a right to use them there, and that no right can be maintained to the use of its waters outside the district.

At the foot of the San Ildefonso Valley the Rio Grande again enters a deep cañon for a course of 50 miles. Along this course it receives many important tributaries that drain high mountains, and on these and timber region, and is a catchment area for a district below. The irrigation can not be practiced to any advantage. It is a pasturage cañon is known as White Rock Cañon. At its mouth the waters can be taken out again and spread over a large valley. In this valley there are already a number of considerable towns. Albuquerque is the principal city, and we will call it the Albuquerque Valley, and the district, including the valley and the catchment area above, the Albuquerque district. It is, of course, a trunk district, and hence belongs to the second class.

Now, it should be established that the people of the Albuquerque district can not maintain rights to use water not caught within their district; that all the volume of the Rio Grande in the San Ildefonso above belongs to the people of that valley; that the only waters which the Albuquerque farmers can use and permanently maintain rights to are those falling from the heavens over their district. The irrigable lands of the Albuquerque district are in excess of the water supply. The nearer to the mouth of the White Rock Cañon they can be used, the greater the area that can be irrigated. Perhaps this district should terminate at Socorro. Perhaps it should go down to San Marcial. A careful topographic and hydrographic survey is necessary to determine this boundary. The district would, at any rate, be more than 150 miles in length, and it is a long sand basin. If the irrigable land should be selected in the southern end of the district, much of the water would be lost on its way; if it is selected in the northern end of the district, this water could be saved. The Rio Grande will irrigate 200,000 acres in the northern end of the valley. But there are lands already irrigated in the southern end of the valley and their rights should be maintained, at least until they are justly extinguished. Doubtless this will ultimately be done. It is of prime importance that no more rights be established in the southern region of the district.

To the east of the White Cañon lies Santa Fé Creek. It is a beautiful stream of water and the region which it drains forms a district of the first class. Here the city of Santa Fé is situated, and the waters of the great creek are all used in irrigation during the summer months. An attempt has been made to store water, but it has proved a failure. The site of the reservoir was among hills that had been denuded of their forests and grasses, and the reservoir was destroyed by the enormous and rapid accumulation of debris. Other and better reservoir sites have been found where the forests are not yet destroyed. The farmers of the district should have control of these forests, or they can not greatly increase the area of irrigation in the district. The lands to be irrigated lie on a plateau in the neighborhood of the city and are already of great value. The principal catchment area is in high mountains where there are extensive forest lands and where there should be pasturage lands, but these are largely destroyed by over-feeding. The pasturage and timber lands greatly need protection in the interests of agriculture below.

Just above Bernalillo the Jemez joins the Rio Grande, and here we have another district of the first class. The Jemez now discharges a part of its waters into the sand, for there is a long stretch of dunes extending from Cia down to the Rio Grande. Still the river has a volume sufficient to carry part of its waters over the sands and discharge them into the Rio Grande. The catchment area is the Tewan Mountains and the Tewan Plateau, a lofty region covered with beautiful forests and the rich grass lands yet uninjured by fire or over-feeding. The mountain meadows are abundant and beautiful, and the forests are among the best in New Mexico. The lands to be cultivated by this river lie on the mesa west of the Bernalillo and Albuquerque. The waters can be stored in the mountain meadows and elsewhere very cheaply, but it will be expensive to take the water across the sand dunes on to the irrigable lands of the mesa. The mesa itself and the catchment area both should constitute one district. The waters of the mountains should be attached to the lands of the mesa, and the right to use the water should permanently inhere there. The settlers in the valley of the Rio Grande should not be able to acquire rights to the waters, for in so doing they will be chiefly wasted. The catchment area is a volcanic district, and volcanic cinders and ashes abound; and these conditions make it necessary to carefully protect the lands, otherwise they will sink the streams and fill the reservoirs. The forest area is, therefore, chiefly valuable as a catchment area, and which should never be denuded of its trees.

The next stream is the Puerco, which comes in below from the west. It heads in the Nacimiento Mountains, on the western slope of the Tewan group. Along this range of mountains there are several beautiful streams that flow into a distant valley into the channel of the Puerco and here land in the sands and pass only in extreme floods into the

Rio Grande. Practically it is a district of the first class. Its waters have been used in irrigation in the settlements near the mountains, which are, to some extent, well situated for such purposes. But farming is chiefly carried on in the valley of the Puerco, and in that region can not be permanently maintained to advantage. The rights to irrigate so far from the mountains must be permanently extinguished if the Puerco is used to the best advantage. The catchment area is the slope of a great mountain range covered with fine forests, and there are many good reservoir sites. The pasturage is also extensive, but the pasturage and the forests must be protected to save the agriculture. The irrigable lands of the Puerco should be carefully selected and no other lands should be cultivated. The reservoirs must be selected in the valleys and on the slopes of the mountains, where they will be subject to destruction by silting if the forests and grasses are not carefully preserved.

From Socorro southward to El Paso is a distance of about 200 miles by the river. There is already irrigation in the Mesilla Valley above El Paso, and there is also much farming below El Paso in Texas and the Republic of Mexico. Through much of the way from Socorro to the head of the Mesilla Valley the river cañons again and there is a natural catchment area for the country below. This upper region should be declared the catchment area for the Mesilla Valley. At the mouth of this cañon there is a place called Point of Rocks, near Fort Selden. Now it is possible to take out all the waters of the Rio Grande derived from the catchment area above, which has already been described at this point, and there is land enough in the Mesilla Valley to use it. But this would cut off all the water from the El Paso Valley below. There is a short pass or gorge just above El Paso through which the Rio Grande runs. This divides El Paso Valley from Mesilla Valley. To maintain the rights of the present irrigators in Mesilla Valley and El Paso Valley alike, it becomes necessary to unite these two valleys into one district, and to divide the waters between them. There is water enough coming in the catchment area described to maintain all the agriculture yet developed and to increase it somewhat. How much we do not know, as the survey is unfinished. Nor do we know how to divide the waters. The El Paso Valley is partly in Texas and partly in the Republic of Mexico. The Mesilla Valley is in New Mexico. It is thus that the waters of the Rio Grande in this district must be divided between three peoples, and unless some authority steps in and makes this division the irrigators of the Mesilla Valley can take all the water and destroy all the farming below in Texas and old Mexico.

The survey has developed the fact that we can store water with reasonable economy and in sufficient amount immediately above El Paso, at the gorge of which I have spoken, to supply the wants of all the farming in the valley below in both countries, and from the same reservoir an additional area can be served; but there is no wisdom in constructing this reservoir unless steps are taken to provide a catchment area for it, and to protect that catchment area from spoliation. It is thus that the El Paso problem can not be solved by the construction of a dam at El Paso and the establishment of a reservoir to hold water for the valley below. A catchment area must be provided, and on providing this the rights of the Mesilla Valley must be maintained. It is true that if the dam is constructed at El Paso now flood waters in sufficient quantities will come down to serve present wants, but these flood waters can be caught above and ultimately will be caught above, and it would be unwise to pay no heed to the ultimate conditions.

How many years ere this will be I do not know. It will depend upon the rate of development, an uncertain factor. But schemes have been projected and begun in the Rio Grande Valley within the last eighteen months to take one-half of the ultimate supply of water. Most of these schemes have been projected without any proper consideration of the conditions to be met in order to utilize the greater amount of land. If they are completed and rights finally established on the ground selected, then one-half of the value of the Rio Grande Valley is forever destroyed. The rights and interests thus established will be so wasteful of water that the Rio Grande will sustain only one-half of its possible population. This statement is very conservative. It may be and it is even probable that the water will be able to do only one-third of its duty. And the Rio Grande is a fair illustration of the facts and conditions pertaining to every great river on the arid lands.

This, then, is needed in the Rio Grande Valley, that its agriculture may develop normally and that all rights established may be maintained. In each district the catchment area and the irrigable lands should be determined and defined. To define the irrigable lands it is necessary to measure the waters, in order to discover how much land can be used. Then the irrigable lands should be declared such, and the law should prevent any other lands being irrigated. Then the catchment areas should be defined, and settlement on the catchment areas for agricultural purposes should be prohibited, and the people farming on the irrigable lands should have a right to control the catchment areas and to protect and use the forests and grasses. Then, in each district the storage basins should be segregated and reserved from sale and occupation, so that they may not fall into the hands of speculators, whose rights would have to be purchased before the waters were stored; but the people who live in the district, as a body politic and corporate, should have a right to control these storage basins for the common use. The dam sites and the canal sites ought in like manner to be designated and preserved from sale to individuals and held for the common use of the people. By this plan the irrigable lands would be held in severalty by the people; the sites for reservoirs, canals, and dams, and the catchment areas would be held in common in such district. But in the El Paso district, in which the catchment area is in New Mexico and the Mesilla Valley, and a part of the irrigable lands in New Mexico and a part in the El Paso Valley of Texas and Old Mexico, some means must be provided to divide the waters. It is an interstate and an international problem; but the rights of all of the people now cultivating the soil must be maintained.

To define the districts, a topographic survey is necessary; to define the catchment areas and irrigable areas, and to select the reservoir sites, canal sites, and dam sites, a topographic survey is necessary; to divide the waters, a hydrographic survey is necessary, and a hydrographic survey is based upon and can be most economically made through the agency of a topographic survey. In selecting the lands in the headwater districts, they should be taken in regions low enough to have a good agricultural climate. In the trunk districts the land should be as near to the points where the waters are taken from the rivers by diverting dams as possible, that these lines may be the shortest and that the least water may be wasted. The reservoir sites, other things being equal, should be selected on the highest lands, where the evaporation is least. As far as possible, reservoirs should be maintained at the least cost and where the danger of destruction is least. The principal lines of canals should all be designated in advance, in order that impedimentary and obstructive rights may not be established. These obstructive rights are of two classes. First, where a lateral stream joins a main stream, the waters of the lateral should be taken to lands sufficiently high up its course to be out of the way of the development of irrigation on the principal stream.

The principal stream usually has a lower gradient, and its waters can not be taken to very high lands; and if the waters of the lateral stream occupy the low lands, the waters of the principal stream can not be used. This condition of affairs has arisen in many cases already in the development of irrigation in the West. The obstructions of the second class relate to low line canals taken out along the course of the stream which runs in a sand plain. If the canals are taken out here, the whole length of line is extravagantly great, and the loss of water is correspondingly great. All canal lines which relate to the utilization of water for irrigation and to the development of agriculture in arid lands—they are all of great importance; no one can be neglected without doing serious injury to agricultural industries. If these things were done in advance of more dense settlement, and then the people permitted to control their affairs in their own way—divide the water among themselves in each district as they please, protect and utilize their forests in obedience to their own judgment, corrected by experience as time goes on, use the pasturage for their flocks and herds, and protect it from destruction that they may thus use it, the arid lands would furnish homes to prosperous, peaceful, and happy people.

Senator PLUMB. Are you going to deal with the question of the underflow or subdrainage? I wish to ask you some questions in regard to that.

Director POWELL. I am ready to answer any question at once, so far as I am able.

Senator REAGAN. That subject will come in better order when he comes to discuss the Gila River.

Senator PLUMB. Very well.

Director POWELL. The Gila heads in the mountains in the eastern part of Arizona and in New Mexico, but the main part in northern Arizona. Running along this line in Arizona there is a line of cliffs rising from 2,000 to 5,000 feet high, so that the region above is from 2,000 to 5,000 feet higher than the region below. This [indicating by the map] is the plateau of Arizona and this the lowland of Arizona. There is a general difference of altitude of 3,000 to 5,000 feet. The streams all head on this plateau or in these high mountains, and as they flow westward, to unite with the Colorado, every stream becomes generally less and less, so that while there may be in dry seasons a great body of water coming from the plateau and the mountains and there may be scores of beautiful creeks and some small rivers that are perennial (even in the dry seasons), yet in dry seasons the low part of the Gila will be a series of sand hills. (See map.)

Senator CASEY. In the dry season of every year?

Director POWELL. It is only in the very wet years that there is water running in the Gila during the dry season.

Senator CASEY. The dry season of the average year?

Director POWELL. In the dry season of the average year the lower Gila is dry. The rain-fall above is 20 inches or more, and in the mountains it may be 24 inches in some places. Below, the rain-fall is from 3 to 10 inches only.

Senator PLUMB. Where does the rain-fall come from in that region? Is it from local evaporation?

Director POWELL. Partly so, but in the main most of the moisture of this region comes from the Pacific Ocean and Gulf of California, though it is used over and over again. It is evaporated and then falls, is again evaporated and again falls, and so on. It is used over and over again in that manner as it passes eastward with the great upper currents of air.

Now, in all these mountains and cliffs from which beautiful streams run out many are found which never reach the Gila at all.

Senator PLUMB. Is that not a feature of mountain drainage everywhere, as in the upper Rocky Mountain region, for example?

Director POWELL. It is common but not universal. It is a special feature of this region.

Senator PLUMB. I have seen many streams in the Rocky Mountains that were rushing torrents for 3 or 4 or 5 miles and then disappeared entirely.

Director POWELL. Yes; but I will show you where nearly all those occur. They nearly all occur in this great basin lying around here [indicating by reference to the map]. That is the great region of lost streams. Within this region there is no drop of water that runs to the sea—the region colored green and olive on that map. All of the water is lost.

Senator JONES. Is there much rain-fall in that region?

Director POWELL. It varies from 3 to 16 inches.

Senator PLUMB. Is it carried by subterranean streams?

Director POWELL. No; it is all evaporated.

Senator PLUMB. Then that is not aided by the moisture carried there, but is simply evaporated and falls again?

Director POWELL. It gets a good deal of moisture from the west. Moisture evaporated in this region [indicating] is carried over on to the Rocky Mountains here. The progress of moisture across the continent from west to east is by steps. It is precipitated and evaporated, and again precipitated and again evaporated, and passes across the continent in that manner, by steps, and it is chiefly thrown down on the mountains.

As to the Gila drainage basin—the lower portion of the Gila is a region where the mountains gather the main part of the moisture, and where these waters flow down and are lost in the sand, ultimately to be evaporated; so that the irrigation of the Gila region depends on three things: First, the utilization of the running streams abounding in these mountains and along Salt River, and streams which head in the mountains. Secondly, it depends upon the utilization of the storm waters; less than one-half of the mountains of the region give rise to living streams. The streams of the mountains of the lower land are in the main intermittent streams. When the rains of the spring start the streams start and run out to the valleys until they are lost, and when the dry seasons come all the streams of the mountains dry up and the waters roll down into those lands and can be recovered in various ways, but in the main, in that country, in part by artesian wells and in part by wells that must be pumped.

While on that subject I will say that the pumping of water from wells is a peculiarity of American industry. I never appreciated its magnitude until this past season. This fall I sent Mr. Nettleton to Spain to investigate some questions. He has just returned, and tells me that there is nothing in France, in Italy, or in Spain to correspond with the industry growing up in this country by the use of pumps for the recovery of water. American genius has done this; it has invented pumps that can be run so cheaply and of such power that it is possible, at an expense of $200 or $300, to irrigate a good farm in any part of the country where good wells are found, by the use of pump-water.

Senator **Casey**. The pumps being run by steam?

Director **Powell**. By steam one way or another.

Senator **Casey**. And it is in this region that they are using those pumps?

Director **Powell**. In this region they are beginning to develop the pumping process.

Senator **Plumb**. You saw some of those pumps in operation in Colorado this past year, did you?

Director **Powell**. Yes.

Senator **Plumb**. Did they seem to be successful there?

Director **Powell**. Very successful.

Senator **Plumb**. Not only on the ground of work but of expense?

Director **Powell**. Yes. They have made the expense trivial. A boy or a woman can run such pumps. They are very simple.

Senator **Jones**. Did they not say they had some pumps in operation to which they sent somebody only once or twice a day to look after them?

Director **Powell**. Yes, they sent somebody to feed them once or twice a day.

The genius for invention has solved the problem for the irrigation of a very large district of country in this Southern region, which is of great importance for this reason: that is the region in America of the highest temperature, the region where the date, the palm, and the orange grow, and where cotton and sugar can be cultivated, and all the products of a subtropical climate grown.

The **Chairman**. Would not that remark apply to the places east of the Rocky Mountains in Kansas and Nebraska where the waters are lost?

Director **Powell**. Yes; but there are few countries where it is lost as it is there. It is lost in the valley of the Arkansas and in the valley of the Platte and in many other places, but there is only a portion lost there, while here it is wholly lost, and the people will have to depend upon the lost water entirely for irrigation or the region will be absolutely desolate.

The **Chairman**. They have some irrigation in the Salt River Valley.

Director **Powell**. Yes, on the streams above, as I have explained.

Senator **Reagan**. The mountain streams all dry up in that place?

Director **Powell**. Yes.

Senator **Reagan**. But you remember that it was a dry season when we were at Phœnix?

Director **Powell**. Yes. I excepted the Salt River and Gila River regions in what I have been saying. All through California and around here [indicating] there are short north and south ranges, which do not rise very high, which furnish no perennial streams. It is in that region of country that they must depend on pump-waters for irrigation, and to some slight extent on artesian waters.

Senator **Reagan**. Senator Plumb made an inquiry about the under-streams that flow through the sand. If you remember, some witnesses had a good deal to say to us about there being underground rivers in some places.

Director **Powell**. Yes. If you wish me to talk on that subject I shall be pleased to explain the matter.

Senator **Plumb**. If you have finished with what you wished to say about the surface waters I shall be glad to ask you some questions about the other.

Director **POWELL**. I shall be glad to answer any questions.

Senator **PLUMB**. In your judgment is this under-deposit of water a standing body of water merely, or is it a flowing stream?

Director **POWELL**. I do not believe it is a flowing stream.

Senator **PLUMB**. That is to say, is it a great cavity into which those streams flow?

Director **POWELL**. It is rather a complicated question. I will explain it. There are two problems with regard to it. Where the waters disappear in the sand, as they do here in the Great Basin, they spread out in what is known as a "sink." Where they spread out in the sands along a great river, as in the case of the Arkansas and the Rio Grande, the valleys of which descend 4, 5, 6, 8, or 10 feet to the mile, the waters gradually creep down these valleys with a distinct forward movement.

Senator **PLUMB**. And are replaced by waters coming behind?

Director **POWELL**. Yes; but not in the sense that there is a stream or flow of water. The water simply percolates through these sands.

Senator **PLUMB**. That would be important as affecting the quantity of this water?

Director **POWELL**. Precisely.

Senator **PLUMB**. As to whether any of those waters if removed by a ditch would be instantaneously replaced by a pump, what have you to say?

Director **POWELL**. I am very glad you have brought that question up. But let me go on one moment. When you pass the mountains of Colorado along these streams for the first hundred miles there are perhaps only 10 or 15 inches of rain-fall, while on the mountains there is an excess of rain-fall. The water is gathered on the adjacent mountains and precipitated. But when you get from 100 to 200 miles away from the mountains the attraction of the moisture is not to the mountains, but is again eastward, and again the precipitation is greater; so that at some distance away from the mountains you get a greater rainfall than you do nearer the mountains. It therefore requires less water for irrigation there than it does above, because nature supplies a greater share. On the other hand, the snows of the valleys are forever supplying a local rain-fall, and the people do not depend on that which comes from the mountains. The increase of local rain-fall to 20 or 22 inches across that country produces rain-water in the valley much faster than it can be pumped out. The quantity of water is ample, but the supply will come from the adjacent country, and not from above, if the water is used in irrigation above. The lands of the valley will be supplied with water by the storms of the plains.

Senator **REAGAN**. At one place the people described to us an underground river. They said they were putting in tubes farther up and gradually raising them so as to pour the water out on the surface.

Director **POWELL**. It is a good illustration of one of the "sinks" that I have been describing. Here is a river running down from the mountains—mountains on this side and mountains on that—with springs, etc., all gathering into a valley, which at last debouches into a plain below. Right by Tucson is a sink in which the water disappears. If you go into that valley you will find that in one place it opens out quite wide, while in other places it narrows up into a cañon. Wherever it is narrowed by the solid rock you will get a good flow of water.

Senator **PLUMB**. A large portion of the water supply of the city of Denver is derived in the same way. But my idea was to inquire whether that was a deposit of water or a flowing stream. Suppose, for instance, you should take out 50,000 cubic inches of water in a given moment of time, the question is whether this flow of water that is back of it, coming from this hidden source, will immediately replace it?

Director **POWELL**. Such questions are properly answered by experience, and so what I have to say——

Senator **PLUMB**. I understand that, but I thought you had made some observations on it.

Director **POWELL**. I have.

Senator **PLUMB**. There is no doubt about water being there, and no doubt as to the possibility of getting it out, because the average slope in western Kansas is about 7 feet to the mile, while 2 or 3 feet is sufficient for that purpose.

Director **POWELL**. My judgment is this, that the supply of water is permanent; that it is permanent by reason of the storm-waters of that region, which are great. Many times in the last twenty-two years I have been over that ground and witnessed storms. When the rains do come the sheet of water that comes down from the adjacent hills is enormous. I am confident the source of water is perennial for that reason, even though the waters of the river should be cut off in Colorado.

Senator **PLUMB**. That is to say that acts practically as a reservoir for the storm-water?

Director **POWELL**. Yes; and on the other hand I do not believe that the supply is inexhaustible. I believe there is a limit to it.

Senator **CASEY**. It might be carried off by constant drainage. You have often seen water where the drainage is constant and where the water, although very full at one time, becomes exhausted.

Director **POWELL**. As to that section of the Arkansas River that runs through the State of Kansas and has a valley several miles in width, I believe that a large area can be redeemed by irrigation by the use of its underground water, yet I believe it has its limits.

Senator **PLUMB**. You think that the taking away of the water will have the same effect underground as it has on the surface streams, that is to say, it will dimish the supply below?

Director **POWELL**. Yes; that is to say you can not irrigate illimitably with it, but it will irrigate perhaps two or three hundred thousand acres.

Adjourned.

SECOND DAY'S SESSION.

WASHINGTON, D. C., *January* 21, 1890.

The committee met pursuant to adjournment. Present, Messrs. Stewart (chairman), Casey, Jones, and Moody.

FURTHER STATEMENT BY DIRECTOR POWELL.

The **CHAIRMAN**. Major Powell, you may resume your statement.

Director **POWELL**. Mr. Chairman and gentlemen of the committee, I propose rather briefly to review some facts relating to important drainage basins, and to continue the statement which I was making at the adjournment of the last meeting of the committee, but in the main I shall omit the engineering problems and confine myself more exclusively to the problems of civil administration.

The next basin in order, continuing from the point where I left off at the last meeting, is the drainage basin of the Colorado.

The Colorado is one of the great rivers of the continent, being more than 2,000 miles in length. It runs in the main from north to south and from highlands to lowlands, so that it passes in its course through many climatic zones. It heads in the Wind River Mountains and drains a large region in the Territory of Wyoming. It also drains a portion of Utah and a portion of Colorado. The regions drained in Wyoming are very cold, because they lie at a great altitude. All the lands in Wyoming that can be irrigated by the tributaries of the Colorado or Green River are lands valuable mainly for the cultivation of potatoes, hay, oats, and perhaps rye. In some few of the low places wheat may be cultivated. But I will designate for our purposes at the present time the potato zone of the Colorado.

Following down the Colorado to the lower regions in Utah and some few valleys in the State of Colorado we get into a region where wheat is cultivated, but the areas that can be redeemed along the Grand and Green Rivers for these purposes are not very great. Still farther down the Uintah Valley, in Utah, and the Grand River Valley, in Colorado, corn may be cultivated. There are some minor valleys for the next 700 miles along the Colorado that can be used for the cultivation of corn.

More than four-fifths of the upper drainage basin of the Colorado lies from 5,000 to 8,000 feet above the level of the sea. About the rim of this basin stand the Wasatch and Uintah Mountains on the west, the Wind River Mountains on the north, and the great Rocky Mountain system on the east; all that vast area, as shown in the map before you, is all drained into the Colorado River.

As there are great gorges from 200 and 300 feet to 5,000 feet in depth, in general the streams run so far below the surface of the country that they can not be used for agriculture. But nearer to the mountains, on each side, there are high valleys in the potato region that I have described.

In the regions below the cañons, at the mouth of the Grand Cañon, as it is called, the Colorado falls into a great valley, across which some mountains stand, but in the main it is a low and very warm valley, and a region where rice can be cultivated. And throughout the world the great rice regions in general are where irrigation is practiced. In this valley ultimately rice and the vegetables and fruits of that zone can be cultivated in great abundance. On the lower Colorado there may be cultivated to advantage, also, cotton, sugar, and especially the date palm, because the country is far to the south and low.

Now these are the problems involved in the civil administration: A part of the waters are in Wyoming, a part in Colorado, a part in Utah, a part in Arizona, and a part of California, and they are to be divided between those States and Territories. But there will be no difficulty in dividing them in the upper regions because the land which can be covered is less than the water will serve. So that all the upper region of the Colorado that can be irrigated may be by the streams, and there will arise no necessity for a division of the water between States, counties, districts, and people. But when we come to the lower portion of the Colorado there they will have to be divided. A small portion of Utah, of Nevada, and California on the west, and Arizona on the east can use these waters, and after all the waters have been used above, as I have described, after all the region is irrigated that it is possible to irrigate, there will still be a vast volume of water in the Colorado that can be utilized and divided between the States and Territories that I have mentioned. But at the present time there are no means by which those waters can be divided between them. It is probable that 5,000,000, 6,000,000, or 7,000,000 acres of land can be irrigated in this lower region. So that ultimately it becomes a problem of great importance to divide these waters.

Passing then from the Colorado drainage, I will omit some of these minor areas and speak of the Sevier drainage.

The Sevier heads in plateaus in southern Utah and runs northward, then turns westward, where it is lost in the desert. The people of Utah have already taken out the waters of the Sevier below the lower part of the valley to irrigate very large areas, and until within two or three years, settlements have been crowded on the head of the Sevier, and the people above are beginning on the upper portion of the Sevier to take out water from its tributaries, and already they have done this to such an extent as to cut off the water from the farms below. So that the problem now is to divide the waters of the Sevier in such a manner as that there will be no conflict. The people above are taking out the waters of the stream on to land which is of comparatively little value for agricultural purposes because it is cold and in the region designated as the "potato region."

The lower valley of the Sevier is warm, and agriculture is practiced there with great success. But, if the process of abstraction of the waters from above continues, as it has been for two or three years past, much of the water of the Sevier will be cut off and the lower settlements destroyed.

Senator CASEY. What are the people above on the Sevier raising?

Director POWELL. Hay, potatoes, oats, etc.

Senator CASEY. Do they raise any wheat?

Ditector POWELL. No; not that I know of. It is possible that there is a small portion where wheat can be raised, but the most valuable lands are in the lower valley.

I will speak next of the Jordan drainage, the Jordan being one of the upper rivers flowing into Salt Lake, and from which the irrigation of a large tract in Utah is had.

Utah Lake cuts in two the valley of the Jordan. Above, the Provo and Spanish Fork, and a number of other small streams flow into Utah Lake. The waters in these upper streams are taken out to irrigate the valleys they pass through. But not all of their waters are used above; a very large amount, in the season when irrigation is not practiced, flows into Utah Lake. Utah Lake is a natural reservoir for the Jordan. Now, irrigation has been carried on and developed in the valley of the Jordan to such an extent that practically the waters of the irrigating season are already utilized. So that, the development or increase of the area of irrigation in the valley of the Jordan, including the whole valley, is to be made by storing the waters, and they can be largely stored in Utah Lake. But if Utah Lake is used as a reservoir, it must be used in part by cutting down the outlet and in part by damming the outlet so that the waters of the winter may be stored therein.

To do this the lands belonging to people above will be flooded. Already there has been conflict there, but the church authorities stepped in and settled the matter. The last time there was conflict, a committee of arbitration was formed, and each of the two counties involved paid one third of the expenses of the damage, and the church from the tithes paid the other third. They settled the difficulty in that manner. But the difficulty still remains, if any increase is to be made in the area to be irrigated in the valley of the Jordan.

And on Bear River we have another difficulty which is more than an intercounty and intercommunity difficulty. Bear River heads in Wyoming, flows northward into Idaho, makes a great circuit in Idaho, and then returns to Utah, where it ultimately empties into the Great Salt Lake. It is therefore an interstate problem, and the people of Idaho and the people of Utah are now in constant conflict. During the past season the governors of those Territories and their citizens have been petitioning the Secretary of the Interior on the subject. There has been much newspaper warfare about the matter, and meetings and conventions have been held to determine how the waters of the Bear shall be divided. A large portion of the valley of the Bear—the warm and valuable portion of the Bear—lies in Utah. The region drained by the Bear—the valley of the Bear—which lies in the Territory of Idaho is cold. There is a small area of good land, but in the main the lands are grass lands and potato lands, such as I have described. So that there is now pressing upon the Department, Congress, or some authority, the problem of dividing the waters of the Bear between Wyoming, Idaho, and Utah.

Passing to the west side of the Great Basin, I will say one word in general of the Great Basin.

The streams which head in the Great Basin, or drain it, do not run to the sea. So that there are many small streams, like the Jordan and the Sevier, which head in the mountains standing about the Great Basin and are lost in the sinks and salt lakes, and many of them in the sand. Of the several drainage basins in Nevada I shall not stop to speak now, except a few.

Here another problem arises peculiar to the region itself. The Truckee, the Carson, and other rivers of Nevada, head in the Sierra Nevada Mountains within the State of California. The main waters used in the western half of Nevada have their sources in California. Nearly all the reservoirs for the storage of waters of these streams must be constructed in California. The people, therefore, who live on these rivers and depend on irrigation have their sources of supply in another State.

If they are to increase the area of irrigation from these streams—and it may be very largely increased; we have already made the survey showing that a very large amount of water can be stored in Lake Donner, Independence Lake, Tahoe, etc., in California—if the people are to utilize these waters in irrigation on their lands below, they will have to go into another State to do it—they will have to construct their canals and reservoirs outside of their own State. It makes a very serious interstate problem, therefore.

I shall pass hurriedly over all these points simply to bring out hereafter the interstate problems in the main. Perhaps I had better refer to the Humboldt River.

The Humboldt River heads in low mountains in central Nevada from many small streams and springs. It is largely supplied with storm water, so that during seasons of storm a great flood of water rolls down the Humboldt River. During exceedingly dry seasons it is almost dried up. The problem of the Humboldt is, therefore, to store the storm waters immediately along this basin and to utilize the small streams on which they now depend in dry seasons.

We have here the great valley of California [indicating on the map]. I shall make no mention of the waters of the San Joaquin and its tributaries, but wish to say a few words about the waters of the Sacramento.

The Sacramento Valley is a region in which irrigation is practiced to some extent, but in which it is not absolutely necessary. During the last two or three years especially the people of that region have come to understand that irrigation would benefit them very greatly, and they are now developing irrigation in that valley. Ultimately they will use a large part of the waters of the Sacramento for that purpose.

There is a double problem involved here. The Sacramento and its tributaries have heretofore been used for hydraulic mining. When the miners and farmers of this region come to understand that it is wise for them to use the waters of the streams for irrigation, the conflict between the farmers and the miners will cease. The works necessary to utilize the Sacramento for irrigation and the works necessary to utilize the waters for hydraulic mining will be common works, and both parties will be interested; so that the problem that has divided the interests of that valley between the miners and farmers can ultimately be settled to the advantage of both.

The CHAIRMAN. I am afraid that is a little overstated. It will never be settled until they get the gold out.

Director POWELL. Perhaps I had better dwell upon that point a little. First, on the American River and all those rivers used for mining purposes they have learned enough to know that the waters can be stored there. If the waters are stored above in the lateral valley to be used in irrigation below in the valley of the Sacramento, an equable stream can be preserved along the Sacramento. A flood stream need never be allowed to run in the valley; the waters can be controlled in such a manner that floods will not spread over the valley.

The CHAIRMAN. I believe that can be done.

Director POWELL. Then the destruction to the land which is sometimes done in two or three weeks of flood-time will not happen.

The CHAIRMAN. The great conflict is that they have a great many storage reservoirs. They can work these mines with these waters by the hydraulic process, but it will not pay to work them by any other. It is estimated that, in the old river beds which run north and south at an elevation of 600 feet above the level of the sea, there are a thousand millions of gold. That is the estimate of experts based on results obtained prior to the injunctions against hydraulic mining. But in working the mines by that process they cover up the land below and that is the controversy.

Director POWELL. The land is covered in this manner: The streams that are used in hydraulic mining tear the hills down and distribute débris over the low lands—the materials of which the hills are composed. The bowlders and gravel of these hills are carried a short distance, finer material much farther, sand a somewhat greater distance, and part of the material, exceedingly fine, is carried very far down the river and there deposited. The rivers, therefore, run like rivers of mud. That débris accumulates along the course of the river, chokes the river, and forms dams and bars from point to point. So that, when the spring rains come and the snows melt the flood comes down all at once, and, the channels of the river being choked, the flood spreads itself over the valleys, and the débris from the channels of the river bury the land many feet. The Senator knows how that is. I have traveled along there for miles when there was a good stage road and telegraph line, and a few years after along that same road the telegraph poles were buried. Here and there one would have its top protruding above the débris.

Senator JONES. How large an area was covered in that way?

Director POWELL. I remember indefinitely the area that I saw covered from 2 and 3 to 30 and 40 feet in depth, but as well as I can remember—it is several years since I was there—it was from 300 to 400 square miles.

The CHAIRMAN. The Bear and the American Rivers when I first saw them had deep banks—40 or 50 or 60 feet deep. The beds of the streams are now above those banks. The highest estimate is that it has covered up 1,000,000 acres of land. Some have put the estimate higher, to 1,500,000 acres of land. But a great deal of that land has become good again by exposure, and it has helped the land that was back from the river by raising the water-bed and moistening that land. So that what was dry land back of the river has become moistened land. But the farms near the river have been all covered up. The miners were enjoined from proceeding with this kind of mining. There is a vast amount of money in these mountains, estimated by the best experts at a thousand millions, and until these injunctions are removed this gold will never be utilized.

Director POWELL. I pass from California directly to the Snake River or Shoshone River, where some important problems exist. The Snake River has its origin in Wyoming, passes into Idaho, crosses the Territory of Idaho, becomes the boundary line between Oregon and Idaho for a long reach, finally passes across the State of Oregon, whence it proceeds north to Washington Territory, and thence turns westward through Washington Territory until it joins the Columbia.

The Snake is a river of great magnitude. Its waters can be stored in part in Wyoming, in part in Idaho. Lakes have already been discovered as sites for reservoirs, by which a large amount of water, 2,000,000, or 3,000,000 acre-feet—that is, water enough to irrigate 2,000,000 or 3,000,000 acres of land—can be stored at very small expense. That is in the upper part of the Snake River Valley.

The waters of the Snake River must be divided between Wyoming, Idaho, Oregon, and Washington, and interstate problems have arisen in part, and will arise hereafter, of great importance; because it contemplates the irrigation of 6,000,000 or 7,000,000 acres of land.

Senator Casey. What products can be produced there?

Director POWELL. It is a wheat and corn region.

Senator CASEY. Throughout its whole length?

Director POWELL. This is a warm valley, a valley in which it is desirable to live on account of its low altitude; but the upper part of Wyoming is high and cold.

In the utilization of the waters of the Snake arise some problems which are found elsewhere, but which can be stated very well here; and perhaps I had better dwell upon them at this point.

If the waters of the Snake should be taken out at points near together by small canals along the river and used on lands near to the river it will be much easier to develop the first, perhaps, 1,000,000 of acres of irrigation along that river. That is to say, it is possible to construct diverting dams and to take the water out of the river by piece-meal along the river here [indicating on the map] for the irrigation of the first 1,000,000 acres of land. If the water should be taken out high up on the river and carried far back over the valley, an area of four, five, six, seven, or eight times as large as I have mentioned—I can not say exactly how much larger until the surveys are completed—can be irrigated by those waters, and if they are taken out in this manner the cost per acre will be much less than if they were taken out by piecemeal.

But further than that, if it should be taken out piece-meal to irrigate 1,000,000 acres of land, then the rights become vested in irrigation works there, and then they can not go above and take the water out, because it will cut the water out from the people below, and they will have to be bought out to increase the area of irrigation. So that it becomes important, if all the waters of the Snake River are to be ultimately used for irrigation, and many million acres of land redeemed which can be redeemed in this manner, to provide now, before little canals are built along its course, that the Snake be taken out higher in a few places in great bodies, or we shall get into the same condition they are in in the valley of the Nile.

It is estimated that the waters of the Nile, which are now irrigating 5,000,000 acres, will serve three times that amount with an annual expenditure less per acre than it now costs to serve the 5,000,000 acres. But if works are to be constructed and the waters of the Nile taken out from the supplies above on the lands where drainage is not so necessary, it can be done only by buying out the interests on the Nile entirely. The English are now working at this problem of how to meet the necessity now existing and drain the lands that are now becoming swamp lands, and make the annual expenditure per acre much less and increase the area to be irrigated. The problem which I stated about the Snake River appears again and again in all the great streams of this country.

The Columbia River heads in British territory. It is a great river and carries a vast volume of water. After it crosses the boundary line between British territory and our own there is a great valley which can be ultimately irrigated, and there is abundant water which can be used. But a large part of the water that is to be used in the United States can be used only by constructing works on British territory; that is to say, a large part of the area which could be irrigated in the United States could not be irrigated without building works on British territory. But, on the other hand, the problem is not so serious. There is more water than the people of the British territory need.

The Kootenay River, one of the important tributaries of the Columbia, in British territory, flows into the United States and returns to British territory, and there arises an international problem; and so it is with a great many of the smaller streams along the border, streams which I need not stop to mention, where international problems are involved.

Passing over to the headwaters of the Missouri River, we find that the Milk River heads on British territory and flows down into the territory of the United States, and with regard to that river international problems are involved. Beside the international problems on the Missouri River we have these interstate problems: That river heads in Montana partly, in Wyoming in fact, and flows through both the Dakotas southward, so that ultimately there is to be devised some means of dividing its waters between Montana, North and South Dakota, and perhaps a part may ultimately be used in Nebraska. The Big Horn and Powder Rivers head in Wyoming and run northward into the Yellowstone, and the waters of each of these rivers have to be divided between Wyoming and Montana.

The Yellowstone itself presents some interstate problems. The chief storage area of the waters of the Yellowstone is in the National Park.

The Yellowstone Lake is a natural storage basin. In it can be stored waters for the irrigation of 300,000 or 400,000 or 500,000 acres of land. Along the Yellowstone River is an important problem worthy of brief mention here. The Yellowstone has its course through Montana in a deep cañon 400, 500, or 600 feet below the mesa above. Along its course is a valley varying from 2 and 3 to 6 and 7 miles in width. A part of that lower valley is valuable for irrigation; a part is not valuable, and if water were used over the whole of that valley it would be largely wasted. But the mesa lands above are good, and it would be necessary to take the waters of the Yellowstone above this region, high up, and spread them over the mesa lands on each side. The Cheyenne and Niobrara Rivers involve problems between Wyoming, the Dakotas, and Nebraska. The waters are to be divided between those sections, and the people are in conflict. Some very interesting letters have passed between the governors of those localities protesting against the use of these waters, and Congress has been appealed to.

Senator **CASEY**. Between Wyoming and Nebraska?

Director **POWELL**. Colorado and Nebraska, and likewise between the governors of Colorado and Kansas. Then below, along the Cimarron and Red Rivers, we have interstate problems.

I think I have dwelt long enough on this point; but I wanted to bring out the fact that something must be devised by the United States to solve these interstate problems which are imminent—some common scheme for dividing the waters between these States and Territories.

The **CHAIRMAN**. Before leaving that point I wish to ask a question. You spoke of the Missouri and Yellowstone. Have sufficient explorations of the Missouri been made to determine whether that river can be taken out or not?

Director **POWELL**. A very large part of the Missouri River can be used in Montana, a part in North Dakota, and another part in South Dakota. It can be used alike in Montana, North Dakota, and South Dakota. I will only mention here the major streams.

Captain **DUTTON**. The Missouri River can not be taken out below the Great Falls for a distance of 300 or 400 miles.

The **CHAIRMAN**. It will have to be taken out above the falls?

Director **POWELL**. It will have to be taken out above. The Yellowstone, like the Snake River, is a great river, and the ultimate utilization of these waters is to depend upon great canals.

Senator **CASEY**. Can the Missouri be taken out above the falls?

Director **POWELL**. It can be taken out between Bismarck and Helena.

Senator **CASEY**. That is the Yellowstone?

Director **POWELL**. No; the Missouri.

The **CHAIRMAN**. The Missouri has three forks there.

Senator **CASEY**. Can it be taken out just above the Great Falls.

Director **POWELL**. That is one of the questions to be examined this summer.

I will very briefly call attention to another problem—the great plain extending from British territory to Mexican territory. There is a region of four or five degrees in width, on a part of which irrigation is absolutely necessary, and on a part of which irrigation is conditionally necessary; that is to say, some years they need irrigation, while in other years the land can be cultivated without irrigation.

The **CHAIRMAN**. And always beneficially?

Director **POWELL**. And always beneficially. I have a map exhibiting the artesian wells of the arid lands, extending somewhat over the arid area and the plain east of the well-defined arid lands. This map needs a little explanation so that you may understand it.

Artesian wells have been found in great numbers. The geological basins in which these wells are found and known are colored in the main, as this [indicating on the map]. We have here a basin with many artesian wells in it [indicating].

We have another here [indicating]—the Colorado Basin, the Denver Basin, one in southern Colorado, one in southern Arizona, and one in southern California; another basin there [indicating], and those basins, the geology of which is pretty well known, are in Utah. You see them here [indicating on the map]. In addition to this the people have gone out of the basins geologically known and have experimented elsewhere. Among all those experiments are failures which do not appear on the map; but the successful wells appear and are represented by the dots you observe here [indicating on the map]. A dozen or fifteen wells have been found in that locality. Each dot does not necessarily represent a single well, but sometimes a small group of wells. In some places a single well is found and is represented by a dot. (See map.)

The CHAIRMAN. What is that group of wells there?

Director POWELL. That is in Texas, a part in the arid region and a part in the subhumid region.

Senator JONES. Are they flowing wells?

Director POWELL. Yes. I have not put in the non-flowing wells. There are a great many wells used for irrigation which do not flow over the surface, but the waters rise near the surface and are taken out by pumps. They do not appear on this map, however. The region of country of which I speak, stretching through there [indicating], is one of great interest because of the attempts which have been made to settle the country without resorting to irrigation. During the past fifteen or twenty years in many places other attempts have been made to settle the region. But the settlers who have gone in there have in the main left, settled and left, settled again and left, and so on from year to year. The region of country is on that border land which will be forever attempting cultivation without irrigation. But two, three, or four wet years will occur in succession, when agriculture will be quite successful; then will come two or three bad years and they will be disastrous and the people will migrate. Now, however, the people are appreciating the benefits of irrigation, and when they come to realize that irrigation is necessary for permanent success and prosperity the difficulties will disappear. But while the water supply is not sufficient to irrigate all that country, it is sufficient to irrigate large areas.

Now, I speak first of these artesian waters not because they are of the most importance or of greater magnitude, but because the people are looking in that direction more than any other.

The regions of country underlaid by artesian waters are not at all known from a geological stand-point—we can not say to what extent they are so underlaid. But there is sufficient evidence to lead one to believe that artesian waters are somewhat abundant.

A geological survey is necessary in order that the geological basins may be mapped, and then experimentations in the areas thus mapped will confine the work to regions where there is prospect of water, and by experiments in part and by geological examinations in part, it will be possible to determine what artesian waters are found in that region. When they are found they will be valuable for domestic and horticultural purposes. And though the cost of boring wells is large, and the cost of redeeming lands will be comparatively great, greater than the utilization of flowing rivers, yet the great value given the land by irrigation will warrant the expense.

Artesian reservoirs can never furnish waters for agriculture on a scale of sufficient magnitude to be considered as an important source of supply. The amount of waters which porous rocks will supply is always very insignificant compared with the amount necessary for irrigating any great tract of land. More than half the agriculture of the world is dependent on irrigation. Of this, a very insignificant amount depends on artesian wells. There are wells here and there in Europe, Asia, Africa, and America, and in some of the great islands, but altogether they furnish a very small amount of water for agriculture. If all the artesian wells used for irrigation in the world were assembled in Dakota, they would not irrigate a county of land. But there are other serious reasons why the attention of the people of the great plains should not be directed too confidently to this resource. It is the experience with artesian wells everywhere throughout the world that if too many are bored in any basin all are destroyed thereby. In the northern Illinois district, it was hoped that the great city of Chicago could be supplied with water for domestic purposes by artesian wells, but experimentation has proved that, while a few good wells could be secured, a great number was impossible; that the supply of water would be absolutely inadequate for the wants of the city; and so the authorities were compelled to resort to the lake for their supply. Now, to irrigate the site of the city of Chicago would take more water than to supply it for domestic purposes; so that the artesian wells of that district would be entirely inadequate to irrigate an area as large as the city, or perhaps one-fifth or even one-tenth of the area. Some years ago it was pointed out that the city of Denver and the region round about was the site of an artesian basin. The first well site proved to be very valuable, and the desire to secure water for domestic purposes therefrom led to their multiplication. More than three hundred have now been bored, and gradually with the progress of the boring the collapse of the wells has resulted, and now all the wells have to be pumped; there is little or no flowing water from them. These instances might be multiplied all over the world, and the experience of mankind testifies that it would be unwise to encourage the people of any district of country to depend upon artesian waters for irrigation on any large scale for farming. Waters for domestic purposes, for irrigating gardens, and for supplying stock ranches may thus be obtained in many regions, and the supply of water that can thus be furnished is of value; but when considered as a source for agriculture, for the cultivation of fields and large tracts of country, it will always be inadequate; and it is unwise to encourage any people to engage in agriculture on a large scale and depend on irrigation from artesian wells.

For the district of which I am now speaking, extending from the British to the Mexican line in a broad belt across the plains on both sides of the hundredth meridian, the people will ultimately be compelled to depend upon another source of supply, and one so important that in comparison therewith the artesian supply sinks into insignificance and seems hardly to be worthy the mention. I refer to the use of the storm waters. One-third of the agriculture carried on by irrigation throughout the world is prosecuted by the storage and use of storm waters, and the experience of mankind in this respect is replete with lessons that can not be neglected. The region to which this is especially applicable is the sub-humid region. It differs from what I have called the arid region in that it generally has a greater rain-fall, distributed more evenly over the country, as it is not interrupted by great mountains where the precipitation is concentrated, having from 15 to 22 inches of rain-fall in the average year; sometimes more, sometimes less. There are many years when agriculture is prosperous without irrigation; there are others when it fails without an artificial supply of water. Gradually with the progress of agricultural development it is possible to cover the country with storage basins, or tanks as they are usually termed, in which water may be held to be used in seasons of drought. By this means the farmers may be able to tide over the dry years, and farming may be made prosperous and highly remunerative thereby from year to year. It is in this direction that the attention of the people of that region should be turned.

There is another source of water for that country of far greater importance than that of artesian fountains, but far less than that of the storm waters. I refer to sand reservoirs along the channels of the streams, especially of the great rivers. In that region of country the stream valleys are often great beds of sand, into which sinks the water which comes from the distant mountains, and into which sink the storm waters that come from the adjacent hills. Experience in other countries shows that this source of supply is worthy of consideration, and the experiments now in progress in the Arkansas Valley give indications of like character.

Mr. Chairman, I have prepared a statement in relation to the artesian wells of the Great Plains which is partly in tabular form, with a brief explanation of the geologic conditions under which these artesian formations exist. With your permission I will present it.

GEOLOGICAL DATA RELATING TO ARTESIAN WELLS IN THE SUBHUMID REGION OF THE GREAT PLAINS.

THE DAKOTAS.

Location.—The artesian wells in the Dakotas are situated east of the one hundred and first meridian, and, with the exception of the one at Pierre, they are east of the one hundredth meridian. They occur in great numbers in the Red River Valley, making a belt through the Dakotas, with adjacent portions of Minnesota and Manitoba, and making a second nearly parallel belt running from Yankton northward to Devil's Lake.

Classification and reference to geological horizons.—The successful wells thus far bored in the Dakotas and adjacent regions, may be arranged in four groups, with reference to the geological horizons from which they derive their water supply. These are, (1) wells of little depth which do not pass through the drift; numerous in the Red River Valley; (2) those which penetrate to the Cambrian rocks, as at Grafton, N. Dak.; (3) those deriving their water supply from the middle or upper portion of the Cretaceous, illustrated by a single well in the western part of Cass County, and by several wells in the Red River Valley which pass through the drift; (4) those penetrating to the Dakota sandstone, the basal member of the Cretaceous. This group is important, and is illustrated by numerous wells ranging from Vermillion and Yankton northward to Devil's Lake.

Wells in the region adjacent to the Dakotas.—Artesian wells have been bored in the States and Territories bordering the Dakotas on the east, north, and west, a knowledge of which is valuable in discussing the possibilities of the subterranean water supply in those States themselves. The favorable conditions for supplying water in the Red River Valley extend northward into Canada, as far, at least, as Winnipeg, and eastward into Minnesota.

The successful wells in Manitoba, with the exception of one at Rosenfeld, about 20 miles northwest from Emerson and St. Vincent, are all in superficial deposits. The well forming the exception has a depth of 1,037 feet, and penetrates to the Cambrian. The water flowing from it is saline.

The shallow wells of Manitoba are as follows:

Location.	Depth.	Strata penetrated.	Water supply.
	Feet.		
Near Letellier	250	Drift (150 feet?) and Cretaceous or Silurian.	Saline and alkaline.
12 Manitoba Wells of Morris	250	.....do.	Do.
Dominion City	107	Drift till under lacustrine and alluvial beds.	Brackish.
Near Niverville (about twenty wells).	40-170	Drift, nearly all till	Good, fresh water.
Winnipeg (several wells)	50-100	......do.	Do.

The successful wells of eastern Minnesota which penetrate strata below the drift are as follows:

Location.	Depth.	Strata penetrated.	Water supply.
Houston County:	*Feet.*		
Brownsville	590	Cambrian	
Wabasha County:			
Lake City	820	......do.	
Goodhue County:			
Red Wing	450	......do.	
Dakota County:			
Hastings	1,160	......do.	
Mendota	857	......do.	Fresh, rising 10 feet above surface.
Freeborn County:			
Albert Lea	300	Devonian	
Blue Earth County:			
Minneopa Falls	1,000	Cambrian	
Nicollet County:			
Saint Peter	200	......do.	
Hennepin County:			
Minneapolis	205	Lower Silurian and Cambrian, *i. e.*, Trenton and St. Peter sandstone.	Fresh, abundant.
St Louis County:			
Tower	400	Archean schists	Do.
Traverse County:			
Brown's Valley	465	Cretaceous (Fort Benton shale), to Dakota sandstone.	Saline and alkaline.
Kittson County:			
Humboldt	644	Cambrian	Do.

The unsuccessful wells of eastern Minnesota are as follows:

Location.	Depth.	Strata penetrated.	Water supply.
	Feet.		
Mankato	2,204	Cambrian	Rose to 90 feet below surface.
Minneapolis	622	Trenton and Cambrian	
Do	1,431	......do	
Do	2,150	......do	
St. Paul	671	......do	
Do	850	......do	
Freeborn	950	Devonian	
Stillwater	3,500	Through Potsdam into Keweenawan	
Duluth	1,507	Archean	
Tracy	724	Through Cretaceous to granite	
Moorhead	1,425	Drift, 220; Cretaceous, 150; Archean, 1,055.	

The wells of Minnesota which are successful but do not penetrate below the drift are as follows:

Location.	Depth.	Strata penetrated.	Water supply.
Blue Earth and Faribault Counties:	*Feet.*		
Sterling, Mapleton, Wells, etc. (about two hundred wells in the vicinity of Maple River, on the area of the Glacial Lake Minnesota).	25-120	Till, with included seams of water-bearing sand and gravel.	Fresh, copious.
Douglas County:			
Osakis	60	do	Fresh, scanty.
Hudson	35	Glacial drift (till) with included seams of water-bearing sand and gravel.	Do.
The following are in the Red River Valley, on the area of the Glacial Lake Agassiz:			
Traverse County:			
Near Wheaton	119-182	do	Fresh, abundant.
Tintah	55	do	Do.
Do	45	do	Do.
Do	67	do	Do.
Near Tintah	35-160	do	Do.
Wilkin County:			
Champion Township, many wells.	50-66	do	Fresh, very copious.
Atherton	11	do	Fresh.
Do	37	do	Do.
Do	45	do	Do.
Clay County:			
Near Barnesville	35	All these go through thin lacustrine and alluvial beds, then are for most of their depth glacial drift (till), with seams of water-bearing sand and gravel.	All fresh, with copious supply.
Near Sabin	180		
Near Moorhead	100-228		
Kragnes	155		
Near Georgetown	180		
Becker County:			
Hamden	75		
Do	110		
Norman County:			
Perley	200		
Halstead	250		
Eight miles northeast of Halstead	165		
Do	219		
Ada	217		
Lockhart	140		
Lockhart vicinity	125-150		
From Ada to Crookston many wells	100-200		
Polk County:			
Near Kittson	80-112		
Do	140		
Carman	190		
Near Crookston	180		
Do	190	Alluvium and lacustrine beds, then glacial drift (till), in which are water-bearing seams of sand and gravel	Fresh, copious.
Do	205	do	Do.
Do	236	do	Do.
Vicinity of Crookston, probably one hundred wells.	165-240	do	Do.
Fisher	285	do	Alkaline and saline, copious.
Near Angus	45	do	
Do	70	do	
South Angus	253	do	Do.
Marshall County:			
Argyle	150	do	Do.
Do	285	do	Do.
Tamarack and vicinity.	74	do	Do.
Do	93	do	Do.
Do	218	do	Do.
Stephen	220	do	Do.
Do	240	do	Do.
Kittson County:			
Donaldson	45	do	Do.
Near Kennedy	95	do	Do.
Near Hallock	119	do	Fresh, copious.
Near Northcote	30	do	Do.
St. Vincent	165	do	Saline, copious.

West of the Dakotas wells have been bored in search of artesian water at the following localities:

Location.	Depth.	Strata penetrating.	Water supply.
	Feet.		
Glendive		Laramie or Fox Hills	
Miles City (fourteen wells)	180–550	Laramie (?)	
Billings	1,000		Not flowing.
Bozeman			
Helena	160	River gravels	200 gallons per minute.

Wells in the Dakotas.—The deep wells of the Dakotas, with exceptions noted later, are situated in a belt ranging from Vermillion and Yankton northward to Devil's Lake, and derive their water from the Dakota sandstone. The available data concerning these is given in the following table:

Locality.	Depth.	No. of wells.	Diameter of bore.	Temperature.	Pressure (per square inch).	Elevation (surface above sea).	Surface of Dakota (above sea).
	Feet.		*Inches.*	*° Fah.*	*Pounds.*	*Feet.*	*Feet.*
Vermillion	350					1,150	
Yankton	610	15	6	62	32	1,196	616
Do	165				140	1,196	
Yankton vicinity		15				1,196	
Tyndall	600				122	1,418	
Mitchell	1,300					1,301	
Plankinton	1,500				140	1,528	
Kimball	1,100				95	1,788	
Chamberlain						1,363	
Letcher	600					1,300	
Woonsocket	1,300				250	1,308	
Artesian City						1,313	
Vilas						1,480	
Huron	863		6	60	170	1,285	422
Brookings	900					1,626	
Miller	1,148		5	60	125	1,587	[illegible]
Highmore	1,552		6	68	25	1,890	[illegible]
Harold	1,300				80	1,801	
Hitchcock	965		3½–4½		186–218	1,139	
Redfield						1,300	
Frankfort						1,296	
Faulkton	1,300					1,595	
Gettysburgh	1,300					2,082	
Ashton	915		6	55	50	1,296	381
Andover	1,070		4½	64	90	1,476	406
Groton	960		5		187	1,301	341
Aberdeen	908	Many.	5$\frac{3}{16}$	60	140–160	1,300	396
Columbia	965		4⅝	60	176	1,304	339
Ipswich	1,270		6	65	70	1,530	200–300
Ellendale	1,087		4-5-6	65	125	1,453	366
Jamestown	1,476	2	6	70	95	1,400	50
Jamestown vicinity	1,321						
Devil's Lake	1,511		3½			1,470	39

Locality.	Artesian head (above sea.)	Water supply (per minute).	Can be irrigated by direct flow, allowing 4 inches for 3 miles.	Character of water.
	Feet.	*Galls.*	*Acres.*	
Vermillion		80	95	
Yankton	1,270	3,000	3,570	Slightly hard, drinkable, used in boilers.
Letcher		Large.		
Vilas				In process.
Huron	1,678	1,400	1,666	
Brookings		None.		Said to end in granite. Minnesota Geological Survey thinks this doubtful.
Miller	1,876	1,000	1,190	Excellent; good for all purposes.
Highmore	1,948	14	16.6	Soft and of good quality.
Pierre				In process.
Hitchcock				Used for irrigation.

Locality.	Artesian head (above sea).	Water supply (per minute).	Can be irrigated by direct flow, allowing 4 inches for 3 miles.	Character of water.
Faulkton	...	...	71	Abandoned; drilling another.
Ashton	1,411	60	...	
Andover	1,684	300	357	
Groton	1,733	...	...	
Aberdeen	1,670	3,500	4,165	
Columbia	1,708	4,000	4,760	Soft.
Ipswich	1,692	...	...	Soft (slightly brackish).
Ellendale	1,742	600	714	Soft; not pleasant to the taste.
Jamestown	1,690	375	446	Analysis given on page 11.
Jamestown vicinity	...	...	...	Abandoned.
Devil's Lake	1,575	40	47	

One hundred gallons per minute will give 4 inches of water to 119.3 acres in three months.

The wells enumerated above derive their water from the Dakota sandstone. Those at Vermillion and Yankton were begun in the Fort Benton. The remainder were begun in the Fort Pierre and pass through the Fort Benton.

Chemical composition.—The water in the wells indicated in the above table is generally brackish or alkaline, not therefore adapted for drinking or culinary purposes, and objectionable for use in steam boilers on account of the mineral salts deposited from it.

The water in the artesian well at Jamestown has been analyzed with the following result:

[Hardness, 21 degrees.]

	Parts per million.	Grains in U.S. gallon.
Test for organic matter:		
Free ammonia	2.4	...
Albuminoid ammonia	.046	...
Permanganate test:		
Oxygen consumed by carbonaceous oxygenic matter in three hours	6.7	...
Nitrates	None.	...
Nitrates	Trace.	...
Silica	35.7	
Alumina	3.5	2.0823
Carbonate of iron	2.2	.2041
Carbonate of lime	188.0	.1283
Sulphate of lime	249.0	10.6743
Sulphate of magnesia	154.2	14.5241
Sulphate of soda	1139.4	8.9044
Sulphate of potash	81.5	66.3602
Chloride of sodium	369.1	4.7523
Phosphates	Trace	21.5296
	2222.6	129.2496

Professor Dodge, the chemist who made the analysis, states that in his opinion this water would not be suitable for regular use as a drinking water.

A qualitative analysis of the water in the well at Devil's Lake has also been made by Professor Dodge, which shows that it is of about the same composition as the water in the Jamestown well.

The following notes from report of Irrigation Committee, Vol. I, 1883, in reference to the water from other wells of the same class as those just mentioned, is here inserted:

Yankton.—Water slightly hard; pleasant to the taste; is used in boilers and gives good satisfaction.

Highmore.—Water very soft and of good quality.

Miller.—Water excellent and good for all purposes.

Ipswich.—Water very soft; contains soda, potassium and allied salts; tastes slightly brackish.

Columbia.—Water contains mineral properties; very soft.

Ellendale.—Water not pleasant to the taste; very soft.

These analyses and notes indicate that the water derived from the Dakota sandstone does not contain sufficient alkaline salts to be injurious to vegetation, especially in a region that has a rain-fall as great as that of the eastern part of the Dakotas.

In various portions of the testimony before the Irrigation Commission, the beneficial effects of irrigation with the water of Dakota sandstone wells are mentioned.

The temperature of the water derived from these wells in general increases with the depth of the boring. This is shown in the following table:

Well.	Depth.	Temperature.	Well.	Depth.	Temperature.
	Feet.	*°Fah.*		*Feet.*	*°Fah.*
Highmore	1,890	68	Columbia	1,304	60
Miller	1,587	80	Aberdeen	1,300	60
Ipswich	1,530	65	Ashton	1,296	55
Andover	1,476	64	Huron	1,285	60
Ellendale	1,453	65	Yankton	1,196	62
Jamestown	1,400	70			

Pleistocene wells.—The wells which do not penetrate below the drift are situated in the Red River Valley, principally in the bed of Lake Agassiz. The formation a few miles back from the river is glacial till, nearer the river the till is overlain by lacustral salt. Fresh water is obtained from the wells south of Blanchford, N. Dak., and Crookston, Minn. Farther north their waters are almost invariably brackish and alkaline, and not suitable for household use or drinking, although they are liked by cattle and horses, and are not injurious for this purpose.

The wells in the Red River Valley number more than one thousand. Of these about one-half are in North Dakota. They range in temperature from 46° to 50° Fah. in the south, to 42° Fah. at the north. The available data concerning a few of those in North Dakota is here inserted:

Location.	Depth.	Strata penetrated.	Water supply.
	Feet.		
Richland County:			
Farmington	93	Thin alluvial and lacustrine beds; then the principal thickness consists of glacial drift (till), in which are water-bearing seams of sand and gravel.	Fresh, copious.
Dwight, vicinity (ten wells)	85-110		
Colfax	85		
Do	125		
Do	128		
Do	135		
Walcott	110		
Do	120		
Walcott, vicinity	104		
Do	131		
Do	227		
Cass County:			
Durbin	160		
Everest	160		
Argusville	157		
Do	158		
Argusville, vicinity	130		
Do	153		
Gardner	125		
Gardner, vicinity, (many wells)	96-200		

Location.	Depth.	Strata penetrated.	Water supply.
Cass County—Continued.	*Feet.*		
Grandin (within an area of 50 rods).	105 158 187 248		
Traill County:			
Quincy	213		
Kelso	109		
Do	110		
Kelso, vicinity	110		
Do	175		
Blanchard (ten wells)	175-404	Partly in cretaceous	Brackish, copious.
Hillsboro	105		
Do	125		
Do	175		
Do	198		
Grand Forks County:			
Grand Forks	265		
Do	270		
Manvel	166		
Do	175	Thin alluvial and lacustrine beds; below these a great thickness of glacial drift (till), in which are water-bearing seams of sand and gravel.	All in this northern part of the valley are brackish and alkaline.
Walsh County:			
Ardoch	164		
Minto	196		
Do	200		
Grafton	156		
Auburn	175		
Pembina County:			
St. Thomas	175		
Glasston	200		
Hamilton	179		
Bathgate	143		
Bathgate, vicinity (eleven wells)	130-160		
Neche, vicinity	220		

The wells not included in the classes already noted are as follows:

Location.	Depth.	Strata penetrated.	Water supply per minute.
	Feet.		*Gallons.*
Grafton	915	Passed through stratified rocks to granite.	1,000.
Tower City	670	Fort Pierre shales to Niobrara horizon.	9½; rises 33 feet.
Casselton and vicinity	317-350	Passed through the drift into cretaceous rocks.	Brackish alkaline, copious.
Amenia and vicinity	250-279	do	Do.
Blanchard and vicinity (six wells)	300	do	Do.
Mayville	395	do	Do.

All of the wells enumerated in the last table, excepting the one at Tower City, are situated in the Red River Valley, and passing through the glacial drift enter older formations.

The one at Grafton passes through the Cambrian and into the granites beneath. Water was first reached at the depth of 503 feet; 400 feet deeper and resting on granite, a second sandstone stratum was reached which contained saline water. The well was continued 12 feet into the granite, but was subsequently filled so as to receive water only from the first water-bearing strata reached.

The remainder of the wells in the Red River Valley which pass through the drift are supposed to derive their supply from the middle portion of the Cretaceous.

Sources of water supply.—The source of the water in the wells which do not pass through the drift, although indefinite and perhaps impossible to determine accurately, owing to the irregular stratification of the deposit, is certainly not distant, and depends on the rain-fall and topographic configuration of the immediate region. It is possible, however, that the salt wells in this region may be supplied from springs in older rocks which are deeply drift-covered. The principles applicable to continuous water-bearing strata included between impervious beds and conducting water from distant sources, can not be applied to wells of this class.

The wells which derive their supply from the Fort Pierre, Fort Benton, Dakota, and Cambrian formations, on the other hand, penetrate evenly bedded strata, and depend for their supply on the hydrostatic pressure of water derived from distant sources.

In order to determine the source of the water in these wells, one must ascertain where the water-bearing strata out-crop at an elevation sufficient to insure a flow at the surface where the wells are situated.

The Cambrian and Silurian rocks underlying the eastern portion of the Dakotas come to the surface in Minnesota and adjacent portions of Canada. It is barely possible, as I have been informed by C. R. Van Hise, that these strata may derive their water from the eastern outcrops indicated. A general western inclination of these rocks from their outcrops west and north of Lake Superior seems probable from what is known concerning them, but the data in hand are not sufficient to warrant positive conclusions.

The eastern outcrop of the Cretaceous system coincides in North Dakota with the eastern escarpments of the Coteau des Prairies along the western border of the Red River Valley. Its western outcrop is along the eastern bases of the various front ranges of the Rocky Mountains and about the Black Hills.

The elevation of the region in which the wells penetrate the Dakota sandstone in the eastern part of the Dakotas is from 1,000 to 1,900 feet above the sea. The water comes to the surface under a pressure of from 15 to 187 pounds per square inch. The maximum is at Groton, the altitude of which is 1,300 feet above the sea. The pressure in this well is sufficient to raise the water 432 feet, and even if the loss of pressure by friction is not considered it is evident that the source of the supply must have an altitude of at least 1,700 feet above the sea. The pressure in other wells in the same series indicates a source of supply at an elevation of 1,950 feet. It is known from railroad surveys and other sources that there is no land to the south, east, or north of Groton at a sufficient elevation to furnish water under the pressure given, even if the water-bearing strata outcrop at the surface under the most favorable conditions. The eastern outcrop of the Dakota sandstone in South Dakota and the adjacent portion of Nebraska has a maximum elevation of about 1,500 feet. It seems evident, therefore, that we must look to the west for the fountain-head of the wells which reach the Dakota sandstone. The nearest outcrop of that formation at the west is about the Black Hills at an elevation of approximately 3,300 feet above the sea. It comes to the surface again still farther west, about the eastern base of Big Horn Mountains, at an elevation of about 4,500 feet.

The general inclination of the Dakota sandstone and of the strata which rest upon it is known to be eastward from the eastern base of the Rocky Mountains, although a secondary structure producing anticlinals probably exists. From what is known of the succession of strata in the eastern and western outcrop of the Cretaceous, and from the suggestion furnished by the high pressure of the water derived from the lower member of the series in eastern Dakota, it seems exceedingly probable that the Dakota sandstone forms a continuous stratum beneath the Great Plains. If the water obtained from this stratum is derived from the Rocky Mountain region as indicated by our present knowledge, it follows that success might be expected if wells were bored in the region between the Red River Valley and the eastern basin of the Rocky Mountains.

The thickness of the Dakota sandstone as given by F. V. Hayden at its outcrop about the Black Hills is 400 feet. At Lincoln, Nebr., as stated by Professor Hicks, it is 204 feet. Along its outcrops it is a porous sandstone sometimes passing into a conglomerate, and where it has been penetrated by borings in the Dakotas it is very friable and open in structure. Its thickness, porosity, and extent, as well as its attitude, so far as is known are all in favor of its being an abundant source of artesian water.

Thickness of strata above the Dakota sandstone.—The formations which occur in the general region under discussion, as given by F. V. Hayden, are as follows:

Name.	Character of strata.	Thickness.
		Feet.
Loup River beds	Fine loose sand, with some layers of limestone	300-400
White River group	White and light drab clays, with some cavities of sandstone and local layers of limestone.	1,000
Wind River deposits	Exposed principally in Nebraska	1,500-2,000
"Fort Union," Laramie	Sandstone with shale	2,000-10,000
Fox Hill	Gray ferruginous and yellow sandstone and arenaceous clays.	500
Fort Pierre	Dark gray plastic clays above; dark beds of very fine unctuous clay, containing much carbonaceous matter with veins and seams of gypsum, etc., below.	700
Niobrara	Lead gray calcareous marls above; light yellowish and whitish limestones below.	200
Fort Benton	Dark gray laminated clays, sometimes alternating near the upper part with layers of light gray limestone.	800
Dakota	Yellowish, reddish, and occasionally white sandstone, with alternations of various colored clays and beds of lignite.	400

The surface throughout the region occupied by the Dakotas has been greatly eroded and it is not probable that the entire series as given above anywhere exists. It is to be expected also that the strata above the Dakota sandstone may be found of variable thickness and lithological character. These considerations as well as the secondary structure of the Great Plains would have to be investigated in order to predict for any locality at what depth the water-boring strata might be reached. Some of the wells in eastern Dakota derive their water supply from middle Cretaceous. The conditions to the west of where these wells are located seem equally favorable for obtaining flowing water from this horizon. It is to be expected, however, that water derived from these strata would be less pure than from the Dakota sandstone and consequently of doubtful value for irrigation. The Laramie may also be expected to yield artesian water.

Beneath the Dakota along the western outcrops there are shales and other impervious strata belonging to the Triassic system. It is to be expected that these coarse Triassic beds will carry water, but the great depth at which they occur underneath the Great Plains probably renders their consideration as a source of water supply necessary; besides, the Triassic strata are so highly charged with easily soluble salts that water derived from them would be too alkaline and saline for irrigation or domestic use.

NEBRASKA.

The geological formations of this State comprise the Upper Coal Measures, and possible Permian; the Cretaceous, but including only the Dakota, Fort Benton, Niobrara, and Fort Pierre, and the White River Tertiary of Hayden.

Lithological composition.—The component beds of the Coal Measures are shales, limestones, and sandstones, in alternating bands; the limestones of greater or less thickness form a prominent feature of the outcrops along the Missouri and in the numerous railroad and water cuts leading to this river.

The Cretaceous formations present the following composition: The Dakota, from 300 to 400 feet of a soft, loose textured, white sandstone, separated by narrow beds of shale into bands of from 50 to 80 feet; its width of outcrop in Nebraska is about 60 miles. The Fort Benton, a series of dark black or bluish gray, compact, argillaceous, shales, with a few narrow limestone bands; in thickness between 300 and 800 feet, but probably nearer the former figure in Nebraska. The Niobrara, between 200 and 400 feet in thickness, composed of shales and limestones, the latter a most prominent feature of the formation, and in Dakota, Nebraska, and Kansas of a decidedly chalky nature rather than that of a massive, hard limestone, as along the foot-hills of the Rocky Mountains. The Fort Pierre, essentially a formation of light gray, plastic, clay shales, of variable thickness in Nebraska, owing to its deposition in undulations of the Niobrara below, and to erosion from its summit prior to the laying down of the White River Tertiary above.

The White River Tertiary is a formation of sandstones, conglomerates, and interbedded shales. It is the surface formation of western Nebraska and southwestern Dakota, where it rarely shows a thickness of over 400 or 500 feet.

Areal distribution.—The areal lines of division between the Tertiary, Cretaceous, and Carboniferous ages are clearly defined. That between the Cretaceous and Coal Measures, which also constitute the eastern limit of the Dakota formation in Nebraska, crosses the Missouri River a short distance below Dakota City, follows down the west side of the river a few miles inward from its bluffs to a point on the Platte about 8 miles above its mouth, when it inclines to the southwestward, passes through Cass, Otoe, Johnson, and Gage Counties, and joins the eastern boundary assigned the formation in Marshall County, Kans. The line of division between the Cretaceous and Tertiary crosses the northern boundary of the State in longitude 100, the southern in 99, and within these limits has a broad convexity to the east, crossing the Platte a little to the east of the ninety-eighth meridian; with the exception of a small area of erosion on the upper Republican, in which the Pierre shales are exposed, the entire State west of this line is occupied superficially by the White River Miocene.

Non-conformities exist both above and below the Cretaceous, the Dakota resting in uneven line upon the Coal Measures or Permian, the White River upon the greatly eroded surface of the Pierre; furthermore, here as elsewhere there also exists abundant evidence of a prominent break in the continuity of deposition between the Niobrara and Fort Pierre formations, within the Cretaceous itself.

Geological structure.—The geological structure of Nebraska is that of gently inclined strata, having a general dip to the eastward somewhat less than the slope of the surface, with a slight "basining up" of the formations in the eastern part of the State, the dip there being to the northwest in continuation of that of the corresponding beds in Dakota and Kansas.

The following altitudes in Nebraska, which are of use in connection with the geological structure, are from Aughey's "Physical Geography and Geology of Nebraska" and Gannett's "Dictionary of Altitudes in the United States."

Locality.	Altitude.	Remarks.
	Feet.	
Scott's Bluffs, on State line	6,051	Northern line of State.
Niobrara River, southeast of Fort Robinson	4,118	
Indian Creek, northwest corner of State	4,013	
Fort Robinson, 103° 30′ meridian	3,781	
Mouth of Snake River, one hundred and first meridian	2,690	
Mouth of Keya Paha, ninety-ninth meridian	1,960	
Niobrara, ninety-eighth meridian	1,240	
Pine Bluffs, one hundred and fourth meridian	5,061	In the southern half of State.
Sidney, one hundred and third meridian	4,095	
Ogallala, one hundred and second meridian	3,216	
Kearney, ninety-ninth meridian	2,157	
Average of five, on ninety-seventh meridian	1,203	Northern to southern boundary.

Central City, the lowest point on the eastern line of the Tertiary, has an altitude of 1,708 feet. The eastern boundary of the Cretaceous will lie between 1,000 and 1,200 feet, a fall of at least 3,000 feet from the western line of the State.

Artesian wells.—Nebraska has apparently been but slightly explored with reference to the possibility of artesian wells. Record has been found of but four, one at St. Helena, a short distance below Yankton; one at Omaha; one at Lincoln, a mineral water; and one at Brownville, in Nemaha County, in the southeastern part of the State.

That at St. Helena derives its waters from the Dakota sandstones, at a depth of 400 feet, and in reality belongs to the system of South Dakota. The flow is copious.

The wells at Omaha, 750 feet, Lincoln, 985, and Brownville, 1,001 feet, derive their water from various strata in the Coal Measures. Of these the well at Omaha affords pure, fresh water. The Lincoln well yielded fresh water (not artesian) at a depth of 100 feet; a strong brine at 244 feet, the base of the Dakota, and medicinal water at 544 feet. The last is the water used. The flow is strong. Of the Brownville well no record of its water can be found.

From the above facts it is observed that the great water-bearing formation of the eastern part of the prairie region has been tapped at but one advantageous point in Nebraska, at St. Helena. Although the geological structure of Nebraska does not afford the confining beds of granite, quartzite, etc., to the easterm rim of the Dakota formation as it does in the Dakotas, nevertheless it is reasonable to presume from the success attending boring in the State of Kansas to the south, where the conditions are approximately the same as in Nebraska, that water may be obtained at numerous points over this belt; furthermore it is not impossible that the Tertiary beds themselves may afford flows at advantageous points within the area covered by them.

Tabular statement relating to the artesian wells of Nebraska.

Geological horizon.	Location.	Depth.	Delivery.	Remarks.
		Feet.		
Dakota	St. Helena, Cedar County	466	Copious	Pure.
Carboniferous	Omaha, Douglas County	750	Good	Do.
	Lincoln, Lancaster County	985	Copious	(1) Brine from 244′ (Dakota), cased off. Mineral from 544′ Carboniferous.
	Brownville, Nemaha County	1,001		(2) No other data
	Beatrice, Gage County	1,200		(3) No flow.

KANSAS.

The geological formations included within the area of Kansas comprise the Subcarboniferous, the Coal Measures, the Upper Carboniferous and Permian, the Trias, the Cretaceous, including, however, only the Dakota, Fort Benton, and Niobrara, and a Tertiary formation, probably Miocene.

Lithological composition.—The Subcarboniferous is recognized in the well-known Subcarboniferous limestone, and occurs only in the very southeastern corner of the State.

The Coal Measures, Upper Carboniferous, and Permian are an alternation of sandstones, limestones, and shales. In the Coal Measures the shales are often locally developed to great thickness; the limestones are very persistent, and the sandstones are rather subordinate. In the higher formations the sandstones become more prominent. The thickness of the Coal Measures is at least 1,000 feet, while the Permian and Upper Carboniferous comprise about 2,000 feet.

The Triassic shales, limestones, and "Red Beds" (shales with narrow sandstone bands), of a variable thickness up to 300 feet, succeed the Permian and Carboniferous rocks. It is probable that this formation is wanting in the northern portion of the State towards the Nebraska line.

The Dakota formation, as in Nebraska, is largely composed of sandstone, but with a somewhat greater development of shales; it varies in thickness between 300 and 500 feet.

The Fort Benton ranges in thickness from 50 to 260 feet—a wide variation—and in its component beds departs a little from the normal composition further north. According to Professor Mudge its upper 60 feet is a bed of limestone, in layers from 1 to 3 feet thick, underlain by 60 feet of bluish-black shale abounding in concretions of a calcareous nature, this series underlain in turn by 140 feet more of shales, somewhat variable in composition and with several narrow bands of limestone distributed through them.

The Niobrara is of nearly its usual character, but is rather more chalky in appearance. Its thickness in Kansas varies from 75 to 200 feet.

The maximum thickness of the Cretaceous in Kansas is estimated by Professor Mudge to be about 900 feet. The basal member, the Dakota, rests unconformably upon the Carboniferous below.

The Tertiary of Kansas consists of cemented coarse-grits and sandstones. Its age is regarded by Robert Hay as Miocene. It is everywhere unconformable with the Cretaceous.

Areal distribution.—The areas covered by the several formations of Kansas are: for the Trias, Permian, and Carboniferous the southeastern third of the State; for the Cretaceous, a broad median belt lying in a northeast-southwest direction; for the Tertiary, the northwestern fifth of the State, together with a small extension from Colorado into its southwestern corner.

The line of division between the Cretaceous (Dakota) and the formations below starts at the Nebraska line, in Marshall County, follows a somewhat irregular line through Washington, Clay, Dickinson, Morris, Marion, McPherson, Rice, Reno, Pratt, Comanche, and Clarke Counties, where it crosses the southern boundary of the State. Its western boundary, or the line between it and the Tertiary, starts in Jewell or Phillips Counties, and passes with irregular trend west-southwestward, leaving the western boundary of the State a short distance north of the Arkansas River.

Of the Cretaceous formations the Dakota occupies a belt along the eastern border of about 50 miles' width, the remainder being occupied by the Fort Benton and Niobrara, but largely by the latter.

The geological structure.—Although both the Carboniferous beds and the eastern half of the Cretaceous exposures have a gentle dip to the westward, there is nevertheless a general rise of the beds to the westward, especially well brought out in the Cretaceous series itself by the exposure of its several members along the western border of the State. This rise, so far as the Cretaceous is concerned, amounts, according to O. St. John, to from 1,100 to 1,700 feet, the altitude of its exposures in Hamilton County being in the vicinity of 3,150. There is, therefore, as in Nebraska, a general eastward fall of the water-bearing beds, with a in slight though pronounced "basining up" to the eastward, with the axis in the region of Larned, extending northeast and southwest.

Artesian wells.—The artesian wells of Kansas derive their waters from four different formations: The Miocene, Dakota, Trias, and Carboniferous. Of these the Miocene wells—with two possible exceptions in Norton and Sheridan Counties in the northwestern part of the State—are at present confined to Meade County on its southern boundary; the Trias wells occur, one at Richfield in Morton County, and one at Larned in Pawnee; the Carboniferous, one at Russell, Russell County, and one at Winfield, Cowley County, while the remaining or Dakota wells are distributed over the Cretaceous belt from near the Nebraska line to that of the Indian Territory.

The Miocene wells of southwestern Kansas have their source in the Miocene grits and sandstones already mentioned as present in this portion of the State. These coarse, arenaceous, and pebbly beds are covered by a soft, bluish, putty-like clay or gumbo, which forms the subsoil of the region, is thoroughly impervious, and is the effective confining stratum for the waters beneath. The gravelly beds receive their waters at their outcrops in the very western part of the State and in Colorado into which they extend. The wells number about sixty or seventy and vary in depth from 50 to 185 feet. A number of them flow from 18 to 36 gallons per minute, and a still greater number flow only from 1 to 6 gallons. None of them are strong wells, though the water of some of the lower ones will rise from 15 to 20 feet above the surface. Concerning the wells in Norton and Sheridan Counties nothing of detail is known.

The wells of the Trias, at Richfield and Larned, derive their waters respectively from depths of 570 and 750 feet. The Richfield well yields 6.3 gallons per minute, but is somewhat mineralized. The Larned well flows over 250 gallons per minute, and rises as a fountain between 10 and 15 feet. Its waters are a strong brine with medicinal properties.

Of the Carboniferous wells, that at Russell is 977 feet deep, the one at Winfield 1,200 feet; both have good flows, but are strongly saline.

The Cretaceous wells of Hamilton County are the only ones of which detailed data exist. They are numerous, range from 200 to 300 feet in depth, and flow from 45 to 100 gallons per minute. Some of them are used for irrigation purposes. The well at Great Bend is 1,400 feet deep, but receives its waters, which are saline, from the Dakota sandstone at a depth of 344 feet. It has a strong flow, which rises 30 feet above the surface.

From the geological structure of Kansas and the results of borings in other States it is quite possible that the Coal Measures may be found productive of artesian waters whenever attempts with this special object in view shall be made.

Tabular statement relating to the artesian wells of Kansas.

No.	Geological horizon.	Location.	Depth.	Caliber.	Delivery per minute.	Remarks.
			Feet.	*In.*	*Galls.*	
1	Tertiary	Edward's well, Meade Co	155	....	36.00	Pure.
2	....do	......do	165	....	32.4	Do.
3	....do	......do	185	....	29.6	Do.
4	....do	Mart's well, Meade Co	140	....	66.6	Do.
5	....do	Bower's well, Meade Co	125	....	37.3	Pure; waters rise 15-20 feet above surface. Temperature Meade Co. wells 60° F.
6	....do	Norman's well, Meade Co	127	....	37.3	
7	....do	Cox well, Meade County	175	....	9	Pure.
8	....do	......do	142	....	9	Do.
9-68	....do	60 other wells, Meade Co	50-175	....	1-30	Do.
69	Tertiary ?	Norton, Norton County	....	....	....	No data; may be Dakota; depends on depth.
70	....do	Hoxie, Sheridan County	....	....	....	
71	Dakota	Smith Centre, Smith Co	....	....	....	No data; may be Tertiary; depends on depth.
72	....do	Great Spirit Spring, Mitchell County.	....	....	....	Natural artesian flow.
73	....do	Miltonvale, Cloud County	....	....	....	No data as to water.
74	....do	Wa Keeney, Trego Co	....	....	....	Do.
75	....do	Hays City, Ellis County	....	....	....	Do.
76	....do	Great Bend, Barton Co	344	....	6.75	Saline; well bored to 1,400 feet, but water from 344 feet; rises 30 feet above surface.
77	....do	Kinsley, Edwards County	....	....	....	No data as to water.
78	....do	Dodge City, Ford County	....	....	....	Do.
79	....do	Santa Fé, Haskell County	....	....	....	Do.
80	....do	Ulysses, Grant County	....	....	....	Do.
81	....do	Opera House, Coolidge, Hamilton County.	239	....	45	Pure; water rises 15-20 feet above surface; now choked owing to opera-house fire. Temperature 61° F.
82	....do	Peck's well, Coolidge, Hamilton County.	298	6	100	Pure and medicinal; water rises 15-20 feet above surface; medicinal properties slight. Temperature 61° F.
83	....do	Border's well, near Coolidge, Hamilton County.	200	....	8	Pure; water rises 15-20 feet above surface; used for irrigation. Temperature 61° F.
84	....do	Burt's well, near Coolidge, Hamilton County.	275	....	35	Do.
85	....do	Nolan's well, near Coolidge, Hamilton County.	240	....	53	Do.
86	....do	Rich's well, near Coolidge, Hamilton County.	240	....	50	Do.
87	....do	Syracuse, Hamilton Co	1,000	....	....	Water rose only to 90 feet below surface.
88	....do	Ashland, Clark County	....	....	....	No data as to water.
89	Triassic	Richfield, Morton County	600	....	6.3	Pure and medicinal; mineralization slight. Temperature 66° F. Dakota furnished no flow; penetrated Trias 265 feet; water from 570 feet.
90	....do	Larned, Pawnee County	750	....	250	Saline and medicinal; water spouts 10-15 feet high Temperature 66° F.
91	Carboniferous	Russell, Russell County	977	....	Good	Saline; may be Triassic.
92	....do	Winfield, Cowley County	1,200	....	..do	Saline; rises 6 feet above surface.

TEXAS.

The geological formations of Texas involved in the areas of artesian wells include the Coal Measures, the Cretaceous, and the Tertiary.

Lithological composition.—The Coal Measures consist principally of limestone, sandstone, millstone-grit, and shale. The limestones and sandstones exist in about equal proportions and constitute the chief part of the formation. The sandstone is both massive and thin bedded, is fine grained or course, passes into grit, or conglomerate, and exhibits every degree of hardness. It is interbedded with shales in successive strata reaching 100 feet in thickness.

The Cretaceous of Texas differs considerably from that at the north. According to Shumard it consists of an upper and lower member. The former consists of limestone and sandstone, in southern Texas the limestone predominating, but being largely replaced by sandstone in northern Texas, the limestone here occurring in thin bands separating the heavier beds of sandstones.

The Lower Cretaceous is composed chiefly of marly clays with some limestone, sandstone, and gypsum. The clays and sandstones occur in alternating beds of variable thickness. The sandstone is fine-grained to coarse, thinly laminated, is often calcareous, and usually quite soft.

Both Upper and Lower Cretaceous vary greatly in thickness, the former reaching a maximum of 1,000 feet on the San Pedro River, the latter 2,500 on the upper Red River.

The Tertiary formation to be considered in this connection occurs as a bed of soft, white sandstone 200 feet thick, known as the Carrizo sandstone. It rests unconformably on the Cretaceous, as does the Cretaceous upon the Coal Measures.

Areal distribution.—The Coal Measures, not less than 2,000 feet thick, are confined to the northern half of the State. They are overlaid by a narrow belt of Permian on their west, the area of the two being inclosed on the east, south, and west sides by the various strata of the Cretaceous, chiefly those of the lower division. The western boundary of the Permo-Carboniferous formation passes through Baylor, Throckmorton, Jones, Taylor, Runnells, Concho, and Menard Counties, the eastern through Montague, Palo, Pinto, and Lampasas Counties.

The Cretaceous series as a whole is of wide extent, the portion west of the Carboniferous area reaching far beyond the western boundary of the State into New Mexico. The prevailing dip of the Cretaceous and Carboniferous formations from near the eastern edge of the latter westward is to the northwest; east of this point it is to the eastward.

The extent of the Carrizo sandstone is at present unknown. Its western boundary has been traced for a distance of about 100 miles, from near the town of Uvalde, southward to the Rio Grande River. Its dip is to the southeastward.

Artesian wells.—The artesian wells of Texas derive their waters from the sandstones of the Coal Measures, from those of the Cretaceous, and from the Carrizo sandstone of the Tertiary.

Of the depth or flow of the wells within the limit of the Coal Measures nothing is at present known, but it is probably somewhat variable from the very nature of their component strata.

Of the depth or flow of the greater number of the Cretaceous wells likewise nothing is known. In the southern part of the State, however, existing data enable the following statement:

The wells of San Antonio, two in number, 225 feet and 450 feet in depth, probably both derive their waters from the lower portion of the Cretaceous, though it is possible the deeper one, to the east of the city, may find its supply in the Coal Measures. The former of the two wells affords an excellent drinking water and has a steady, though not strong, flow; the latter has also a steady flow, stronger than that of the shallower well, and its waters, although used for ordinary drinking purposes, have medicinal properties that may render them of special value in the future.

The Cotulla well, 1,008 feet deep, is also probably of lower Cretaceous origin, though it may extend a short distance into the Carboniferous; its waters have a strong flow and are of superior medicinal properties.

In the northern portion of the State, the wells of Fort Worth and Dallas derive their waters from the basal sandstones of the Cretaceous, at a depth of 350 and 750 feet, respectively. The dip is to the eastward. In this section the upper confining stratum is apparently the limestones of the chalk formation (Niobrara ?).

The Tertiary well at Carrizo Springs penetrates the Carrizo sandstone to a depth of 175 feet, and has an excellent flow of fresh water four inches in diameter.

Tabular statement relating to the artesian wells of Texas.

No.	Geological horizon.	Location.	Depth.	Caliber.	Delivery.	Remarks.
			Feet.	*In.*		
1	Tertiary	Carrizo Springs, Dimmit County.	175	4	Good	Pure.
2	Lower Cretaceous (probably Dakota).	Cotulla, La Salle County	1,008		do	Medicinal; jets above surface 6 ft.; water alkaline-saline. Temperature 86° Fah.
3	do	San Antonio, Bexar Co	225		do	Pure.
4	do	San Antonio (near), Bexar County.	450		do	Pure and medicinal; could be used for medicinal purposes.
5	do	Dallas, Dallas County	750		do	Pure.
6	do	Fort Worth, Tarrant Co	350		do	Do.
7	do	Weatherford, Parker Co				No data as to water.
8	do	Canadian, Hemphill Co				
9	do	Tascosa, Oldham County				
10	do	Armstrong, Armstrong Co.				
11	do	Mobeetie, Wheeler County				
12	do	Clarendon, Donley County				
13	do	Childress County				
14	do	Cottle County				
15	do	Floyd County				
16	do	Margaret, Hardman Co				
17	do	Crosby County				
18	do	Pepper's Ranch, Kent Co.				
19	do	Haskell, Haskell County				
20	do	Anson, Jones County				
21	do	Roby, Fisher County				
22	do	Snyder, Scurry County				
23	do	Dawson County				
24	do	Trent, Taylor County				
25	do	Sweetwater, Nolan County				
26	do	Colorado, Mitchell County				
27	do	Big Springs, Howard Co				
28	do	Marienfeld, Martin Co				
29	do	Midland, Midland County				
30	do	Glasscock County				
31	do	Coke County				
32	do	San Angelo, Tom Green County.				
33	do	Centralia, Tom Green Co				
34	do	Aroya, Ward County				
35	do	Toyah, Reeves County				
36	do	Wild Horse, El Paso Co				
37	Carboniferous	Wichita Falls, Wichita County.				
38	do	Archer, Archer County				
39	do	Henrietta, Clay County				
40	do	Montague, Montague Co				
41	do	Throckmorton, Throckmorton County.				
42	do	Jacksborough, Jack Co				
43	do	Palo Pinto, Palo Pinto Co.				
44	do	do				
45	do	Albany, Shackleford Co				
46	do	Abilene, Taylor County				
47	do	Tebo, Taylor County				
48	do	Baird, Callahan County				
49	do	Eastland, Eastland Co				
50	do	Eastland County				
51	do	do				
52	do	Stephenville, Erath Co				
53	do	Comanche, Comanche Co				
54	do	Coleman, Coleman Co				
55	do	do				
56	do	Runnells, Runnells Co				
57	do	San Saba, San Saba Co				

In the hasty review which has thus been made of the various drainage basins of the arid region, I have pointed out that there are a number of international questions involved in the use of the rivers for irrigation. One of these questions you have already had presented to you, namely, that of the Rio Grande Del Norte, where the rights of the people of the Republic of Mexico as well as the rights of the people of Texas are threatened and almost destroyed by the people of Colorado and New Mexico. Already claim has been made for more than $1,000,000 by the people of the lower country to re-imburse them for their lost values, or to restore to them by some means the volume of water necessary to carry on their long-established industries of agriculture. Ultimately the problem on the Colorado will be of far greater magnitude. The Colorado itself can be used in our territory, or in Mexican territory, and can be made to irrigate in one or the other country, or in both, many millions of acres. Above, it is in the United States; below, it is in Mexico. Who shall divide the waters between the two nations? On our northern boundary line similar questions are asked. The Columbia and some of its tributaries, some of the tributaries of the Missouri, and others of the Saskatchewan running northward, cross the boundary line, so that their waters must be divided between the two nations. Altogether the problem of the utilization of the rivers for irrigation in the western half of the United States presents international questions, that must ultimately be settled, far exceeding in importance and in values those that relate to fisheries, or any other international subject affecting the industries of the country. In some localities the questions press for solution now; in others they will arise in the immediate future, and must be solved if peace is maintained.

The international problems sink into insignificance in comparison with the interstate problems. Every great river and every great tributary of the entire arid region and of the subhumid region, or more than one-half of the area of the United States, exclusive of Alaska, runs through two or more States and Territories. In a few cases they are boundary lines, in others they head in one political division and run through another. In all these cases the waters must be divided on some equitable and wise principle. In general the headwater States and Territories have it in their power to control the situation. They can take the water and laugh at the rights of the people lower down the rivers. The North Platte is to be divided between Wyoming and Nebraska; the South Platte between Colorado and Nebraska; the Arkansas between Colorado and Kansas; the Canadian River between New Mexico and the Indian Territory; the Pecos between New Mexico and Texas; the Rio Grande del Norte between Colorado, New Mexico, Texas, and the Republic of Mexico; the Colorado between Wyoming, Utah, Colorado, Arizona, Nevada, and California.

All the principal rivers of Nevada head in California. The Bear River is to be divided between Wyoming, Idaho, and Utah; the Snake is to be divided between Wyoming, Idaho, Oregon, and Washington; the Columbia is to be divided between Montana, British America, and Washington; the Missouri and its tributaries are to be divided between Montana, North Dakota, South Dakota, and perhaps Nebraska. In this enumeration I have only taken up the more important streams and have omitted many minor ones that involve severally great interests. Many of these in single cases will involve values of one to five millions of dollars. It is safe to say that the distribution of industries between the States through a division of the waters to be used in irrigation involves industries now established or to be developed of not less than

$1,000,000,000. These problems are already pending in many places to the extent of many millions of dollars and they must all be solved in the immediate future if peace is to be maintained.

The history of interstate feuds in the United States relating to the boundary lines and fishing interests in dividing waters is replete with lessons showing that even such small interests kindle animosities and create difficulties of serious importance. Shall State arm against State over disputed questions relating to the use of water? Will it not be an act of wisdom to settle these disputes in their incipiency before the passions of the people are inflamed and before rights and interests are established. If neglected it will result in the establishment of agricultural industries in various regions that must inevitably be destroyed.

The development of these industries, the growth of vast interests, is now in progress, and the people in many districts are already piling up claims against the Government of the United States which will ultimately amount to vast sums; and if it shall continue for twenty years more as it has progressed for the past five years, claims against the Government will be pressed involving many hundreds of millions of dollars; and if such claims are rejected, hundreds of thousands of people will have their industries destroyed, and will be left in abject poverty to abandon their homes and fields and to migrate to new regions.

Again, if the development of the country is to go on in the present method without regulation and without prevision, agriculture will largely be driven to the mountains, about the sources of the great rivers which ought to be used in the valleys below. If, on the other hand, the right to take out the waters above is overthrown, through the courts and through legislation, and the right to the flow of the stream at the lowest points in the valley where irrigation is necessary is established, the waste of water will be enormous, and not one-fifth, and perhaps not one-tenth, of the possible area of agriculture will be realized. For the ultimate prosperity of the agriculture of those lands, and for the avoidance of conflict, it is necessary that the waters of the entire arid region be divided and relegated by drainage districts to the best lands, in such a manner that the people of each district will know what lands can ultimately be irrigated and what waters can ultimately be utilized; and it is possible by some simple measures of prevision to anticipate nearly all of the difficulties which I have pointed out, in so brief and imperfect a manner, and have them all solved in advance of dense settlement. I have already alluded to the improvident and obstructive rights which are being established along the course of many streams—rights which must ultimately be extinguished, and some of which are now in process of extinguishment. A proper administration of this trust, this heritage of wealth and homes for the people, may be devised. Millions of wealth of this nature may be created which must necessarily be extinguished in the near future. Is it wise to permit its creation?

There is still one other very important class of facts which must be mentioned. The reservoir and canal sites should remain in public possession, in trust for the people who will need them. The statutes already provide for their discovery, segregation, and reservation, but some provision must be made for their utilization. It is manifestly not the purpose to reserve them from use, but to reserve them for use, and to prevent them from falling into the hands of individuals or corporations for speculative purposes. But to whom shall they be turned over for use, and under what conditions shall their utilization be permitted, is the problem yet to be solved.

Equally important with the reservoir and canal sites are the sites for diverting dams along the courses of the streams. It is often the case, and perhaps generally the case, that the waters of a stream may be taken out at a particular place, and the entire volume controlled thereby, and the owner of such a site would have the command of all the agriculture dependent upon that stream. All reservoir sites and canal sites and diverting dam sites should be the property of the agriculturists and not of water companies. The waters themselves should be the property of the farmers and not of companies. If the water for agriculture is to be supplied by companies organized under national statutes or other charters they should be organized only as common carriers of water. It should be established that the land which is irrigated appropriates the waters, and that they are not appropriated by canals, but the water belongs to the farmer and not to the water company. And I believe still further that in the interest of peace and prosperity the farmers should not only own the waters and lands but they should also own the irrigating works.

Such are some of the more important institutional problems relating to the arid lands. The conditions of agriculture in the western half of the United States are unlike the conditions prevailing in the eastern half of the United States, and unlike the conditions of western Europe, from which our people came. The new conditions demand new institutions.

I have reviewed somewhat at length in the two examinations which you have given me the principal problems involved in the arid lands. But I have presumed, and I wish to present it modestly, to formulate in the shape of a bill the ideas which I wanted to present, thinking I could do it in a more systematic and concise manner in that way. I think that this bill, if adopted or enacted into a law, would inaugurate a system that would solve the particular problems which I have indicated. Already some of the members of the committee have heard me talk on this subject. But I will give you an outline of the bill:

First, it is incumbent upon the Government of the United States to, and it is necessary that it should, divide the waters among the different States and Territories, from the fact that in twenty or thirty cases the problems are interstate problems, and in some of these cases the problems have arisen and the people are now in conflict. This conflict, too, is bitter. In other cases they involve only different districts within the same State or Territory. The theory of this bill is that the waters ought to be divided by the General Government.

Senator **MOODY**. Upon what principle of constitutional power do you attribute the authority of Congress to make these regulations and divide the water?

Director **POWELL**. I provide for it in my theory, not on a principle of law but on a principle of policy, and the last section of the bill provides that certain sections of the bill shall have no force nor effect until the State or Territory involved accepts it.

Senator **MOODY**. Congress would have the right to legislate for the Territories in those particulars undoubtedly. But the query was, what authority would Congress have to legislate upon such a subject for the States. Of course, if you take that theory, that the State will have to accept, that ends the matter.

Director **POWELL**. I have adopted that theory to meet that point.

I have also shown to the committee that all of the lands can not be irrigated, and that it is necessary to select the best.

I have presented to the committee a brief outline of the timber lands of the arid region, and have shown how the timber lands are being devastated by fire. There is before Congress a number of bills providing for a forestry organization by the General Government to protect these forests.

There is still another interest in these arid lands that I may mention before reading the provisions of the tentative bill.

In the area of the arid lands there are vast regions valuable only for pasturage. But if all the rivers, all the creeks, all the brooks and the springs, and all the artesian waters, and all the storm waters are utilized that we hope may be utilized in that country, there will still remain two classes of lands which will not be irrigated for agriculture. There will be large areas valuable for pasturage and valuable for the growth of timber. The timber lands are unfit for agricultural purposes. Waters, in the main, can be found there, but they are so high that agriculture is not profitable. Where timber grows frosts may be expected any month of the year. This tentative bill includes all the interests of that country—the pasture land and timber land, and provides a way for the use of that timber land and the use of that pasturage by the people, and provides further that only the irrigable lands shall be disposed of by the General Government.

If you will pardon me, I will read the bill through, first without comment, and then take up the various divisions and explain their purport and purposes.

(The proposed bill was then read to the committee.)

Director POWELL. Mr. Chairman, the theory of the bill is that there are natural hydrographic basins or drainage areas; that the people of each of these districts should be organized into bodies corporate and politic and constitute commonwealths for the regulation of irrigation, the division of waters, the protection of forests, and the protection of the pasturage lands, and for the utilization of all of these values.

The CHAIRMAN. How would you manage where there are vested rights and you want to get grants to give the districts power to institute proceedings for condemnation; where you want water rights; where you want to take out a ditch to cover land, and where you would have a conflict of water rights?

Director POWELL. I have concluded that that would be a matter for State regulation and not for the United States, and the bill provides that the States must enact the necessary laws. With the knowledge already at hand it is possible to outline most of the natural basins which are described as irrigation districts in this tentative bill. I place before you a map of the arid region outlining such natural districts. It also exhibits the county lines and the State lines, and shows how such districts would be relegated to counties and to States. Most of the districts embrace portions of two or more counties. The county lines, like the State lines, are artificial. In the main they follow parallels and meridians, as do the State lines, and hence usually do not coincide with the natural district lines. A number of districts embrace lands in two or more States or Territories.

The CHAIRMAN. How do you manage to give a district jurisdiction when it is partly in two States?

Director POWELL. I propose that the people of a district embraced in two States organize under United States laws and under State laws which are specified in the bill after the States and Territories have provided for such action, and by the consent and authority of the interested States and Territories.

Section 1 of the bill provides for the survey and designation of the irrigation districts, and three classes of districts are provided. They may be called head-water districts, river-trunk districts, and lost-river districts.

Section 2 provides that the irrigation survey shall select the irrigable lands, and to be governed in the process by the following rules: First, the conditions necessary to secure the greatest area of irrigable land; second, the conditions necessary to secure the most valuable lands for agricultural purposes by reason of climate; third, the conditions necessary to secure the most valuable agricultural lands as determined by soil and subsoil; fourth, the conditions necessary to secure lands that can be irrigated and cultivated with the greatest economy.

Section 3 provides that all lands heretofore irrigated in the arid region or for which irrigating works have been constructed, and all lands selected for irrigation by the Survey, shall be considered as irrigable lands.

Section 4 provides that the United States Survey shall designate the trunk sections of rivers and large creeks, and determine and locate the places on such trunk sections where dams may be constructed, and the routes to be followed in the construction of canals from such trunk sections, and that all shall be done in such a manner as to protect the water rights of the several districts and to prevent the construction of improvident and obstructive works of irrigation, and that it shall be unlawful to construct improvident and obstructive works.

Section 5 divides the waters among the irrigation districts, so that the people of each district will know definitely what waters they are entitled to.

Section 6 provides that whenever a source of water supply and the necessary irrigation works in any district lie within the boundaries of another State or Territory than that where the lands irrigated are situate, the people of the district shall have the right to construct and maintain their works in the State where they are situate, and that it shall be unlawful to levy any tax on or establish any obstruction to the use of such waters, sites, or works by the State or Territory in which they are situate.

Section 7 provides that the irrigable lands may be homesteaded in tracts of 80 acres. It re-affirms the laws relating to mining lands, coal lands, and town-site lands, and provides that all other lands shall remain in the possession of the General Government, to be used by them as catchment areas for the waters of irrigation, for the forests which they grow, and for the pasturage which they furnish, and that the sites of reservoirs and other irrigating works shall remain the property of the General Government, to be used by the people in their corporate capacity.

Section 8 affirms the right of every man who owns an acre of land to his portion of the waters set apart for the irrigable lands of his district.

Section 9 makes it unlawful for any person or corporation to construct irrigating works except in conformity with the statutes of the State or Territory and of the United States.

Section 10 provides a general form of organization for irrigation districts.

Section 11 relegates to the commissioners of each district the authority and duty to provide laws and rules for the use of the waters of the district in irrigation and for other purposes, for the protection and use of the timber and fire-wood of the district, and for the protection and use of the pasturage of the district.

Section 12 provides that such irrigation districts shall be organized under State or Territorial laws, and further provides four methods by which irrigation works may be constructed: First, by co-operative labor; second, by taxes levied on the lands irrigated; third, by the issuance of irrigation-district bonds; and fourth, by contract with companies. But when constructed by the last method, the irrigating works shall after a term of years become the property of the district. It also provides that the State or Territory may enact general laws for the protection and use of forests, and for the protection and use of pasturage.

Section 13 provides for State supervision of irrigation.

Section 14 provides that cities and towns may be excluded from the irrigation districts, and that the waters used for domestic purposes may be designated by State statutes.

Section 15, which is the last, provides for the general consent of the States and Territories involved.

It will thus be seen that the proposition is to organize irrigation districts with natural boundaries, and to relegate to each district the great body of the problems which are involved in this new industry of agriculture; and it divides the waters between the districts in a simple and effective manner. It also proposes that the irrigable lands shall be selected in the interest of all the people, that the greatest amount of agriculture may be carried on; and it provides for the protection and use of the forest and pasturage lands by the people who are interested therein. The vast increase in the value of lands by irrigation makes them an object of speculation. We are starting in a speculation in the West which I believe if unregulated by law, as it now is, with rights to waters undetermined, as they now are, will result in disaster to the farmers and the investors alike; and it will further result in this: that the water and the lands will go into the hands of a few persons, namely, the promoters of irrigating schemes. Be that as it may, the problem of fixing water rights somewhere, so that the farmer and the investor alike may be secure, remains, and is one of the serious problems that must be met; and I propose in the plan which I have presented that the Government of the United States interfere in the matter to the least possible extent; that it divide the waters—not to the farmers—but between districts and States, and then, under guarded provisions, turn over the whole subject to the States and districts and allow them to work out the matter to their satisfaction.

The committee here adjourned, to meet on Friday morning, the 24th inst., at 10 o'clock.

THIRD DAY'S SESSION.

WASHINGTON, D. C., *January* 24, 1890.

The committee met.

Present: Mr. Stewart, chairman; Mr. Plumb, Mr. Casey, Mr. Moody, Mr. Reagan, and Mr. Jones, of Arkansas.

STATEMENT OF DIRECTOR POWELL—Continued.

Mr. chairman and gentlemen of the committee, the work of the Irrigation Survey is naturally divided into three parts and organized into three branches, for there are three classes of work which are best accomplished by three classes of specialists. These are designated as topographic, hydrographic, and engineering branches. Topography is the basis of the work, and on it the hydrography and engineering depend. This will plainly appear when I come to describe those branches.

Topographic work is map-making. On the passage of the act of October 2, 1888, parties were immediately put in the field and work has been continued up to the present time, chiefly in the field, but to some slight extent in the office. The maps have not all been constructed, but are in part in manuscript. None of them have yet been engraved. The sheets of the map, or the several maps in detail, are constructed with grade curves, or contours, having a vertical interval of 25 feet in the valley and over the more level grounds.

Every 25 feet of elevation above the level of the sea is determined over the entire surface, and the lines on the map represent every 25 feet of change, so in passing from upper to lower heights you have a descent of 25 feet from curve to curve or line to line, as shown on the map. In the foot-hills the lines are 50 feet apart in altitude, and in the mountains they are 100 feet, and yet in any steep regions they are 200 feet apart; so they vary from 25 feet to 50 feet, 100 feet and 200 feet, depending on the nature of the declivities. Such contour maps are very easily understood and express the chief or important facts of natural topography in the simplest manner. It is thus that valley, hill, and mountain, with all necessary detail of relief, are expressed to the eyes in definite quantity. The map shows that the summit of the slope is distant from the foot of the slope say a quarter of a mile, and that the summit is 25 feet above the foot. In this manner the altitude above the level of the sea of every portion of the country is represented, and the whole form is presented at a glance. With a little experience a map of this character is read as easily as a page of print—more so; it is in fact interpreted as a picture. Such are the maps we are making, and I wish to show where they have been made under the two appropriations for the Irrigation Survey.

With the appropriations that have been made it has not been possible to prosecute work in each of the States and Territories of the region and we were compelled to make a selection of districts. In doing so it was thought best to inaugurate work in the most densely peopled regions and where the scarcity of water was most keenly felt. For this reason the Arkansas Valley in Colorado, portions of the Rio Grande in New Mexico, the Truckee and Carson in California and Nevada, the Snake or Shoshone River in Idaho, and other important districts were chosen. I place before you a map of the arid region upon which are colored the districts which have been surveyed up to the present time, and will go on to describe them in detail, commencing on the Arkansas River in the State of Colorado. All of this district as shown on the map, extending from the headwaters of the river in the high mountains of central Colorado nearly down to the Kansas line, and embracing the entire drainage, has been surveyed. We have had two seasons of work in this valley. The first season commenced in October, when there were only a few weeks of good weather left. Still we pushed the work through the winter. In the main the parties beginning in October, 1888, did not return to the office until this fall. It chanced to be a warm and dry winter in the country and we pushed the work through the cold season. The area surveyed in Colorado in 1888 was 13,000 square miles; the area surveyed the present summer was 9,900 square miles; making altogether 22,900 square miles. The area surveyed in Colorado on the Arkansas embraced all the drainage of the Arkansas nearly (but not quite) to the Colorado-Kansas line. You will see by the map to which I now point that there is but a small part yet remaining.

Other parties were put in the field in New Mexico, in the region about Santa Fé and Albuquerque on the Rio Grande, and in the region near El Paso on the Rio Grande.

In New Mexico we have mapped 6,370 square miles; in California we did 6,680 square miles; in Idaho we did no work during the last year; this summer we have, however, done in Idaho 1,900 square miles, made a topographical survey of that; and in Montana we did 5,200 square miles. So that under the act creating the Irrigation Survey and the appropriations made therefor we have already made topographical maps over an area of 43,050 square miles.

I have another map hanging before you which will set forth certain other facts bearing on this subject.

The survey under the present organization and surveys previously prosecuted under the control of the present Director of the Survey have been made with a view that they might ultimately be used for this purpose. So that we now have a topographic survey ready for the use of the Irrigation Survey of an area of 250,000 square miles, and all of that work is finished, in the field and in the office. To this must be added the 43,530 square miles accomplished by the Irrigation Survey. The maps are in part in the engraver's hands, under contract by the Public Printer, for their engraving. About two-thirds of them are already engraved, and we have proof-sheets.

Senator REAGAN. What surveys are those?

Director POWELL. The surveys previously made under my charge. All the areas in blue are surveyed in this manner, covering altogether 250,000 square miles.

The CHAIRMAN. Do you reckon in that the King and Wheeler surveys?

Director POWELL. I am going to speak of those because they are also shown on this map. The Hayden surveys are marked in light blue. Those maps were not constructed to be used for this specific purpose, but the work of the Hayden surveys was done in such a manner that some additional cost is necessary to prepare them for use for this purpose. There are about 120,000 square miles to be completed in this manner. Again, the King survey is colored yellow. The King survey is not so well adapted to this work, and more has to be done on the area surveyed by King, that his maps may be utilized for this purpose; but probably the work can be done at one-half the cost of carrying on original work. The Wheeler survey, which is colored brown, as you see, and is scattered over the country, was done in the main on a scale of 4 miles to the inch, and for our purposes we need a scale of 4 and 2 miles to the inch. Then it was not constructed in contours, and hence is unavailable for the irrigation survey. The Wheeler survey serves as a general reconnaissance for planning topographic work, but not for irrigation work. So then altogether, besides what has been done under the appropriation for arid lands, we have 250,000 square miles of map ready for use; 140,000 square miles partly ready for use; 80,000 square miles on which much work is yet to be done, and about 100,000 square miles of reconnaissance work.

Senator PLUMB. In that connection let me ask you what if anything in the shape of monuments have been put on the ground which would indicate the altitude or meandering of the lines?

Director POWELL. In the work over which I have had control myself all the triangulations of the work in blue are marked in such manner that they can be re-discovered, are marked and described in the report.

Senator **Plumb**. With the aid of these maps a local surveyor could identify them without resurveying them, I suppose?

Director **Powell**. Yes.

Senator **Plumb**. These maps would be, I suppose, what are called topographic maps, that is, they would indicate the slope and elevation, the contour, etc.?

Director **Powell**. We divide the work into three classes, each of which is dealt with; the hydrography, which describes the courses of all streams, with all their meanderings; second, the hypsography, as it is called, the elevations of all the hills and mountains; third, the culture. The lines of all high roads, of all railroads, canals, town sites, cities, etc., the boundary lines of States and Territories, counties, etc., those things which man has put on the country and are represented on the map, we call "culture." These maps represent the hydrography, the hypsography, and the culture, or that which man has put on the ground.

Senator **Plumb**. Then with the use of those maps the local authorities, or any one interested in the development of the country, would be able to understand the lay of the land just as though he himself had made the map?

Director **Powell**. Precisely; the object is to construct maps in such manner that any man may go upon the ground, take the map in his own hand, and select the sites for reservoirs, and select the routes for canals with the map before him. On selecting the routes for canals, a subsequent survey would be needed for the purpose of determining the constructive elements—the fills, the grades, the cuts, etc., that would be necessary for a canal, but the general route of a canal can be planned on the map without going on the ground. That is true not only for every canal, but for every road and for every railroad. So that wherever, in the United States, the surveys have been carried on as shown on the map, no railroad company has to make a preliminary reconnaissance or trial-line survey. From our maps all such enterprises may select their routes before they go onto the field, and they systematically do that, and have been doing it for several years, and as far as our surveys have progressed.

There is one thing of importance that I wish especially to call attention to in relation to the topographic maps. That is, that in general the reservoir sites in any region of country are in excess of the wants. There are usually more reservoir sites than will be needed. The topographic survey reveals all practical reservoir sites, and hence reveals more than will be needed. There comes then to be a necessity for a selection of the best sites. And the topographic maps furnished then practically the chief data necessary for this purpose, as well as for other purposes which I have mentioned.

I am passing very rapidly, Mr. Chairman, and briefly over these points, because there is so much of the matter. If the members of the committee wish to ask any questions as I go along I shall be glad to reply.

In planning a system of irrigation work we are at once confronted with the question, What is the amount of water to be controlled and used? The lands are abundant, the water is scarce. The entire arid lands are naturally divided into irrigation districts, each one composed of a catchment area and a farming area, for in farming regions, where agriculture is carried on by irrigation, the lands which catch the rain and supply the water are not those which are cultivated. To select from a large tract a smaller one to be irrigated, it must first be determined how much water the catchment area will furnish for the purpose, for on this will depend the quantity of lands to be reclaimed. The amount of water also determines the character of the irrigation works. More water requires larger dams, canals, and reservoirs; less water needs smaller works. The water running in the channels in each of these catchment districts—and there are many thousands altogether—is variable from year to year, from month to month, and even from hour to hour at flood time, and it becomes necessary to determine the mean annual volume, the minimum annual volume, the maximum annual volume, and the maximum volume of the floods. The mean annual flow gives the limit of general agriculture from year to year; the minimum annual flow limits the agriculture in seasons of drought; the maximum annual flow controls the plan of the works, for they must be constructed in such a manner that they will not be destroyed when it comes; the maximum flood volume also must be known, for this ultimately brings the greatest strain upon the works, and they must be constructed to withstand it.

In the plan of the survey the volume of water running in the streams of the catchment districts, and which is furnished to the farming districts, is determined by making a topographic map as a basis for a hydrographic survey.

The first process is stream gauging. The measurement of the streams is accomplished by a twofold process. First, a river-gauge is established, with a float, by which the height of the river is recorded automatically during the year. That is to say, a nilometer, as it is called, is established in such manner that the rise and fall of the stream lifts or lowers a float, and in lifting or lowering this float it records the rise or fall upon a paper by a little machinery attached to it; so that we have the record from day to day and month to month and year to year automatically recorded of the height of the stream. Then, the cross-section of the stream where the nilometer or river-gauge is used is determined for different heights of water. A continuous section from low water to high water is made, so that if we know how high the water is at any moment of the year we know the cross-section at that time.

Senator JONES. Does the nilometer show the length of time at which the river stands at any particular stage?

Director POWELL. Yes. It has clock-work, by which the whole history of the rise and fall is preserved.

Senator JONES. Does it show the velocity also?

Director POWELL. No, sir; I am coming to that. The next is the velocity of the water passing the cross-section. That varies in the different portions of the stream. It varies from side to center and from top to bottom, and it varies with every rise and fall of the river. It becomes necessary therefore to have another class of instruments, known as current-meters. By finding the mean velocity of the passing water and the cross-section of the stream we determine the volume of water passing for a given stage. Then we must find it for each stage marked upon the river-gauge or nilometer. This gives us the flow of the river. It is all plotted. If you remember, a plat of that kind was presented to you in Arizona.

With this river-gauging, then, we steadily gather the data to show how much water the river will carry—not at one time, but at all times, varying from day to day through the year.

It is in this manner that we gauge the rivers and creeks. The number of places where such "gaugings" must be made is very great. We have estimated that about 20,000 would be needed. To make that number of gaugings, each one for a series of years, so as to obtain the mean, maximum, and minimum annual flow and the maximum flood volume, would take a long series of years and would be enormously expensive. But a cheaper, shorter, and it is believed a more accurate method has been devised. This method involves the construction of a topographic map and the gauging of a few typical streams.

It is thus that attention is first called to the catchment area, and of this we must have a topographic map, which will show its superficial area, its declivities, and its altitude above the level of the sea. Other things being equal, the greater the area the greater the amount of rain caught. Other things being equal, the greater the declivities the greater the amount of water furnished to the streams, for flat lands with accumulated soils and sands hold the water back and by evaporation return it to the heavens. Lands with great declivities have less soil and sand, and their slopes gather more water into the natural channels. In the arid region of the United States there are altogether vast tracts, perhaps in all one-fourth of the entire area, where no considerable water runs off. There are other regions, altogether very extensive, where the slopes are so steep and rocky that the greater part of every storm runs down; and between these extremes all gradations are found. The water supply, therefore, is dependent upon declivity. The altitude of the catchment area is also an important factor, for within limits, other things being equal, the greater the altitude the greater the rain-fall. To obtain altitudes, declivities, and areas, a topographic survey is necessary, and the topographic survey having been made, the cheapest and best method of assembling the facts, so that they can be understood, is to construct a contour map. The entire area of the arid country—including the low deserts where no waters flow away—is composed of catchment areas. Each tract or district is a catchment area—not for itself, but for some other district, which in turn is a catchment area for still another. It is thus that a map must be made for all parts of the country but the flat deserts, and they are included in the others, and in some cases constitute the irrigable lands to be farmed, for while they are desert without water, they are the *best* farming lands when irrigated. Hence, practically, the entire country must be mapped, and the flat lands are mapped without expense worthy of mention.

Now, to make this map serve for hydrographic purposes something more is needed. A few streams must be gauged. Suppose we have found a drainage area of 10,000 square miles with maximum declivities, so that most of the water is gathered into channels and passes from the catchment area to irrigable lands below. Here, where the water is all brought together in one stream, we gauge it and find how much water an area of that size having determined declivities will afford. Now, wherever we have another catchment area with similar declivities if the rainfall is the same we have to make but the topographic map to determine the water which it will supply. It is in this manner that the preparation of a topographic map is a part of a hydrographic survey. A few streams are gauged, the general rain-fall is determined, and the catchment areas are measured topographically so as to obtain horizontal and vertical dimensions.

The next part of the hydrographic work is to determine the amount of evaporation. When water is stored in reservoirs an amount, known in a general way but not known in a very close way, is lost by being returned to the air. In order to know how much water can be saved it is necessary to know how much will be lost in this manner, and at these gauging stations we establish evaporating stations for the purpose of determining the amount of evaporation from day to day through the year. The machinery for this need not be described; it is very simple.

The next element in the hydrographic survey is the determination of the quantity of sediment carried in the water. All streams carry with them the drift of the slopes and hill-sides of the catchment area. Some streams carry much, others little. Some streams carry much at one part of their course and less at another part.

The life of a reservoir is an important factor, to be determined, and this must be determined by discovering how long it will take under the conditions to fill that reservoir with sediment. In order that this may be provided against it must be determined how much material must be removed from the reservoir annually in order to make its life continuous. The streams therefore have to be gauged for sediment, and an apparatus is provided for the purpose. Connected with these stations we have rain-fall gauges wherever we have established work of this character. The reading of the rain-fall gauges takes practically but very little time, and we can do it without expense. But in the main we are assisted in this work by local enterprise. In most of the States and Territories the people have organized weather bureaus, or some system for determining temperature, rain-fall, winds, etc. We have it so arranged that all this material is aggregated in our office. In most of the States and Territories ultimately people will work uniformly on our system. They are asking us already to take general control of their plans and are gathering the facts necessary for our work, so that we do not have to perform that work ourselves to any great extent. In addition, we avail ourselves of the material collected by the Signal Service.

Besides the organizations to which I have referred, there are individuals who of their own will have organized such observation systems for themselves; and especially I may mention, in this connection, railroad companies. So that there is pouring in upon us from all parts of the arid lands a vast amount of information in relation to rain-fall, to temperature, and to the course of the winds.

I shall not weary the committee with a detailed statement of the hydrographic stations we have established; but I have the results of the work up to the present time in tabulated form in this paper, and with your permission I will simply hand it to the reporter that it may be incorporated with my remarks.

Summary of hydrographic results.

The daily average flow in cubic feet per second has been obtained for the following rivers:

COLORADO.

River.	Station at—	Results.
Arkansas	Cañon City	Apr. 17, 1889 to end of year.
Do	Seven miles above Pueblo	May 1 to Sept. 1, 1889.
Do	La Junta	May 20 to Sept. 1, 1889.
Do	Lamar	May 26 to Sept. 1, 1889.
Purgatoire	Las Animas	May 22 to Oct. 1, 1889.
Huerfano	Hermosilla	June 30 to Sept 1, 1889.

Summary of hydrographic results—Continued.

NEW MEXICO.

River.	Station at—	Remarks.
Rio Grande	Del Norte	July 1 to end of year. (Discharges at intervals, also measurements of canals.)
Do	Embudo	Dec. 20, 1888, to Nov. 30, 1889. (Daily discharge complete.)
Do	San Marcial	One gauging only.
Do	El Paso, Tex	May 10, 1889, to end of year (complete).
Jemes	Jemes Pueblo	Mar. 20 to Nov. 5, 1889. (Discharge partially computed.)

ARIZONA.

River.	Station at—	Remarks.
Verde	Above junction of Salt River	Discharge from Aug. 15 to Sept. 30.
Salt	Above junction of Verde River.	Discharge from Aug. 1 to flood at end of Nov.
Gila	Fifteen miles above Florence	Discharge from Aug. 30 to end of year.

NEVADA.

River.	Station at—	Remarks.
Truckee	Essex, Nev	Discharge from May 20 to Sept. 30.
Carson		Few gaugings.
Purser Creek, Squaw Creek, Little Truckee, and all important tributaries.		Gauged in high water.

IDAHO.

River.	Station at—	Remarks.
Wood	Hailey	Discharge from June 23 to end of year.
Snake	Eagle Rock	July 1 to end of year.
Do	Above Fall River	One gauging.

UTAH.

River.	Station at—	Remarks.
Bear	Battle Creek	Discharge Oct. 15 to end of year.
Do	Collinston	Discharge July 22 to end of year.
Ogden	Ogden Cañon	Discharge Aug. 20 to end of year.
Weber	Weber	Discharge Oct. 15 to end of year.
American Fork	American Fork	Discharge Aug. 1 to end of year.
Provo	Provo	Discharge July 15 to end of year.
Spanish Fork	In cañon	Discharge Aug. 1 to end of year.
Sevier	Joseph City	Discharge Aug. 20 to end of year.
Do	Leamington	Discharge Aug. 20 to end of year.

MONTANA.

River.	Station at—	Remarks.
Yellowstone	Horr, Mont	Aug. 12 to Nov. 30, 1889.
Do	Springdale	Special gaugings.
Sun	Near Augusta	Aug. 5 to Nov. 30.
West Gallatin	Bozeman, Mont	Aug. 16 to Oct. 30.
Missouri	Cañon Ferry	Sept. to Nov. 20.

Also various canals, small tributaries have been gauged to furnish special data for use of division engineers.

Rain-fall measurements.

Locality.	Stations.	Measurements.
Arizona	30	June to Dec., 1889.
Colorado	10	June to Dec., 1889.
New Mexico	35	March to Dec., 1889.

Evaporation estimates.

[Monthly evaporation in inches.]

	1888.	1889.										
	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
Montana:												
Livingston											*3.2	2.9
Bozeman										4.5	4.3	1.9
Great Falls											†2.7	‡1.0
Springdale									‡6.8	‡7.1		
Hogan										†6.1		
Utah:												
Fort Douglas									10.5	5.7	‡4.8	
Provo											‡3.3	
Arizona:												
Tempe								13.7	14.1	11.0	6.4	4.4
Texas:												
Fort Bliss						11.0	10.7	9.6	11.4	9.2	6.8	4.6
Colorado:												
Cherry Creek							8.1	7.9	8.6	6.2	4.2	‡2.6
New Mexico:												
Embudo	†6.0	3.0	2.9	3.6	4.9							

* Based on 16 days' observations.
† Based on 14 days' observations.
‡ Based on 8 days' observation.

SILT.

The amount of silt carried by the Rio Grande at Embudo, N. Mex., was measured from January 15 to April 15, and by the Rio Grande, at El Paso, from June 10 to the end of the year (when the river was flowing).

Average volume of water (according to the assumption that a cubic foot of dry sediment weighs 85 pounds).

	Embudo, N. Mex.	El Paso, Tex.
	Per cent.	*Per cent.*
Minimum	.0014	.0139
Maximum	.0413	1.4167
Average	.0101	.3865

The third part or branch of the survey relates to the locating or planning of irrigation works—the engineering branch as we call it. So that we have three branches—the topographic, the hydrographic, and the engineering—under different managements, in general, in the field, needing men specially trained in each to accomplish the work properly.

The basis of the work of the engineering branch is the topographic survey and the hydrographic survey. The outcome of the work, the purpose for which it is all done, is not realized until the work of the engineering branch is finished. The organic statute of the survey provides that we shall select diverting dam sites, canal sites, and reservoir sites, and withdraw the same from market that they may remain in the possession of the General Government. It also provides that the lands to be irrigated shall be segregated that they may be obtained only under the provisions of the homestead act. All of these sites and lands have to be discovered. In their discovery, the entire country has to be overlooked or surveyed, and this is the work of topography. Usually there are many more reservoir sites than are needed and the best should be selected; for this purpose all must be discovered; water should be stored in the mountains whenever it is possible, as there is less loss by evaporation there. All the mountain reservoir sites must, therefore, be discovered; but a part of the water falls upon the foot-hills and valleys, and that also must be stored. So there must be reservoirs below, and this lower region must be examined. Wherever it is possible we must store the water away from the streams so that the reservoirs may not be destroyed by floods. But this is not always possible, so the whole ground must be studied for reservoir sites, then the stream channels themselves must be studied for dam sites.

Then there are canal sites from the diverting dams to the reservoirs and from the reservoirs to the lands to be irrigated, and these canal lines must be discovered. In any basin many possible lines may be found; the best should be selected, to make this selection all must be known. When there is more land than can be served by the water, the best should be selected; to do this all must be known. Now the topographic survey discovers all possible reservoir sites, all possible dam sites, all possible canal sites, and all possible irrigable lands, then constructs a map with all these facts shown upon it. The engineering survey now steps in to complete the work and the selections are made by an examination of the map, which is a miniature counterpart of the country with quantitative elements represented by contour lines. It will sometimes happen that two lines or two reservoir sites have advantages so nearly balanced as shown by the topographic map that a choice can be made only by a more refined examination. But in general the special sites will be discovered on the map. Now, these special sites must all be examined in a detailed manner in order that the works may be planned, and such refined surveys are expensive and it is necessary to reduce them to a minimum, which the preliminary topographic survey accomplishes—the topographic survey is a preliminary or reconnaissance survey to discover what the refined and costly work of the engineering survey must do, and is a great saving of expense.

While I can not go over all the ground which we have covered in this work, I have brought a few examples to illustrate what is done, and have brought this map with me to show what the survey will be when it is finished. I would like to have you consider first the Arkansas Valley. (See map.)

All the works on the Arkansas are not yet planned, but something has been done, and one illustration may be presented. On the Arkansas we have discovered a number of reservoir sites. This is the first reservoir which we planned on the Arkansas, and it is incomplete. Here we have a map with grade curves of the Twin Lakes, high up on the Arkansas River. These are 5-feet grade curves, showing the outlines and the outlet to the lakes. Here [indicating] is the outlet, and a section across here shows where the dam is to be constructed. In Arkansas twelve reservoirs like these have been surveyed in detail, maps drawn of them, and data secured for all estimates of capacity and cost, but the data has only been collected, and it has not yet been assembled, so that I can not report it. The Twin Lakes which you see here have a capacity of 100,000 acre-feet. That is a capacity, under proper conditions, to store water for the irrigation of 100,000 acres. The cost of the reservoir will be about $60,000, and the cost of the canal, to bring the drainage of another stream into this, so that all may be stored into one after awhile, will be about $75,000. The total cost therefore will be about $140,000 for the whole system of works, to store 100,000 acre-feet of water, or about $1.40 cents per acre-foot.

Senator **REAGAN**. By acre-feet, do you mean a foot deep on an acre of ground?

Director **POWELL**. Yes, sir; an acre-foot of water is an acre of water 1 foot deep. When irrigation, under average conditions, is practiced with economy, it is believed that an acre-foot of water will supply an acre of land for one year, and we adopt that as being convenient for many purposes.

The **CHAIRMAN**. That will vary somewhat, of course?

Director **POWELL**. It will vary very greatly. I am giving only a general and mean figure.

On the Arkansas now fifty reservoir sites have already been discovered. Of these, twelve of the most promising have been studied with much care and the data collected, as I have said, for their plans. The data collected show that we can store, on the sites for the reservoirs already selected, water enough to irrigate three times the amount of land now cultivated, so that the whole area cultivated on the Arkansas will be three times as much as that now cultivated.

Senator **CASEY**. And that total would be what, do you remember?

Director **POWELL**. I have the figures at my office, but I have not them with me.

The Rio Grande is the next that I shall present to you. The other work, as I told you, is unfinished and it would be difficult to present the real work without the figures and papers.

I now show you a plan of the work for the storage of water on the Rio Grande, immediately above El Paso. The Rio Grande flows from the left to the right of the map. The dam is to be constructed at this point [indicating a point on the right of the map] and a topographic survey has been made, not only of the sites of the reservoirs, but also of the larger part of the region above El Paso, for the purpose of determining the region of country upon which this reservoir must in dry seasons depend for its water. The maps are not constructed in the office, but the data is at hand and draughtsmen are at work on them at the present time. With a 60-foot dam this reservoir will store 537,000 acre-feet, and we expect to find water sufficientf or that purpose, but of this we are not yet sure, as the survey of the entire area is not yet finished. The estimated cost of this reservoir is $1,100,000.

The **CHAIRMAN**. That is, the reservoir, without the condemnation of land?

Director **POWELL**. No, sir; with a detailed project.

The **CHAIRMAN**. Covering all?

Director **POWELL**. Covering all. There are, running along the course of the Rio Grande, two railroads, and I have had the engineers of the survey run lines outside of the reservoir sites (for the railroads run into the reservoir sites) and to compute the cost of the construction of such roads, and have assumed that the reservoir would cost not only the amount necessary for the construction of the dam, but for the construction of lines of roads which would take the railroads out of the reservoir sites.

The **CHAIRMAN**. Does that embrace the land to be condemned?

Director **POWELL**. That embraces the land to be condemned.

Senator **JONES**. Where on this map is the dam to be constructed?

Director **POWELL**. Along here, at this point [indicating].

A final report of the irrigation district to be served by this water, will embrace, first, a map of the district where the water is to be caught, extending over the district where the water is to be used—the irrigable land, as you see; second, a map of the region on a large scale. Then plans for dams, canals, and all the engineering work necessary to go with it.

The CHAIRMAN. That will only include the portion on our side of the United States?

Director POWELL. On our side.

The CHAIRMAN. The other side will be about the same but a little larger, probably.

Director POWELL. In California we have discovered a good many reservoir sites. The best one is on the Monaco Meadows, in Kern County, which has a capacity of 320,000 acre-feet. The survey of one site has been completed, that of Clear Lake, near San Francisco. The results are not yet finally on paper. An extended reconnoissance has been made in California, in Butte and Lassen Counties, and two large reservoir sites have been discovered there. Altogether fifteen reservoir sites have been reported for withdrawal, and about forty more will be reported soon, in California. But I have them tabulated elsewhere.

In Nevada, surveys have been made on Weber Lake, Independence Lake, and Donner Lake, in the Truckee Basin, and also in Hope Valley and Long Valley, in the Carson Basin. A canal line has been surveyed, to extend for some miles above Wadsworth. It was intended at the beginning of the season this year to make a careful study of Tahoe Lake to be used as a reservoir. A study was made of it, but it was unsatisfactory and the work will have to be done over—the theory on which it was made being wrong.

In Idaho the work has been done on the Snake River and its tributaries. The Snake, or Shoshone, River, is one of the great rivers of the Western region, and a series of reservoirs has already been discovered. Here on the map is the Snake River. It heads, as you see, in Wyoming. A large part of the water of the Snake River must be stored in Wyoming, in the high mountains where the rain and snow are accumulated. In that region of country we have discovered three very fine reservoirs. The Jackson Lake reservoir, which you see here, will store 1,000,000 acre-feet of water at a cost of $250,000, or at the rate of 25 cents per acre-foot. The Swan Valley reservoir, which you see here, will store 1,500,000 acre-feet of water, at a cost of 25 cents per acre-foot. We have plans for these dams ready. The Fall River reservoir, which you see here, and which will be partly in the Yellowstone Park, partly in Wyoming, and partly in Idaho, will store 500,000 acre-feet of water with an inexpensive dam, but the cost of construction of the dam is yet unknown. Several canal lines have been run along the Snake River at different places, to find out where this water can be used. The water stored above must be used below on the plains, here, in the main in Idaho. The region of country in Wyoming and in Yellowstone Park is not an agricultural region.

Senator JONES. Is there water enough in the water-sheds of these reservoirs to fill them?

Director POWELL. Yes, there is ample water; much more than we are yet able to store.

The waters of the Snake River and its tributaries, properly taken out, and taken to the high lands, first, and recovered after irrigating the high lands and again used on the low lands—from the facts which we are now in possession of we are able to say that at least 10,000,000 acres of land can be redeemed.

Senator JONES. That is, as it now is?

Director POWELL. No; but by the utilization of the river, by canals, and reservoirs, complete. This will involve the construction of a number of reservoirs, the sites of only three of which are now planned or known, though in a general way we know of others.

I shall pass from the Snake, rapidly, to speak of the Montana work. In Montana we have done work on the Gallatin, the Madison, and the Jefferson Rivers—the rivers which unite to form the Missouri—and we have done work on Sun River to the north of them, and we have done work on the Yellowstone River, during the past season. I can not detain you long enough to explain all of these works. The plans which I have brought with me this morning relate to Sun River, and I shall be able very briefly to lay before the committee a very interesting system of works.

The general plan of the Sun River is here on a very small scale, because the topography is not finished. On the first map the course of the river, the lands that can be irrigated, and the sites of the canals are delineated.

The second map which I present shows the plan of reservoir No. 1, marked on the first map. The reservoir itself is illustrated by this map. The dam on the river is at this point. These are grade-curves of 4 feet elevation; passing from one line to another you rise 4 feet; so that anywhere you can make a section across the reservoir that will enable you to compute the capacity of the reservoir. The site of the dam is at this point [indicating]. The capacity of this reservoir is 43,000 acre-feet. The plan of the dam itself it shown on this diagram.

These maps which I now show you of the Sun River illustrate the character of the report we are going to make of that region. The first, the general topography on which are placed all reservoirs and canal sites; second, a sheet exhibiting such reservoir and each canal by itself; and third, a sheet like this (exhibiting the elements of construction in the works themselves), and all to be accompanied with text or written explanations, including the elements of cost, etc., with directions of how to construct the dam.

Reservoir No. 2, on the Sun River region, is represented on this sheet. It has a dam shown on the corresponding sheet, which I hold in my hand.

The CHAIRMAN. How large is that?

Director POWELL. It has a capacity of 65,000 acre-feet.

On the map we have a plan of the waste-weir. I need not exhibit to you all these plans; we have plans of waste-weirs, of dams, of reservoirs, and of canals, and the course of the river and a part of the topography. I think that is sufficient. I need not go into details. It is a small river and we were able to complete it in a short time.

The CHAIRMAN. Have you figured up the expense of those dams?

Director POWELL. Yes. That will be inserted in the record also. I have it in my tables.

We find that the water of the Missouri can be taken out below Helena, near a town called Toston, a very favorable point, so that at that point all the water that is not used above in the Gallatin, Madison, and Jefferson Rivers can be extracted from the river and poured out on lands of great value.

The CHAIRMAN. How much of the river is above that point?

Director POWELL. It is a very large river above that point.

The CHAIRMAN. There is a large water-shed above that?

Director POWELL. Yes, a very large water-shed. The whole of the valleys of the Gallatin, Madison, and Jefferson lie above it, and the whole drainage area from Yellowstone Park down to that place. At that place it is possible to take out all the water stored in the reservoirs above.

The CHAIRMAN. How extensive is the region that would be covered?

Director POWELL. The canal line is about 72 miles in length, and will cover a broad section of country, varying from 20 to 30 miles in width. Below that point the river cañons in places, and I do not really know much about it except from general topographical information; practically we have no engineering data on which to speak.

On the Yellowstone, the chief reservoir on which we have worked is the Yellowstone Lake, which lies in the park. A magnificent reservoir can be made out of it at a cost comparatively trifling—simply opening up 2 or 3 miles of channel below and putting in a head-gate and controlling the river, so as not to lift the lake at all, but to drain it down 2 or 3 or 4 feet each year, so that it will never be higher than it is now.

The CHAIRMAN. That would be very cheap then?

Director POWELL. Yes. The chief cost of the work will be in the construction of the canal. The immediate valley of the Yellowstone furnishes only in places favorable sites for irrigation. It is in part subject to floods now, and in part subject to cloud-bursts that strike the cliffs and bad lands on each side, and these cloud-bursts on the cliffs and bad lands destroy irrigation works below. Then there is not enough land lying in the immediate valley to utilize all the waters of the Yellowstone or any very considerable part of them when they come to be stored. We hope to be able to carry the water out near Livingston on to the mesa lands above without serious engineering difficulty.

The CHAIRMAN. What is the character of those lands generally?

Director POWELL. They are partly rolling; many of them have gentle slopes. Altogether these lands are as good as there are in the world for agriculture.

The CHAIRMAN. They are not too high up?

Director POWELL. No; they are good wheat lands. The operations of the survey have been extended in another direction. The statute requires that we shall determine sites of reservoirs—segregate them from the public lands, and report them to the Secretary of the Interior and to the land department, and under that statute they are withdrawn from sale that they might be used by the people as reservoirs. We have made a number of these selections, and all of them I have in a table before me, but I shall not read them now. It would take too long, and the matter is too statistical for an occasion like this, but I will hand the table to the stenographer, and he can insert it in my remarks. The table embraces only a very small part of the reservoir sites that have been discovered, and includes only those which the engineers have selected. Many others will be selected out of those already discovered.

COLORADO.

No.	Name.	County.	Drainage basin.	Capacity.	Delivery.	Cost.
				Acre-feet.	*Acre-feet.*	
1	Twin Lakes[1]	Lake	Arkansas.	Very large.	125,000	Very moderate.
2	Leadville[2]	do	do	10,000	7,000	Do.
3	Clear Creek No. 1[3]	Chaffee	do	10,000	10,000	Do.
4	Hayden[3]	Lake	do	62,000	62,000	Very large.
5	Sugar Loaf[4]	do	do	18,000	10,000	Moderate.
6	Crane	do	do	2,000	2,000	Rather large.
7	Tennessee	do	do	20,000	12,000	Moderate.
8	Cliff Creek[5]	do	do			
9	Cottonwood Lake[6]	Chaffee	do	15,000	15,000	Very large.
10	Clear Creek No. 2	do	do	2,000	2,000	Moderate.
11	Wilson Creek	Fremont	do	4,500	4,500	Very large.
12	Oil Creek Valley	do	do	7,500	7,500	Do.
13	Slate Creek	El Paso	do	3,500	3,500	Prohibitory.
14	West Oil Creek	do	do	2,000	2,000	Large.
15	High Park	do	do	30,000	30,000	Very large.
16	Cottonwood Creek No. 1.	Fremont	do	3,000	3,000	Moderate.
17	Cottonwood Creek No. 2.	do	do	2,000	2,000	Prohibitory.
18	Beaver Creek No. 1	do	do	2,500	2,500	Large.
19	Beaver Creek No. 2	do	do	2,000	2,000	Do.
20	Middle Beaver	El Paso	do	1,200	1,200	Very large.
21	Seven Lakes	do	do	6,000	6,000	Large.
22	Yorkville	Fremont	do	3,000	3,000	Prohibitory.
23	Big Turkey Creek	Pueblo	do	5,500	5,500	Very large.
24	Six Mile Creek	Fremont	do	3,000	3,000	Do.
25	Eight Mile Creek	do	do	13,500	13,500	Do.

[1] A thoroughly good site.
[2] Good site.
[3] Cost probably $1,000,000 or more.
[4] Fair site.
[5] Small site; its delivery can be made part of Sugar Loaf Reservoir.
[6] Possibly not prohibitory but doubtful.

CALIFORNIA.

No.	Name.	County.	Drainage basin.	Capacity.	Delivery.	Cost.
1	Clear Lake[1]	Lake	Clear Lake	Very great.	Small	
2	Independence Lake[2].	Nevada	Truckee	35,000	20,000	Moderate.
3	Weber Lake[3]	Sierra	do	15,000	10,000	Do.
4	Donner Lake[4]	Nevada	do	45,000	25,000	Do.
5	Monache Meadows[5]	Tulare	Kern	350,000	(?)	Do.
6	Big Meadows[6]	do	do			
7	Little Yosemite[6]	Mariposa	Merced			
8	Tenaiya Lake[6]	Tuolumne	do			
9	Tuolumne Meadows[6].	do	Tuolumne			
10	Eteanor Lake[6]	do	do			
11	Kennedy's Meadows.	do	Stanislaus			
12	Kennedy's Lake[6]	do	do			
13	Bear Valley	Alpine	do			
14	South Highland Lake	do	do			
15	Rattlesnake Creek No. 1.[7]	Modoc	Pit River.	Very large.	Large	Moderate.
16	Rattlesnake Creek No. 2.[7]	do	do	do	do	Do.

---

[1] This lake has been thoroughly surveyed, but reports not yet received. Office work ~~has not~~ reached stage of estimates.
[2] A very good reservoir site.
[3] A good site.
[4] A very good site.
[5] Delivery will probably be very large; present indications are that this is the most effective site now known in California.
[6] These reservoirs have been reported worthy of examination and survey. No estimates practicable at present. In a general way most of them will be costly in proportion to delivery; some probably too costly.
[7] Present indications are that these two are very valuable reservoir sites of large delivery. Not yet surveyed.

IDAHO AND WESTERN WYOMING.*

[Snake River Basin.]

No.	Name.	County.	Drainage basin.	Capacity.	Delivery.	Cost.
				Acre-feet.	*Acre-feet.*	
1	Jackson Lake[1]	Fremont County, Wyo.	Snake, South Fork.		1,000,000	Small.
2	Swan Valley[2]		do	1,500,000	1,500,000	Do.
3	Falls River[3]	Yellowstone Park.	Snake, North Fork.		500,000	Do.
4	Blind Creek	Elmore	Boisé		160,000	Do.
5	Fair Creek	do	do		60,000	Do.

---

[1] Capacity much greater than possible delivery. The delivery depends upon unsettled questions. If the proportion of precipitation which runs off from the water shed is nearly as large as in the case of Yellowstone Lake its delivery may exceed considerably 1,000,000 acre-feet.

[2] There is no question that the water supply is ample, and more than sufficient to fill this basin.

[3] Capacity probably much exceeds the inflow.

*The storage capacity in the Payette and Weiser Valleys is known to be large, but has not been surveyed. There is also a large portion of the Upper Snake Basin which remains to be even reconnoitered for sites and there is no reason to suppose that the above approximates the limit of storage possibilities in that basin.

MONTANA.†

1	Sun River System, No. 1.	Lewis and Clarke and Cascade.	Sun River.	12,000	12,000	Moderate.
	2	do	do	13,000	13,000	Do.
	3	do	do	63,000	63,000	Do.
	4	do	do	42,000	42,000	Do.
	5	do	do	65,000	65,000	Do.
	6	do	do	12,000	12,000	Do.
	7	do	do	3,000	3,000	Do.
	8	do	do	3,500	3,500	Do.
	9	do	do	2,000	2,000	Do.
	Yellowstone Lake		Yellowstone.		1,300,000	Small.
	Logan Valley		do		250,000	Moderate.
	Beaver Head, No. 1		Beaver Head.	500,000	400,000	Do.

† There are a large number of great reservoir sites not mentioned here which have been reconnoitered, but only to a sufficient extent to determine the fact that they have good dam sites, and a large water supply. Any estimate of their actual capacity and delivery would at present be premature. On the Madison River, Mr. H. M. Wilson is of the opinion that there is storage capacity with full delivery for at least 800,000 acre-feet at a low cost per acre-foot. On the Jefferson and its forks there is nearly as much. Sixty-two reservoir sites, all of which are believed at present to be practicable and moderately costly have been reported for withdrawal in Montana Their united delivery may be roughly estimated at not less than 4,000,000 acre-feet.

UTAH RESERVOIR SITES.

1	Utah Lake[1]	Utah	Salt Lake.	Very great	Not great.	Small.
2	Gunnison[2]	San Pete	Sevier	2,000	2,000	Do.
3	Bear Lake[3]	Rich	Bear River	Very great	Problematical.	Large.
4	Desert[4]	Millard	Sevier	800	800	Small.
5	Cottonwood[5]	Salt Lake	Salt Lake.	Small	Small	Large.
6	Panguitch Hayfield	Garfield	Sevier	Very large	5,000	Moderate.
7	Plateau Valley	do	do	Moderate.	2,500	Do.
8	Panguitch Lake[6]	Iron	do	25,000	11,000	Very small.
9	Marysvale[7]	Pi Ute	do	10,000	10,000	Rather large.
10	Otter Creek	do	do	25,000	25,000	Moderate.

---

[1] Surface 140 square miles; lake shallow; maximum depth only 14 feet.

[2] Projected; not constructed.

[3] Water-shed now draining into lake relatively very small; area of lake, 120 square miles. Dam site doubtful; can be filled by diverting Upper Bear River.

[4] Projected; not constructed.

[5] Valuable as possible source of supply of water for use of Salt Lake City. Too costly and too small for irrigation.

[6] An excellent site.

[7] Cost probably not prohibitory.

Senator **REAGAN**. That is a list of the reservoirs that have been selected?

Director **POWELL**. That is a list of those already selected and defined. The list is arranged by States. It will be seen that there is a large number.

Irrigable lands have been segregated in the same manner, and all segregations have been completed in Montana.

The total amount of lands selected as irrigable in Montana is 11,500,000 acres; in Idaho the total amount of land selected as irrigable is 10,900,000 acres; in Utah the total amount of land selected as irrigable is 2,200,000 acres.

There will be reported in a few days in our office for the State of California 1,800,000 acres; and for New Mexico, on the Rio Grande and in the Rio Grande Valley, 5,200,000 acres, all of land segregated as irrigable land.

I thought I would bring here our method of record. I have brought a map showing where irrigable lands of Montana are situated which have been designated. They are colored green. In the aggregate about 30,000,000 acres of land have been segregated and withdrawn from the market to be offered to the people for homestead entries, as the statute provides. There have also been withdrawn many miles of canal lines. The sites of these lines remain, under the statute, in the possession of the Government, as I understand it. In the same manner many hundred reservoir sites have been withdrawn from the market, enough to store water sufficient to supply many millions of acres.

In a very brief manner that outlines the work that has been accomplished with the appropriations that have been made in the last two years, amounting in all to $350,000. It is not all expended; there being a sufficient amount of money on hand to continue the work until the 1st of July, partly in the office and partly in the field.

The **CHAIRMAN**. What length of time would it take to do the engineering work, or how early could you do it so that the people may know where to locate the reservoirs, etc.? How long would it take to do sufficient work in each State for all practical purposes, so that they could have it in hand?

Director **POWELL**. That is a difficult question to answer; it depends on the rate of appropriations.

The **CHAIRMAN**. Of course I do not expect exactness in the answer; but I would like to know about what rate of progress you can make.

Director **POWELL**. I think it would take a long term of years at the rate at which we are now going. It would take fifteen to twenty years at the rate at which we are now going. It was understood when the estimates were made that that work would go on very much faster hereafter than now—I would like to get it all done in six or seven years. At the rate of appropriation on which the original estimates were made we ought to get the material practically ready in seven years, and one-seventh of the work can be done each year.

Senator **JONES**. With what amount of annual appropriation?

Director **POWELL**. About $1,000,000 a year; that is if we have to segregate the lands and do all those things which the act of 1888 and the subsequent act of 1889 impose upon us.

The **CHAIRMAN**. Suppose you were to leave out all except the reservoirs, and the points at which the ditches were to be taken out, how long would it require, how rapidly could you designate the reservoirs and the points, leaving out the surveys of lines further than would be necessary to designate the proper places?

Senator **Jones**. You have to have the survey made, I suppose, before you can tell definitely?

Director **Powell**. I can not do final work in any one basin without completing it all in that basin, and no part of the work is available for the people of such basin until it is all finished. We can not plan a system of works by piecemeal. We can not commence at the wrong end and plan backwards. We can not plan a reservoir and then afterward discover its site; we must know its site first. We can not plan until we know the amount of water which will be furnished to it, and by what diverting dam and what canal the water can be brought to it, and what lands can be irrigated by it, and what canals must be constructed from the reservoir to the lands. That is, we must discover the facts upon which the plan is to be based before the plan is made. We can not make the plan and afterwards discover the facts to fit it. The topographic survey must come first. The facts must be discovered by some method or other, and the topographic method is the cheapest way of discovering the facts, and the most accurate, and the most speedy. It would be possible to plan works by guessing at the facts, but when the plans were finished they would be worthless; perhaps they would be inadequate to serve the purpose; perhaps they would be extravagantly expensive because made on too elaborate scale. But the greatest danger of all would be to plan works which would not withstand the floods and be destroyed. The fortunes of the people depending thereon would then be wrecked, and in all probability many lives lost. It would be foolish and dangerous to plan the works ignorantly without regard to the facts which should govern their construction. Such a course should not be contemplated. The only question which can arise is, what is the best method of obtaining the facts; how can they be accumulated economically, thoroughly, and speedily?

Senator **Jones**. The surveys may show that such preliminary locations are bad. You have to make the surveys before you can know?

Director **Powell**. I do not think it is wise to give to the people plans for reservoirs and canals, and designate lands on which these waters may be used, until the surveys are completed, except to say that "these places are reserved." I mean as it is completed from year to year; certain areas can be ready every year, but the whole of the States and Territories would take seven years, as I have said.

The **Chairman**. We will have a number of different localities in which the people will be anxious to get to work, and a good deal of pressure will be brought to bear upon us all the time. I want to see how this can be relieved.

Director **Powell**. We propose to relieve the whole situation by taking the most densely settled areas first; then it must be understood that there is a certain amount of irrigation in every country which can go on independently of all surveys. There are small streams, springs, creeks, etc., on which the people can go ahead themselves. This general survey has its chief importance in connection with the great rivers, and with large creeks and streams, where large reservoirs may be constructed.

In some places the people's work is carried as far as possible, and where irrigation has been developed as far as possible by this means we are pushing in, first to show how that industry may be developed by the larger projects. But none of these will cut off the minor irrigation work. The major irrigation, the larger enterprises, will be developed from region to region in each State and each Territory as these regions become more important. The minor undertakings are already under way.

Senator REAGAN. Did you have any plan for distributing this work, so that the various new States and Territories may have their relative advantage?

Director POWELL. I shall estimate by States and Territories this year. The first year it was supposed to be experimental, and the matter was made at my request in bulk and not distributed, allowing me to select particular places to illustrate what could be done. The estimates will come in this year by States and Territories, so that it will be divided among them all.

Now, Mr. Chairman, on this subject I want to say something in relation to the plans. The work which we have done relates to the control of the stream water. What we have done does not relate to waters which are to be derived from artesian and other sources.

The CHAIRMAN. And it does not include storm water?

Director POWELL. It does not include storm waters. When estimates were originally made and planned for the survey, under the direction of a resolution of Congress I planned only for the control of the stream waters, and made no plan for the use of storm waters or for the use of well waters. The people of that region of country seem to demand that the other subject should be investigated. If that is done, the areas to be covered must be mapped in the same manner and somewhat more minutely, and a geological survey is necessary.

Artesian waters are found in geologic basins, where the formations are turned up—bent into basins or great geographical bowls, that hold the water, and where there are formations or strata of harder rock, practically impervious to water, and between which are sandstone or shales pervious to water. If there is to be anything done of value to the people it involves geological survey, and if that is done the basis of it is, like the rest, to be a topographic survey, for the maps are necessary. It is impossible to marshal the facts and understand their meaning without having them asemsbled on maps to show their proper relation. So that, as for the plains, they must be topographically and geologically surveyed. That will develop the basins. In addition to that, provision should be made for a little experiment in boring. As these basins are developed, experiments may be made from time to time in boring to test the accuracy of the geological conclusions. It would require, first, a geological survey; second, experimentation by boring, to be of any real and permanent value.

The CHAIRMAN. Your survey has not included boring?

Director POWELL. No; the law does not provide for geological work or survey under the appropriations for the Irrigation Survey.

Senator CASEY. What is included in a geological survey?

Director POWELL. The formations that underlie the country are to be discovered by going along the streams and by examining in that country the wells, every exposure, and every quarry for the purpose of finding strata and observing their relations, their position, where they dip under, and where they come up, etc.

Senator CASEY. That is, a geological survey involves a determination of what is under the surface?

Director POWELL. Yes; what is revealed only to the eye of the geologist.

Senator JONES. You have to make a tographical survey before that?

Director POWELL. It should be made at least *pari passu* with it; and to show the meaning of all the facts they must be assembled on maps. It is better to make it in advance.

Senator **CASEY**. But no such detailed topographic survey is necessary where the water can be found in wells, as in the case of running streams, because the water is generally used where it is taken out. Is not that so?

Director **POWELL**. Yes. The topographic survey for the use of the artesian waters is not necessary. That is a very simple matter, because that is seen by the man who stands by the well. The topographic survey for the discovery of artesian waters is another thing—not for the use of them but for the discovery of them.

Senator **CASEY**. The Geological Survey has an attaché, summer after summer, in our State, driving over the country and ascertaining all the facts, has it not?

Director **POWELL**. Yes.

Senator **CASEY**. Are not the data already collected by that attaché sufficient for topographical purposes?

Director **POWELL**. No, sir. The topographic survey which we have been conducting in that country has not been on the plains, but in the mountains. The topographic survey heretofore has been chiefly valuable to the mining people.

Senator **CASEY**. But you have had in eastern Dakota a man for several summers, at least, examining the country north and south, tier by tier, until he has been over all of Dakota; is not that true?

Director **POWELL**. For the purpose of discovering the succession of rocks.

Senator **CASEY**. Does he not take the altitude?

Director **POWELL**. Not for the purpose of making maps.

Senator **CASEY**. What I want to know is, if the cost of a topographic survey could not be dispensed with until the facts underlying the water question are ascertained?

Director **POWELL**. I think they should go on together. I do not think we could make reports satisfactory to the people without a topographic survey. The work could not be made satisfactory without maps and the map making and the geological work should go on together.

Senator **CASEY**. The one thing we and our people desire to know is, what is the extent of the artesian basin underlying that country; they care nothing for the topography of the country, because their hopes and their courage are dependent on what they ascertain in regard to the water that may be obtained. Now, as this is a question of expense, and the money to be appropriated for the purpose has to be granted by Congress, we want to make the expense involved as trifling as possible until we ascertain those essential facts. Therefore I suggest that perhaps an expensive topographical survey may be dispensed with until we know the facts about the water. Would not that be the better plan? Mr. Chairman, would not that strike you so?

The **CHAIRMAN**. We will discuss that after hearing all the facts.

Senator **CASEY**. It was by way of discussing it that I have stated what I have.

Director **POWELL**. If the artesian waters are to be discovered in such a manner that we may predict something of them—so that we can say to the people, "Bore here and you will get water," or "Do not bore there because you can not get water"—that would be of value. To do that a geological survey based on topography is the cheapest and the quickest method. If we go into that country and write books about guesses as to how the strata lie, about the sandstone and the limestone here and there without having determined definitely where they lie and at what depth they lie and as to their character, whether they be pervious or impervious to water, but go in with a general statement to the people that it seems to be a good country for the boring of artesian wells, and if it should afterwards turn out that it is not a good country for that purpose our reports would be of no practical value. Unless we should be able to say positively "Bore here, and you will succeed; if you bore there you will fail," the reports would be of no practical value.

In order to be able to say to the people "You can do this and you can not do that," you will require a map based on a survey. Geology is expressed in topographic features. The map-making collects and arranges these facts of geology in a manner the most economic. All sound geology is based on topography. No good conclusive geologic work is done in the world without this basis.

The CHAIRMAN. In passing through that section of the country the committee took all the testimony that it could get regarding the condition and the character of the rocks. Suppose now that the United States should make a reasonable appropriation for additional wells to determine the extent of that basis, and an intelligent man, a geologist if you please, were to diligently inquire and make a careful record of what had been discovered—of course your experimental wells would determine in other places—might you not with one or two intelligent men to observe and record what has been done, and with the Government making some more wells, determine with considerable certainty so that the people might see where they could sink wells, so as to be making a practical move?

Director POWELL. We can take the artesian basins that we know of. Some of these basins are pretty well discovered and defined, as I have said before. We can say to the people as to certain places, "Bore here" or "Bore there."

There are other places where the artesian basins are not well known, but experiments have been made in them. There are others it is probable now entirely unknown. We know that there are some artesian basins, but we do not know their outlines. One man bores in one place and gets no water. The money of the man who gets no water is therefore lost. To trace the outline of that basin and be able to say to the people "You can bore and get water but if you bore 1 or 2 miles away you can not get water," that we can not do until we have studied the geological structure.

The CHAIRMAN. Yes, but that takes a good deal of time. The people are on the ground. and they are boring wells. Their hope is predicated on the prospects of getting water. My idea is to aid them in what they are now doing by collecting the facts as to the penetrations——

Director POWELL. That we are doing.

The CHAIRMAN (continuing). Doing that carefully—ascertaining the levels at which they will have struck water, formulating the information as fast as possible, and giving them all the knowledge available; and then, under an intelligent man, having some Government money expended in boring other wells to relieve them of the experimental expense. I have received I suppose twenty or thirty letters from enterprising men in that section, and one from a gentleman in New York, the other day, who said that he owned some land there and wanted to sell it to settlers. He wanted to know what information there was to be had as to the developments that had been made there in artesian wells, and what the Government could do or would do. It occurred to me that it would be well if you could have somebody who was a good geologist to classify what has been done, without waiting for the topography—without waiting for the general geological survey; simply to classify what well-sinking has been done; and then to let some chances be taken, without speaking with absolute certainty, but giving them all the facts, as to where water is found. They will not want to wait until you have done all your work, so as to be able, as you say, to speak positively. They want to do something right away. The people are there and want immediate relief.

Senator CASEY. Will you be able to determine the limits of that basin without the experimentation?

Director POWELL. No, sir; not fully.

Senator CASEY. Is it not better to immediately proceed with experimentation to ascertain the expanse of those basins, instead of waiting for the topographical survey that will involve considerable time and expense? The very fact that the Government is taking an interest in this matter will be of great value to the people of that country. Their courage will be greatly aided. As to a topographical survey, the average citizen knows nothing of it. If he sees a hole being bored in the ground he knows what that means; he knows that it means business. The more important part of the country to water is the uplands, away from the river. What the people desire is that they shall know whether they can have water. Coming over this country, for instance toward the Red River, they will want to know whether they can get water, and at what expense. Can not that be ascertained by experiment, and can not the other work be followed up as inaugurated? That is to say, can not the beginning of the work be the boring of experimental wells?

Director POWELL. The work which is to be done there can be considered from two stand-points. It can be considered from the standpoint of what will be known when it is finished, or it may be considered from the stand-point of its progress—what will be known in the stages of its progress.

While the topographical work is going on, as I should work, the geological work is going on, the experimentation is going on; and the geological work is confirmed, as it is going on, by the experimentation. And when it is finished we will know the whole thing; but we will only know parts, as we finish the work in parts, as we go along. But as we go along the work will be developed *pari passu*.

Senator MOODY. The people who have sunk these wells are not scientific people, but mere well diggers. The information which they have obtained they have not preserved.

The CHAIRMAN. Some of them have.

Director POWELL. We have more facts than they dream of.

Senator MOODY. They have not the facts which would enable them, or enable a scientific man, to determine the strata and the extent of the basin and all that. Of course you are aware that right here on the banks of the Missouri River, the very southernmost point of South Dakota, they have several wells. We know the fact, of course, that they were obliged to go only from 450 to 650 feet, according to the elevation on which they started, to strike that basin which brings the water to the surface with force, and of course we know the fact, for it is a familiar one, that the pressure there is from 60 to 80 pounds to the square inch. The other day they struck a well at 760 feet at Huron. They had to go 900 feet elsewhere. They got a well at Redfield at about 1,100 feet, and so on. They had to go as far as 1,300 feet on the divide between the Jim River and the Missouri River.

Here is a quartzite stratum along the eastern side of North and South Dakota. That red quartzite which they call jasper, sometimes granite, they have attempted to go through, but they have never found any water at any depth that they have gone through that. So we call that the "rim," or the "rim-rock." No experiments have passed over the Missouri River, or over the divide, in fact they have not got quite on the divide.

Now, the query is whether it would not be advisable to put a force into the field at once for the purpose of making a fairly good survey to show what area of this country can be utilized for irrigation—to experiment with this water—to see for example whether there is anything in the water which would be detrimental to crops.

The CHAIRMAN. I think the water is very good.

Senator MOODY. And then to dig experimental wells over west and across along the Missouri. Where we get across into the western part of the country we know there is plenty of surface water, and people are using the surface water for irrigation; they are constructing ditches in this region of country. One of these ditches is 25 miles long. But going farther north, into the western part of North Dakota, we do not know how much use can be made of the waters. What we want is that these people already there on the ground—600,000 people are located there—may know where they can get water. The farmers will have to depend upon bringing water to the surface to furnish moisture either in the atmosphere or upon the lands, because there comes sometimes a series of years in which they do not have sufficient rain-fall.

Senator CASEY. And four-fifths of the people are farmers and directly dependent on their farms.

Senator MOODY. Now, as Senator Casey has said, what these people want is courage. The courage of conviction is what they greatly desire, and if the Government will give them sufficient money to dig experimental wells they will take care of the rest.

Senator CASEY. But their courage must be built on that which is palpable to their eyes. They can not be expected to look upon this question from a scientific stand-point at all.

Senator MOODY. They want results.

Director POWELL. But what shall the people be given courage to do, to bore wells where they will ultimately fail or to bore wells where they will meet with success? Suppose they are advised to bore wells on barren ground; the first failure of that kind would react and all courage would be lost. I do not wish to give the people courage to lead them on to failure, to waste their energies in seeking disaster.

Senator MOODY. Will not the expenditure of a few thousand dollars there by the Government absolutely determine the question as to where that artesian belt exists and where to bore?

Director POWELL. Artesian water can be discovered in part by experimentation and in part by tracing out the formation of the ground.

Senator MOODY. And one must go with the other, you think, or ought to go with it?

Director POWELL. Yes, precisely. The geological examination without the experimentation will more or less be futile. The experimentation without the geological examination will be wasted. That matter has been up before Congress again and again, and appropriations have been made for Texas and Colorado. Fifty thousand dollars has been expended by the Government and thrown away, and yet there are artesian waters in that State. But the wells were bored without the examination of the geological structure and were not placed where the water was to be found.

Senator MOODY. Is it not practical with a comparatively small appropriation or expenditure for you to put into that country a corps of engineers and others right at once?

Director POWELL. I have estimates sent to the Secretary for each of the Dakotas of $50,000, with the idea that the work there was pending, that it was necessary, and that they wanted the work done at the earliest possible day.

Senator MOODY. Fifty thousand dollars for each of the Dakotas?

Director POWELL. Yes.

Senator MOODY. Is that enough?

Director POWELL. I have asked for $50,000 each for North Dakota, South Dakota, Nebraska, Kansas, and Texas, to be used in this work. With that amount of money I propose to take up, first, the study of the artesian waters and storm waters. My judgment is that the storm waters will be most valuable. I want to be frank with you. I think the people are mistaken, but the people believe in the artesian wells and I am going to meet them.

Senator CASEY. And the population lies where the storm water is not available without very great expense, such as the tapping of the Missouri, or something of that kind.

The CHAIRMAN. Oh, no.

Senator CASEY. I am living in that region and am familiar with it.

Director POWELL. My idea is that the people are looking to the artesian waters, and I should push artesian examination first; but I believe that it will be but a small resource, and that the great resource will be in the storm waters and river waters.

Senator CASEY. The experimentation is different in our case, because there are facts that exist from which you may proceed, and the examination of the basin should be from what is known outward.

Director POWELL. Yes; you have artesian basins but how much water will they supply is the vital question.

Senator CASEY. That is a different thing from an examination in a country where no well has ever been discovered.

Director POWELL. Already we have facts in relation to the two Dakotas upon which we can proceed with a great deal of confidence about the artesian waters. There has been sufficient study of the geology and sufficient experimentation to make a basis from which to start.

Senator CASEY. The confidence of the country with regard to the James River Valley itself is established; but the notion exists in the minds of the people that when you have left the particular formation which makes that valley (of which they know nothing, but which they suppose is the formation inclosing the valley) they will not be able to get water. They have not the courage to expend money for wells there. If the Geological Survey will ascertain that the basin is not confined to that particular valley, experiments will go on by the people in all directions, but they must have some one thing to give them that courage.

The CHAIRMAN. Suppose that, taking the places that are known, experimental wells were sunk outside, where the probabilities are great, but where people are not willing to make the experiment, the Government money would not be wasted, would it?

Director POWELL. Some would be wasted and some not.

The CHAIRMAN. If where you succeeded and gave courage then private enterprise would take hold of it; even if you did waste some money the information would be valuable. By sinking the well the formation would be discovered as you went down. What would be the average cost of these wells?

Senator **Moody**. The well at Redfield, complete, 1,050 feet in depth, cost $3,100.

The **Chairman**. What did the well at Huron cost?

Senator **Moody**. That will cost more, although it is not quite so deep.

Senator **Casey**. That well at Jamestown cost $7,000. But there is nobody who knows just what a well is going to cost.

The **Chairman**. I should like to get at a general average, to see how much money is necessary to accomplish any useful purpose.

Senator **Moody**. Mr. Holt, whom you met at Huron, I suppose, gave the matter a great deal of attention, from the fact that he has had the management of a farm mortgage company there.. He told me that they had received an offer from a responsible company to sink thirty-five wells in that region of country for $35,000.

The **Chairman**. What would be the average depth of those wells?

Senator **Moody**. The average depth would be about 800 feet.

The **Chairman**. If they went to the higher lands they would have to dig deeper wells?

Senator **Casey**. That would be relatively more expensive. I saw Mr. Holt and other people at Huron quite late in the season, and the people on the ground were quite doubtful as to whether it could be done at that price. So that I think that you will need to reckon on these wells costing $5,000 each, taking the average of the country up and down.

Senator **Moody**. Possibly, if you reckon on the divide, that may be so.

The **Chairman**. Major Powell has got $250,000 for the plains.

Director **Powell**. Yes; if the work is to proceed on the theory that the basins are to be discovered by the boring of wells then the appropriation should be larger. If you want immediate results and want to proceed on the theory that the investigation must be made by experimentation, the appropriation should be larger and it should be expected that much of it would be wasted.

Senator **Casey**. That could not be avoided.

Director **Powell**. With that understanding we can go ahead experimenting.

Senator **Moody**. If every experiment was to be a success we would not want you to make any experiment. We would make it ourselves. It is for the very purpose of determining absolutely that it is no longer an experiment that we want this done.

The **Chairman**. The situation out there is very pressing.

Director **Powell**. If you will give me sufficient money, I can, within one year, put a corps of geologists and engineers boring on the plains, but it must be understood that much would be wasted, and when the work is finished not a very great supply for agricultural purposes will be given. The amount of water to be obtained from artesian wells is very small, but what there is will be of value.

Senator **Moody**. That is what we want.

Senator **Casey**. That is what we want, so far as North Dakota is concerned.

Director **Powell**. Many of the wells bored would be failures; others would be successes. A double corps would be needed—a corps of engineers and a corps of geologists.

The **Chairman**. There is a vast population there now that are suffering, and the Government can afford to give them courage, if it is possible to do so. If it could relieve them at once and stop their sufferings it would be a great blessing to that country, for it is really suffering. There are 600,000 people there and they have lost their courage. They want immediate knowledge in order to give them courage. They are a vigorous and active people and only want encouragement.

Senator **CASEY**. They want the knowledge that the Government is taking an interest in this matter. They want it in a palpable form.

Senator **MOODY**. Of course we know the existence of this rim-rock. I believe you call it Sioux quartzite?

Director **POWELL**. Yes.

Senator **MOODY**. It is a formation by itself. Of course we know there is a little out-crop of that quartzite on the Jim River, which is not very material, and there is nothing of it as you go west. The limit of this artesian basin, west, has never been found. In other words, it has never been a total failure to find the artesian basin. So we think, or at least we hope, that the proper investigation by scientific men—by the men that you will be able to send out—would supply sufficient facts, so that it would hardly be an experiment to dig a well.

The **CHAIRMAN**. How much of an examination would it be necessary to make to examine the Missouri River as to where it could be taken out, etc.?

Director **POWELL**. If any ordinary appropriation is made we will be able to do that next year.

The **CHAIRMAN**. I do not mean a general survey, but to ascertain the particulars?

Director **POWELL**. I understand. The single fact could be determined easily; it is a question of levels.

Senator **MOODY**. The situation of the country is such that after getting out of the influence of the Jim River, you have to take the water from the Missouri. You can not climb this ridge.

The **CHAIRMAN**. Oh, no. That is the thing we want investigated.

Senator **CASEY**. The bulk of the population of North Dakota lies east of what is known as the Coteaux.

The **CHAIRMAN**. Are you through with your general statement, Major Powell?

Director **POWELL**. Let me say just one word more, Mr. Chairman. If I beg for thorough work, which will not ultimately lead to disappointment, I want you to understand my motive in the matter. We can do work that will be valuable to the people at once, in some cases, but in many cases it would bring disappointment. If we are hurried in doing it, instead of doing it in a careful, scientific manner, many people will fail and will say "We have failed because we followed the recommendations that were given." We know of three artesian basins in the Dakotas: That on the Red River has been carefully surveyed. Its supply of water is limited; but it is in a region of country where irrigation is not necessary. Farther west there are two other basins, imperfectly known; one of them gives no evidence of being of great value; the other gives evidence of being one of the finest basins in the world and is worthy of the most thorough examination; and yet we can not hope for a great supply of water for irrigation from it. Water for towns, villages, gardens, ranches, and even for powers, may be obtained, and perhaps some small amount of water for farming purposes; but artesian waters are always limited, and excessive boring destroys them. The great basin of the Dakotas should be utilized to its fullest extent, but it must not be tapped beyond th.. or the whole thing will collapse. That has been the experience of many artesian basins; and it seems to me that it would be wise to direct the attention of the people more to the storage of storm waters. There are many portions of the Dakotas where this can be done advantageously and cheaply. Yet I do not wish to discourage the use of artesian waters to the utmost extent of the supply.

The principal supply of artesian waters in the two Dakotas is from the Dakota sandstone. All the great wells are found in it. We do not have to discover that sandstone; we know its extent throughout the country, but we do not know how much water it will yield. We do know that the supply is limited, that it can not be great; that it will be impossible to multiply wells indefinitely; and we do not know but that this source has been drawn upon nearly to its limit. Should I say to the people that this sandstone is found from north to south throughout the Dakotas and from the ninety-seventh meridian westward nearly to the Rocky Mountains, and that you can in most places find artesian waters in it—which is a fact—it would give the people courage to bore, and many wells would be immediately sunk, and the probabilities are that the supply would soon become exhausted and all existing wells destroyed. What we want to know is to what extent this source can be drawn upon and when the boring of wells into it must be stop. But what is still more important, we wish to discover whether there are any other water-bearing formations. All this can be determined in the most speedy and most economical manner by a geological survey based on topography and by an occasional experiment to verify the inferences of the geologist. The geologist is able to say that such and such rocks and such and such districts will not afford artesian waters. His first conclusions are therefore negative, excluding certain rocks and certain districts. Then he discovers other districts where the character of the rocks and the geological structure give probabilites that artesian waters may be found, and these probabilites must be tested by experimentation.

And finally, Mr. Chairman, I wish to be understood as expressing the opinion that when all the artesian waters are discovered and all utilized there will still not be a sufficient amount of water for the region of country of which we have been talking, extending along the plains from our northern to our southern boundary, greatly to affect the industries of agriculture. Artesian waters have always been and must be inadequate to meet the wants of irrigation, except here and there for gardens, orchards, vineyards, and for stock purposes. The great fields of Dakota can never be cultivated by artesian waters. To encourage the hope for success in this direction, on any scale adequate to the needs, is to give the people a false hope that will lead them to disaster. I know that the people see streams of water bursting out of the ground here and there, impelled high into the air, and in times of drought these are beautiful scenes. I know that they have reached the conclusion that there is a lake of water underground, and that rivers flow beneath their feet, and that they have but to tap these sources to receive an abundant supply. But I also know that these opinions are groundless; that the waters which they obtain are only those which percolate through porous sandstone from a long distance away, and that the supply is exceedingly limited. I know that the sandstone in which it is found is widely spread, but I dare not tell them of its extent lest they be tempted thereby to spend vast sums of money in vain, and reach still worse results by destroying the fountains already developed. It is my opinion that the resource is not exhausted, that some more wells can yet be successfully sunk into the Dakota sandstone, but to what extent it is safe to go on as they have begun I dare not say until a proper examination is made. I am not willing to deliberately face the facts before me and encourage the people as you desire.

Mr. Chairman, the discussion of this subject of artesian wells has come at the end of a long hearing, and little time has been given to it in view of its importance. I should be much pleased to be heard by the committee at greater length on the subject, and to prepare myself with maps and diagrams, that the question may be fully understood.

Is it wise to encourage the people to gamble for water with the dice loaded against them?

FOURTH DAY'S SESSION.

WASHINGTON, D. C., *January* 31, 1890.

The committee met. Present: Mr. Stewart, chairman; Mr. Plumb, Mr. Casey, Mr. Moody, and Mr. Reagan.

The CHAIRMAN. I will say to those who are here to-day that we have gone over generalities sufficiently. We have collected a vast amount of general material. What we want now is to hear from any person present who has practical ideas as to what can and ought to be done to facilitate irrigation; how it can be directly got at; what aid the Government can give most advantageously and with the least expense to make a profitable development of the arid regions. We would like to confine gentlemen to that. I would like to hear from two or three on that point. Mr. Nettleton is a practical man; and we will hear from him; also Mr. Hinton. (Addressing Mr. Hinton.) The committee would like to hear your views as to the practical methods of procedure desirable on the part of the Government to aid irrigation. We have already gone over a great deal of ground, and have collected the general history of the subject from the testimony taken throughout the country. Major Powell also has given us a good deal of the general history. We will, therefore, necessarily limit those whom we are to hear to-day to practical suggestions as to what ought to be done.

STATEMENT OF RICHARD J. HINTON, IRRIGATION ENGINEER, U. S. GEOLOGICAL SURVEY.

Mr. HINTON. In the work before us, Mr. Chairman, at present there seems to be two distinct points to be aimed at, for largely the running waters within the arid region are being daily and almost hourly consumed. By that I mean the streams and the waters in sight. The points to which I should direct then my attention would be: first, that we should aim at the conservation of the storm or surplus waters, which must necessarily be stored in the high altitudes of that region, and, secondly, the restoration for use in agriculture of the waters under the earth.

These two divisions at the present moment seem to me to be the essential purposes for which engineering efforts should be made. I suggest then that the great area lying east of the Rocky Mountains—the plains and foot-hills—from the 97th practically to the 101th degree of west longitude must come first, because of the great population that has gone in there, and of the large amount of struggle and of pecuniary effort that have been made by them; also, owing to the condition in which they are being constantly placed by reason of the insecurity or uncertainty of the water supply. These severe conditions arise not so much by the deficiency of the water supply—taking the years through—as by its unequal and unsuitable division. What we call the great plains region, then, has for the work of reclamation to be first considered, upon the ground that the largest part of the population to be benefited by irrigation are to be found therein.

The problems involved in that fact are, of course, two-fold, as in the whole field: These are the storage of the surplus waters in the Rocky Mountains proper and in the valleys of the streams flowing there, and the obtaining of an adequate knowledge of the waters within the earth, so as to make plans and lay out the best methods for their economic use in the near future.

In the two Dakotas, our journey last summer, and the evidence that has been taken by the committee, show the most remarkable artesian water-belt, I think, known in the history of the world. The statistics are very limited thus far as to its definite limits, but I have obtained a list of about forty of what I would call town-wells, having depths from 1,600 to 1,800 feet and a pressure of from 80 to 220 pounds to the square inch. These are within a comparatively limited area, which, with perhaps two or three exceptions in the James Valley, would be below a level that would allow them to be supplied from the seepage or percolation of the Missouri River. I do not say that they are so supplied, because no one can tell that at present, but the levels are such and the geological indications, so far as known, are such as to give reasonable ground for the belief that some of those wells may be so supplied.

Senator CASEY. From the Missouri River?

Mr. HINTON. From the seepage and percolation of the Missouri River. From my observation, covering many years, and of late years very closely applied, I am convinced that we know very little as to the practical extent of percolation or loss, the underflow some call it, from the waters of the great rivers flowing across the plains, and through the arid region generally. That is the field of observation that we have to develop. I believe that under this so-called underflow is in a large degree the source of a very great many of the springs and of the wells that we find in those regions.

Senator CASEY. Of the artesian wells, also, do you think?

Mr. HINTON. Of the artesian wells, also. I could not put that forward as anything more than a reasonable suggestion, because there has yet been no investigations of a character sufficient to warrant anybody in positively stating such a theory.

It has been said that we need a topographical survey for experimental work in that region. Against the able and distinguished gentleman who assumes that, I hate to place myself as hostile, but I believe that the experience of all engineers testifies that it is a fact that topography can not indicate clearly or definitely where any artesian or other water may be found. Geology certainly can help in that direction and it certainly will help. The Dakota basin seems to be geologically delimited, so that its eastern rim is well defined; its general formation is understood, and if there can be an appropriation for the purpose of definite experiment in regard, first, to the artesian water supply, its area and sources, and second, to the gauging of the great stream that runs through the Dakotas that is the Missouri River, so that we may know definitely the amount of water, of the volume, etc., that flows through its channel at any given time, we shall have accomplished a piece of work that, well done, will be done for all time, and does not depend upon a topographical survey or even upon a more definite geological examination.

If I am asked to recommend the way, I beg to suggest a considerable appropriation for these definite purposes: first, of ascertaining the character, through the boring of experimental wells, by the river gauging suggested, and by the location of tanks or small reservoirs, of the water supplies of the two Dakotas; secondly, to place the States of Kansas and Nebraska, with their Arkansas and the Platte River Valleys, in another district, find out the same class of facts therein, and in addition investigate the best manner of recovering the great body of water which sinks into the earth—the water which flowing from the mountains spreads through the broad channels I have named, and finally sinks into and is extensively retained by the stratum of gravel and sand, immediately below the soil.

There are artesian wells in northern and central Nebraska. Reaching over into northern Kansas, in the Republican Basin, will be found a large body of water lying near the surface, which can be made of great agricultural value, at little expense, by experimental work and development.

When we come to southern Kansas, we find that there has already been some work done in the way of ascertaining the value of the seepage or percolation of the Arkansas as it flows eastward. At Dodge City, though the work has been temporarily stopped by the winter storms, they have already run some 20 miles of tunnel or drift. The average fall of the Arkansas River from the mountains is about 7 feet to the mile. This insures the possibility of putting in levels for the purpose of obtaining that under-supply and distributing it over the land at no great expense.

Senator CASEY. Point out on the map the regions to which you refer, as you go on.

Mr. HINTON. This is the Arkansas River [indicating], here is Dodge City. At Dodge City they are running a tunnel in westward. The average fall from the mountains, then, is at least 7 feet per mile. The project is to take it out on either side by reservoirs and laterals, and distribute it on the land. In the counties to the south, there is a considerable artesian well region. There are a number of artesian wells in Meade County and elsewhere in that section; of this, the committee has taken evidence.

In eastern New Mexico there is an extensive region of large springs, showing the existence of water under ground that comes with great force to the surface, We find when we come to northern Texas, and to what is known as the Staked Plains and the Panhandle region of that State, that there are in existence to-day a great body of wells. Some are artesian in character, but there are many that flow so near to the surface and with such force that it is evident that if these wells were sunk deeper they would have the artesian quality; they would strike that stream. It is a general belief there, among both engineers and practical observers, that the water under the Staked Plains, the water from which these wells are supplied, has the character of a flowing stream. Some experiments have been made in the neighborhood of Marienfelt, Odessa, and Midland, on the Texas Pacific Railroad, which seem to indicate the correctness of that theory. The altitude lowers abruptly, and the land is of a totally different character. Beyond the westerly limit of the Staked Plains the land is all of a distinctively arid character, as arid as Nevada or Arizona. It has no precipitation exceeding 8 to 11 inches of fall per annum. But throughout northwestern Texas there is unquestionably a large underground water supply. The springs which come to the surface, the evidence of the wells upon Staked Plains and in the Panhandle region, indicate this. Indeed, the testimony all goes to show that there is a supply sufficient if it could be brought to the surface to answer the purposes, by small storage, of almost that entire region. The rain-fall will average 20 inches per annum.

The CHAIRMAN. You do not mean by that statement to say that it would be sufficient to irrigate all the land, do you?

Mr. HINTON. No; not all of Texas west of the 97th meridian. By no means. Of course the valleys of the Colorado and of the Pecos Rivers must largely be a surface-irrigation region, supplied by those streams. But still a large portion of the area can be supplied by a small storage system that may be made by conserving the local rain-fall from the surplus of the wells, by their storage, and by that of seepage or drainage water also. My own judgment is that on these great plains running through, east to west, between 97 and 103 degrees, in the main, small storage rather than great works will for a long period of time to come be the reasonable and safe means of supply for the people living therein.

Looking at the Great Plains region practically, and as a matter of legislative recommendation, I should say that this Government may reasonably and properly expend sufficient money to find out the water supplies thereof; to ascertain how they can be most economically conserved and used; in short, to learn definitely to what extent these plains may be made permanently available for agriculture, or whether, in fact, they must be in large part retained only for pastoral purposes. This knowledge may be obtained, rapidly and with sufficient accuracy, without the delays necessarily incidental to a full topographical survey, or even of a minute geological survey. The pioneers will go onto these lands. They should have accessible the information requisite to their proper direction.

Of course, I beg leave to say, that it is the business of legislators to see that a proper topographical and proper geological survey shall be carried on, but I do not think the Irrigation Survey is necessarily dependent on their progress. On the contrary, I suggest, with all deference to abler men than myself who express a contrary opinion, that the delays incident to their completion will result in a positive injury to the irrigation work. There are competent engineers in the Survey, and there are facts sufficiently known as a basis for their action, so that it would be possible to commence at once the work of investigation for experimental artesian wells in certain directions; the work of developing the quality and the character of the percolation of the great valleys I have named, the Arkansas, the Platte and others, the flow and character and volume of the Missouri, as it runs through these regions. All this is absolutely necessary. Engineers and geologists may arrive rapidly at proper conclusions. The railroad surveys made across the plains will give all the needed altitudes. A series of field reconnaissances can be vigorously pushed. All the preliminary facts can be arrived at in a proper manner some time before this Congress adjourns, and at a day early enough to enable it to have some definite information before it on which to base any other action that it might deem desirable. I want to add that whatever money expended experimentally on these lines will not need to be continued. A topographic survey, or rather a series of topographic maps, is not a precedent condition.

The CHAIRMAN. Your attention has also been called to Arizona. There are a large number of petitions from there for experiments such as you suggest.

Mr. **HINTON**. Arizona is a region over which I have traveled and observed almost as much, in days past, as I have in Kansas and the central region. In southern Arizona there are areas of underground supply that can be developed. The Santa CruzRiver, for example, flows under ground to Maricopa, in the Gila Valley. It runs into the Gila River near that point. The Santa Cruz River rises a few miles below the southern line of the United States, in Mexico. It runs almost directly north to Tucson. Nine miles beyond Tucson it is lost under ground, and then, for some 87 miles it flows under ground, until it enters the Gila and helps to swell that river. The valley of the Santa Cruz contains about 1,140,000 acres, a very large proportion of which, if there were water for it, could actually be brought under the most efficient horticultural use. It is a region admirably adapted for fruit. At the Mission of Tumacacori, and at Tubac, Calabasas and other places, there are the remains of fruit gardens that the missionaries planted and used. I have seen, in years past, all the semi-tropical fruits growing on farms that were maintained there against the Apaches. The Santa Cruz River should be taken out, as near its source as possible, and distributed by means of high-line canals.

The land is very fertile. The river has a great drainage area at its head. It is fed by several very important small streams on both sides, and if it were taken out and placed in a new channel, and distributed over the valley, the entire region at and below Calabasas could, I believe, for some 10 or 12 miles wide and 150 miles long, be made a perfect garden. We used to fancy in years gone by, in traveling over the Cienega, north of Tucson, that we could hear the waters running under ground. I do not know whether that was a correct inference or not. Eastward, and lying beyond the Dragoon Mountains, will be found the San Simon Valley, or plain, known in the olden days as the principal route southward of the Apaches. You can get water in the San Simon and Sulphur Valleys anywhere at from 8 to 40 feet below the surface. All through, in this low table-land, you will find wet places—the Mexicans call them cienegas. There are a number of ranches in that valley now supplied by such waters, from either wells or tanks and ponds. The San Pedro River also, between the San Simon and the Santa Cruz, rises in Mexico, as the Santa Cruz does, and can be, by storage near its head, made of much greater service than is now the case. Upon the plateau on which Tombstone is situated they have some artesian water, and I understand there are two flowing wells at that place.

Crossing into New Mexico, over the Chiricahua mountains, and beyond the eastern foot-hills of that range, you reach Deming and the table-land around it. Water has been found there from within 25 to 40 feet of the surface. It is an important railroad junction. It is so near that slight pumping brings it to the surface, and makes it valuable for the small irrigation, for fruit and gardens, that is going on in that region.

From what I can learn in relation to it, it would be possible to develop the whole well or artesian water-power there, and create a small storage system which would bring a large proportion of that mesa, or bench land, under cultivation for grass and root crops, as well as for fruit. Through this region and up to the lower foot-hills, water can almost always be found a short distance from the surface. Most of these little valleys of that region could be reclaimed by the use of small storage.

The **CHAIRMAN**. What have you to say as to Salt River and the Gila, and their valleys?

Mr. HINTON. The Salt River and the Gila are necessarily to be developed by large systems of irrigation. I do not believe that the Government of the United States will have to expend any large sums of money in the direction of assisting Arizona or the capitalists who may interest themselves in the reclamation of those two valleys. When I first visited Salt River, years ago, there was considerable land in the hands of small farmers with little ditches. The same thing can still be seen in the Mesilla and the Rio Grande Valley. Within a few years, as the evidence taken last summer will show, the Salt River Valley has passed under the control of a large corporation. The supply is better managed and of a much better character. If their propositions are carried out it will still further increase. There is probably no region, even in California or any other State within our borders, that presents a larger future as a horticultural or fruit-raising region than the valley of the Salt River and the valley of the Gila. On the Gila there are points where storage reservoirs should be maintained—at the buttes, near Florence, and above. Large irrigation systems are always desirable.

This region through here is a cañon region [indicating on the map]. It is not itself of much use for agriculture or even for pasture, but it is of great service as a source of water supply. In this region [indicating] the irrigation would be accomplished largely by local storage, some of which will be quite extensive, as at Walnut Creek; but it will be what in the future will be known as a secondary system. It will not be the high altitude storage system.

In regard to high altitude work we must bear in mind that what we now really know of the precipitation over the whole of this region relates more to the valleys and the table-land than to any other part. All the meteorological or weather service reports that we have had have been simply for the purposes of local trade and traffic. We have had no system of observations of a definite and distinct character in regard to the mountain ranges. The rain chart presented in the last census by Mr. Gannett, and of which I have a copy here, and which has been improved by later observations, shows that the only record we have of rain-fall definitely from the ninety-eighth degree to the Pacific Ocean will range, going from the east to the west, from 20 inches down to 8 and 9 in the basin, and up again to 18 and 20 or 24 on the Pacific coast. At some points it will fall as low as 3, 4 and 5 inches. This is the record at Yuma, in the Colorado Desert, at Mojave and elsewhere. We know as a matter of fact, though not from a recorded series of observations, that the rain-fall and snow precipitation on the mountains is as from 3 to 5 inches in excess of what it is in the valleys below. The average snow-fall on the Sierras will be from 60 to 70 feet of loose snow, giving us on the basis of 11 inches of snow to 1 of water from 5 to 6 cubic feet of water. All, or nearly all, of this water runs to waste. At least 90 per cent. of it passes away in evaporation, or largely in the ground. The largest portion disappears below.

The first great feature of an irrigation survey proper will be the conservation of these storm-water supplies. I take it for granted that it is not necessary to accompany a survey for that purpose by an attempt at an accurate topographical survey of the lay of the land. I have never seen or heard of any country in which a topographic survey has been considered a condition either precedent or subsequent to successful irrigation. The chief objects, then, of a United States irrigation survey to my mind are, first, to delimit, so as to be known of all men, the drainage areas; secondly, to define the available reservoir sites within those areas; and thirdly, to indicate the channels by which they can be most economically distributed when made.

So far as the Government of the United States is concerned, it being definitely understood that there is no work of construction to be undertaken, the object that it should have in the establishment of an irrigation survey is to achieve those definite and distinct points, the delimitation of the drainage areas, the definition of the reservoir sites, and the indication on the maps, the simplest and clearest that can be made, of the leading, most economical, and safest methods of storing and subsequently distributing the waters that are to be conserved.

The work I have indicated as that which in my judgment should be done east of the mountains would be largely in the way of experiment. Some of it might fail; other portions of it would, I believe, succeed. I do not know positively; no one does; but I believe so. But, when the wells are once sunk so that we have found the definite basis of supply; when the rivers and streams are gauged; when we have examined into the question of the value of the percolation of the great streams like the Arkansas and the Platte, the money expended on that would have settled the questions at issue. The encouragement which will be thus given to industry and effort will be quite sufficient to induce private capital to go in with them. Behind that and beyond it the work of the great storage basins must go on. Each drainage basin is supplied in the main only by its own local precipitation. We do not get any more water practically than falls upon it. In, therefore, developing such a region as the Arkansas Valley, while we do not necessarily now have to establish, and might not this year or the next have to establish, the high storage basins, we must expect to see them developed and completed finally in order to insure continuous security and safety to the entire valley.

First, then, I would take the Arkansas Valley as one practical fact. I would take the valley of the Rio Grande, which is in peril, as another. Both of them, owing to the great snow-storms of the passing winter, may be very well situated next summer, yet all the time they are in peril. This is owing to the use of the water in Colorado, the State wherein they both rise. The proper use of the Colorado use is water. It is necessary to develop the facts indicated by the Director of the Geological Survey. I believe they are facts. In the Rio Grande Valley there will be found to be a series of great storage and drainage basins, each portion of which can be served by its own high altitude precipitation by the snow and storm waters stored in the mountains that mark the drainage rims and outline these great basins.

Utah comes next in my judgment. The people of that Territory have developed the primary forms of irrigation in a manner and to an extent unknown elsewhere in the country, but they have reached pretty nearly the limit of their capacity in that direction. And with the recurring arid or dry seasons they are always in danger of losing their prosperity through the loss of crops. They have 600,000 acres of land under water, and usually irrigate that much. Last year, as the testimony before your committe shows, not more than 350,000 or 400,000 acres of that land were in cultivation. Utah needs deliberate and definite work in regard to defining and delimiting, as I have said, the drainage areas and their reservoir sites with a view to the encouragement and support of those people. It will also need some work in the development of the underground supply, because in the basin of Utah Lake and elsewhere to a limited extent there is an underground supply produced by the drainage of those great waters, and the United States might profitably spend a little money in testing the capacity and extent of the areas thereof.

The same is true of Nevada. Nevada, perhaps the chairman will permit me to say, is looked upon as rather the lost sheep of the American Union; as having very little capacity for anything now except the possible discovery in years to come of a new bonanza. I do not hold that opinion, and I have passed much time traveling through Nevada in the last fifteen or twenty years, and have studied it closely, and I believe it is possible to make Nevada, by a comparatively moderate expenditure, by means of the reclamation of its arid lands from water supplies that are in sight, a State that will support a population of at least a million of people in the comfort which irrigation produces to the community wherein it is practiced. I should like to say here that farming by irrigation produces a more comfortable life, more prosperity, and, so far as my observation goes (and it extends from America to Egypt and from there to China), it produces more food supplies, more sustenance from the land, and brings more comfort, prosperity, and certainty to those who work by it than any other system of farming does. It makes the production of food almost as certain as the weaving of cloth.

I have gathered a few items regarding Nevada which will take but a moment or two to state, because there are some problems involved there in the question of reclamation that need consideration.

The area of that State is 71,737,600 acres, of which the water area is but 1,081,600 acres. The timber is estimated to cover 2,600,000 acres; the pastural area is estimated to be 30,000,000 acres, the mineral area 15,000,000 acres; the desert and saline deposit, 3,656,000 acres, and the agricultural area is placed at 20,000,000 acres. That is the area to be reclaimed, if water can be obtained.

The State board of reclamation appointed to consider the question of irrigation therein, in the report embodied in your testimony, presents a series of statements by counties, which will show an area of 17,981,000 acres as possible for reclamation, of which area 2,198,000 acres can, in their judgment, be reclaimed by wells and springs that are known to exist. In Esmeralda County, in the southwest, there is an area considered to be reclaimable, and also in White Pine and in Nye County, in the southern and eastern part of the State. There are sixty-five artesian wells in Nevada. The average altitude of the State is considerably over 4,000 feet above the sea-level. It is a mountain bowl, surrounded by high ranges, and the fact that there is found even that limited number of artesian wells would indicate the necessity at least of examining into the character of the drainage or underground water supplies. There are a large number of important springs.

The trouble with Nevada is, in the main, that the drainage area that will most surely supply the water needed for reclamation is found largely within the limits of other States and Territories. In the north, the rivers head up in the northerly and northwesterly territories. On the west, the easterly slopes of the Sierras are unquestionably part of the drainage area of Nevada. I am not speaking of political lines, but of the natural features. The great lakes that lie upon the Sierra Nevada are mainly upon the eastern slope of those mountains and the waters naturally and properly belong to the people of Nevada. Take Lake Tahoe, 78 square miles of its surface (that is, two-fifths), are within the lines of the State of Nevada; the remainder is within the lines of the State of California. Lake Tahoe is ranked with navigable waters and belongs then to the Federal Government. It is all on the eastern side of the mountain. The ranges rise from 3,000 to 6,000 feet above it. Lake Tahoe has a drainage area of at least 1,200 square miles; the valley of the Truckee has a large drainage area. From Lake Donner and the other lakes that are known along that range water can be obtained. Lake Donner has been surveyed and its boundaries meandered. It is now reserved for irrigation purposes. Sufficient water can be obtained for western Nevada without the loss of a single cubic inch to California. By the storage of water in the mountain lakes alone enough can be obtained to reclaim from 1,000,000 to 3,000,000 acres of land. Even if it be but 1,000,000 acres it will amply repay all its cost and double at once the values of the State.

That land is worth nothing, or very little more than nothing now. It would be worth from $15 to $30 an acre if it were watered. That would make as prosperous a community as could be formed within the borders of the Union. Nevada was born during the war, and by her mines hundreds of millions in precious metals have been added to the general wealth of the country. The larger proportion of those who have benefited by that development have left Nevada to struggle through the poverty and indifference that are now surrounding her people. I think it is within the range of legislative action to consider whether this child of the mountain and of the war can not be benefited by some special work and special appropriation to carry on that work. I hold that Nevada stands first with New Mexico and the Dakotas, with Kansas and Utah, as among the earliest regions to be considered.

The committee will understand that I am an officer of the Geological Survey, and that I am not placing myself—not intending to, at any rate—in direct opposition to the Director in any of my suggestions. I design only to do my duty to those on whom falls the responsibility of legislation. I am obeying orders to me imperative. My observations and my knowledge then, such as they are, lead me very strongly to the conviction that a topographical survey, a platting of the entire arid region upon the scale of 4 or 20 feet to the square mile, is absolutely unnecessary for the carrying on of an irrigation survey such as I have understood Congress to have designed in the making of its appropriations. I have seen irrigation practised from Utah to Egypt and from California to China, and I have studied its entire history, but I have never yet seen or learned of a region in which a topographical survey was a condition precedent or even subsequent, so far as success was concerned.

I believe the Irrigation Survey should take on very largely the feature of a great reconnaissance, conducted by civil engineers competent for that purpose. I have in my own mind framed a little idea as to what it might possibly cost to put such a work for the next year under way. Of course, I do this without having that definite knowledge of the administrative needs which come only from the direction of a large office and of the handling of the expenditures thereof.

I have placed the total appropriation at $750,000, of which I should expend, or should indicate the expenditure of, $350,000 for the development of the underground water supply—the wells and the river underflows in the region lying east of the mountain. The other $400,000 I would expend in as rapid and as complete a series of surveys as possible—surveys or reconnaissances by proper engineers competent for that purpose. I think that ten or twelve such parties could be put into the field and practically a large part of the work of delimiting and defining could be done. The need of rapid work is shown by the fact that seven-tenths of the arable portions of our remaining public domain is now found within the arid region.

The Irrigation Survey divides into three parts, as a method of administration, in my mind: First, the civil engineers, whose work it is to obtain the information; second, the hydrographic engineers, whose work is of a delicate and important character, in the ascertaining of the water supplies, their extent, their volume, etc.; and third, the creation practically of a new division, which has never yet, in any large sense, been attempted. We want a small corps of trained observers in climatology. We ought to have a small number of stations at least, in the highest altitudes in which they could be placed with safety to those who are to work therein. We ought also to have an appropriation large enough—it would not be a great amount of the total—to encourage the taking of volunteer observations in mining and lumber camps and in other places where labor and human habitation go on in those high altitudes, and we should have some persons to superintend and to gather and obtain this knowledge. It has been suggested to me by a gentleman who has studied this question and is familiar with the work that $10,000 or $12,000 expended properly in that direction would be as beneficial as anything that could possibly be done.

This is not simply weather service observation. Weather service observation is a minor division really of the greater service suggested. What is needed is the study of climate in its largest aspects; in these regions and under those circumstances that will bring the most return. First, then, I say, that an irrigation office wants a competent civil engineer and staff; second, it wants a competent, but small staff of hydrographers, and third, it wants a small staff of students or observers in climatology.

Senator REAGAN. Would you not extend that to the valleys as well as to the mountains?

Mr. HINTON. I would, of course; but the valley observations can be properly carried on by the Signal Service, now in existence, and so that there could be perfect co-operation. A very large proportion of the lower altitude work can be carried on by a little extension of the present weather service machinery, but the law and appropriations for the present machinery do not embrace that of which I am speaking—they are not intended to embrace it—they are not designed to cover it, and Signal Service men are not properly or particularly well trained to do it. I would simply supplement their work and bring the two into harmony. That is why I say it does not require a very large sum of money.

In carrying out the work of an irrigation survey during the present year, at least, it is not necessary to press this class of work in the regions where the population, so far as is known does not immediately demand it. I should aim to carry that work out in the regions where it is mostly to be required for immediate necessities. I have indicated in part what those are. At the same time I believe it will be possible within three or four years to close up entirely the field-work of the irrigation survey proper. If I am not mistaken the topographical survey, which is doubtless a necessity for the future, which every great country will carry on, and should carry on, is a question of time, so that if the irrigation work is to depend on the progress of the topographical survey according to areas covered as presented here it would take some twenty years or more to complete it at the present rate of expenditure. It would take less than that at a larger rate of expenditure, but it would take not less than $8,500,000 or $9,000,000 to complete in conjunction with the irrigation work a topographical survey of the region west of the one hundredth meridian of longitude. It is estimated to cost $5 per square mile, and I have heard so competent an engineer as the able officer in charge of the irrigation survey declare that he can do the work needed for 1 per cent. of the lowest cost estimated for a complete topographical survey.

I think, then, that this topographical work may well wait on the progress of the population and the growth of wealth. I do not believe either that it can now be done with that sufficient accuracy by the means now in hand that will warrant the attempt. The makers of maps who have had the handling of the topographical maps made by Wheeler and Hayden, and others in the West heretofore, find the grossest errors. At various times I have been told of localities in which a difference of as much as 1,000 feet has been found. The topographical survey that is now being carried on is certainly in the largest sense a much more accurate attempt at that work than has ever been attempted before in the country. But it can wait, as I suggest, upon the progress of population.

I want to call attention, if I may be allowed to do so, to the necessity of action on the part of Congress at this present session with regard to the boundary matter and the international dam at El Paso. It was once my fortune to live in that city for twelve months. At the time I thought it was an ill fortune, but I have got over that idea since. I have traveled through northern Mexico a good deal and have studied the condition of the people there, and have been up and down that valley and I know something of the circumstances that surround it.

Unless some action is taken to definitely determine the boundary-lines between the Republic of Mexico and that of the United States at the point where they come together at El Paso and below it is quite certain that there will be continued trouble, disorder, and want of peace from year to year. It is not a question primarily of irrigation; it is a question of international obligation. Under the treaties of the United States the people of Mexico are entitled to certain rights. Under the circumstances which surround the flow of the water in the Rio Grande they are deprived at present of those rights, and they are deprived not by their own action, but by the action of that portion of the American people who live within the upper boundaries of the Rio Grande. It is not, of course, an intentionally hostile action, but its effect is the same. It is therefore necessary that action should be taken. There have been, as you are well aware, surveys made and plans devised which are admirably adapted for the establishment of an international dam and reservoir at El Paso. In a little publication which I have received this morning (I think it has not been made a matter of record even) Major Mills estimates the total cost of the dam—the purchase of the land and the railroad removals that would be required——

The CHAIRMAN. I think Major Powell gave those figures.

Mr. HINTON. The total amount is $1,007,599. I did not know whether they had been given.

So far as the survey is concerned the work has progressed. I take the liberty of urging that such legislation be had as will bring about at an early day the appointment of an international commission for the purpose of settling that difficulty. I shall be glad to answer any questions which the committee may ask.

Senator CASEY. In the matter of experiments, in my State, for instance, how many wells would you guess would be required to make that test as to the extent of the irrigation basin?

Mr. HINTON. Colonel Nettleton, who is the engineer of the Rocky Mountain portion of this present survey, is here with us, and I think he can give you, because he is an experienced well-man, a better hypothetical statement than I can.

Mr. NETTLETON. I never was in Dakota in my life.

Senator CASEY. Major Hinton has made certain estimates of the proper amount to be expended for work of that kind. There should be some basis for those estimates. Of course work in our country would depend entirely on the number of wells necessary to be put down. As he has named an amount that would be proper for the work, I suppose he has given some thought to that.

Mr. HINTON. I would myself suggest this: that a special appropriation be obtained at once for the purpose of putting it into the hands of the proper persons and making a reasonable inquiry into all the facts, and reporting thereon, at the earliest moment. I have the names of some forty wells.

Senator CASEY. Mainly in South Dakota?

Mr. HINTON. Yes. But there is hardly a single fact upon which we can predicate any definite statement.

Senator CASEY. Do you know the depths of those wells?

Mr. HINTON. Yes; we have the profiles, and can give the widths across. We know the geological formation, largely, and can obtain very much of that information. Some of it can be obtained here without going to Dakota.

STATEMENT OF E. S. NETTLETON, SUPERVISING ENGINEER.

The CHAIRMAN. Please state to the committee your occupation, and whether, in your profession, you have had experience with the work of irrigation; if so, how long.

Mr. NETTLETON. I have been for forty-five years in the profession of civil engineering—twenty years in irrigation and hydraulic engineering in the West, mainly in Colorado. For the last twenty years I have been connected with the Department of Irrigation, mainly in Colorado. I have been connected principally with large corporations, and for four years I was State engineer in Colorado, creating and organizing the department of water engineering. I have also assisted in draughting our State laws relating to irrigation. I joined the United States Irrigation Survey last May, as supervising engineer, for the eastern half of the arid country.

The CHAIRMAN. I wish particularly to inquire, from your experience and knowledge of the country, what is the best and cheapest way, from an engineering point of view, to complete a survey sufficient for the uses of agriculture by irrigation, also how it can be most speedily prosecuted and with least expense—in fact, what ought to be done to secure such a survey and what is necessary to accompany it.

Mr. NETTLETON. As I understand the law upon which the appropriations are made for this purpose, it seems to me that the whole of this work can be accomplished by what I would call an irrigation engineering survey—including sufficient topographical work and sufficient hydrographical work. It seems to me that the whole can be done under one head or in one department——

The CHAIRMAN. Would you have the engineers do the necessary topographical work as they proceeded?

Mr. NETTLETON. Simply do what topographical surveying is necessary—not surveying any pasture lands or mining sites outside. The hydrographic work is a part of irrigation engineering, and that can be done under the same management. So I do not see any necessity for separating or making three divisions, all working separately from each other in the field, none knowing the work of the others until the next year, perhaps longer.

It is a fact that the engineering work is dependent largely on the hydrographic work. In many localities we find a large number of reservoirs and it is a question whether there are not more reservoirs than water. It is only by the hydrographic work that we can determine whether the basin is too large. The hydrographic and the topographic work should go together.

The CHAIRMAN. Suppose you should reserve temporarily more reservoirs than are required, and you found you did not have water sufficient, you could only utilize those that you had at first water enough for; the others could remain reserved, and if you found, by experience, that there was a deficiency of water supply, and you got people into the country, then you could make other reservoirs and increase your supply. It would not be necessary to know the full extent of the rain-fall, etc., before making the reservation.

Mr. NETTLETON. I was basing my suggestion on doing the work in the quickest time possible and with the least money.

The CHAIRMAN. That is what I want to get at—the Government work that should be done to enable the people to carry out the rest.

Mr. NETTLETON. In the arid country the first thing would be the finding of reservoir sites—ascertaining their extent and estimating the capacity of the dam to impound the water. I believe it is in the law that we are obliged to make estimates of the cost. That necessitates the making of a thorough survey.

The CHAIRMAN. Of the reservoir sites?

Mr. NETTLETON. Yes; also of their capacity. I think it is also necessary to have the drainage matters established. Then it is necessary to run the preliminary lines of high-line canals.

The CHAIRMAN. You would not make a working survey, but run the general lines and leave monuments.

Mr. NETTLETON. I am not certain whether the law does not require the cost of these irrigation canals, and if it does, it needs something more than a rough high-line to determine the cost of an irrigation canal.

The CHAIRMAN. If they had a reservoir site set aside and the high-line run, the people then could understand the situation.

Mr. NETTLETON. Yes.

The CHAIRMAN. Might not the estimates of cost on the ditches be postponed and that work done afterward?

Mr. NETTLETON. Yes; I think that if either was dropped out the estimates of the cost of canals might be.

The CHAIRMAN. Might be postponed?

Mr. NETTLETON. Yes; I think it would be well to make surveys of the reservoirs so as to make pretty close estimates of the cost.

The CHAIRMAN. And of the high-line ditch?

Mr. NETTLETON. Yes.

The CHAIRMAN. Then the people would go into it and make their own estimates of the cost of the other parts?

Mr. NETTLETON. Certainly.

The CHAIRMAN. What expenditure, if you have estimated it, would be necessary per annum, to prosecute this work with vigor or as fast as it is required?

Mr. NETTLETON. Covering the whole arid country do you mean?

The **CHAIRMAN**. Yes, leaving out the experiments for wells, because that is temporary, and we have to estimate that separately. I mean for a survey for the arid country, locating reservoirs and indicating the lines of ditches—how much per annum would be necessary to carry on that work?

Mr. **NETTLETON**. That will depend on the time given to complete the work. The best and most economical way would be to extend it through a series of years—five, eight, or ten years—beginning in a small way with small appropriations and gradually increasing the appropriations as we get a better knowledge of what to do. This is all new work to all of us, and my idea would be that commencing in a smaller way and feeling our way along. would be better than to expend a large amount at first, part of which might be useless.

The **CHAIRMAN**. And you would use that money where the immediate demand is to arise, for use by the people?

Mr. **NETTLETON**. Everything else being equal, I would.

The **CHAIRMAN**. You would distribute it then in different localities, where they have population?

Senator **PLUMB**. That is, you would use the money in sections where people are already on the land rather than to entice them into new areas.

Mr. **NETTLETON**. Yes; I would try to develop that country where the people are—where it is possible to do so.

The **CHAIRMAN**. You would develop the inhabited localities?

Mr. **NETTLETON**. Yes; and if such development was not possible I would let the people know it.

The **CHAIRMAN**. I wish you would think it over carefully and particularly, then make a short statement in writing after you have looked over the field, and see where money is required. You have a knowledge of the country and how money can be expended to advantage. Give us a short paper on that. Take your time to do it.

Mr. **NETTLETON**. Do you wish me to name the localities and the amounts?

The **CHAIRMAN**. The amounts that would probably be required, yes.

Mr. **NETTLETON**. For one year?

The **CHAIRMAN**. For one year.

Mr. **NETTLETON**. I will do so.

STATEMENT OF EDWIN WILLITS, ASSISTANT SECRETARY OF AGRICULTURE.

The **CHAIRMAN**. The committee will be glad to hear any statement you may have to make that is of interest in regard to irrigation.

Mr. **WILLITS**. You sent to the Department of Agriculture last summer, Mr. Chairman, inquiring if we had any information on this subject. I will simply say that from the time I came to the Department irrigation was a matter of great interest to me. The first question I asked was, what was being done about it. I called upon the heads of divisions for information. They reported to me, and I had it in writing, but unfortunately it was on the general subject. Some of the gentlemen have come here this morning with information in writing. I do not know that we have anything to say in reference to the specific questions that you want answered.

I desire simply to emphasize the fact that the Department of Agriculture is highly interested in the subject. Some of its chiefs have been across the country this year, but they have not, after all, specific knowledge. Their knowledge is general; therefore we can not answer many of the questions that you desire. I would like, however, to present the papers, and you can file them. We did not come here to make speeches, but to gather information for ourselves on the subject. I have nothing further to say except this: Colonel Hinton has referred to the absence of any study of climatology. I have seen the perfect weakness of all the information we have now on that subject. It is the great impending question in the Department of Agriculture.

The whole weather service has been confined to the mere skirmish of weather forecasts, etc., without studying the great broad question of climatology. I will emphasize what the colonel has said, that the subject is much broader than the question of ordinary rain-fall.

The CHAIRMAN. Is your Department doing anything in that line?

Mr. WILLITS. Nothing. To tell the truth we are waiting to see whether the weather service is to be transferred to us. If it is, one of the things that we shall do will be to organize it in that direction.

The CHAIRMAN. It seems to me that the weather service, if it is to extend all over the country, should be placed in your Department.

Mr. WILLITS. I have nothing to say on that subject, but I have simply said that if you do not transfer the weather service to us, and we should come at the next Congress and ask that you give us the power to study this question and its effect on vegetation and plant life, I hope you will do so. It is a great question. It is the most important question pending as a scientific and practical question. I have merely spoken of it because Colonel Hinton has referred to it.

Years ago I was very much interested in Colonel Hinton's Report on Irrigation. We had no information except what his report furnished to us. So I wrote a letter to you, asking that in some way or other that report might be incorporated into the report of this committee in some shape, modified as it might be. It is full of instruction generally.

That is all I have to say this morning, except to add that I would like to be permitted to have some papers filed.

I would also like to have Professor Fernow make a statement on the subject of forests. I should also like to have Doctor Merriam talk a little to the committee on ornithology and mammalogy—on the question of what effect irrigation will have on animal life and bird life—what new animals will probably be brought in or old ones driven out by irrigation. I do not ask that he be heard to-day, but at any time at your leisure.

Doctor Riley made a very important report on the influence of irrigation on vegetation and on Rocky Mountain life. I will present that also.

STATEMENT OF B. E. FERNOW, CHIEF OF THE FORESTRY DIVISION.

Mr. Chairman and gentlemen of the committee, you are discussing here a question of the building of a stable, and my subject has only to do with the feeding of the horse. That question you have overlooked. It is a question it seems to me of considerable importance, and, although apparently subsequent to the building of the stable, I think it will be desirable to take it into consideration, as it will become absolutely necessary to feed the horse when you have him.

I do not want to go into any discussion of the relation of the forests to water supply, but the practical question whether it has any influence or not has been called into doubt. The intelligent and practical man who does not wish to listen to arguments on the subject can go and see what other nations have done. France, Italy, Germany, Austria, all have done something for irrigation. The people of France have expended $50,000,000 for reforesting their country, for water supplies, and propose to expend $50,000,000 more. They expend it on a very small part of their territory—the southeastern mountains only. The effect of the work that they have done has shown that it was the proper work.

I call the attention of the committee to the fact that this work is being done, because propositions have been ventilated as to the desirable effect of getting rid of the forest area which the United States possesses. Italy, a small and poor country, has found out that 1,000,000 acres of their mountain districts must be reforested, and in their budget will appear $1,000,000 for their forests alone. Austria has found out that a portion of her territory must be reforested. Prussia, with a very good forestry department and area, expends $250,000 every year to rebuy the waste lands which must be reforested. All those countries are spending these large amounts of money through their forestry administration. France appropriates $5,000,000 a year for the forestry administration. Prussia appropriates $6,000,000 a year for the same purpose. I call attention to this only to show that these nations that are poor and must look after every penny, having no surplus to expend, expend this money because they deem it absolutely necessary. The United States has 70,000,000 acres of forest. They pay no attention to it. It is being devastated and burned up. That is the only point I was anxious to make before the committee.

But with regard to the feeding of the horse. I believe it is now well established that it is not so much a deficiency of rain-fall in the arid region or so much a deficiency of water supply as it is the difficulty as to the amount of water that is being lost by evaporation. In Denver there are 60 inches of evaporation and 49 inches of deficiency. That is about the way it is throughout the whole arid region. The question then is, when you have the stable and the horse, where will the feed come from. Anything that will decrease evaporation is of importance And it is important that it should be attended to now, while it is possible to preserve that which will decrease evaporation—namely, our forests.

In order to aid in looking after those in the broader areas you should have timber belts all through your arid region to help irrigation.

The CHAIRMAN. The great problem now is to reserve the timber belts that we have and to preserve them from the dreadful destruction by fires to which they are subject each year. The fires in summer make alarming havoc in the forests. This committee rode from the Yellowstone, where we struck the mountains, in Montana, to Tacoma, through so thick a smoke, for 1,000 miles, that we could not see a mountain on either side. Have you anything practical to suggest as to how, before the country gets settled up, and gets it under control, as they do in older countries, to check those forest fires? Have you studied that question?

Mr. FERNOW. Yes.

The CHAIRMAN. Have you mentioned it in your report?

Mr. FERNOW. I have done so in various reports, though I do not think I have done it in this report. It can be done, however. It is only a matter of good-will. It has been said that it could not be done on account of the expense. We have the money and we have the people. It is a very easy thing in mountain regions to control a large area with a small force, even against fires. It would be easy to use fire for the purpose of checking fire. By burning over some parts at the proper time, taking proper pains to have guards established in certain belts, whenever a fire should break out—and it will be impossible to prevent it—there should be a possibility of controlling it. At present it is a lack of possibility of controlling these fires that makes them so detrimental and makes them sweep over so large an area.

The forestry people have proposed for Canada a system of guards—a body of Government servants. The Government of Ontario has adopted the proposition—has appointed certain forest guards, whose duty it shall be to look through the country, each guard having his beat and putting out any fires that may be detected, the Government acting in co operation with the lumbermen. One-half of the expense is borne by the lumbermen and the other half by the Government. The appointment of the men is made by the Government on the nomination of the lumbermen. The Government in Canada owns the forest area and only leases out the right to cut the timber.

Mr. Fernow submitted the following paper:

DEPARTMENT OF AGRICULTURE.
FORESTRY DIVISION.
Washington, D. C., June 30, 1889.

SIR: In obedience to your letter of April 21, referring to a request of the chairman of the Senate Committee on Irrigation, I have the honor of submitting the following report on those points of the inquiry which fall more more or less directly under the observation of this division, namely, in answer to the following proposed questions:

(5) The area of timber land within the dry section of the United States, west of the hundredth meridian.

(6) The extent and effects of tree planting.

(7) The influences of forests and forest culture on the conservation of water and their known or probable effects on the distribution of the water for irrigation purposes.

The time which could be devoted to the preparation of this report having been exceedingly brief, not much new material could be brought together, and the report is, therefore, mainly a condensed restatement of what has been discussed before in various reports from this division. In fact, the statistical material on hand for the answer of these questions is only meager and does not allow much direct and positive statements, which may cover the ground in all cases, nor could I attempt to use the material on hand exhaustively without unduly lengthening the report. Most of the report is therefore devoted to the general discussion of the relation of irrigation schemes to forcs conditions, and to a statement, as concise as possible, of what is known of the influence which the forest exerts upon water conditions.

In the form of appendices I have tried to furnish more special answer to the questions propounded and information which leads to their answer.

I append, also, as containing information directly bearing upon the subject of this report, Bulletin No. 2 from this division, which gives detailed information on the forest conditions of the Rocky Mountains, and a copy of my Annual Report for 1888, which discusses at length one of the claimed forest influences, namely rain-fall.

Through the courtesy of Mr. Abbot Kinney, late chairman of the California State Board of Forestry, I am enabled to append a clear and concise statement of the forest conditions and forest influences experienced in southern California. Thanks are also due for statements received from Col. E. T. Ensign, Forest Commissioner of Colorado; and G. C. Bracket, secretary of the State Horticultural Society, Kansas; and from Prof. Mark W. Harrington, of Ann Arbor, well known as authority in meteorological questions.

It is to be hoped that the subject of the relation of forests to water supply, as yet but little understood in our country, will receive the attention which its importance in connection with irrigation problems deserves, and that this division will be enabled to make a more careful survey of the forest conditions of the region and their relation to water supplies than has been possible with the limited means at its disposal.

Respectfully,

B. E. FERNOW,
Chief of Forestry Division.

HON. EDWIN WILLETS,
Assistant Secretary.

THE RELATION OF IRRIGATION PROBLEMS TO FOREST CONDITIONS.

By B. E. FERNOW.

The following report has been written under a full realization of the importance which the discussion on the relation of forest-cover to water conditions must assume at the present juncture.

The importance and magnitude of the investigations into the problem of irrigation for the Western arid regions can not be overrated; it may be likened to the discovery of a new continent, not by a lucky adventure, but by knowledge, skill, science, and art.

In such an enterprise every factor bearing upon the problem must be carefully considered, every means which may help to increase and properly utilize the scanty supply of moisture must be employed, if we expect to produce the highest attainable result, if we intend to bring the largest possible area into fruitful condition.

The main question of the problem is, by what means can the precipitation falling over the area comprised in the arid region be made to do the most duty? And the special proposition to be discussed in the following report is whether, in what manner, and to what extent a forest cover may be expected to assist in the thorough utilization of the precipitation and atmospheric humidity for agricultural purposes; although, in the consideration of a great national enterprise which like the one proposed is to promote the development of a poorly timbered or treeless country, the significance of the forest in all directions, as a source of raw material, of health, of comfort, etc., should also find proper recognition.

The relations of water conditions of the earth and vegetation in general is graphically expressed in the words of a poet who speaks of "Afric's arid sand where nothing grows, because it does not rain; and where no rain does fall, because there nothing grows."

This interdependence of vegetation and moisture conditions has been experimentally proved; it is only an apparent paradox when we say that the presence of vegetation is at the same time a necessary condition of its existence.

This is especially true of the forests. The forest, by its growth, creates its own favorable conditions of growth. The treelessness of the plains and of much of the arid region may possibly explain itself in this way. By the destruction of the forest which originally covered this region, the very condition of its existence and of its natural recuperation was destroyed; and thus in a reverse manner, reforestation of parts by artificial means may make natural reforestation over the whole area possible by and by.

"A tree by itself is doomed where a forest once established is comparatively secure."

The failures in forest culture on the Western plains may be considered mainly due to the fact that tree-planting and not forest planting has been attempted.

The discussion of forest influences has, unfortunately, become a popular one, before a proper and positive basis has been established for it by scientific investigation and observation. This is unfortunate, because the consequence has been that extravagant claims have been made by popular writers without proper basis, and, on the other hand, the overstatements have created a distrust in the offices claimed for the forest, even in the minds of some scientific men. The very popularity of the theory of forest influences seems to be sufficient reason for these to deny and scorn their existence. A competent writer, presenting a popular treatise on this subject, says, with proper emphasis, "Nobody is entitled, at the present stage of our knowledge, to declare the question of forest and water settled one way or the other. Nobody who has not the fundamental knowledge of meteorological science and scientific observation is entitled to participate in the discussion, and the public at large, especially, can only be called upon to study and reflect, but not to take sides in blind partisanship."

Unfortunately, again we are called upon to act upon the strength of our convictions in this question; we are called upon to conserve, perpetuate, and husband carefully our remaining woodlands, on account of their influence upon climate, soil, and water conditions; or else to disregard this claimed influence.

Those who doubt the existence of such influences—some of which are proved beyond doubt—should not forget that the first conception and rational explanation of the existence of forest influences originated with the profoundest student of nature that this century has produced—Alexander von Humboldt—and such able observers as Buffon, Boussingault, and Becquerel sided with him; and in our own country the ablest writer on the subject, George P. Marsh. Let them also consider that forest destruction is the easily and readily accomplished task and is the tendency of mankind, while forest conservation is possible only to the rationally-thinking, the civilized, and progressive man.

It is, therefore, at present, still the duty of a government to give preponderance to the weight of opinion on the positive side, which seems well supported by experience as well as argument, and to shape its policy accordingly.

Considering the relation of forest conditions and irrigation problems with reference to the special case of the arid regions of the West, the writer, after much study and a hurried and partial inspection of the ground, feels justified in stating briefly and boldly, without being able to argue them at length, the following conclusions:

(1) Reforestation on the plains and forest preservation on the mountains is of greater national concern than the location of irrigation reservoirs.

(2) While the location, construction, and systematic regulation of such reservoirs, under Government control is, under given conditions, feasible and desirable, their purpose will be better subserved, if, at the same time, attention be given to forestry in connection with the irrigation systems.

(3) While forest preservation and extensive reforestation not only are coadjutators of irrigation system, but supply in part the conditions which irrigation and reservoirs are designed to accomplish, neither the one nor the other will invite private enterprise, at least for a long time to come; on the other hand, the location of irrigation reservoirs and ditches has been and will be, as need arises, accomplished by private enterprise. This statement is made without disparaging any attempts on the part of the Government to assist such private enterprise and to give it systematic direction.

(4) Certain difficulties and dangers which attend the construction of reservoirs will be increased by continued forest destruction in the mountains, induced by the neglect on the part of the Government to rationally administer this valuable property of the nation; and these dangers and difficulties will be avoided or reduced by a national forest administration and reforestation.

Such conclusions are based mainly on the assumption that a forest cover exerts certain influences which affect conditions of water supply and other climatic conditions.

When considering these influences, especially with reference to agricultural pursuits, it is a mistake to discuss them separately, since vegetation does not depend on any one factor of climate, but is rather the balancing of several factors which produces favorable conditions of growth. Vegetation does not, as is so often stated, depend on rain-fall—certainly not on the mean annual rain-fall—but on conditions of atmospheric as well as soil humidity and conditions of transpiration and evaporation respectively.

The simple mechanical impediment, then—a timber-belt or even a single row of trees opposed to the progress of a drying wind—is sufficient to affect the crop under the shelter of a windbreak, lowering the rate of evaporation and transpiration.

Therefore agriculturists in regions with plenty of rain-fall yet find it advantageous to have recourse to irrigation in order to supply the exhaustion by rapid evaporation and transpiration. The wonderful growth of the Sequoias on the Pacific coast and Sierra Nevada finds certainly not its explanation in the amount of rain-fall, which in the former locality is less than on the Atlantic side, and occurs nearly all in winter with hardly any in summer. But the mists and fogs coming from the ocean reduce the rate of evaporation and help to economize the moisture of the soil during the long period of vegetation. One of the most important studies in connection with irrigation problems will be that of the rate of evaporation and of the influences promoting or retarding it.

In this direction hardly any data are as yet collected, and we can hardly anticipate how much a single "chinook" of twenty-four hours' duration may waste the water of a reservoir or dissipate the snow which lacks the protective forest cover.

If, as is claimed, there has been observed in the plains region any effect of tree-planting on water-supply, it is most likely this mechanical effect which the timber-belt or wind-break exerts, allowing a better utilization of the moisture by the crops. At first sight this mechanical shelter may appear of too restricted a character to deserve notice, yet many facts concur in showing that it is a most important element in local climate. According to Becquerel, a simple hedge 6 feet in height will give protection for a distance of 70 feet; and, according to Hardy, a belt of trees every 300 feet will defend vegetation against the action of the wind. Every traveler in the prairie will have experienced the calm which a small growth of shrubs not higher than 6 feet creates, while the wind is blowing many miles an hour outside of this shelter. Quite a number of instances can be cited where the crop thus protected had outlived the parching blast from the South, while the neighboring field was destroyed by the rapid evaporation. In fact, this influence of a wind-break as a mechanical barrier to the progress of winds is so well understood that it requires no discussion, no argument.

That a timber-belt, and more so a succession of timber-belts, will afford so much better protection is evident.

Thus, if no other influence were conceded to the forest in the plains, this one, which tends to conserve the moisture within the range of its protection, would make systematic forest plantations a most desirable adjunct to irrigation systems.

Summer and winter drought, *i. e.*, rapid evaporation, is the bane of the farmer in the plains; and this is due to the continuous dry winds, which can be checked by rationally disposed timber-belts.

Another merely mechanical influence which needs no argument or discussion with the observer of natural phenomena, is that which the forest cover on the mountain-sides exerts in retarding the melting of the snow and the drainage of the water, thus prolonging the period during which the same may be made available. Complaints that the snows do not lie as long into the summer as they used to, before the forest-cover was removed, may be heard all along the eastern Colorado Slope, where irrigation has been practised in the most rational manner and the waterflow the best observed. By the rapidity with which the water now flows off the bared mountains the effectiveness of the ditches is reduced by four to six weeks, there being an accumulation of flow at a time when it can not all be utilized and a dearth later on when it could well be used.

Some one, evidently but little conversant with the economies of nature, has suggested that in connection with the reservoir system it would be desirable to remove the forest cover, so that the snows may drift into the cañons, there to slowly give up their waters to reservoirs and ditches. Even if the favorable results thus anticipated could be reasonably expected to follow, the dangers invited by this method of storage are simply incalculable. These have been over and over again, and *ad nauseam* pointed out in various reports, and the consequences of deforestation have so palpably been experienced by European countries not only, but even in our own, that it seems a waste of energy to rehearse them again. They are briefly the following: First, more rapid melting of the snows, especially under the marvelously exhausting influence of a "chinook;" secondly, the more rapid flow of surface waters, which carries with them the thin mold and earth, gradually baring the rock and ending up in the creation of destructive torrents, which in France have carried débris over fertile lands 150 to 200 miles into the plain, to correct which an expenditure of more than $50,000-000 has been necessary. By the destruction of the natural storage which the forest offers for snows and rains, giving up their waters gradually and for a longer period, we invite floods and droughts alternately.

The conditions, in the Rocky Mountains at least, are quite similar to those of the French Alps, and, in fact, the experiences, although only limited on account of the undeveloped state of their territory, have been quite similar, especially around Greeley and Colorado Springs. Among the dangers and difficulties which attend the construction and maintenance of reservoirs are, in the first place, their incapacity of taking care of flood waters and their liability to unforeseen bursting. In regard to both these points I call attention to the experiences of French engineers, related in the "Annales des Ponts et Chaussées," some of which are also given in George P. Marsh's classical volume, "The Earth as modified by Man." These dangers are particularly increased by the conditions of rain-fall in the region under discussion, the rains being occasionally very heavy and in the nature of cloud-bursts. Professor Harrington reports one such cloud-burst which resulted in a flood, carrying away miles of railroad track on the level at the base with such violence that the rails were bent. The recent experiences in Pennsylvania, Virginia, and other parts of the country will serve as testimony of the force of such water accumulation.

The reservoirs must be built on such contingencies, and a study of the cloud-bursts in the irrigation area is therefore highly desirable, especially as they are not as yet matters of regular record. That cloud-bursts, like all violent exhibitions of meteorological phenomena, seem to occur more often in large unwooded areas, may also point again to the employment of reforestation, as a preliminary or concomitant of the construction of irrigation reservoirs in the prairies and plains, as a measure of protection.

The following passages from good authorities exhibit pretty well the relation of forest cover to irrigation problems.

Mr. Hubert Vischer, engineer to the State Forestry Board of California, uses the following language in his report to the board:

"The agricultural development of the uplands of the coast range—and there is little else but uplands—will be as dependent upon irrigation in time as are the lands of the southern portion of the State now.

"Referring to our notes upon the general hydrographic conditions of the range, it may be inquired how water can be procured? The location of the main streams being depressed and their grade slight, to bring water upon uplands would imply outlays which the value of the lands will never warrant. Storage of water in the tributary streams and gulches can not succeed, owing to the precipitous slope of their channels and the consequent lack of storage depth. Storage of water upon higher-lying lands may, in special cases, succeed, but generally will be unfeasible, as the arable lands which it is sought to water are themselves in most cases situated at considerable elevations. Wells and the development of springs will be found, like the last expedient, only applicable in exceptional cases.

"Of all the means of storing water only one remains—nature's own means. It is only necessary to prolong the flow of natural channels for a short period—a month or a fortnight would often suffice—and to accomplish this is within the power of being effected by stimulating tree growth upon very limited area of ground, especially if due regard be had for impounding snow where practicable;" and Mr. E. S. Nettleton, former State engineer of Colorado, says in regard to forest conditions and water supply: "The fact that our system of farming has changed within the past few years by substituting for the summer crops those which require water earlier in the spring and later in the fall, makes it more important than ever to secure as uniform a flow of water in our irrigation streams as is possible to do throughout the whole irrigating season.

"To accomplish this end, I call your attention, first, to the importance of the preservation of our mountain forests, and the recovering of the mountain districts with a new growth of timber. The details of how this work is to be accomplished, and the arguments proving the benefits to be derived therefrom, I will leave for abler ones to discuss. I take it for granted that some will say, 'This forestry subject is one of the future; we want something of immediate benefit and relief.' While this may be true in part, yet the protection and preservation of the mountain forest of the present day is an immediate necessity, if we desire to protect our streams from an intermittent and diminished flow.

"Neglecting to take steps toward preserving the forests and encouraging the recovering of the mountain sides with timber, because we can not see immediate and profitable returns, is no good excuse.

"We should do this much for the benefit of those who are to follow us, and who will make this country equal at least to any of the irrigated countries in olden times, which history tells us have supported a much denser population than is possible to support in a country where the people have to depend on rain-fall for a more or less successful agricultural industry."

Another important influence of the forest, in connection with irrigation problems, is its tendency to raise the water-level in its immediate neighborhood; a well established fact.

The forest influences, which may reasonably be claimed to exist, have been discussed in my report for 1886, which is herewith appended. Such forest influences are claimed to exist in the following directions:

(1) On sanitary conditions.
(2) On local climate.
    (*a*) On temperature conditions.
    (*b*) On humidity of atmosphere.*
    (*c*) On distribution of rain-fall in time, and, locally perhaps, on quantity.
(3) On soil conditions, on water-level, and on water-flow.

The question of forest influence on the amount of rain-fall has been discussed at length in my report for 1887 also appended; from which it will appear that there are no data as yet on hand upon which the questions may be even qualitatively settled.

There is one point to which the writer would call special attention and which has too often been lost sight of when discussing the influence of the forest on climatic conditions, namely, that the condition of the forest itself plays a very important part in determining its influence. Such conditions are given in the extent, the density, the position, the composition of the forest and the age or height of the tree.

It has been very generally overlooked that these conditions of the forest are of greatest moment and may alter absolutely the nature of the influence, so that the exact opposite of the expected influence may become apparent; when, for instance, a forest on the leeward of a water surface deprives the open land beyond of the benefit of this water surface.

The influences exerted by the forest can, almost all, be referred to the mechanical barrier which it interposes either horizontally or vertically to the action of the sun or the winds, or to the percolation of water; hence the nature of this barrier, its extent, density, and continuity must needs determine the nature of its influence.

In conclusion, the writer deems it proper in this place to call attention to the culpable ignorance of the bearing which the forests of the Rocky Mountains and California have upon the water supplies and irrigation problems, as exhibited in the management or rather absence of management of the same on the part of the Government. This matter has formed the basis of the appended report on the forest conditions of the Rocky Mountains, where the deplorable state of affairs has been set forth in unequivocal language.

---

*Definite statements of the observed influence of deforestation on the conditions of atmospheric humidity will be found in the report of Hubert Vischer to the California State Board of Forestry, where the effect of the removal of the redwood forests around Humboldt Bay is noted. This report deserves special attention for the clear and business-like manner in which it treats of the present conditions and future of the north California forests and their relation to the development of the country.

It would be indeed a most irrational proceeding to promote the establishment of irrigation reservoirs, without at the same time arresting the irrational forest destruction which is invited by the neglect of Government to administer its property rationally.

APPENDIX A.

AREA OF TIMBER LAND WITHIN THE DRY SECTION OF THE UNITED STATES WEST OF THE HUNDREDTH MERIDIAN.

This section comprises regions of widely different character topographically and climatically, and the distribution of forest areas is accordingly a different one in the various regions.

PLAINS REGION.

The plains region, which may be said in general, to comprise the area east of the 7,000-foot level, is practically without timber lands; the only trees are found lining the banks of the larger streams, sometimes in clumps or even groves of from 100 feet to one-half a mile in width, the species found belonging to the Atlantic forest and consisting mainly of cotton-wood, elm, green ash, box-elder, hackberry. Going westward even these fringes of trees cease and the only occasional trees seen are cottonwoods.

This timberless region may be estimated at, roughly, 400,000 square miles.

The only mountain islands within this region, which are forested, are the Black Hills in Dakota and Wyoming, with about 2,400 square miles more or less wooded, and some of the mountain ranges in southeastern New Mexico of similar extent.

Altogether it would be difficult to find as much as 2 per cent. within this vast area that shows what may be fairly called a timber growth.

ROCKY MOUNTAIN REGION.

The area of the Rocky Mountain region proper has been carefully canvassed and set forth in the accompanying report on the forest conditions of the Rocky Mountains.

From the data given in the report, the following table is constructed, which approximates the ratio of mountain land and plains and gives the forest area which is found in the region by counties. From this we find, that of the 269,881 square miles which fall within the mountain region proper, 22.23 per cent. is reported as timbered, representing 60,075 square miles (38,400,000 acres).

MONTANA.

Counties.	Area.	Mountain.	Plains.	Total forest.	Mountain forest.
	Sq. miles.				
Beaver Head	2,800	2,800		1,100	1,100
Choteau	26,000		26,000	350	
Custer	20,000		20,000	200	
Dawson	2,700		2,700	200	
Deer Lodge	5,000	5,000		2,400	2,400
Fergus	7,500		7,500	700	
Gallatin	7,100	7,100		1,600	1,600
Jefferson	2,200	2,200		350	350
Lewis and Clarke	2,100	1,100	1,000	400	400
Madison	4,500	4,500		900	900
Meagher	5,700	3,000	2,700	1,100	1,100
Missoula	24,500	24,500		16,200	16,200
Silver Bow	576	576		60	60
Yellowstone	3,600		3,600	25	
Crow Indian	7,200	4,000	3,200	700	700
Indian reservations	24,300		24,300		
Total	145,776	54,776	91,000	26,285	24,810

Mountain forest, 24,810=45.4 per cent.

COLORADO.

Counties.	Area.	Mountain.	Plains.	Total forest.	Mountain forest.
	Sq. miles.				
Arapahoe	4,700		4,700		
Archuleta	1,026	1,026		450	450
Bent	9,070		9,070		
Boulder	768	768		275	275
Chaffee	900	900		500	500
Clear Creek	450	450		200	200
Conejos	1,320	1,320		300	300
Costilla	1,450	1,450		450	450
Custer	750	750		200	200
Delta	1,150	750		500	500
Dolores	800	800		150	150
Douglas	850	850		300	300
Eagle	1,750	1,750		300	300
Elbert	5,800		5,800	100	
El Paso	2,650	1,300	1,350	500	
Fremont	1,450	1,450		450	450
Garfield	7,250	7,250		800	800
Gilpin	140	140		50	50
Grand	1,800	1,800		700	700
Gunnison	4,000	4,000		1,200	1,200
Hinsdale	1,440	1,440		450	450
Huerfano	1,160	1,160		250	250
Jefferson	760	760		175	175
Lake	420	420		200	200
La Plata	4,000	4,000		1,500	1,500
Larimer	4,000	4,000		700	700
Las Animas	6,500		6,500	500	
Logan	3,000		3,000		
Mesa	3,850	3,850		275	275
Montrose	2,040	2,040		640	640
Ouray	190	190		110	110
Park	2,000	21,000		600	600
Pitkin	1,090	1,090		540	540
Pueblo	2,350	1,200	1,150	125	
Rio Grande	1,300	1,300		275	275
Routt	6,200	6,200		1,050	1,050
Saguache	3,150	3,150		1,175	1,175
San Juan	450	450		100	100
San Miguel	1,375	1,375		260	200
Summit	750	750		275	275
Washington	2,220		2,220		
Weld	5,300		5,300		
Total	100,200	61,129	39,070	16,625	15,400

Mountain forest, 15,400=25 per cent.

WYOMING.

Albany	6,922	6,922		840	840
Carbon	13,526	13,526		1,360	1,360
Crook	10,709		10,709	400	
Fremont	20,957	20,957		3,300	3,300
Johnson	11,121	11,121		1,800	1,800
Laramie	11,200		11,200	80	
Sweetwater	10,550	10,550		40	40
Uinta	12,140	12,140		2,400	2,400
Yellowstone Park	3,259	3,250		1,840	1,840
Total	100,366	78,466	21,909	12,060	11,580

Mountain forest, 11,580=14.8 per cent.

NEW MEXICO.

Bernalillo	8,350	8,350		1,450	1,450
Colfax	7,000		7,000	1,275	
Dona Ana	10,260	10,260		75	75
Grant	10,090	10,090		800	800
Lincoln	24,450		24,450	920	
Mora	3,830		3,830	720	
Rio Arriba	7,500	7,500		175	175
San Juan	7,200	7,200		250	250
San Miguel	11,630		11,630	1,300	
Santa Fé	2,490	2,490		1,375	1,375
Sierra	3,200	3,200		250	250
Socorro	16,500	16,500		2,050	2,050
Taos	2,300	2,300		900	900
Valencia	7,700	7,700		960	960
Total	122,500	75,510	46,990	12,500	8,285

Mountain forest, 8,285=11 per cent.

SUMMARY.

	Square miles.	Acres.
Total area	468,851	300,064,640
Total mountain area	269,881	172,723,840
Total plains area	198,970	127,340,800
Total forest	65,470	41,900,800
Total mountain forest	60,075	38,448,000

Mountain forest equals 22.23 per cent. of total mountain area.
Mountain forest equals 92 per cent. of total forest.

INTERIOR BASIN.

The area of timber land in the States which partly make up the Interior Basin is approximately as follows:

Washington.—Total forest area estimated at 30,000 square miles. The bulk of this lies in the eastern part of the State west of the Cascade Range. The counties which may be referred to as parts of the arid region, the timber land in which is confined to the spurs and ridges and to the east slope of the Cascade Range and to the Blue Mountains, namely, Spokane, Whitman, Walla Walla, Columbia, Yakima, Klickitat, contain approximately 6,500 square miles or 23 per cent. of their area more or less forested. The interior, however, is entirely destitute of tree growth, the few trees along the rivers having mostly been cut. The yellow or bull pine is the main timber, with red fir, hemlock, spruces, and other conifers added on the better sites.

Oregon.—The total timbered area of the State is estimated at 30,000 square miles, confined mainly to the Western mountain ranges and the Blue Mountains in the northeastern part of the State.

The counties which fall within the dry section, namely, Umatilla, Union, Grant, Wasco, Lake, and Baker, a total area of round 63,000 square miles, have about 12,000 square miles timbered, or less than 20 per cent. Yet, with the exception of the forests of Wasco and Lake Counties on the eastern slopes of the Cascades, the timber growth is mostly open and scattered, even on the Blue Mountains, and the trees of stunted growth. Yellow pine, red fir, and larch are the principal trees, with lodgepole pine on summits.

Idaho.—With the exception of four counties—Kootenai, Lemhi, Nez Pérces, and Shoshone—which belong to the Rocky Mountain region proper, or are otherwise climatically outside of the dry region, the rest of the State, with over 60,000 square miles, may be considered part of the Interior Basin. This part contains of timbered land an estimated area of 9,140 square miles, or about 13 per cent. The bulk of this lies north of the Snake River; the counties south of this river may be said to be almost timberless, containing less than 1 per cent. of forest area in confined localities and of scattered growth.

Utah.—The area west of the Wahsatch Range with round 30,000,000 square miles may properly be considered as part of the Interior Basin and counted practically timberless, excepting a few mountain ridges which bear a stunted growth of juniper and piñon in their recesses. The forest area of the State which is found in the mountain ranges and on the high plateaus extending in a southwesterly direction, is estimated at 6,000 square miles, or less than 12 per cent. of the area within which it is found, the timber being found of inferior size and quantity and mostly confined to the cañons. The Colorado River plateau is for the most part untimbered.

Arizona.—The total forest area is estimated at round 15,000 square miles, or less than 14 per cent., and is confined to the high Colorado plateau above the 7,000-foot level, where a considerable body of continuous though open timber growth is found, and to the mountain ranges in the southeast. Along the streams and cañons are also found scattered deciduous trees. The yellow pine is the most valuable timber tree. The southern part shows in its tree growth Mexican types like the acacias, mesquites, and others. A scrubby growth of oaks and junipers furnishes needful fuel for domestic use and in mining operations.

Nevada.—This State, as a whole, is treeless, the most barren and naked in the whole region, with less than 3 per cent. or only 3,000 square miles bearing a timber growth, and that of little account, except around Lake Tahoe, where it has been, however, largely cut. In other parts the tree growth is confined to the recesses of the mountain ridges in the central and southern portions of the State, consisting of a stunted growth of *Pinus flexilis* (white pine), scrubby piñon on the lower slopes, mountain mahogany, and occasional junipers.

California occupies part of the Interior Basin, with portions of all the counties which cross the Sierra Nevada and which mostly also form part of the Sacramento and San Joaquin Valleys. A separation of the area of timber land which occupies the region under discussion from that on the Coast Ranges and Sierras, is well-nigh impossible.

The southern counties of California south of the interior valleys, with about 50,000 square miles, are estimated to have 1,000 square miles timbered, occupying the cañons and the tops of mountain ranges above 3,000 feet. The area absolutely or nearly timberless east of the Sierra may be calculated at about 23,000 square miles, of which perhaps 2 per cent. has a timber growth on the mountain ridges and slopes. The interior valleys, comprising a total area of about 34,000 square miles are more or less timbered; 4,000 to 5,000 miles may be estimated as entirely destitute of timber, and 15 per cent. of the balance—or 4,500 square miles—may be considered well timbered, while an open growth of oak of little value is found to cover, more or less, all the land that is not cleared.

There are, however, no data on hand which allow even a reliable estimate of these conditions. The map of the State Forestry Board of California, which promises to analyze the forest areas, is not yet available for this report.

APPENDIX B.

THE EXTENT AND EFFECTS OF TREE PLANTING IN THE DRY REGION.

Forest planting, or rather tree planting—for the planting is as yet hardly anywhere done in such a manner as to deserve the name of forest planting—has been practiced to a limited extent; enough, however, to show that it can be done, with or without irrigation, if properly attended to. The twenty-five counties of Kansas which are entirely and seven more which are partly within this region, report 39,810 acres of timber trees, seedlings, and older plants, growing in 1888. Most of this is cottonwood, walnut, honey locust, green ash, box-elder, elm, hackberry, catalpa, mulberry, Osage orange, and some few other varieties; all of the Atlantic forest trees have been grown successfully. Some successful tree planting has also been done without irrigation in Colorado and Nebraska west of the one hundredth meridian, but its extent is not known. A small amount of timber planting has also been done in the region of the Interior Basin, and a larger amount in California, where groves of considerable extent are in existence.

Statistics, from which to estimate the area of artificial timber, are not on hand outside of those given for Kansas. A canvass, to ascertain how many plantations over 5 acres in extent there were in existence, was attempted two years ago, but the returns give, evidently, no reliable result, and are therefore here omitted.

It would seem that the entries under the timber-culture act should furnish, at least approximately, an idea of the area planted to timber, but since it may be said that the majority of these entries have not only changed hands and thus appear in the annual statement repeatedly, but have also been changed to entries of other kind, no result can be obtained from the study of these figures.

The status of timber-claim planting is exhibited in the appended table. From this it will appear that 38,985,910 acres were entered under the timber-culture act up to June 30, 1888. This should represent a planted area of 2,436,620 acres, if the law were complied with and the entries not changed. Allowing ten years for timber-claim planters to prove up their entries (the law places it at eight years, allowing extensions on account of failures), the entries of the first six years—from 1873 to 1878—alone give us some point of comparison for the estimation of result. During that time 4,394,256 acres were entered, while only 783,838 acres or 17.8 per cent. of these entries were proved up, representing an area assuredly planted of less than 50,000 acres.

It is asserted that a better percentage will be obtained from the entries of later years. Altogether, however, the consensus of unbiased testimony goes to show that timber-claim planting, as a rule, does not produce the results sought after and has mostly been used as a means for speculation in Government lands.

There is also considerable planting of wind-breaks and groves done on homesteads, which is said to be attended with better results.

Altogether, however, the amount of tree planting is infinitesimal if compared with what is necessary for climatic amelioration, and it may now be recognized as well as later, that the reforestation of the plains must be a matter of national enterprise, which can not be expected from the individual citizen.

The reforestation of the plains as well as the preservation of the forests on the Western mountains, is, in fact, of greater national concern, and requires in greater degree national action than the proposed irrigation surveys.

As to the effects of the tree-planting on climatic conditions but little can be said, and the statements of opinion which refer any climatic changes to this factor must be taken with caution. There is, however, one influence which can be claimed without dispute, that of breaking the force of winds locally and protecting houses and single fields that lie within the cover of a windbreak or grove against the deleterious influence. I call especial attention to the observations on this point in the appended letter of Mr. Kinney. The experience there recorded is that had in all parts of the region, and records are on hand showing the distance to which a windbreak would protect a field against a burning southwester, while the neighboring unprotected field would succumb to the blast. The consequence of this mechanical action of the trees would also tend to diminish the rate of evaporation. This is probably all the effect —and one not to be underrated—which is due to the tree-planting in extensive shelter-belts and occasional small groves. To produce considerable changes in temperature or increased precipitation, the planting is done in too small parcels and the growth not old enough, and is also mostly too open to effect that marked difference of insolation over the forest and the field which makes the former a factor in climatic influences.

To produce great climatic changes the operations must be on a larger scale, more contiguous, and with more intent to shade the soil than has been hitherto the practice.

In this region are situated several military reservations, which could be devoted to no better purpose than planting them to forest many sections at a time. Such planting would not only furnish an incentive for imitation by settlers and supply them with plant material, it would improve conditions in the immediate neighborhood and form a nucleus for the national forest administration, which is now a necessity and whose inauguration can only be a question of time.

Entries under timber-culture act.

Years.	Initial entries.	Final entries.
	Acres.	
1873	50,246	
1874	851,225	
1875	493,694	
1876	607,984	
1877	520,673	
1878	1,870,434	
1879	2,766,573	
1880	2,193,184	
1881	1,763,799	
1882	2,566,686	23,371 acres, or 46.5 per cent. of entries of 1873.
1883	3,110,930	97,836 acres, or 11.5 per cent. of entries of 1874.
1884	4,084,464	91,600 acres, or 18.5 per cent. of entries of 1875.
1885	4,755,006	90,301 acres, or 14.8 per cent. of entries of 1876.
1886	5,301,309	141,694 acres, or 27.2 per cent. of entries of 1877.
1887	4,224,398	204,620 acres, or 10.9 per cent. of entries of 1878.
1888	3,735,305	134,416 acres, or 4.9 per cent. of entries of 1879.
	38,985,910	783,838 acres, or 17.8 per cent. of entries first six years.

	Acres.
Entries first six years	4,394,256
Entries last ten years	34,591,654

The year 1882 was the first in which, under the terms of the act, final entry could be made. The original act of 1873 required 40 acres of every 160 to be planted with trees, "not more than 12 feet apart each way." By an amendment of 1878, only 10 acres of every 160, and the same proportion for smaller sections were required to be planted, but 2,700 trees were required to be planted on each acre instead of the 302 under the original act; and on final entry at least 675 thrifty trees were to be growing on each acre. The amendment was made applicable to all final entries, obliging those who had made entries under the act of 1873 to have trees enough growing at the time of final entry to make the number of acres required by the act of 1878.

Original and final entries under the timber-culture laws from 1873 *to* 1888.

States.	1873.	1874.	1875.	1876.	1877.	1878.	1879.	1880.
	Initial.	Initial.	Initial.	Initial.	Initial.	Initial.	Initial.	Initial.
Arizona	....	196.51	320.10	1,197.15	2,440.00	1,600.00	3,280.00	719.65
California	329.75	8,878.06	29,065.53	20,524.23	10,586.03	8,029.42	14,458.81	12,120.31
Colorado	....	2,272.24	3,453.82	6,514.22	3,343.33	17,436.73	16,142.03	30,302.14
Dakota	3,560.00	124,997.29	61,969.75	119,835.23	68,266.92	579,804.04	728,687.83	868,748.39
Idaho	....	180.83	2,583.25	1,973.89	7,035.91	22,169.53	22,013.93	23,300.04
Iowa	145.96	3,816.05	9,127.52	8,563.42	4,791.56	7,535.47	6,577.67	4,714.05
Kansas	9,642.17	282,479.07	168,269.06	185,596.43	238,020.44	593,295.17	1,167,582.77	408,261.74
Louisiana	....	....	....	....	....	....	80.43	40.00
Minnesota	14,710.15	113,131.63	63,673.73	140,126.30	76,021.53	377,017.78	257,642.50	123,735.36
Montana	....	....	....	....	398.59	960.00	3,134.20	6,835.32
Nebraska	21,858.07	312,712.09	130,894.26	106,499.74	90,812.90	195,306.68	465,968.94	475,275.87
Nevada	....	....	....	....	240.00	600.00	160.00	560.00
New Mexico	....	....	....	1,128.00	....	320.00	1,891.93	2,887.95
Oregon	....	....	882.68	1,793.18	2,509.37	18,446.21	17,046.59	73,061.66
Utah	....	....	....	399.88	338.50	1,280.00	2,328.93	4,044.05
Washington	....	2,482.22	3,324.14	5,374.28	19,746.75	78,237.00	68,506.10	134,637.65
Wyoming	....	80.00	130.47	160.00	....	....	....	240.00
Total	50,246.04	851,225.99	473,694.53	599,917.97	524,551.85	1,902,038.03	2,775,502.66	2,169,484.18

States.	1881.	1882.		1883.		1884.	
	Initial.	Initial.	Final.	Initial.	Final.	Initial.	Final.
Arizona	760.00	1,352.77	....	4,336.85	....	5,483.10	....
Arkansas	....	....	....	100.00	....	80.00	....
California	24,538.28	39,882.99	....	44,190.05	160.00	72,340.65	160.00
Colorado	26,473.31	47,436.05	160.00	58,685.02	....	137,933.07	160.00
Dakota	868,400.36	1,446,532.34	521.68	1,745,419.58	14,968.12	1,748,640.22	21,870.93
Florida	....	....	....	....	....	320.00	....
Idaho	28,680.26	33,965.61	....	40,105.17	....	56,171.52	80.00
Iowa	3,644.25	6,235.62	....	3,373.40	2,165.33	3,246.17	2,794.93
Kansas	268,575.09	273,053.55	9,915.52	237,860.95	24,965.06	397,525.25	23,093.70
Louisiana	2,293.40	1,004.02	....	7,754.26	....	38,788.88	....
Minnesota	167,582.16	176,741.42	2,998.50	122,750.39	11,495.25	95,638.50	12,324.75
Montana	16,535.20	35,409.94	....	53,952.71	....	63,283.25	....
Nebraska	240,306.94	298,520.11	9,975.42	481,704.70	43,522.32	1,068,806.66	30,010.91
Nevada	1,040.00	1,520.00	....	280.00	....	159.79	....
New Mexico	2,039.26	3,351.99	....	22,091.82	....	17,945.83	....
Oregon	31,176.40	88,038.77	....	116,334.14	240.00	148,356.16	160.00
Utah	3,921.52	3,831.71	....	7,509.99	....	11,192.09	....
Washington	77,008.62	87,524.76	....	139,737.05	320.00	173,142.27	914.44
Wyoming	784.30	2,284.44	....	14,204.15	....	46,027.62	....
Wisconsin	40.00	....	....	....	....	....	....
Total	1,763,790.35	2,546,686.09	23,571.12	3,110,930.23	97,836.08	4,084,463.87	91,599.66

States.	1885.		1886.		1887.		1888.	
	Initial.	Final.	Initial.	Final.	Initial.	Final.	Initial.	Final.
Arizona	19,542.87	160.00	15,772.93	160.00	20,199.99	320.00	45,374.52	....
Arkansas	640.00	....	2,025.22	....	840.00	....	600.00	....
California	94,064.73	480.00	155,674.29	....	165,382.29	40.00	240,216.76	49.82
Colorado	204,983.61	240.00	719,947.95	480.00	1,437,636.50	550.00	970,281.39	760.00
Dakota	1,328,966.24	21,207.06	1,116,250.72	39,591.67	650,420.88	57,311.41	626,629.79	29,996.36
Florida	....	....	....	....	....	....	160.00	....
Idaho	48,255.01	....	49,959.92	240.00	38,912.89	400.00	51,717.37	891.92
Iowa	3,647.43	1,437.63	2,869.03	1,014.00	2,187.30	2,888.56	4,945.80	1,207.26
Kansas	1,169,303.34	27,133.16	1,920,802.22	42,657.93	732,545.85	56,502.34	689,256.24	26,202.86
Louisiana	15,598.16	....	9,914.50	....	9,402.56	....	11,469.63	....
Minnesota	79,410.47	13,618.07	65,026.14	24,311.44	52,306.69	25,009.52	56,622.65	15,003.25
Montana	41,207.88	....	43,031.12	160.00	38,847.15	280.00	36,407.58	39.68
Nebraska	1,468,114.28	24,767.25	969,706.78	28,278.93	794,047.24	52,541.82	660,915.58	48,264.82
Nevada	....	....	120.00	....	640.00	....	560.50	....
New Mexico	16,286.10	....	15,603.08	....	23,695.75	....	39,692.37	326.96
Oregon	97,331.30	160.00	93,160.05	880.00	93,137.44	920.00	126,979.96	4,416.68
Utah	15,842.86	80.00	25,632.56	....	21,638.09	160.00	30,234.71	420.40
Washington	84,568.21	1,017.49	85,745.23	3,920.00	67,568.02	7,686.47	89,980.09	6,816.41
Wyoming	67,243.20	....	100,167.64	....	74,989.10	....	53,260.16	....
Total	4,755,005.57	90,300.66	5,391,309.38	141,693.97	4,224,397.83	204,619.62	3,735,305.10	134,416.12

Total number of acres entered from 1873 to 1888, inclusive, 38,958,558.45.

Total number of acres entered from 1873 to 1880, inclusive, 9,346,661.03 ; on which final proof and entry might have been made in 1888 or earlier.

Total number of acres on which final proof was made, 784,037,23, or 8.4 per cent. of possible number.

Total number of acres planted, 784.037 ÷ 16 = 49.002.

Total number of trees declared to have been planted and cultivated, 38,076,350, or less than one tree for each acre entered for timber culture.

APPENDIX C.

SOUTHERN CALIFORNIA.

"This portion of California is divided by parallel ranges of mountains, which here and there coalesce and become a confused mass of peaks. Between these ranges are valleys of various extent, but all of any agricultural value within 60 or 70 miles of the sea. To the east of the main Sierra Range lie the great deserts of Mojave and Colorado. These are broken by low barren hills devoid of any verdure whatever.

"The rain-fall varies between 25 inches at some points on the sea coast and mountain ranges, to 3 or 4 inches at points on the desert. The desert rain-fall usually occurs in summer. These conditions, as far as the United States are concerned, are peculiar to the Pacific slope. The result of this distribution of the rain-fall makes the use of water for irrigation essential for most crops not maturing in winter or the rainy season, and adds a great value to permanent water supplies for domestic as well as for agricultural puposes.

"The climate in this country is divided into a wet and a dry season. In the wet season it ought to rain but it often does not. In the dry season it ought not to rain but occasionally does.

"*Timber Area.*—Area of timber land in southern quarter of California—an area, say, of 50,000 square miles—timber 1,000 square miles, or one-fiftieth of the whole. This timber is confined almost exclusively to the tops of the mountain ranges, and to an altitude varying between 3,000 and 8,000 feet. There is also a small amount of timber in the narrow cañons which carry the water from the mountains to the valley.

"While the forests of timber trees are thus shown to be very limited in extent, and far below the proportion which has been demonstrated in European countries to be needed for the best productive capacities of a country (about one-quarter), the brush, or chaparral, covers extensive areas in southern California. In Los Angeles County, which is the great agricultural producer of the south, timber trees cover one-twenty-fifth of its area, and are so inaccessibly situated in the mountains as to supply none of the immense demands for lumber of the community. One-third of the total area of the country is in chaparral. This brush-growth is from 2 to 12 feet in height. In some places it is so thick as to be almost impenetrable, while, as we pass to the back ranges and the desert, it becomes so thin and scattered as scarcely to be deemed of importance on the water-sheds.

"San Bernardino County has one-fiftieth of its area in timber, which is sufficiently accessible to be considerably used for local purposes; one-fifth of the area of this county is in brush.

"San Diégo County has about one-fortieth of its area in timber, which is used locally in a small way, and about one-fifth in brush.

"The other counties composing the district have a somewhat smaller proportion of covering of forest and brush.

"The chaparral throughout the entire area is confined to the mountains and foothills.

"On the western and southern slopes of the first important ranges from the ocean it is densest. As we go back towards the desert the brush-covering decreases in density, until, on the desert itself, all the ranges are perfectly bare. The natural covering, as it now exists, is a reliable indication of the extent of the rain-fall, modified to some extent, perhaps, by the exposure of the mountain-growth. That on the northern, or shaded side, is proportionately greater than that on the southern.

"*Effects of deforestation.*—On the other hand, extensive areas of brush land have been denuded by fire, and some waste in this way has taken place among the timber trees. These have also been much thinned out in the localities named, from which lumber is being taken. The effects of this destruction of brush and timber have been plainly appreciable in every case.

"There have been two effects which have followed the destruction of the brush or forests on the mountains of this district. The first—production of torrential action from such denuded water-sheds. Great numbers of these cases have been noted, where the rain-fall has been delivered with suddenness and with great volume, together with a large amount of débris, sand, bowlders, and gravel, from burned-off places. The results have been disastrous, sometimes in a small and sometimes in a large way, according to the area denuded. Some lands have been cut and gullied, others have been covered with dèbris and injured in this way. A number of orchards and other agricultural lands in the San Gabriel Valley have become the beds of torrents, owing to the destruction of brush on the foot-hills of the Sierra Madre Range.

"The second effect of the destruction of the mountain covering, and the consequent rapid discharge of the rain-water, has been the diminution and sometimes entire drying up of the springs and streams coming from injured water-sheds. The most notable cases of these results, easy of access and examination, are as follows:

"Fire on the Mission Cañon water-shed at Santa Barbara; subsequent destruction of the company's works situated in said cañon, and diminution of summer flow of water.

"Fire in Tejunga Cañon; subsequent injury to lands of E. L. Wicks by flood and cutting, and probable augmentation of damage by great flood of Los Angeles City in 1882 and 1883.

"Fire on the water-sheds of Soledad Cañon; subsequent destruction of bee ranches by flood, and of roadway and property of Southern Pacific Railroad. The damage to this railroad involved an interruption of travel for nearly six weeks, and in the neighborhood of $1,000,000 in money. This fire was set by stock-herders, nominally to benefit pasture.

"Edwards' fire on Precipice Cañon water-shed; subsequent diminution of summer water supply from this cañon. Destruction of brush on foot-hills on Sierra Madre Mountains near Pasadena; subsequent appearance of two torrents, which have continued to do great damage to orchards, agricultural lands, etc.

"Fires on Santa Anita, San Gabriel, Sawpit, San Dimas, and San Antonio Cañons, and in many other localities, with similar results.

"The destruction of small wood at Los Coyotes Ranch; subsequent disappearance of spring in said locality.

"For further detailed accounts see page 27, First Biennial Report of California State Board of Forestry.

"Notice may be called, in a general way, to the fact that where the rain-fall is the heaviest—say 25 inches on the steep chaparral-covered Sierra Madre Range—floods have done no damage except from burned water-sheds; while from the bare hills of the Colorado Desert, with a rain-fall of 4 or 5 inches, extensive damage is done every year or two to the only thing there to damage—the road-bed of the railway.

"The consideration of these facts makes it apparent that the brush and forest mountain lands of southern California of no direct value to agriculture, are of great indirect value to every industry in that section.

"*Extent and effect of Tree-planting.*—Tree-planting throughout this area has been carried on to a considerable extent. It has, however, been limited to the fertile valleys upon the western water-shed. In a few places on the edge of the desert, but where water has been brought down, as at Riverside, San Jacinto, Antelope Valley, etc., considerable areas have been planted to fruit trees, with forest trees as wind-breaks to protect them.

"The effect of this tree-planting has been to diminish the force of the winds. The orchards planted along the edge of the Sierra and cultivated area, planted up to and during 1880, suffered a great deal from the hot dry desert winds. I have seen the bark of the trees and the fruit frequently excoriated by the sand carried by the wind, so that the tree and fruit gave the appearance of having been subjected, on the windward side, to a sand blast. Since 1882 I have not known of anything of this kind on the westward side of the mountains.

"Another effect of the plantations has been to diminish the efficiency of the wind-mills—at Riverside, for instance,—which is a colony reclaimed from the desert and now shipping about 2,000 car-loads of product annually, the domestic water being taken by wind-mills from deep wells. When the colony was first started the wind-mills set up to pump this water did more work than was necessary. I am informed now, by some of my friends having orchards at this point, that they experienced the greatest difficulty in getting from their wind-mills a sufficient supply of water.

"The hot desert winds have been undoubtedly lessened in force in our valleys, and so also have what we call trade winds.

"This trade-wind is one which blows in the dry season from the ocean towards the desert. In some places it blew very strongly, so much so as to stunt and disfigure trees subjected to it. One of these places was the Santa Maria Valley. The settlers in this locality have planted wind-breaks of great extent, with the effect of doing away with the damage of this wind. The only place where forest culture has been undertaken to any considerable extent is in Los Angeles County. Several large plantations have been made here with a good profit to the experimenters. There has, however, been no sufficient forest work, in the proper sense of the word, to modify anything, except in a very local way.

"*Recommendations.*—A forest policy should be inaugurated to maintain the integrity of the forest-covering for the purpose of preventing the formation of torrents or destructive floods, and the protection of the permanent water supplies of the country.

"Wherever the desert lands have been brought under water; that is, had water brought so that they could be irrigated, as at the great and productive colony of Riverside, they have proved very fertile. If the policy be adopted by the Government of making valuable and habitable vast extents of the Mojave and Colorado Deserts by irrigation, the storage of water for this purpose would necessarily be in the high ranges receiving considerable rain-fall. If the brush covering, or forests, be burned or destroyed on the water-shede furnishing the supply of such reservoirs, the unimpeded rain-fall flowing off more rapidly must carry great quantities of débris, sand, gravel, etc., which will destroy the efficiency and value of the reservoirs by filling them up. Consequently, co-incident with the adoption of such a policy, a rational forestry system should be inaugurated." (Abbot Kinney.)

Mr. Fernon also called attention to the annual report for 1889 of the forestry division on "The Forest Conditions of the Rocky Mountains," etc. He filed a printed copy of the same. It is already printed for the Department of Agriculture.

STATEMENT OF C. V. RILEY, ENTOMOLOGIST DEPARTMENT OF AGRICULTURE.

The CHAIRMAN. Please state your position.

Mr. RILEY. I am Entomologist of the Department of Agriculture.

The CHAIRMAN. On what subject is the paper which you submit?

Mr. RILEY. On the general subject of the importance of extending any system that may be adopted of irrigation from the entomological stand-point; that is, with the view of checking the ravages of some of those insect pests that do so much damage in the West, particularly the Rocky Mountain locust, or so-called grasshopper, and chinch-bug.

As these matters have been published and the recommendations of the Entomological Commission, which had the study of the grasshopper question in charge, are on record, I have referred to those recommendations. I will only say in a few words that there is nothing concrete to say to you except this, that we dealt with the Northwestern region. Practically these facts stand out boldly, that the native home of that grievous pest is this extreme Northwest region, the permanent breeding ground of that insect.

The only way in which it will be possible in time to overcome this pest is by an extension of settlement. The mode of irrigation that will enable you to extend your settlements is the mode I believe to be the feasible mode. So far as this country is concerned, we have simply suggested some system which must be taken up by the Government, because it is beyond the power of private enterprise—some system that will enable you to save in reservoirs the immense waste of waters from the chief arteries, like the Missouri, and the waste that comes from the overflow system, by building reservoirs that shall hold it.

The CHAIRMAN. We have considered that subject very much, but after we shall have accomplished all that we can accomplish in regulating the irrigation of the arid lands there will be a large area of land above the lines of the ditches that will be liable to be the breeding ground still of those insects.

Mr. RILEY. What is called the permanent region, which is essentially the arid region, trenches upon the subarid region. I have not the time, even if I had the ability, to discuss the points that should be brought up for consideration before you as to what the irrigation system should be. It should of course embrace the underground currents as well as others.

We made a suggestion ten years ago—now somewhat antiquated perhaps—which was that the Government should donate a strip of land running from the Black Hills to the northwest line—right to the boundary—to any company that would undertake to develop a system of irrigation and improvement; believing that that region once thoroughly developed, these pests would be got rid of. If you can retain sufficient water to enable you to cultivate trees or any other crop in this settlement you would at once solve the question of the vast devastating swarms of grasshoppers.

I believe that Government aid should come in only where private enterprise will end. In all valleys which give promise of development I think we can depend on private enterprise developing as much as possible; but Government aid should come in when that will end.

That is why I think Government service should consist largely, as has been well said, of locating possible reservoirs, indicating what they will cost and availing ourselves of the large bodies of water that are annually sent into the sea during the high tide seasons.

The CHAIRMAN. Then your idea is that as the country west of the great plains is developed and brought into cultivation the home of the grasshopper will be limited gradually or cease to exist?

Mr. RILEY. Without question, in proportion as settlements extend. Anything that will permit settlers to live and cultivate the soil, in proportion as that settlement encroaches on the arid land we shall have less and less of those grievous periodical devastations of the grasshopper.

Mr. Riley submitted the following:

REPORT TO THE SECRETARY BY THE DIVISION OF ENTOMOLOGY IN REPLY TO INQUIRIES OF THE COMMITTEE.

The question of the proposed reclamation of the arid lands of the West by irrigation is of great importance from the entomological stand-point, and particularly in view of its influence upon the destructive appearances of the Rocky Mountain locust, or Western grasshopper, which at irregular intervals has greatly damaged the agriculture of certain of our Western States and Territories. The last important invasion of this pest occurred during the years 1874, 1875, and 1876, and the devastation which it occasioned at that time is so fresh in the minds of all as to require no elaboration of the importance of the subject. The reports of the United States Entomological Commission, an organization founded in March, 1877, and composed of Profs. C. V. Riley, A. S. Packard, and Cyrus Thomas, consider the question of the influence of irrigation of a large extent of the arid territory upon the increase of this pest, and from the first report of this Commission, published during the year 1878, and the second report, published in 1880, can be drawn a complete summary of the writings on this subject and the views in full of the Commission. Copies of these reports would accompany this statement, but they have been long out of print. They may be found, however, in the library of the Geological Survey.

One of the important results arrived at is the conclusion that an extensive system of irrigation upon a scale of greater magnitude than any which can be undertaken by a pioneer population will be not only necessary to the carrying on of agricultural operations within the belt of territory mapped out as the permanent breeding ground of the locust, but that the prime result of such an introduction of diversified agriculture into these regions will be the abolishing of the conditions necessary to a permanent reproduction of the species, and a consequent reduction to a minimum of the danger of the appearance of destructive migratory swarms. The one fact, that according to the careful statistics gathered by the Commission the loss from this pest during the years 1874 to 1877 amounted to upwards of $200,000,000, is a mighty argument for the expenditure of the sums which it is proposed to devote to the purpose which Senator Stewart's committee has now under investigation. The words which follow are quoted from the first report above referred to:

"It is evident, therefore, that the final and complete solution of the locust problem depends to a certain extent upon the possibility of modifying, to some degree at least, the aridity of the great plains of the Northwest, which undoubtedly form the native breeding grounds of these insects.

"By most persons this will be considered equivalent to saying that the locust problem will never be solved. It would scarcely be proper for us here to enter into a discussion of the question of the possibility of modifying the condition of the dry area, but we can not refrain from placing upon record our protest against any such conclusion as this. That man, with a mind that can bring art, science, and mechanics to the perfection now visible on every hand, must be forever unable to convert the desert into fertile fields or to redeem the waste places of earth we can not believe, unless we are shown that the moisture which once supplied these areas has forever taken its departure from our globe.

"To what extent these dry areas of the West can be supplied with water and rendered fertile must be determined by those who are proficient in this particular branch of science; but that large sections can be redeemed by proper efforts, if made on a scale of sufficient magnitude, we have no doubt.

"By utilizing all the water that flows down from the mountains for the purposes of irrigation; by collecting in reservoirs the winter supply and distributing it in the growing season, a very large section of these plains might be brought under cultivation, and extensive forests grown where now the surface is naked and barren. Every field brought into cultivation, every grove planted, is just so far a step toward the ultimate solution of the locust problem; and the nearer these can be brought to their native home the more effectual will they be in rooting them out. If extensive efforts in this direction were made in British America, north of Montana, also in eastern Montana, western Dakota, and the regions around the Black Hills, it would not only be of immense benefit in supplying new agricultural fields for emigrants but solve the locust problem. It would also be a most effectual method of settling the Indian question in this region. Just what can be done in the way of redeeming these areas we can not say, but when their settlement depends upon it, and the welfare of a much larger area south and west also depends upon it, certainly the question is worthy of consideration by our national authorities.

"The day is not far distant when our National Government will be compelled to meet this important question and to test the ability of man to accomplish the work.

"The progress of settlement westward must necessarily be slow when it, as is now beginning to be the case, impinges upon the sterile area; it can only push onward when the front line is backed by a dense population and farms studded with groves. It is possible that if there were no other impediments to overcome than this sterility, formidable as it is, the gradual filling up of the border area with an active population would modify the conditions sufficiently, at least, to allow the pushing into and redemption of a belt of considerable breadth. But when to this difficulty is added the devouring locust the hope of success is greatly diminished." (First Report U. S. Entomological Commission, pp. 126–127.)

Further quotations from this and the second and third reports of the Commission are appended and should be studied to enable a full understanding of the probable influence of such a course as the Commission has recommended. The desirability of forest planting is frequently mentioned in these extracts and the influence of such a move in altering for the better the conditions of the permanent breeding grounds of the locust can not be overestimated.

The effect of irrigation upon the Rocky Mountain locust dwarfs into comparative insignificance anything which may be said concerning its influence on other destructive species, yet there are many forms which depend for their existence and multiplication upon a dry climate and which a thorough system of irrigation would render comparatively harmless.

This has been recognized by the prominent writers upon economic entomology, and I may quote the words of my chief, Professor Riley, as follows:

"I have repeatedly laid stress in my writings on the importance of irrigation in combating several of our worst insect enemies, and aside from its benefits in this direction every recurrence of a droughty year convinces me of its importance as a means of guarding against failure of crops from excessive drought. I am glad to know that many farmers, and especially small fruit-growers in the vicinity of New York, are preparing in one way or another for irrigation whenever it becomes necessary, and I was pleased to hear Dr. Hexamer, at the late meeting of the American Pomological Society, urge a general system of irrigation as the most profitable investment the cultivator can make in a climate subject to such periods of drought as ours is known to be."

Perhaps the most striking example among this class of insects is the chinch-bug—a species which damages certain cereal crops to the extent of upwards of $50,000,000 in years of abundance. This insect is directly influenced by moisture and seldom occurs in numbers in the more eastern States, except after two or more successive seasons of drought. After a year of successive multiplication these insects will often be found to have hibernated in immense numbers, and it is a well known fact that heavy rainfall the succeeding spring will destroy them almost completely. This being the case, the artificial system of irrigation will enable the agriculturist to hold this insect completely in check, and such a system as it is proposed to introduce in the West will render the grain-growers of the reclaimed regions independent of the damage which may be done by this insect and will enable them to compete on most advantageous terms with the grain-growers of the more eastern localities whose crops are occasionally subject to almost total loss by this insect enemy. I again quote from Professor Riley:

"Irrigation, where it can be applied—and it can be in much of the territory in the vicinity of the Rocky Mountains where the insect commits sad havoc, as with a little effort in many regions in the heart of the Mississippi Valley—is the only real available practical remedy after the bugs have commenced multiplying in the spring. I wish to lay particular stress upon this matter of irrigation, believing as I do that it is an effectual remedy against this pest, and that by overflowing a grain field for a couple of days or by saturating the ground after as many more in the month of May, we may effectually prevent its subsequent injuries." (Seventh Rept. Ins. Mo.)

We may mention also the case of the grape-vine phylloxera and may again quote from Professor Riley:

"Submersion, where practicable, and where it is total and sufficiently prolonged is a perfect remedy. This is what even the closest student might expect, as he finds that excessive moisture is very disastrous to the lice. M. Louis Faucon, of Graveson (Bouche du Rhône), France, has abundantly proved its efficacy, and has, by means of it, totally annihilated the insect in his vineyard which was suffering from it four years ago. From his experience we may draw the following conclusions:

"(1) The best season to submerge is in autumn (September and October, when the lice are yet active and the vines have ceased growing. Submergence for twenty-five to thirty days at this season will generally rout the lice. (2) A submergence of forty to fifty days, in winter, is required, and even where the water is allowed to remain during the whole season, the vineyard does not suffer. (I should consider this very doubtful.) (3) A vineyard should never be inundated for a longer period than two days in summer, or during growth; and though these brief inundations at that season affect only the few lice near the surface, and are by no means essential, they are nevertheless important auxiliaries to the more thorough fall or winter submersion, as they destroy the few lice which are always invading a vineyard in infested districts. These summer inundations will be necessary only after the winged insects begin to appear; and three or four, each lasting less than two days, made between the middle of July and the fall of the leaf, will effect the end desired. (4) An embankment should be made around the vineyard in order that the water may evaporate and permeate the earth, but not run off and carry away any nutritive properties of the soil.

"The varied success which has attended the different attempts to rout the enemy by inundation, is owing to the lack of thoroughness in many of them. The ground must be thoroughly soaked for a sufficient length of time. Temporary irrigation does not accomplish the end for the reason that it does not reach all the lice, and does not break up the numerous air bubbles which form in the soil and prevent the drowning of many of the insects." (Sixth Rept. Ins. Mo.)

Too much in fact can not be said of the advantages of a system of irrigation in fighting many insect pests. A good instance occurred in our experience in the spring of 1879 when the Army worm appeared in great force upon a large grass plantation near Portsmouth, Va. The plantation was divided into sections by irrigating ditches and it was only necessary to turn on the water to isolate a badly infested section and to devote it by rolling, fire, or some other means of destruction preventing ready spread of worms to other sections. In the same way rice planters have a ready means of fighting insect pests at hand.

Other insects might be particularized, but the general statement that from the stand-point of the economic entomologist irrigation in general is a great help in fighting insect pests, and from the marked illustration of the great good to be accomplished by the reclamation of the arid regions in connection with the damage done by the Rocky Mountain locust, it will probably be considered that further elaboration will be unnecessary.

Respectfully submitted, May 13, 1889.

L. O. HOWARD,
Acting Entomologist

EXTRACTS FROM THE REPORTS OF THE UNITED STATES ENTOMOLOGICAL COMMISSION.

In the permanent region which embraces the Rocky Mountain plateau and the bordering plains from the middle of Colorado northward the rain-fall is insufficient for agricultural purposes, and hence irrigation has to be resorted to. In the temporary region this is unnecessary. The plains and plateaus of the permanent region are to a large extent distinguished by the presence of *Artemisia*, Chenopodiaceous plants, and what is usually termed "bunch-grass;" in short, by all the characteristics of a drier climate. One other peculiarity which should not be overlooked appears to mark roughly the southern boundary of the permanent home of the Rocky Mountain locust, and that is the isothermal curve or line of the fiftieth degree of mean annual temperature, which also corresponds very nearly with the isothermal curve or line of summer temperature of seventy degrees. But this applies only to that portion of the region which extends upon the plains east of the mountains.

If any practical means of exterminating the locusts in this permanent region could be devised the whole locust problem could be solved, and nothing further would be necessary. But when we take into consideration the vast extent of this area, and the fact that a very large portion of it can not be brought under cultivation without a material change in the climatic conditions, there appears but little hope that such a means of actual extermination will ever be devised, however much we may hope to check the injurious increase of the pest by the means recommended in the concluding chapter of this report. Our discussion of the future prospects of this region in reference to agriculture may as well, therefore, proceed on this basis. (Second Report United States Entomological Commission, pp. 15–16.)

* * * * * * *

A careful investigation of this subject for several years and repeated visits in person to this region have served to convince us that, with the advantages afforded by the system of irrigation necessarily adopted, there is no reason why the agricultural area lying along the east flank of the range should suffer any more from these pests than portions of the temporary regions. (*Ibid.*, p. 19.)

* * * * * * *

This agricultural belt, extending from Colorado into British America, is partly along the margin of and partly in the very heart of the permanent breeding-grounds where the swarms that invade the temporary region originate. It follows, then, as a natural consequence, that just so far as the numbers are lessened by the operations in this section, just so far will the agriculturists of the temporary region be benefited, and, as we will hereafter see, like operations in the latter region will benefit those in the permanent region. We are fully aware of the fact that the part of this vast region which can be irrigated and cultivated is small in comparison with the whole area which forms the native home of the species, but, fortunately, in one respect this cultivated belt occupies in part, at least, the point of departure of the swarms which invade the temporary region. This fact, therefore, renders it more important that it be occupied by an agricultural population.

Although we have admitted that we are unable to present any plan of exterminating the locusts that holds out sufficient promise of success to justify the General Government in undertaking it, it does not necessarily follow that there is no plan of modifying the evil which the Government would not be justified in undertaking. On the contrary, if the views we have advanced be correct, they suggest a means by which the General Government might greatly aid in bringing about the desired result; and, fortunately, the result would be beneficial even should we be mistaken in the opinions advanced.

As will be seen by what has been stated, the great desideratum is to settle the cultivable belt alluded to as rapidly as possible with an agricultural population. Wherever valuable and permanent mines are discovered in the neighboring mountains, the arable areas in the vicinity will be taken up and cultivated to an extent at least sufficient to supply the demand for agricultural products, as in parts of Colorado. But there are large sections where no such influence will be brought to bear, and this is the case along that portion of the belt where the agricultural population is most needed for the purpose mentioned.

An examination of map No. 1, in our first report, will show that a comparatively limited belt in central Montana, extending from the Big Horn Mountains northwest to the British line, a little west of Cypress Hill, forms the turning-point of the locust movements. Without now repeating the data which may be found in that report, we may summarize it by saying that from this region a large portion of the swarms come which visit Dakota, Minnesota, Nebraska, and Kansas; from this area also proceed a large portion of the swarms that move southwest into Idaho and Utah. This appears to be the point to which most of the returning swarms from the temporary region direct their flight.

That there are other areas in the permanent region which appear to be special breeding-grounds, as points of departure, is certainly true, but none to such an extent as this, and none affecting an agricultural area bearing any comparison with the area affected by the locust swarms originating in this belt.

Even should it be shown by subsequent investigations that as a rule the swarms falling on the temporary regions come from intermediate points, as central and southern Dakota and northwestern Nebraska, the facts already ascertained warrant us in asserting that, as a very general rule, they originate in the belt mentioned.

It is evident, therefore, that if any method can be devised by which an agricultural (not pastoral) population can be thrown into this belt, it will form one of the best possible means of modifying the evil. If they can be effectually distributed in this area the result will be of immense value to the agricultural interests of Dakota, Minnesota, Nebraska, Iowa, and Kansas, in fact of the entire temporary region. We do not pretend that it will wholly relieve this area from locust invasions, but it will very materially lessen their extent and injury.

In order to carry on agricultural operations to any great extent in this belt, an extensive system of irrigation will be absolutely necessary. It will have to be on a scale of greater magnitude than any that will be undertaken by a pioneer population. We doubt the propriety of the General Government undertaking such a work directly, if it is possible to accomplish it in any other way. This, we think, may possibly be done by giving the land for this purpose. We are fully aware of the opposition at present to the Government's donating any more of the public land, but the circumstances of this case bring it out of the general rule. If donating the entire body of public land, in the belt described would suffice to settle it with an agricultural population, not only would the very purpose for which it is held be accomplished, but, if our views are correct, the result would be of immense benefit to the border States.

We therefore suggest the following as probably the most feasible plan of accomplishing the desired end: Let the United States donate a belt of 50 or 60 miles in width, running from the Black Hills west-northwest, so as to strike the Yellowstone River a short distance above the mouth of the Big Horn River; from thence northnorthwest, by way of Fort Shaw or the mouth of Sun River, in the direction of Fort Hamilton, in British America; this to be granted on condition that the company to which said land is granted shall, within a given time, construct a railroad from the Black Hills along the line designated, to the international boundary, shall undertake and carry out, to an extent to be designated, a system of irrigation, and shall equip and keep in operation said road for a certain number of years.

Whether such grant will be sufficient inducement for any competent company to undertake the work specified is probably the chief difficulty in the way of successfully carrying out this plan. On this point we do not feel qualified to express an opinion. That such a road, starting from the Black Hills, if once built, would soon be connected southward and eastward with other roads, can not be doubted. That it would be the best possible means of bringing an agricultural population into this belt can not be doubted. It would also be an important factor in settling the troublesome Indian problem in this section of the West.

If the plan should be adopted it might be well to colonize, if possible, with Russian peasants who are accustomed to fighting locusts.

The advantage to be derived from this plan consists chiefly in the fact that it is possible to destroy the young to a very large extent by the use of the proper means. If this is done in the very heart of their breeding-grounds, it greatly lessens the numbers that will migrate. Not only does it prevent the number destroyed from migrating, but for each one killed, so to speak, an entire family brood of the next or migrating generation is destroyed. In other words, the destruction of thousands there would be as effectual as destroying millions of the migrating swarms. The means of destroying the young, as before stated, can be made more effectual in the sections where irrigation is carried on than where it is not.

As shown in our first report, the destruction of the young locusts bred in the temporary region from the invading hordes not only gives immediate relief, but also tends to postpone future invasions by so lessening the numbers in the returning swarms that a longer time is required for development. With an agricultural population in the area designated, the work of destruction would then be carried on at each end of their migratory route.

Here we may also remark that the present idea of making that section of our country peculiarly pastoral area, while doubtless profitable to the present and for two or three generations to come, will in the end entail hardships upon those to follow. It can no longer be doubted that while the destruction of forests was the chief agency, yet the pastoral habit of the people of Western Asia and other oriental countries, once so fertile but now so barren, was one important factor in producing the present dry and barren condition of those countries. No country in the interior of a continent, unless supplied with numerous lakes or numerous and permanent rivers, can remain permanently fertile and productive if given up largely to pasturage of sheep, goats, and cattle without cultivation. The rapid destruction of mountain forests and pasturing their slopes and bordering plains will most certainly have a tendency to render that portion of our country more dry and barren.

Unless, therefore, our Government adopts some policy by which an agricultural population can be thrown into that area the day will most assuredly come when it will be as barren and desolate as the plains of Arabia. The development of the locusts is but an incident of the change from a former condition of abundant moisture to the present dry one. But this branch of the subject we propose to omit at present.

It will be seen, therefore, by the foregoing that we think it is possible to modify to a very large extent the operations of the locusts so far as these relate to the area along the east flank of the mountains, and that the General Government may, without any very great expense, very greatly assist in the work. (*Ibid.* pp. 19-22.)

* * * * * * *

This certainly shows a very moderate climate for this northern latitude. Wheat, oats, rye, and barley grow well, and Indian corn is also raised without difficulty and produces good crops. Such fruits as apples, plums, cherries, currants, raspberries, and gooseberries may be grown and matured here, the climate presenting no serious obstacles.

The amount of land that can be brought under cultivation depends wholly upon the amount of water that can be obtained for irrigation. If the plan for making reservoirs for preserving the winter supply should ever be adopted, the breadth of the agricultural belt would be very largely increased, and this would be doubly beneficial in assisting to destroy the locusts and tending to increase the moisture in the atmosphere by forming a larger evaporating surface. The growth of trees and shrubbery around these reservoirs would also be beneficial in the same direction.

But experience in the settlement of these mountain regions and Western Territories shows that no such extensive works will, or in fact can be, undertaken by a pioneer agricultural population. Some efficient aid of some kind must be given if such a scheme is ever carried into effect, and if the land itself will do this, the Government will act wisely in giving it for this purpose. (*Ibid.*, p. 23.)

* * * * * * *

As shown by our first report, the region around Salt Lake is subject to repeated locust invasions from the north, apparently the resulting broods of the swarms that originate in that portion of Montana of which we have been speaking, and which, pouring over the mountain pass at the head of Jefferson River, move down Snake River Valley.

If the scheme we have suggested should be carried out and should prove beneficial in reference to the eastern area, it would have, to some extent at least, a like effect as to this section. If it is possible to establish and maintain an agricultural population in the Upper Snake River Valley, this would have a strong tendency to modify the evil. But the present barren aspect of this region would seem to forbid any hopes of ever accomplishing this desired end. Still there appears to be one possible means of bringing this about, at least to a limited extent. The demand of trade will doubtless complete the railroad already started in that direction, which is one step toward the desired end, but something more is required in this case.

Snake River affords a large body of water which, if properly utilized, would irrigate a large breadth of land, and, notwithstanding the barren appearance of the soil, is really fertile when irrigated. It is possible, with a moderate expense, to throw dams across this stream at certain favorable spots, and by this means to spread the water over the adjoining plains. A work of this kind would, of course, have to be done by the General Government. The feasibility of this project could easily be ascertained by an officer of the Engineer Corps of the Army; and as this is on the line of the chief intermontane thoroughfare and also of the locust invasions of this region, the subject is certainly worthy of the attention of the Government.

As will be seen by what we have presented on this subject, the philosophy of our plan for modifying the evil is to place an agricultural population in the very home of the species, which from necessity would be compelled to wage a constant warfare against them.

By stirring the soil their nests would be disturbed; by fighting the young their numbers would be diminished; and as irrigation would be necessary the effect of dry seasons on the crops would not be felt as in the temporary region. The possibility of inundating to a considerable extent their egg deposits by the winter supply of water would tend to diminish their numbers. The fact that their breeding-grounds are chiefly in the limited agricultural areas is also another argument in favor of the plan.

That large areas would be left where locusts breed and pour down on the nearest cultivated areas, as in western Colorado, is certainly true; but this does not lessen the value of the plan proposed, nor is it a reason why it should not be put into operation. (*Ibid.*, pp. 24, 25.)

* * * * * * *

Naturally with the increase in the number of farms and advance of the settlements upon the frontier the devastation by locusts will be felt less. They will divide their ravages among more farmers, and hence none will feel the losses nearly as much as did those who were isolated from their neighbors during past invasions. Thinly-settled districts suffered much more than those which were more thickly settled; and those lying out upon the prairie than those adjoining and interspersed with groves. During these invasions there was no year but in which a portion of the crops was saved and harvested by the farmers of the extreme eastern portion of Nebraska and other sections of country that were comparatively thickly settled, and that were situated near some natural timber-belt and interspersed with planted groves; while, on the contrary, those that were far away from these natural and artificial groves, and thinly settled, were entirely devastated by the hordes of ravenous insects. Hence we are compelled to acknowledge that the settling of a country in which the settlers are tree-planters has a tendency to diminish the ratio of locust injury.

Tree-planting is not only a matter of great importance to the inhabitants of a country like ours in supplying a much-needed material for fuel during our severe winters, when at times it is impossible to obtain coal—either from the failure of a sufficient supply at the mines, or from the impracticability of reaching towns where it can be obtained—but it is also of untold benefit as a moderator of climatic extremes. By planting trees throughout the Temporary Region wherever they will grow, in time the area in which the locust is capable of continuing its existence but two or at most three generations, without having recourse to the arid regions hitherto referred to as the permanent breeding-grounds, will be increased. Aside from the greater amount of humidity that would naturally follow tree-planting, the spread of locust-feeding birds would be correspondingly increased, and the amount of good thus accomplished could hardly be estimated. As long, however, as there are no retreats or building places in which these little feathered friends of ours can rear there little ones, we need not look for their aid in fighting insect enemies.

The increase in the number of settlers would also add to the number of individuals to fight the locusts, and hence help to increase the sum total of their dead and to diminish the swarms otherwise remaining to do damage and to increase at the ratio of a hundred-fold. (Third Report U. S. Entomological Commission, pp. 44, 45.)

Mr. WILLITS. Dr. Vesey was to have been here, and he had a statement, too, but I will send the paper up.* Dr. Merriam is here, and I would like the committee to hear from him.

The CHAIRMAN. We will hear from Dr. Merriam.

STATEMENT OF C. HART MERRIAM, ORNITHOLOGIST.

The CHAIRMAN. What is your position?

Mr. MERRIAM. I am chief of Division of Ornithology and Mammalogy of the Department of Agriculture.

I was desired by Secretary Willits to come here and speak of the availability of certain areas of the arid lands for the introduction of certain agricultural crops and certain birds and animals which are injurious or beneficial to mankind.

In the southern part of the arid lands camels have been already introduced. Many years ago the War Department introduced camels in this country, and herds are now supposed to be living in western Texas and in Arizona.

Nothing has been done to utilize them as beasts of burden, but there can be no doubt that enormous good and enormous value would result to the arid land by the proper introduction and domestication of the camels of those regions. The herds now roaming wild over considerable areas in the arid lands could be put to very useful service. Our arid lands extend from the Mexican border to the plains of the Saskatchewan and embrace a number of distinct climates. Each of those climates is adapted to the wants of certain classifications of animal and vegetable life. We find that we are able to subdivide the West into a number of areas which we call life areas, because each of those areas possesses associations of plants and mammals, birds, reptiles, insects, etc., that are not found in continuous areas, and we find in applying agriculture to those areas that the same areas that support definite associations of plants and animals in a wild state are adapted by nature to definite kinds of agricultural crops and to definite breeds of animals.

This is a subject that has been almost entirely overlooked in studying the question of the relation of climatology, particularly of temperature and humidity, to the relations of life; it is one of the utmost importance. I think it is not saying too much to state that agricultural science in this country is going to be completely revolutionized whenever it is studied in connection with the natural life areas and the climatology of the country. Experimental agriculture will cease.

---

* Dr. Vasey's paper was not received.

The **Chairman**. Have you to any considerable extent classified the sections, and the animals belonging to them?

Mr. **Merriam**. I have been engaged in that work for the last four or five years, and have a number of maps now in progress of the whole United States, showing the primary, secondary, and tertiary life areas in which the country is subdivisible. That is the work in which I am now engaged.

The **Chairman**. That would not come within the scope of our report; but I agree with you that it is a very important subject of inquiry, if you can ascertain as to each region when developed what will be the products, and what animals will thrive there, and what will be suitable for them for food. That information will be most valuable to settlers in order to inform them what animals they may keep.

Adjourned.

FIFTH DAY'S SESSION.

Washington, D. C., *March* 13, 1890.

The committee met pursuant to adjournment.

Present: Mr. Stewart (chairman), Mr. Moody, Mr. Casey, Mr. Reagan, and Mr. Jones, of Arkansas.

STATEMENT OF CAPT. C. E. DUTTON, U. S. ARMY, CHIEF ENGINEER U. S. IRRIGATION SURVEY.

The **Chairman**. Captain, you are an officer of the Army?

Captain **Dutton**. I am, sir.

The **Chairman**. And assigned to the Geological Survey?

Captain **Dutton**. Yes, sir.

The **Chairman**. State what connection you have had with the Irrigation Survey, what your position has been in that survey, etc.

Captain **Dutton**. When the survey was first authorized by law Major Powell requested me to take charge of the field-work of the engineering and hydrographic parties. The details of the field-work were drawn up and submitted by myself to the director, and were approved by him, and, since the passage of the law and since the time when the appropriation became available, I have had charge of the engineering and hydrographic work.

The **Chairman**. Has there been any other work than hydrographic and engineering work done in connection with the survey?

Captain **Dutton**. Within the limits of the appropriation?

The **Chairman**. Yes.

Captain **Dutton**. Yes, sir. There has been a large amount of topographic work, with which I have had nothing to do.

The **Chairman**. Of the $350,000 that have been appropriated how much has been expended for hydrographic and engineering work, and how much for topographic work?

Captain **Dutton**. Out of the first appropriation—you will remember there were two——

The **Chairman**. (Interposing.) There were two.

Captain **Dutton**. Out of the first appropriation of $100,000 $36,000 were allotted for the work under my charge.

The **Chairman**. The engineering and hydrographic work?

Captain **Dutton**. Yes, sir; there was a contingent fund reserved for expenditure under the immediate charge of the director, for office expen ses, and for special expenses which could not be foreseen in the original estimates, and also to be a kind of insurance fund against any deviation which might compel us to exceed this allotment or else sacrifice valuable work. The amount of that, I think, was $6,000. The remainder of the $100,000, that is, $58,000, I understand was applied to topography.

The CHAIRMAN. As regards the second appropriation?

Captain DUTTON. As regards the second appropriation, the original allotment to the work under my charge, that is, the engineering and hydrographic work, was $110,000. There was a contingent fund of $20,000, and $120,000 was allotted to the topographic work.

The CHAIRMAN. Has all of that appropriation been expended?

Captain DUTTON. The last appropriation?

The CHAIRMAN. Yes, sir.

Captain DUTTON. No, sir.

The CHAIRMAN. How much has been expended of what was allotted to the hydrographic and engineering work?

Captain DUTTON. I can not give the exact figures, but I can approximate to them off-hand. There still remains available for expenditure about $29,000, reckoning from the 1st of March, for the work under my charge. As regards the work in the topographic branch I am unable to say how much remains unexpended.

The CHAIRMAN. The $29,000 will be expended as you go along, in completing the work?

Captain DUTTON. Yes, sir; to complete the office work, and more especially to keep the hydrographic work going, which it is absolutely necessary to maintain constantly, without any intermission, in the field, that is, to a certain extent. The great bulk of the remainder now unexpended is being applied to the hydrographic work.

Senator REAGAN. That is, the remainder of the $120,000.

Captain DUTTON. The remainder of the $110,000. That is a class of work which requires more constant and steady expenditure than the engineering work, because it is necessary to keep up stations in the field constantly.

The CHAIRMAN. Is there any connection, in practical operations, between the topographic work and the engineering work; how do they co-operate, if at all?

Captain DUTTON. There is a certain amount of general utility for engineering and hydrographic purposes to be found in a good topographic survey. According to my understanding there is no absolute dependence upon topographic work for the proper conduct of good engineering and hydrographic work; in other words, an engineering and hydrographic survey could be conducted with good results, meeting the purposes and requirements of the law, if there were no topographic survey. Our results probably would be in some measure better spread upon the record, better published, and made more intelligible, if we had good topographic work in advance, and good topographic work would undoubtedly be accompanied by certain conveniences; but the question of necessity is one of degree.

Senator REAGAN. I do not understand these things very well. Will you define the difference between what you call engineering and hydrographic work and topographic work, so we can see what the differences between the two classes is?

Captain DUTTON. In order to carry out the purposes of this law, as it has been understood in the survey, and in order to meet all the special requirements of the law, which provides for investigating the extent to which arid lands can be redeemed by irrigation, one of the first things which is necessary to know is the available water supply, and not merely the water supply, but also what the water can do—how much a given quantity of water can do, both in general and in particular—as a general rule and in particular cases. It is therefore necessary to make what we call a hydrographic investigation to know how much water we have at our command. The hydrographic work has been understood to include the measurement of the waters flowing in the streams, and to ascertain the rate or distribution of the flow of streams during different parts of the year, to know when the waters are at a maximum and when at a minimum. It is also necessary to know what we term the "duty" of the water, to know how much land the water can irrigate, and if, as is actually the case, it varies from place to place, to know the causes upon which that variation depends—what influences the duty of the water.

There is one other very important matter in this connection which it is necessary to investigate, and that is the subject of evaporation, which becomes a highly important one in reservoirs, and especially in the largest reservoirs, for reasons that will readily suggest themselves to you. A large reservoir is generally a shallow one, and a very large basin can not under any ordinary circumstances receive a sufficient quantity of water to cause a great rise and fall in that reservoir. Now, if the proportion of evaporation to the amount of available inflow of a reservoir is very large it becomes a very important question to know how much that evaporation is, and there are very many cases where the value of a reservoir will turn upon the ratio which exists between evaporation and inflow. Therefore it is necessary to make an accurate investigation of the rate of evaporation. There is still one other question which we consider—a hydrographic one—which we have not as yet taken up systematically, but have only investigated in one or two localities, and that is the quantity of sediment which the streams transport. That becomes a matter of very great importance in determining the life of a reservoir, how long it will take to fill it. These are practical matters which the hydrographic service is expected to investigate. The engineering survey investigates questions of a different character, but into the investigation of the engineering survey the hydrographic survey enters as an important factor. The engineering survey is required to first investigate the possibilities of diverting water from streams, storing water, and the amount of land which can be irrigated by works of a specific character. I think it will appear quite clearly that if we are to obtain the information as to the amount of land which is susceptible of being irrigated we must have for each locality and each district some definite idea of the kind and the extent of the works which are to irrigate them. Therefore the engineering survey is required to form some definite project of works for the irrigation of each district. Their instructions have been to endeavor to select the best. I can perhaps convey to you that idea more forcibly by reading to you a portion of the instructions which were given early in this investigation to some of the engineers:

> I desire herewith to place before you certain governing considerations of a general character with reference to the surveys you are expected to make and to the results you are expected to accomplish. In each hydrographic basin it is desired to take the problem; what are the available sources of water supply, and by what means the water may be most fully utilized? A hydrographic basin may mean the water-shed of a large stream or of a small one, or a great river or one of its tributaries; but whether it means a trunk stream or a branch of it (a question to be decided by the engineer), it is assumed that there is some form of development and construction of the work

> which may be judged to be the best that the engineer can devise. The engineers should take no account of works which are already constructed; nor should their judgment be swayed by any opinion on their part as to what works private enterprises and capital are likely to undertake in the next few years. They should rather address themselves to the question already propounded; what is the best system, the one which will utilize the greatest amount of water and produce the greatest amount of irrigation? It is not forgotten that as a practical matter irrigation development in each district starts with a small beginning, with works proportional to that beginning; that it advances through successive stages, by more costly works superseding the primitive ones. But of these the engineer should take no account. His project should embrace what is in his judgment the best system, irrespective of what is or actually may be constructed. At the same time his project should be a practical one, involving no extravagances of engineering, nor transcending the possibilities of attainment, or of maintenance after attainment. The plans should also have a certain unity, and should contemplate a single system of works for each irrigation district. If both reservoirs and canals are required, the reservoirs should be, if possible, projected as adjuncts of the canals. No doubt it will happen sometimes that the rivers alone are more than sufficient for the available land, as in the northernmost States and Territories, or that reservoirs alone are possible, as in parts of the southernmost Territories; but still, even in such cases, unity of plan should, so far as practicable, be kept in view. Engineers should seek to minimize the extension of their projects of distributive works by which water is taken from canals and reservoirs and put upon the land. With a given high line canal it will generally be possible to propose many ways of distributing its water, but the distributive system will in other cases probably be of a distinctive character, forming a vital part of the entire project, and its development in the project will then be necessary.

This instruction was deemed necessary in order to meet the requirements of the law for investigating the extent to which the arid lands are capable of being redeemed by irrigation.

Senator Reagan. You have stated that there would be some convenience in a topographic survey. Is not a topographic survey to some extent indispensable to this work in ascertaining the altitude of the place where you locate your reservoir, the relative altitude of the ground to be irrigated, and to run the lines of the canal?

Captain Dutton. Yes, sir; to know the line of the canal it is necessary to have an exceedingly minute and very carefully detailed topographic survey on a very large scale. It is also very necessary to have a thorough-going survey of the reservoir site itself, and most particularly of the dam site. For this purpose a topographic survey is an absolute necessity; but in speaking I had reference to a more general topographic survey of the whole country. A topographic survey to show the lines of a canal would have to be made upon a scale never less than 1,000 feet to the inch, and is more frequently 100 or 200 feet to the inch, whereas a general topographic map of the very largest size means a survey upon a scale of about 10,000 feet to the inch; that is, our scale for engineering purposes would have to be ten, fifty, or even one hundred times as large as that of a general topographic map. And there is another point in that connection. The most important feature of an engineering survey for engineering purposes deals with the vertical element; that is, with altitudes. The horizontal elements, although important, are far less so than the vertical elements. Now, it would be impracticable to construct a topographic map, at a reasonable cost, with a degree of accuracy at all commensurate with the accuracy which is demanded by the engineering surveys of a canal, or even of a reservoir.

Senator Reagan. Is not such a topographic survey as is being made in the country where you have been a very great convenience to the engineers when they come to arrange the details of the hydraulic part of the work?

Captain Dutton. Yes, sir; it is a convenience; there is no question about that.

Senator **REAGAN**. And it is of great convenience in considering the engineering problems?

Captain **DUTTON**. It is a great convenience. I notice that all my engineers are calling very largely for maps, and the best maps they can get.

Senator **REAGAN**. Are you advised as to the extent to which the topographic surveys have been made and how near they are to completion throughout that Western country generally?

Captain **DUTTON**. Yes, sir; I have a pretty good knowledge of that subject. I know where they have been made and I know their general character.

Senator **REAGAN**. State to the committee about the extent of those surveys.

The **CHAIRMAN**. And also state their general character.

Captain **DUTTON**. Well, sir, you are aware that topographic surveys of various qualities have been going on the Western country for twenty years. They have been made by different organizations of the Government. Some have been made with much more care and much more skill than others. A very large portion of the West has already been so surveyed. There has been a topographic survey made of that portion of the State of Colorado which lies west of Denver. The entire portion of the State west of Denver was surveyed under Dr. Hayden. There has been a very large portion of New Mexico surveyed, by what we are in the habit of calling a mere reconnaissance survey, under Captain Wheeler, of the Engineers. It is on a much smaller scale and much more hurriedly done than a topographic survey, and it has but little of the vertical element in it. We do not consider it a topographic survey. But some portions of New Mexico have been surveyed by the Geological Survey, perhaps about one fourth of the Territory. Nearly one-half of Arizona has been surveyed by the Geological Survey, that, however, being the northern portion of the Territory. About two-thirds to three-fourths of Utah has been surveyed by the Geological Survey. The Wheeler survey made extensive surveys in Nevada, while the Geological Survey has made none there except in the extreme western portion of the State. The Wheeler survey has made very extensive surveys in California, and the Geological Survey has followed them up with their topographic survey, which now embraces about one-fourth, perhaps one-third, of the State—a very fine map. Southwestern Oregon has been surveyed by the Geological Survey, but probably not more than one-eighth or one-tenth of the State has been surveyed.

No surveys of any kind have been made in Washington, and the Geological Survey has made no surveys in Idaho until within the last year, and very few surveys of any kind have been made there excepting in the southeasternmost portion. In Montana a survey was made by the Northern Pacific Railway, known as the Transcontinental Survey, embracing a belt of territory which was adjacent to the Northern Pacific Railroad, mostly within the limits of its land grant, and other portions have within the last three or four years been under survey by the Geological Survey. Perhaps one-fifth or one-sixth part of Montana has been surveyed. In Wyoming there has been very little topographic work done, although a survey was begun there by Dr. Hayden during the last few years of the existence of his own survey, but only a small amount of progress had been made upon it. In the States and Territories east of the one hundredth meridian, within the arid belt, the Geological Survey has been making surveys in the valley of the Arkansas River, and still more extensive ones in the eastern portion of Kansas. It has also been making some extensive surveys in central Texas, gradually expanding its work there. That carries us into the humid region, and there has been a great deal of surveying done, of course, in the Mississippi Valley.

The CHAIRMAN. Suppose a corps of engineers, having a report of the hydrographic work, so that they would have an approximate knowledge of the precipitation and evaporation, and the amount of water flowing in a stream, should go into a valley to locate a reservoir and the lines of ditches for the purpose of conveying the water to such lands as could be irrigated, how much information could they obtain from any topographical map that has been made of any portion of the country? Would they be able to rely on such a map, or would it be necessary for them to do their own work independent of that?

Captain DUTTON. The most valuable information they would get from a general topographic map would be a more accurate means of computing the area of the different water-sheds. I know of no other purpose which would be an indispensable one which would be served by such a map as that. But it becomes a matter of very grave moment to know what the water-shed is. It can be very readily ascertained by a few days' labor, or, if it is a large one, by a labor of a week or two; but as a general rule the exactions of accuracy in the size of a water-shed are not so great but what they can be made fairly and with a sufficient degree of approximation by existing data.

Senator JONES. Why do you have to know the area of a water-shed?

Captain DUTTON. In order to form some judgment in advance of the amount of water which is likely to run off from it in flood-time.

Senator JONES. Then you rely on the area of the water-shed and the average rain-fall to make your hydrographic examinations; or do you measure the streams for the purpose of making your estimates?

Captain DUTTON. Both.

Senator JONES. You do not rely on either one, absolutely?

Captain DUTTON. We place our main reliance upon stream-gauging.

Senator JONES. That is much less expensive than the other?

Captain DUTTON. No, sir; far more expensive. Stream-gauging is very expensive work.

Senator JONES. Is it more expensive than a topographic survey in ascertaining rain-fall?

Captain DUTTON. Oh, no, sir.

Senator JONES. That is the question I asked.

The CHAIRMAN. The captain meant sufficient topographic work to ascertain the area of the water-shed. That amount of topographic work would not cost as much as the topographic work.

Captain DUTTON. I think I can get a rough approximation of almost any water-shed from existing maps.

Senator JONES. Is that sufficient for practical purposes?

Captain DUTTON. Yes, sir.

The CHAIRMAN. Then there is another thing which, it seems to me, you would want to know in planning for a dam. You would not only want to know the amount of water that would come down in flood-times, approximately, but you would want to know the declivities of the water-shed, to determine how rapidly it might come down.

Captain DUTTON. Yes, sir.

The CHAIRMAN. Could the engineers in the field also make allowance for the declivities of the water-shed and judge of the probabilities of strain upon the dam, so as to make allowance for it?

Captain DUTTON. They could get some light upon that subject——

The CHAIRMAN (interposing). Would a topographic map give you some light?

Captain DUTTON. Yes, sir.

Senator JONES. Is it indispensable?

Captain DUTTON. It is not indispensable.

The CHAIRMAN. When they were making the survey could they take the altitude with sufficient accuracy to form a reasonable judgment of it?

Captain DUTTON. Yes, sir. We have no difficulty in getting altitudes in a few hours, or in a day or two at the farthest, with all the accuracy that topographers get it, because the country is now so completely covered with railroads. Topographers are obliged to rely on the railroads as a starting point for their data, and engineers can do that as well as topographers. If a case arises where the locality is very remote from a railroad he can get his altitude in precisely the same way the topographer gets his, that is, by a mercurial barometer. That is a rough way, but it gives the altitude with a fairly satisfactory degree of approximation.

Senator JONES. How long a system of observation does it require in the basin of a stream to determine the minimum water-fall and the maximum water-fall; I mean for practical purposes?

Captain DUTTON. It takes a great many years, Senator. Hydrographic observations once begun should be conducted without intermission for a long period of years, and I think that as soon as practicable the States themselves, or possibly the irrigation districts, should have that business gradually turned over to them and devolved upon them. It is their business, their province. Sooner or later all the irrigation must come——

Senator JONES (interposing). What do you think was the cause of the accident in Arizona the other day?

Captain DUTTON. An insufficient waste-weir.

Senator JONES. That is not the point I had in mind. What was the cause of the engineer making that mistake? I assume that he was competent, that he knew his business, that he knew the size of waste-weir necessary to carry off the water; but it seems that more water came down than he calculated on. Now, no matter if he had been gauging that for a long while, he could not, of course, know how much water would come down in an excessive flood unless a flood came during his observations. The question is whether you can arrive at such information by observations of the flow of the stream as to enable you to reasonably guard against accidents to works of this character, or whether it is necessary to have an examination of the country and know the area drained and the steepness of the water-shed, the amount of water that falls in an average year, and all that—whether that would be a more accurate way of guarding against destruction from floods than to depend on the gauging of the streams.

Captain DUTTON. The case of the Walnut Grove Dam, I think, brings out your suggestion very forcibly. There was a water-shed of about 325 square miles. Under any ordinary circumstances, under any ordinary rain-fall, there would have been no danger of overflowing that reservoir; but, on the other hand, those who have been acquainted with Arizona for a considerable number of years are aware that every now and then there comes an exceptional storm, and engineers who have made a special study of the subject of reservoirs and the storing of reservoirs are well aware that when the precipitation comes very rapidly and very suddenly there is a tendency to a definite ratio between the amount of rain-fall and the amount of run-off, so that there is a possibility of making a computation of the amount of water that is likely to flow into a reservoir when the rain-fall exceeds a given amount in a given number of hours; and, now, it seems to me that the engineer who had charge of that work should have studied that problem more than he did; that he could have foreseen that there was a liability of such a rain-fall, and the precedents which have been given by the English engineers in India and by the Italian engineers in the Piedmont should have been ample to warn him of the possibility of such an accident as that.

Senator REAGAN. Was there not some defect about the masonry?

Captain DUTTON. I think not.

Senator MOODY. How large was that dam? What was the length, width, and height of it?

Captain DUTTON. The dam was 110 feet high. The bottom of it I am not accurately informed about. I have made some inquiries on the subject, but have as yet received no reply. I understand, however, that the basal dimensions were ample. It belongs to a type of dam which has become very popular in California of late, which is known as the loose-rock dam. There are some great advantages about a loose-rock dam. A leak is of very little consequence.

Senator MOODY. For what reason?

Captain DUTTON. Because the water which flows through the front of the dam flows through the back, through the interstices of the stones, and exercises no internal pressure. If water gets into a dam constructed of masonry—gets inside—it is likely to burst it by hydrostatic pressure and destroy it; but in a loose rock dam there is no danger of that kind.

Senator MOODY. No danger of undermining?

Captain DUTTON. No danger of the undermining or bursting of the dam.

Senator MOODY. At what point from the bottom did this break occur?

Captain DUTTON. It occurred at the top, by the overflow of the dam. The waste-weir being insufficient to carry off the water, it began to overflow. If you have a dam of such great height as that and the water is permitted to overflow it, its destruction is absolutely certain.

Senator MOODY. A fall of water 110 feet makes a pressure of how much to the square inch?

Captain DUTTON. Well, it depends whether it falls unchecked or is checked.

Senator MOODY. Unchecked, as it would flow over a dam.

Captain DUTTON. The pressure would be terrible It would be a difficult matter to compute. Its destructive power would be great.

Senator MOODY. I desire to ask a question on another branch of the subject. You say there was $110,000 of this $250,000 that was assigned to the engineering and hydrographic surveys?

Captain DUTTON. Yes, sir.

Senator MOODY. And $120,000 was assigned to the topographic survey?

Captain DUTTON. Yes, sir.

Senator MOODY. Can you state generally for what the balance of the $110,000 was expended?

Captain DUTTON. There was allotted to Montana, $9,500; to Colorado, $19,500; to New Mexico, $8,500; to Idaho, $10,000; to Nevada, $15,500; to California, $13,000; making $76,000 for engineering work.

Thirty-four thousand dollars was allotted for the hydrographic work, making $110,000.

Senator **MOODY**. Commencing with Montana, please state where and in what work that was expended?

Captain **DUTTON**. A large proportion of it was expended in making surveys of the Sun River Valley and in making reconnaissances of the Yellowstone and the Three Forks of the Upper Missouri and the country lying between the Yellowstone and the Missouri Rivers.

Senator **MOODY**. What practical work was done in the Sun River Valley? Were any reservoir sites selected or lines of canals or ditches run?

Captain **DUTTON**. There were ten reservoir sites first selected, of which one was rejected, as being impracticable. The remaining nine were carefully surveyed, and the dam sites were thoroughly contoured on a very large scale, and the survey brought to such a condition that estimates of the cost of construction can be made at any time, whenever a Board of Engineers can agree upon what is the most suitable form of dam to be constructed. There is a high-line canal, taking water from six to nine reservoirs, which constitute a system, and bringing the water out upon the bench lands above Sun River, where it can be utilized.

Senator **MOODY**. Do you take the water from all those reservoirs into one canal—one general canal—or do you run a canal from each one of these reservoirs?

Captain **DUTTON**. A high-line canal takes the water from all the reservoirs; so they are practically one system.

Senator **MOODY**. Is that the mode of expenditure of the balance of the money, generally speaking, in all the States and Territories you have mentioned?

Captain **DUTTON**. That is not the exclusive method of the engineering work. In the Arkansas Valley the work has been somewhat different. It has there been devoted partially to the same end, that is, to devising a unified scheme for the maximum development of the irrigation possibilities of that hydrographic basin.

Senator **MOODY**. That is, selecting sites?

Captain **DUTTON**. Selecting sites and estimating the cost of construction.

Senator **MOODY**. Carefully surveying the sites?

Captain **DUTTON**. Yes, sir.

Senator **MOODY**. Locating the sites of dams?

Captain **DUTTON**. Yes, sir.

Senator **MOODY**. What else?

Captain **DUTTON**. Preparing surveys which can be utilized at any time.

Senator **MOODY**. Which can be utilized for the distribution of the waters.

Captain **DUTTON**. Yes, sir.

Senator **MOODY**. Outside of that what special work has been done?

Captain **DUTTON**. In addition to that there has been the selection of a large number of possible reservoir sites, which up to the present time have not been co-ordinated with any particular system, but which may be co-ordinated at any future time. Furthermore, there has been a considerable amount of money expended in the segregation of irrigable lands.

Senator **MOODY**. What do you mean by the segregation of irrigable lands? Do you mean the ascertainment of the areas of the lands that are susceptible of irrigation?

Captain DUTTON. The law provides, as you will remember, that all of the lands which are rendered susceptible of irrigation by such hydraulic works as are mentioned in the law are withdrawn from occupation, sale, and entry. Of course it is necessary to specify what those lands are, giving the township, range, section, quarter section, etc. Now there are a great many lands about which we are uncertain, but there are still others, of very large extent, about which no uncertainty exists, and it was deemed best to take those instances where no uncertainty existed at all and have them reported to the Secretary of the Interior for withdrawal from entry, occupation, and settlement, and do it promptly.

Senator MOODY. You have ascertained, then, by your surveys, the areas of lands susceptible of irrigation and that can be brought under irrigation by means of this system of reservoirs and distributing works that you have been planning?

Captain DUTTON. Yes, sir.

Senator MOODY. And marking upon the ground?

Captain DUTTON. We took the Land Office surveys. They are marked on the ground, in most cases. We took the Land Office plats, and from draughts of the Land Office plats we made our own draughts and certified them to the Department.

Senator MOODY. Do you do that by survey or mere observation?

Captain DUTTON. By sending a competent party upon the ground to identify the corners.

Senator MOODY. Will you state generally, as briefly as you can, how the $120,000 which was assigned to the topographic service has been expended?

Captain DUTTON. I only know in a general way where the field-work has been?

Senator MOODY. I am only asking for the information you have gathered from your familiarity with the office work.

Captain DUTTON. I can only state that from my general knowledge of where the work has been carried on. There have been a number of field parties at work in the Sierra Navadas, along the boundary line between California and Nevada. There has been a field party at work in the Snake River Valley, in the vicinity of Idaho. There has been a very large field party, or series of parties, at work in the Arkansas Valley in Colorado. There has been another large party at work in the valley of the Yellowstone and on the upper forks of the Missouri,—and a year ago—I am not certain whether it is within the present year or not, but a year ago there was a party at work in the Rio Grande Valley, in New Mexico. I am not certain whether they have been continued during the present fiscal year or not.

Senator MOODY. What work do these parties do that is of value so far as the purposes of irrigation are concerned, except to furnish these information maps that you have spoken of, that you take and then go upon the ground to locate absolutely the reservoirs by actual surveys? What service have they performed in the direction of irrigation?

Captain DUTTON. Well, there are two stand-points from which that question can be answered.

Senator MOODY. I would like your views upon it.

Captain DUTTON. I think I had better answer it——

Senator MOODY (interposing). What I am trying to get at is this: I would like to know, if the committee has the patience to allow me——

The CHAIRMAN (interposing). Certainly.

Senator MOODY. I would like to know how much of this $250,000 has been expended for the purpose of irrigation and how much has been expended for the purpose of mapping and platting the country. In that light I would ask you, captain, what work the topographic parties have done.

Captain Dutton. I think the best answer I could give you would be to try to explain the matter from the stand-point of the Director himself.

The Chairman. Give the engineers' views and the Director's, both.

Senator Jones. It seems to me that you are likely to bring about confusion here. A topographic map may have great value in many different ways. It may or may not be necessary to have it for the purposes of irrigation. I do not believe you can have an intelligent method of irrigation without a topographic survey; but when a topographic survey is made it can be——

The Chairman (interposing). We want his view.

Senator Moody. I understood the captain to say—and I may have misunderstood him—that the topographic surveys which were important for irrigation purposes were made by the engineering surveys.

Senator Jones. He said those that were indispensable.

Senator Moody. They must have these vertical surveys.

Captain Dutton. And on a very large scale.

Senator Moody. On a very large scale; in other words that the mere togographer does not undertake to fix with any degree of accuracy the line of any canal or the altitude of any place, except for mere topographic purposes, and that after he is through with his work, or if he does not do the work, the engineering corps that is engaged in locating dams and reservoirs, and canals for the distribution must go upon the ground and make exact and accurate surveys. Of course every man understands that if you are going to run water from a reservoir you have to run some sort of levels, and run them with accuracy, and that a mere topographic survey will not do; but the topography you speak of, as I understand it, is that topography which comes from these accurate survey by engineers. Am I correct?

Captain Dutton. That is correct; entirely so. To answer your question as you originally put it, I would say this: It was the Director's idea originally to have a topographic map constructed with a degree of accuracy which would be sufficient to enable engineers to dispense with costly and cumbersome parties of transitmen and levelers, and to produce maps which, taken in the hands of the engineer and carried into the field, would enable him to lay down his canal lines with as fair a degree of accuracy and certainty as if they were actually run by transit and level. That was his way of making an irrigation survey. I think that the Director was under a misapprehension as to the degree of accuracy in his maps which was attainable by the methods actually used by the topographers and under the requirements which were laid upon them. My belief is that no such degree of accuracy as would be necessary for the engineer was at all attainable by the methods adopted by the topographers, and I am quite confident that the topographers think the same way themselves, with the possible exception of Professor Thompson. That was the Director's desire in having a topographic map made.

The Chairman. Now, give the engineers' side of the question.

Captain Dutton. The engineers' side of the question, I suppose, would be this: That a topographic map can not by any possibility be made with any such degree of accuracy as is required for the crudest and most general purposes of the engineer. In the next place, the requirements of the engineer are for a very large scale map, a map merely of a strip of ground a few hundred feet wide along the path of his traverse; also for a very detailed map, on a scale never less than 200 feet to the inch, and most generally 100 feet to the inch, sometimes 50 feet to the inch for dam-site purposes. This minute survey on a very large scale is to enable the engineer to take the map into his office and estimate quantities, as we say. Similarly, also, the survey along the line of his traverse on a very large scale is necessary for precisely the same purpose as the railroad engineer makes it, in order to be able to estimate the quantity of excavations he has got to make and how to adjust his cuts and fills.

Senator MOODY. Pardon me for referring to another subject. What is the lowest grade of flow which you provide for in the canals or ditches to which you have referred?

Captain DUTTON. The lowest grade that I know of for a canal is about eight-tenths of a foot to the mile. The tendency among engineers is to adopt lower grades than they used to in high line canals, and if the country and economy of work will admit of it, they now prefer rather lower grades than they have ever used before.

Senator MOODY. How much is that to the rod?

Captain DUTTON. I should have to apply the arithmetic to it. It would be a very minute fraction of an inch.

Senator MOODY. Now, with that fall of grade what is the percentage of evaporation as the water passes through the canal; or let me ask, primarily, what is the degree of evaporation?

Captain DUTTON. There is no way of stating evaporation, Senator, except——

Senator JONES (interposing). In proportion to the surface.

Captain DUTTON. There is no way of stating evaporation except by ascertaining the amount of water evaporated in a given time, so many hundredths of an inch in a day, or so many inches in a month, or so many feet in a year. That is the only way in which we can state evaporation.

Senator MOODY. I have heard it asserted by hydraulic engineers that the average evaporation in a canal or ditch running slowly, as you have indicated would be the case, of course with a fall of eight-tenths of a foot to the mile, was about 3 per cent. a mile.

Senator JONES. Three per cent. of the volume of the water?

Senator MOODY. Yes, of the water in the canal or ditch.

Captain DUTTON. When I say that eight-tenths of a foot to the mile is the smallest grade that I know of I do not wish you to understand that is the grade for any great length of a canal. It is for only a certain portion or section of the canal, where certain reasons necessitate the use of a minimum grade. A minimum grade should not be resorted to in all cases. What the engineer wants is a grade which will enable him to get his water from the source of supply to where it is required in the shortest possible time. If he gets his grade too great, it will wash out his canal; if he gets it too low, it will increase the cost of construction.

Senator MOODY. The extent of evaporation depends largely upon the surface which is covered by a given amount of water?

Captain DUTTON. It is always in proportion to the surface, other things being equal. We consider that evaporation depends on three quantities: The first is the temperature of the water; the second is the absolute humidity of the air. There is still a third, the rate at which the wind is blowing, the wind factor being really the most important and the most difficult to handle.

The CHAIRMAN. I desire to ask one or two questions, and I want to call the attention of the committee to this matter. In constructing dams in northern Arizona, Nevada, New Mexico, parts of Utah, and parts of Idaho, where they have cloud-bursts in summer and violent storms sometimes in winter, that produce unusual floods, would any general topographic survey be of as much use to you as a particular examination of a given stream, with a view of ascertaining the evidences of what had happened there in the way of floods in the past? For example, if you have been through that country you have seen places where these cloud-bursts to which I have referred have occurred, carrying down immense rocks weighing hundreds of tons and gullying out deep ravines in the bald mountains, where the precipitation generally starts. Are there not evidences on the ground which would warn a person familiar with the country to build no dam under any circumstances in certain places, no matter what the topography might indicate? Are there not such places?

Captain DUTTON. Plenty of them.

The CHAIRMAN. Where any dam would be torn out. I have in mind a cañon in California—Panamint Cañon—which is very narrow and very steep. At the foot of that cañon there are immense rocks, some of them 50 or 60 feet high, which have been carried down through the cañons by the floods, by these cloud-bursts which prevail there, which occur frequently. To build a dam there would be folly. Now, when you deal with that country is it not more necessary than anything else to observe the evidences on the ground, ascertain the experience of those who have lived in the region, and if you are going to utilize that water take the water out of the stream and build your reservoir somewhere else? In dealing with a country like Arizona, is it not one of the first things to do to see what nature has already done and avoid those places where these cloud-bursts have occurred, and would a topographic map be of very much use to an engineer who is sent on the ground to find a safe place to locate his dam?

Captain DUTTON. It would not be of any special use.

The CHAIRMAN. It would be convenient to show the geography?

Captain DUTTON. Yes, sir; but when it comes to practical work, it would not be of any particular use.

The CHAIRMAN. What delay would be necessary in this work if we should wait for sufficiently accurate topographic surveys to precede the engineering work?

Captain DUTTON. A good many years, unless the topographic survey was conducted so as to meet the wants of the engineers at the very start.

The CHAIRMAN. Is there any topographic survey now in existence that is sufficiently accurate for use in locating a dam and line ditch without this same engineering work which you speak of?

Captain DUTTON. I think that probably some of the English ordnance survey maps might——

The CHAIRMAN (interposing). I mean in this country that has been made by any of the surveys you have mentioned?

Captain DUTTON. I do not think there is.

The CHAIRMAN. You are familiar with what has been done. Take for example this district. Do you know of efforts having been made to secure an accurate topographic map of this?

Captain DUTTON. I know the Coast Survey made some good maps during the war, and I think the city engineer has run some careful surveys.

The **CHAIRMAN**. Has not the Coast Survey been at work for the last few years in trying to make an accurate map?

Captain **DUTTON**. Possibly they have.

The **CHAIRMAN**. You have not seen that map?

Captain **DUTTON**. No, sir.

The **CHAIRMAN**. Do you know whether that map of the District of Columbia, on which they have spent so much money, is sufficiently accurate for locating a line of railroad, or a ditch, or a dam? Could you do those things by that map without engineering work? I suppose that is the best map we have in the United States.

Captain **DUTTON**. I would have to study the map before I could form an opinion.

The **CHAIRMAN**. You have not studied the map?

Captain **DUTTON**. No, sir.

The **CHAIRMAN**. Then we need not, in your judgment, wait for the topographic survey to prosecute what surveys are necessary for immediate use.

Captain **DUTTON**. I do not think it is necessary.

Senator **REAGAN**. Captain, has the hydrographic and engineering work covered the whole ground of the topographic work? If it has not, what proportion of the topographic work has been covered by the hydrographic and engineering work?

Captain **DUTTON**. While the topographic and engineering work are in most cases in the same neighborhoods, the only case of actual coincidence is in the Arkansas Valley. The topographic work was commenced there about a year and a half ago, I think, and the engineering work only last summer. In all other portions of the West the two fields of labor have not coincided.

Senator **REAGAN**. If you should take a topographic map, according to the way the work is now being done, could you not lay down a common road or railroad by it?

Captain **DUTTON**. You could point out in a general way, perhaps, where a common road might be laid out. I think, however, there are some portions of a topographic map where that would be very doubtful. As to a railroad, I should say no. It would not dispense with the necessity of a railroad survey.

Senator **REAGAN**. You could get the general line of a railroad from it?

Captain **DUTTON**. Well, in a general way you could. I think so.

Senator **REAGAN**. Can you take a topographic map and select any particular stream and determine the catch basin of that stream by it and the amount of land that would be irrigable?

Captain **DUTTON**. No, sir; you would have to go over the ground to ascertain the amount of irrigable land.

Senator **REAGAN**. Where it is above 4 feet altitude you could get the place where your reservoir would have to be located, you could get the size of your catch basin, and you could determine what lands are lower than your dam?

Captain **DUTTON**. They only make the maps with 20-foot contour.

Senator **REAGAN**. Then I have been wrongly informed at the Department, for I was told there that they had made the maps on a 4-foot contour.

Captain **DUTTON**. Possibly it may be that in the Mississippi Valley.

Senator **REAGAN**. No, I am talking about the Western country.

Captain **DUTTON**. It is a 20-foot contour, unless they have changed without my knowledge very recently. I know a few months ago it was understood to be 20-foot contours in the valleys, 50-foot in the foot-hills, and 100-foot in the mountains.

Senator **Jones**. You say a topographic map is of very little value to the engineer in locating irrigating works.

Captain **Dutton**. I think they are of only general value.

Senator **Jones**. And are by no means necessary.

Captain **Dutton**. I do not think they are necessary within the meaning of the law, and yet there is this to be said about it: The term "necessity" has a practical interpretation; is not easy to define. We are every day certifying that certain things are necessary on our bills and on our vouchers. While in a certain sense and in the ordinary acceptation of the term they are necessary, in an absolute sense they are not.

Senator **Reagan**. What is the use of a topographic survey?

Captain **Dutton**. To furnish general information about the country and a knowledge of the laws of distribution.

Senator **Reagan**. Has the Government made a mistake in authorizing these topographic surveys?

Captain **Dutton**. No, sir; I think not. I think no money has been better spent.

Adjourned.

Department of the Interior, U. S. Geological Survey,
Washington, D. C., March 31, 1890.

Dear Sir: I have the honor to acknowledge the receipt of your letter of 29th instant, desiring me to inform you concerning the expenditures made in the Geological Survey under the appropriations made in 1888 and 1889 for irrigation surveys, viz:

First. Of the exact amount of the two appropriations of 1888 and 1889, the first for $100,000 and the second for $250,000, which was assigned to topographical work and to engineering surveys for irrigation purposes, and how much has been used in the office for topographical work and how much for the work of irrigation.

Of the first appropriation for $100,000, the sum of $40,000 was at first allotted for engineering and hydrographic work, but at a later period $4,000 of this sum was transferred to the allotment for topographic work, making the allotment for engineering and hydrographic work $36,000 for the fiscal year ending June 30, 1889. A sum of $4,000 was understood to be reserved by the director for office expenditures. The amount finally allotted for topographic work I understand to have been $60,000. As regards the last two items, however, my statement is not necessarily conclusive, since I have had no formal or official notification thereof. As to how much has been used in the office for topographical work and how much for irrigation work, I can not give a complete answer except by stating the general nature of the case.

There are numerous expenditures, such as heating, lighting, watchmen, messengers and clerks in the Director's office, purchase of stationery, printing, express charges, carpenter work, repairs, etc., which are for the common benefit of all branches of work under the Director's administration, and it would be impracticable to charge these expenses to the several allotments except in an arbitrary way. They become, therefore a charge against the reserve funds which are divided off from each appropriation. Moreover, it is usually the case that expenses slightly overrun the the allotments, and the excess is paid from the reserve fund at the end of the fiscal year. The work under my charge overran the $36,000 allotted by the amount of $743.33. How much the topographic work overran its allotment I do not know.

During the present fiscal year the sum of $110,000 ha sbeen allotted for the engineering and hydrographic work. My understanding is (though I have not been informed officially to that effect) that $120,000 has been allotted to topography and $20,000 held as a reserve fund. To what extent the allotments will have to draw on the reserve fund at the close of the year can not, of course, be exactly foreseen at present. Up to this date there are charges for work under my control amounting to $3,667.44 which were not estimated for at the beginning of the fiscal year and which will become a proper claim against the reserve fund. I do not now see any reason to expect that this amount will be materially increased. Of the state of the topographic allotment I have no information.

If I rightly apprehend the purport of your first inquiry, your desire is to know what disposition has been made or is intended to be made of the three portions (engineering, topography and reserve) into which the appropriation has been divided by the discretionary action of the director. With that understanding, the nearest approach which I can make to the exact information you seek is as follows:

From the first appropriation of $100,000, $36,743.33 have been explicitly expended for the engineering and hydrographic work. For the topographic work, I understand that $60,000 have been allotted and presumably expended. Of the remaining $3,492.23 I have no knowledge beyond the fact that there have been numerous sources of necessary incidental expenditure to which it may have been applied for the common benefit of both the engineering and topographic work without being distinctly chargeable to either one alone. A portion of it might also have been available at the end of the fiscal year to meet expenses in excess of the allotment for topography.

Second. You further inquire how much of the entire expenditure was for topographic work during the last fiscal year in the region west of the one hundredth meridian and whether the topographical work of the arid region since the appropriations for irrigation has been carried on with money for topography or with money appropriated for irrigation.

I have not the full information and knowledge which are necessary to give an exact answer to this question or to furnish the figures. But in general terms, I understand that on July 1, 1888, topographic parties were at work in the arid region under the appropriation for topography only, and continued to work so during the remainder of the summer. The first appropriation for irrigation became a law on October 2, 1888, and within a very few weeks parties were put to topographic work in the Arkansas basin at the expense of the irrigation appropriation, and in the spring other parties took the field in California, New Mexico, and Montana under the same appropriation. During the current fiscal year my understanding is that all of the topographic work of the arid region has been at the expense of the irrigation appropriation and that no portion of the topographic appropriation has been expended there.

Third. In what section was the first $100,000 appropriated for irrigation expended in engineering work for irrigation and what amount of irrigation survey was completed with the first appropriation and what area of land was covered? Where has such portion of the second apprppriation as was assigned to irrigation been expended, and what was accomplished in each district?

Immediately after the passage of the appropriation October 2, 1888, measures were taken for organizing the hydrographic work. As the funds could not become available until the 1st of November, when the winter would be upon us, it was deemed unwise to immediately organize the engineering work. For the hydrographic work skilled men of high intelligence were necessary, and there were probably not two dozen men in the United States who knew how to gauge a stream, and not one of the few who did know were available. It is an art requiring manual skill, the intelligence of an educated hydraulic engineer, and the temperament of a somewhat scientific observer and manipulator. Neither was there any well-established and generally-accepted method of stream gauging, nor any standard instruments. In short, there was no regular practice. It was necessary, therefore, to create men, methods, and instruments. It was believed that good gauging would be impracticable in wintertime, and of little value even if it were practicable, and hence that no better course could be followed than to select promising, well-educated, and ambitious young men, put them into a camp of instruction in a moderately warm climate during the four or five months of winter, and let them acquire the necessary skill, work out methods of gauging, and ascertain by trial the best kinds of instruments to be used. This was done. A good comfortable camp was established on the Rio Grande in New Mexico, and fourteen young men sent there early in December. They applied themselves with great zeal and interest, and with two or three exceptions proved to be most excellent men. When the spring approached I had about a dozen men at my command who knew what was wanted of them and how to do it. Up to the 1st of April the expense of the work for all purposes was $10,400. The men were then distributed to their stations; two in New Mexico, two in the Arkansas Valley, one in California, one in Nevada, two in Utah, one each in Arizona, Idaho, and Montana, and one at El Paso, Tex. Gauging stations were established in the following basins:

Rio Grande and tributaries, 6 stations; Gila and Salt Rivers, 3; Carson and Truckee 7; rivers of Utah, 14; Snake River basin, 5; Upper Missouri and Yellowstone, 12; Arkansas basin, 6.

Evaporation stations were also established at El Paso, Phœnix, Yuma, Clear Lake, California; at several localities in Utah, two in Idaho, five in Montana, and two in Colorado. About seventy special stations were established at high altitudes in Arizona, New Mexico, and Colorado for observing rain and snow fall at places not reached by the Signal Service. Many hundreds of gaugings were performed and a large amount of special inquiry made into the duty of water. At the close of the fiscal year the work was progressing in a highly satisfactory manner except in the Carson and Truckee basins, and though the work here was not what was expected it has proved to be less faulty than was at one time feared. Everywhere else it has been better than was anticipated for the first season.

The engineering work was not organized until spring, first, because winter work is undesirable unless an emergency demands it, and, second, because the allotment at my disposal was insufficient to accomplish any work of much value. In May two supervising engineers, Messrs. Hall and Nettleton, were appointed, and four division engineers, Messrs. Foote, Bodfish, Bridges, and Wilson. The funds remaining available would not admit of more than buying the outfits and putting the parties in the field in time to accomplish three or four weeks' work, *i. e.*, just make a beginning of their work, by the time the fiscal year closed. The parties were launched in the Arkansas basin under Mr. Bodfish about June 1; in the Snake River basin under Mr. Foote about the middle of May; in Montana under Mr. Wilson about June 1; and in the Truckee basin under Mr. Bridges about the middle of June. At the close of the fiscal year it may be said that something had been begun by the engineers but nothing had been completed.

The only segregation work was the withdrawal of Utah Lake and Bear Lake as reservoir sites, which were carefully surveyed for that purpose by two of the hydrographers.

The total cost of the engineering work, including all expenses, direct and indirect, up to June 30, 1889, was $7,550.19, of which the greater portion was for the outfitting of the parties The total cost of the hydrographic work and the expenses of my own office, including also the purchase of a large number of new instruments of a costly kind, was $29,193.14.

Under the second appropriation the following work has been done:

There have been practically seven divisions of engineering surveys, one of which was not anticipated at the beginning of the year, viz, Utah, but was opened in consequence of special orders of the Secretary of the Interior.

First. Montana. Mr. Wilson began his work by an energetic reconnoissance of the valleys of the Yellowstone, the Gallatin, the Madison, and the Jefferson, the Missouri between Bozeman and Great Falls, the Sun River, and the upper portion of the Musselshell. He went alone on horseback, with only a hand-level in his pocket, and in the course of a little more than three months reported sixty-three large reservoir sites for withdrawal, and about 11,000,000 acres of land for segregation. The reservoir withdrawals were well done and satisfactory in every way. Question arose in my mind concerning the segregation of so vast an area (about 17,500 square miles), but a careful examination of his report, in conjunction with a knowledge of the country, satisfied me that the doubtful questions were whether he had not omitted land which he should have included, rather than included land which he should have omitted.

Mr. Wilson soon reached the conclusion that some of the best lands in Montana might be watered by a system of reservoirs and canal, taking the flow of the Sun River. He immediately began a survey there. In the course of the season his assistant, Mr. J. B. Rogers, ran a preliminary line of a canal 80 miles long, surveyed ten large reservoirs on a scale of 500 feet to the inch, and dam sites and waste-weirs 100 feet to the inch, with 2 foot contours, all in sufficient detail to enable close estimates of cost to be made. It is a fine piece of survey work, and shows admirably how much can be done by intelligent projects and how great are the possibilities of a sound comprehensive, systematic development. The cost of the entire engineering surveys in the Montana division up to March 1, including expenses in field and office, is $6,574.71.

In the Arkansas division, Mr. Bodfish, under the immediate eye of Mr. Nettleton, was instructed to investigate the possibilities of increasing the useful water supply of that river by storage, and of utilizing its return waters upon the plains near the Kansas line. He has surveyed in great detail ten large reservoir sites in the vicinity of Leadville and Buena Vista, also one on Monument Creek, near the base of the front range. He has examined all the tributaries on the north or left bank of the river for reservoir sites, reporting twenty-five of them for withdrawal. The southern tributaries would have been examined had not the premature coming of winter buried the country deep in snow. He has, I believe, exhausted the reservoir sites so far as he has gone. He has also run a canal line, starting from near Granada, above Garden City, a distance of 146 miles, to test the question of using the return waters in the river upon lands of western Kansas. The project of utilizing Twin Lakes for a reservoir is a most promising one and the survey work has been done in a highly satisfactory manner. The total expenditure in this division up to March 1 is $9,466.13.

In the Rio Grande division the engineering work was not started until July. Mr. W. W. Follett was appointed division engineer. He at once began the survey of a project for a dam and reservoir at El Paso, and completed his survey about the last of August. It included a contour and cross-section survey of the great reservoir basin, with close estimates of capacity; sounding the quicksands in the bed of the river to ascertain the surface of the bed rock in two sections of the river; a close survey of the two dam sites, and a relocation survey of the Southern Pacific and Atchison, Topeka and Santa Fé railroads. His report of a project, with estimates of quantities and of cost, has been submitted.

During the winter Mr. Follett has been engaged in the segregation of irrigable lands in the Rio Grande Valley in New Mexico. He was instructed to proceed to the office of the Surveyor-General in Santa Fé and prepare a compilation of the Land Office plats of that valley, and to then make a close detailed segregation, denoting all land grants, railroad grants and all claimed lands, section by section, and to verify the segregations upon the ground. Also, to select all possible reservoir sites and report them for withdrawal, and all natural dam sites, whether on the main river or its tributaries. He was to begin his work at Fort Seldon and work northward to the Colorado boundary, cleaning up as he went. He has sent weekly reports of his itineracy and lists of specifications of selected lands, and is now within about 60 miles of the Colorado line. He has reported about sixty reservoir sites. The amount of land reported I have not computed, but it will be some millions of acres. This careful segregation was deemed necessary here by reason of the tangle of land grants and other claims in various stages of adjudication. The cost of the El Paso Reservoir surveys was $2,210.59. The cost of the segregation work up to March 1 was $1,744.10.

In California a survey was made of Clear Lake to ascertain its possibilities as a storage reservoir. This was an extensive survey and the work was of a high order and in the most thorough detail; in fact, I think it will rarely happen that so extensive a survey will be called for.

A well-equipped party was also sent into the mountains around the headwaters of the Stanislaus, Tuolumne, and Merced Rivers to search for reservoir sites. Eight good sites were found and were surveyed. Some doubtful ones were also discovered and marked down for further examination.

A reconnoitering party of two men was sent into Lassen and Modoc Counties, east of the Sierras, to search for reservoir sites, and found two very large ones with a considerable water supply. This party expended a large amount of money and accomplished but little.

A fourth party was sent to Owen's Valley to segregate irrigable lands and examine the headwaters of the river for resernoir sites. They were instructed to make a close segregation in the same manner as Mr. Follett was in New Mexico. They completed the segregation work in the lower valley for a distance of about 100 miles along the river front and were about to proceed to the upper valley when the early severe storms set in and put an end to the work. Their results have been reported in a satisfactory manner as far as they went. The total cost of the work in California was $11,483.47 to March 1.

In the Truckee and Carson basins Mr. Bridges made detailed surveys of Donner, Independence, and Webber Lakes as reservoir sites. A survey was made for a reservoir in Long Valley, with canals taking water across the Carson River to the lands on the east side of the Carson Valley. This last survey was not approved, nor was it authorized or intended. A survey was also made of Hope Valley at the headwaters of the west fork of the Carson. A trial line was surveyed from a point about 5 miles above Wadsworth to the lands southeast of that town to ascertain the possibilities of carrying water to them from the Truckee River. A large amount of canal line was surveyed by Mr. Bridges, but as none of the others was authorized or approved no further mention is made of them. His management of his division being very unsatisfactory he was relieved from duty by me, and at my request was asked by the director to resign. The surveys of Donner, Independence, and Webber Lakes and of Hope Valley are of some value, but not commensurate with the expenditure. The accounts of the engineering work in this division were closed on the 30th of September, and at that time the expenditures were $13,495.36. Since that time further office expenses were incurred in the office of the supervising engineer, Mr. Hall, which bring the total amount to about $15,500. The exact figures it would require considerable labor to extract from the itemized vouchers. They appear on my books with the expenses of the office of the supervising engineer.

In Utah it was originally intended to do nothing but hydrographic work, but circumstances forced other work upon us. Mr. Newell, as hydrographer, was found to be an object of great interest to the people of the Territory, who sought his official action with great eagerness. He was soon required by me to make a survey of Utah Lake, which was done in the preceding year. It soon became manifest that numerous other reservoir sites ought to be examined, and this was done and the sites were withdrawn but not surveyed. Later, an order was received from the Secretary of the Interior to segregate the irrigable lands in Bear River Valley. Instructions were therefore given Mr. Newell to make a close segregation, section by section, and to verify his work on the ground, and also to add to it some traverse and level work to clear up doubtful questions in some localities where disputes or complications by reason of existing claims and filings might arise. The work was speedily accomplished. Over 2,000,000 acres were reported for segregation, and a plat of the work, based on the Land Office plats, was furnished and duly certified. The cost of the segregation work was $1,579.56.

In Idaho Mr. Foote was instructed to survey thoroughly a project for a pair of grand canals, taking water from the Snake River at Eagle Rock, one branch running south to Pocatello, the other running west into the desert. This was to be only a single feature of a comprehensive system of canals and reservoirs for utilizing as much of the water of the river as could be stored in addition to its natural flow. An excellent dam site with an ample waste weir was found at Eagle Rock, and a location survey was begun at once without any preliminaries on the left bank, and carried 70 miles to Pocatello, where the line was tailed into the Portneuf.

The line was carried on to the westward nearly to American Falls, where it was found to be impracticable to carry it further. A new line was started at American Falls, and carried only 14 miles, as it was found to be impracticable. Another line was surveyed from the Snake near Minedoka, but was not completed, owing to stormy weather. It was found to be practicable.

Mr. Foote also made a reconnaissance up the forks of the Snake River in search of storage capacity. An indefinite amount of it was found at Jackson Lake, but present appearances indicate that the whole annual flow of the fork issuing from Jackson's Lake would probably be not much more than 500,000 acre-feet, while the capacity of the basin is probably four or five times that amount. The dam site is excellent.

Another grand reservoir site was found in Swan Valley, much lower down, on the South Fork. Here the flow of the river is very much greater. The capacity of this site is more than a million, and may be nearly a million and a half acre-feet, with plenty of water to fill it. A good dam site with an abundant waste weir exists. Another immense site was found on the Falls River Branch of the Snake where probably 300,000 or 400,000 acre-feet could be very cheaply stored. Several other large sites were found, but not sufficiently examined to enable statements to be made with confidence concerning them.

Mr. Foote was further instructed to report all irrigable land in the valley of the Snake above American Falls for segregation, and he has reported over 10,000,000 acres.

During the past month he has begun a location survey of the other canal, taking water at Eagle Rock on the other side of the Snake, and his parties at last accounts were in the field. Before the close of the present fiscal year it is expected that more than 100 miles additional of canal line will be surveyed. These location surveys of Mr. Foote are done in a very thorough manner, and his drawings are cross-sectioned and afford the means of making estimates of cost. His plats have been received and are apparently excellent work. The total cost of the engineering work of this division up to March 1, has been $9,590.19.

It remains to add the expenses of my own office and those of the supervising engineers, of which separate accounts are kept. The salaries of the supervising engineers are included in them, my own salary being paid from the appropriation for the Army: Chief Engineer's office $7,119.39; Mr. Nettleton's office, $4,966.87; Mr. Hall's office, $7,151.50.

My own office includes a disbursing agent, who does all the disbursing under my charge; a single type-writer; two draughtsmen, who prepare all the segregation work for the General Land Office, have charge of the engineering maps and drawings, their proper recording and filing, also of the hydrographic records and reductions and miscellaneous draughting work.

As regards the hydrographic work during the fiscal year I may speak more briefly. Many of the chief rivers of the west have been put under thorough observation by gauging and by continuous records of rise and fall. They are the Arkansas, the Rio Grande, the Gila and Salt, the Carson and Truckee, all the rivers which flow into Salt Lake and Utah Lake, the Sevier River in Utah, the Snake with its forks, the Wood River and Lost River in southern Idaho, the Weiser, Payette and Owyhee, the Missouri, the Yellowstone, the Gallatin, Madison and Jefferson, and the Sun River. Many of these have observing stations at several points and on their minor tributaries not specified. We now have continuous records worked out, computed and exhibited in diagrams, showing their daily discharges for the whole summer and until the rivers were closed by ice. In the southern territories the records are continuous throughout the winter. The hydrographic work has, on the whole, gone on with better success than was expected at the start, and much credit is due to the young men who have accomplished it. The work, however, gives plain indications of being somewhat starved by reason of excessive but unavoidable economy. But another year will, if permitted to continue, show a very great advance. The total cost of the hydrographic work from July 1, 1889, to March 1, 1890, has been $19,984.72.

The following is a summary of the work done and the cost:

Reservoirs fully surveyed to estimates.

Montana	10
Colorado	10
El Paso	1
California division	9
Truckee and Carson	5
Total	35
Reservoirs reported for withdrawal	144

Canal lines fully surveyed to estimates.

	Miles.
Snake River Basin	157
Arkansas River Basin	146
Total	303

Canal lines roughly surveyed.

	Miles.
Montana, Sun River	80
Truckee Basin	22
Total	102

NOTE.—About 160 miles of canal line were surveyed in the Truckee and Carson Basins, but only 22 miles are accepted by this office.

Number of acres of land reported for segregation, about 30,000,000.

Cost of work.

	First appropriation.	Second appropriation.	Total.
Hydrographic	$29,193.14	$19,984.72	$49,177.86
Engineering work:			
Montana division	1,080.11	5,494.60	6,574.71
Arkansas division	1,308.94	8,157.19	9,466.13
Rio Grande division		3,954.69	3,954.69
California division	605.01	10,878.46	11,483.47
Truckee and Carson	2,314.01	11,181.35	13,495.36
Utah		1,579.56	1,579.56
Snake River	2,242.12	7,348.07	9,590.19
Supervising engineers		12,118.37	12,118.37
Total engineering	7,550.19	60,712.29	68,262.48
Chief Engineer's office		7,119.39	7,119.39
Aggregate	36,743.33	87,816.40	124,559.73

Very respectfully, sir,

C. E. DUTTON.

Hon. WILLIAM M. STEWART,
United States Senate.

SIXTH DAY'S SESSION.

WASHINGTON, D. C., *March* 14, 1890.

The committee met pursuant to adjournment.

Present, the chairman, and Senators Reagan, Jones, Moody, and Casey.

FURTHER STATEMENT OF DIRECTOR POWELL.

The CHAIRMAN. Major Powell, the point that the committee desires your views upon this morning is as to the necessity of topographic surveys preceding the engineering surveys for irrigation, the relation of the two classes of surveys, and whether the engineering surveys can be carried on independently of the other, or whether they are necessarily connected.

Director POWELL. Mr. Chairman, there are two branches of the subject which I wish to present: First, the plans and methods of the survey, as necessary to carry out the provisions of the statute; and second, I wish to call attention to and review the statutes and the reports which I have made to Congress on calls from the Senate which represent the needs of an irrigation survey, for the purpose of showing that the wording of the statute and the representations made by me to the Congress prior to the passage of the statute are in harmony with what has actually been done. That is, I wish to show, first, what the irrigation survey should be, what is necessary to be done, and the information required; and second, to show that before the passage of the law I had fully set forth the facts to Congress, and that the wording of the statute calls for the work which has actually been done.

The CHAIRMAN. We are not complaining of what has been done. We simply want to know how these surveys are dependent upon each other.

Director POWELL. These two lines I would like to be heard upon. First, then, I wish to address myself to the question, what is necessary to be done in an irrigation survey, and how can this be done in the most economic manner? The statute provides, first, that the extent to which the lands can be redeemed by irrigation shall be determined; second, that reservoir sites shall be selected; third, that canal sites and sites of other hydraulic works, such as diverting dams, etc., shall be selected; fourth, that the lands made irrigable by these hydraulic works shall be selected; and, finally, that all of these sites and lands shall be segregated—that they shall be selected on the ground, as I understand it, and be certified to the Land Office, in land-office terms of township, range, section, etc., for the purpose contemplated in the law. In order to accomplish the end a survey had to be prosecuted and a series of discoveries made. These discoveries may be divided into three classes: Those relating to the land—the catchment areas, the sites for diverting dams and canals, the sites for reservoirs, and the irrigable lands. These necessities give rise to the topographic branch of the Irrigation Survey. Second, those relating to the water; that is, it is necessary to determine the amount of water which can be used for irrigation in each hydrographic basin or area drained by one important stream and its tributaries. It is necessary to determine the mean amount of water for the irrigating season in each basin, and also the mean amount of water for the entire year, and it is also necessary to determine the minimum amount in seasons of excessive drought and the maximum amount in seasons of excessive rain-fall. It is also necessary to determine the amount of water required to irrigate an acre of land, that is, to determine the "duty" of water. The necessity for determining all of these facts in relation to water gives rise to the second branch of the Irrigation Survey, that is, the hydraulic branch. Third, those relating to estimates of the cost of dams, canals, and reservoirs. For this purpose the sites of the dams must be surveyed with accuracy and the constructive conditions as to the proximity and character of materials must be studied. The sites of the reservoirs discovered by the topographic survey must be carefully examined and plans for their construction made. The sites of canals, the general routes of which are previously discovered by the topographic survey, must be carefully run upon the ground and marked, and the amount of cutting and filling determined, and the ground minutely examined for the purpose of discovering its character, whether it be in sand, clay, gravel, or solid rock, as all of these facts affect the cost of the work. Having studied these facts the cost of construction can be properly estimated. These three classes of work all relate directly to the Irrigation Survey. They are all required by the provision of the statute, and no one can be neglected without disobedience to law. The three kinds of work give rise to three branches in its organization, which we call the topographic, hydrographic, and engineering branches.

The topographic survey is the work primarily necessary to the discovery of sites, though it has another use in the hydrograpic survey, as will be shown when that point is reached. In investigating this subject for the purpose of determining the best and most economic method of discovering the various sites required, it was decided that a topographic survey was proper. If a specific reservoir site is already known, and the body of land to be served by the waters from that reservoir is already known, the simple problem is to find a way for a canal from the reservoir to the land. Such a survey would need only the work necessary to run a number of trial lines on the ground and then to select the best from these. But the problem before the survey was not to irrigate some one man's farm from some one stream or reservoir site; it was not to irrigate some particular piece of land to suit some particular person; but the problem was to discover all of the reservoir sites, all of the canal sites, and all of the lands that could be irrigated in any given hydrograpic basin. How this could be done in the cheapest manner was the question which I had to solve. Having a specific reservoir in sight and a specific body of lands in view, and wishing to take the water from that reservoir to that piece of land, I can run trial lines and find the best route at the rate of about $25 per mile for each of the trial lines; but the final line selected must be run again with great care; the whole ground must be studied, very exact levels must be run, and all the characteristics of the line must be determined, in order that the cost of the canal may be discovered. But in the work of the irrigation survey the reservoir sites, the canal lines, and the lands to be irrigated have all to be discovered—ten, twenty, fifty reservoirs perhaps in one hydrographic basin; scores of canal lines, 10, 20, 50, 100 miles in length. To run many such trial lines over the ground for the purpose of selecting a few would involve great cost. The system of discovering canal lines by a topographic survey instead of by a trial line survey is very much less expensive. Certainly it would not cost more than one-third of the amount. To discontinue the topographic survey and inaugurate a trial-line system would be to increase the cost of the work fully three times. In the same manner the reservoir sites are to be discovered, and their relation to the streams which furnish them water and to the lands which they are to irrigate must be determined. Some of these reservoir sites are in the mountains—the best are there; some are in the valleys and on the plains. They are therefore widely scattered throughout all parts of each hydrographic basin. To discover them by trial lines instead of topographic surveys with contours would be to increase the cost of the work at least three times.

A hydrographic basin may furnish only a half a dozen good reservoir sites, or it may furnish two or three hundred, as the case may be. Some will be small, sufficient for reservoirs to hold 1,000 acre-feet of water; others will be great, sufficient for reservoirs to hold 1,000,000 acre-feet, or even 2,000,000 acre-feet of water. One reservoir site may be excessively expensive, another very economic; that is, it may cost $10 per acre-foot of water to store it, or it may cost but 10 cents per acre-foot of water to store it. It becomes necessary, therefore, for economy's sake, to select the best sites. In order to do this it is necessary to discover all of the reservoir sites of each hydrographic basin. If I were to select a score of reservoir sites in a basin at random and have these reserved to be used by the people in the future, and it should be found that half, or many, or all of them were not as good as other sites in the same basin, and that a system of reservoirs could be constructed to store the water for one-half or one fourth of the cost that would be required in the basins carelessly selected, the whole work would be repudiated by the people; it would be misleading and injurious. It is therefore necessary for me to know in each basin all of the reservoir sites in the basin, that the best may be selected. This means that I must know every valley in the basin.

To illustrate the method of discovering these reservoir sites, I have brought with me the maps constructed by the topographic survey in the upper basin of the Arkansas in Colorado. These are the maps constructed in the field. On examination you will see that they are in contour lines; that the vertical interval from one contour to another in the valley region is 25 feet, in the hill regions 50 feet, and in the mountain regions 100 feet. It is not necessary to do the work in the mountains with the same degree of refinement as in the valleys. For more than twenty years I have been engaged in making topographic surveys in connection with the other work under my charge. During that time I have employed a corps of men of ability and genius, and during that time I have topographically surveyed about a half million square miles of country, on various scales and with varied degrees of refinement. Through the inventive genius of the men who have been employed on this work new methods of survey and new instruments have been devised, so that the whole system of topographic surveying has been revolutionized, and to correspond with it the method of map construction has been greatly developed and improved. The work has been improved in quality and enormously decreased in cost; and gradually other nations of the world are adopting our system.

The topographic survey which we are making in connection with the irrigation survey is in most particulars the same that we are making for the geological survey. The topographic work necessary for the one is necessary for the other, and we were making these maps for the Geological Survey before the Irrigation Survey was inaugurated. The cost of the irrigation survey, therefore, was only the cost of what was additional to the work already in progress. The work of the irrigation survey is, for the reasons I have stated, in the first place a topographic survey, because the sites for the works and lands are to be discovered, and it is the cheapest and best way of discovering them. In the maps before you you will see that the topographers have discovered forty-three reservoir sites and marked them upon the maps. They are colored in blue. The contour lines are colored in light red, as you see, and the reservoir sites are determined by the contour lines. Each site represents a valley basin, and in general terms, the height of the dam, the size of the basin, and its capacity are revealed by the maps which the topographers have constructed. From these about twelve or fourteen have been selected by the engineers as being, all things considered, the most eligible. The twelve or fourteen must be surveyed with greater care for the purposes already indicated, that is, to determine the cost of construction and to mark them upon the ground. That is the work of the engineering branch of the survey. In the same manner these maps reveal the general lines of the canals. They show, for example [indicating on the map], that the water from this reservoir can be taken along this line to this body of land. The map reveals other lines by which it can be taken and shows that this one is the best, and the engineers have selected it and have actually run it upon the ground and obtained the facts necessary to estimate its cost.

When called upon by a resolution of the Senate for a plan for these surveys, and by the appropriations committee for an estimate of cost, I selected and recommended this method of prosecuting the work, because I believed it would be the most economic; and I estimated the cost of the topographic work, in addition to what had already been done in the country, to be about $4,000,000. In making this estimate I took into view the fact that already work had been done under the general appropriation for the Geological Survey, and that that work would not have to be done again. I further estimated that to determine the amount of water in each hydrographic basin that could be used for irrigation and the amount of land which could be irrigated thereby would cost an additional sum of $1,500,000; and finally, when it was decided by the committee that the sites should be surveyed for the purpose of estimating costs and of segregating the lands and reporting them to the Land Office as reserved under the provisions of the act, another $1,500,000 would be necessary, making in all for the irrigation of the arid lands the sum of $7,000,000. But this estimate was based upon the consideration that the work should be done in the manner which I have pointed out. If this cheap and comparatively accurate topographic method developed in the survey had not been known, and had the old methods of topographic surveying been in vogue, I should then have had to decide whether it was cheaper to make the discoveries of sites by the old method of topography or by the system of running trial lines; but having developed a more economic topographic method, it was only necessary to decide between this new method and the trial-line system; and the new method is by far the cheaper and in every way the more satisfactory; for, having done it, the entire work can be published and submitted to the people—not as the opinion of men engaged in the work, but as facts determined by instrumental survey—and presented by simple contour lines on maps, so that they can see for themselves all the facts and conditions.

Senator JONES. What is the scale of those maps?

Director POWELL. One inch to 1 mile. That is the field scale. We do not publish on that scale. It is reduced to 2 miles to 1 inch for publication.

The CHAIRMAN. Right in this connection let me make an inquiry. You have got these drainage basins mapped. Now, suppose an engineer should go into one of these drainage basins with such maps as you have, would it not be necessary, in order to do accurate work, to follow up the stream and work carefully over this ground again, to determine where to locate his reservoir and canals?

Director POWELL. No, sir. I will come to that.

The CHAIRMAN. Then could not an engineer, with the boundaries of the drainage basin indicated, go into the drainage basin and make accurate surveys and locations; or even if they were not indicated, could he not determine the boundaries of the drainage basin and do the mere engineering work with a view of practical work?

Director POWELL. No, sir; the engineer——

Senator JONES (interposing). This dotted line on the outside indicates the water-shed. [Pointing to map.]

Director POWELL. The dotted line is the catchment area. That shows what will feed this reservoir. [Indicating on map.] I will come to that in the latter part of my statement. I want to answer the chairman. An engineer who should go in there without the topographic map would have to select the site. If he went in to select the site, he would have to select it by running trial lines, and to run trial lines would cost three times this. Now, when he comes to this reservoir, the engineer surveys it, but not all this catchment area. Instead of surveying the area outlined here, he surveys this area, the dam site itself, only, and surveys it in a minute manner. The topographic survey has found the reservoir site and the catchment area. The engineer has all the facts. Now, the engineer who goes in there runs a more careful line to find the amount of water that reservoir will hold, and the length and height of dam necessary, and that is all he has to do.

Senator JONES. In order to make an accurate reservoir is it not necessary to run those minute lines?

Director POWELL. Certainly.

Senator JONES. Before the people can go in and occupy the lands these lines have to be run?

Director POWELL. Yes, sir; those in that little basin; but we have saved him all that work [indicating on map], and have done it in the cheapest possible way.

Senator JONES. This work of setting apart and getting the areas is pretty much done all over the country, is it not?

Director POWELL. No, sir; nowhere in the United States except where I have made surveys.

Senator JONES. Have you not had the engineering work in certain cases precede your topographic surveys?

Director POWELL. Yes, sir, I have, and that I wish to refer to. On the passage of the act the people of the Western region were exceedingly anxious to have results. In the general study of this subject for the twenty years in which I have been engaged, and during which Mr. Gilbert, my first assistant, has been engaged, I knew of very many sites; they did not have to be selected. I knew that Providence Lake was a site; I knew that Utah Lake was a site; I knew that Hope Valley was a site; I knew that a number of other localities were sites; but I did not know all, only a small number. I set the engineers at work on places which I already knew, in order that I might meet a local want at the very earliest day; but still they had in each of those cases to run trial lines, and the money expended in those unnecessary trial lines, if I could have had the topography of the sites which I already knew, would have paid 50 per cent. of the cost of making the map. If I had had a topographic map, even of the sites which I already knew, I could have saved enough in the running of trial lines to have paid 50 per cent., or one-half, of the cost of the map, and that has been demonstrated over and over again on the Arkansas and on other rivers. The greatest waste which I had in that manner was in Nevada. The engineer who went there ran unnecessary trial lines, as the chairman knows. He was the first man to raise an objection to this work; he organized the movement against the topographic work and wasted money in running unnecessary trial lines.

The CHAIRMAN. When an engineer runs his trial lines for his ditch he must be governed by something besides topographic maps, must he not?

Director POWELL. No, sir. Suppose that I have selected the reservoir and the land. That had to be done first. Now I want to know how I am going to get the water from that reservoir to that land.

The CHAIRMAN. Can you select the land before you know definitely where the ditch is to be located?

Director POWELL. I can with a topographic map; otherwise I have got to run trial lines, either one or the other. Without that map I must run trial lines. To make selections by running trial lines is to increase the cost of the work three times.

The **CHAIRMAN**. Can you select with sufficient accuracy to enable people to locate on the lands?

Director **POWELL**. I can.

Senator **MOODY**. In making these topographic maps you run these lines, do you not?

Director **POWELL**. Yes, sir. I run them with plane tables by methods which we have developed in the Survey. To explain it would require a long trigonometrical statement. Let me further say that in addition to the discovery——

Senator **MOODY** (interposing). Right here let me ask, can you run a line with such accuracy as to enable the engineer to follow any line without himself running levels and lines in the usual way, with transit and levels?

Director **POWELL**. Suppose that we have a reservoir at one point, and some land at another point, 10 miles away. I can say from the topographic map that the best line that can be made from that reservoir to that land must run along that hill and meander down that valley, and down that hill, through that valley, to that land——

Senator **MOODY** (interposing). You could do that with the eye.

Director **POWELL**. And having done that the engineer ultimately runs over that ground, and from the reservoir site to the lands for the purpose of doing one other thing. The statute demands that we shall furnish an estimate of the cost. The engineer has to go over the ground and determine the nature of the soil, the nature of the excavations which will be required, what amount of cutting there must be in one place, and what amount of filling in another place, and so on, in order to get at the cost of constructing that canal; but the site of the canal is selected from the map, without any trial lines whatever. I have in my office, Mr. Chairman, three classes of men——

Senator **REAGAN** (interposing). That is the same method that is observed where a preliminary survey of a railroad is made, the details being attended to afterward?

Director **POWELL**. The first thing is to make the selection, as we would in the case of a railroad survey, by trial lines, or by topographic surveying, ultimately selecting one, and then make an accurate survey of it. I have adopted the method of discovering the sites, which is the cheapest of all. But, Mr. Chairman, the topographic work is an important part of the irrigation survey for other reasons than those already explained, and such reasons are even more potent. The amount of water furnished by a hydrographic basin must be discovered. If a reservoir is to be constructed it must be known how much water can be furnished it annually before its size and the character of its works are determined. To select the lands to be irrigated I must know how much water there is to serve and how much water each acre of land will require; that is, the amount of water and the duty of water. In general, there is more land than the water can serve. Only one-eighth or one-tenth of the country can be irrigated, because there is not water enough to irrigate more. I must find out how much water can be got to serve that land. How would I do this? This was the most difficult and complex problem presented to me when the survey was inaugurated. How could we gauge all the rivers, creeks, and brooks of two-fifths of the area of the United States—all the waters flowing in the streams of that region—in order that works for their control and use might be constructed and lands for them to serve might be selected? There is a vast number of these streams, as will be seen by a review of the entire ground. To gauge one stream means what? It means that we have to discover the velocity of the current, which varies from shore to central line and which varies from top to bottom, so it becomes necessary to determine the velocity of the current in every part of the cross-section of the stream, because the flow is not uniform, it being greater in the center and less at sides and bottom, but exceeding variable for different forms of cross-sections. Supposing it to be gauged in this manner on one day of the year, that night a rain falls and the stream is enlarged, the entire conditions are changed, the cross section is larger, and the velocity of the current is greater. So it changes from hour to hour and from day to day, rising with the rains and falling with the drouths.

To find out how much water flows down the stream during the year it is necessary to find out how much water flows in that stream at every stage of its volume, from the lowest water to the highest water. This is done by the use of current meters. Then it is necessary to employ a river-height gauge to determine how high the water is at each hour of trial, and having discovered how much water flows at each stage and how much time it remained at each stage, we are able to determine the total flow of the year. But some years are dry, other years there is great rainfall; so the streams vary from year to year, and their volume in minimum years must be determined, and their maximum volume, and their average volume from year to year. To gauge the flow of each river and brook in the manner which I have indicated would require an enormous outlay of money, so great that when I studied the problem, as I did before the Survey was organized and before it was authorized by Congress, I reached the conclusion that the work could be done in another and cheaper manner, and in a manner altogether more satisfactory. I reached this conclusion after a very careful study of the subject myself and after having submitted it to other gentlemen associated with me. The same conclusion was reached by all the gentlemen except one; that was Captain Dutton. The plan was to make a topographic survey of the catchment basins which should determine with reasonable accuracy their area, with reasonable accuracy their declivities or slopes, and to gauge a few of the streams in the manner which I have indicated and to find therefrom under varying topographic conditions and varying altitudes, and varying rain-falls, the amount of water which could be derived from each square mile of the territory of the basin.

Permit me to make this plain by the use of an illustration which will serve well for that purpose and better than a long discussion of the subject by which the scientific methods might be elaborated. Suppose I wish to know how much water there is running annually from the roofs of the houses of Washington. Shall I put a water-spout on every roof and gauge each one for every day in the year and for a series of years in order to get the mean annual flow ? Such was the plan advocated by some ot the engineers, but such was not the plan adopted by myself. Now suppose I gauge the amount of water which falls from the roofs of a dozen houses in Washington, or even a less number, so as to get a good fair average of what every square yard of roof surface will deliver during the year. I can then easily determine how much water a square yard of roof surface will furnish during a year; and having found that a yard of surface, for example, on a general average, will furnish a yard of water 30 inches in depth during a year, I have the means of determining the amount of water which any roof in the city will afford by simply measuring that roof. This is certainly a very much simpler and just as satisfactory a method as to put a current-gauge on every water spout of the city. To do the work of the survey by gauging all the streams would cost an unknown sum, but certainly not less than $10,000,000. So I determined to gauge a few typical streams and measure their catchment areas; that is, to determine the extent of catchment area and to base the computations of water supply upon the factors thus developed and upon the factors derived from the measurement of rain-fall. But it is necessary not only to measure the superficial area of the catchment basin, but also to determine the declivity or slopes of the ground by which the water would be gathered into streams and delivered to the irrigating works. The necessity for determining this element can be very simply explained.

The CHAIRMAN. The hydrographic survey is different from the topographic, to some extent, is it not?

Director POWELL. No, sir. A hydrographic survey is a topographic survey, but something more is added. A hydrographic survey determines the areas by a topographic survey. I was trying to explain that in my illustration of the roofs of the houses. I have to measure the roofs of the houses, from which the area of the roofs, the catchment area, is determined. It is the method of determining the areas which supply these basins. But there is another thing——

The CHAIRMAN (interposing). You have to approximate the area of the basin, do you not?

Director POWELL. It is not sufficient to approximate the area. It is necessary to determine the declivities. That is a problem which seems very simple when it is stated; but you will find that we have to determine the slopes of all the hills for the purpose. Suppose the rain falls over a district of country that is level, or nearly level; in that arid region no great quantity of that water will flow into a reservoir. It will be gathered up so slowly into pools that it will all evaporate. But suppose it is like that of the Hassayampa, of which the dam has just been swept away. Then all the water which falls upon the catchment area, after the soil is once saturated, will immediately be gathered into the reservoir. It is a region of steep declivities. Here is the source [indicating on the map]. Here is Mount Tritle; here are four great mountains encircling the basin. When a great storm comes on those mountains the water rolls down into the basin. They sometimes have storms in that western country which will give 2 inches of rain-fall in two or three hours. The Hassayampa dam drained a mountain declivity of 325 square miles of nearly naked rock. When the big storm came it only required seven or eight hours by my computation to bring the maximum supply of water against that dam. The maximum supply of water against that dam was 6¼ acre feet per second. There was that much water coming down every second for nearly an hour. Provision had to be made for it, and the declivity had to be known in order to construct the work properly. It was not only necessary to provide a proper way to dispose of the surplus water when it came, but also to know how much water could be stored there. If it had been a flat country there would have been no need to make a dam there, for no water would come down; but it being a steep country, a vast amount of water could be collected.

Now to make my illustration from housetops complete, suppose that the flat housetop is covered with a great thickness of sand, so that all the rains falling thereon are absorbed and finally evaporated by the sun. Then from such tops no water can be caught in the spouts. Suppose that others have varying declivities, and that the greater the declivity the less the amount of sand, until some are so steep that no sand will remain on them. The steep roofs will deliver all their water. Now similar conditions are found in the natural slopes of every drainage basin of the West. Some regions are so flat and sandy that the waters all evaporate, and nothing can be obtained from them; others are so steep and rocky that almost the entire rain fall is discharged into stream-channels. It is wholly a question of declivities, and we are therefore compelled to determine these declivities. We want areas of catchment basins and declivities of catchment basins. To get these we make a topographic survey, in the cheapest manner that it can be done to be useful to properly solve the problems. The plan, therefore, is to measure drainage basins and determine their areas and declivities, to see what water they will shed in the streams; then gauge a few typical streams with accuracy, and with these facts—and some collateral ones which need not be here explained, as that would complicate the subject too much for simple statement—we have the data necessary to plan the works to control the water, so that it can be put upon the land.

The CHAIRMAN. I have heard it suggested by engineers that in some portions of that arid region there are places where no dam could be safely built, and that those places would be generally indicated by the large bowlders and rocks at the mouths of the cañons, showing that water-spouts had come down with such force as to carry those bowlders through the cañons; and I have heard it suggested—and I want to know what there is in that suggestion—that they would have to avoid those places because of the evidences that water-spouts are likely to occur there. I have also heard it suggested that a good engineer in constructing a dam on those torrential streams would always leave a sufficient waste-way to carry the whole body of water at flood-time, that there should be an ample allowance, so that there would be as large a water-way as there was before the dam was constructed, and that on the ground many things besides the declivities had to be taken into consideration.

Director POWELL. In the first place, as to water-spouts. I hold that the suggestion which they make about water-spouts is valueless. You might as well say you will find the places where lightning has struck and will not build houses in such spots. The distribution of water-spouts is now here and now there. I mean by "water-spouts," tornadoes. Their distribution is not controlled chiefly by the topography of the ground, but by movements in great bodies of air more or less loaded with vapor.

The CHAIRMAN. Now, let me make a suggestion. At Eureka and Panamint Cañons, the former of which has been known about twenty years, there are bald mountains above, where clouds meet and cause these cloud-bursts or water-spouts. In Eureka Cañon the town has been destroyed once or twice, and they have had to build back on the hills to get away from the floods. There have been four or five water-spouts or cloud-bursts in that same place. Panamint Cañon has not been known so long, but there is a similar formation there—bald mountains, the tops of which are very high. Large bowlders have been carried down and land-slides have been produced by these cloud-bursts. We know from observation that they have appeared periodically and that they are liable to occur again; that there are a great many places where they have repeated themselves.

Director POWELL. Let me make an explanation, Mr. Chairman. A tornado is one thing; what is usually called in the West a cloud-burst is another thing. The term "cloud-burst" does not mean anything, really, to a scientific man except a big storm. Those occur in all lands, but they are peculiarly destructive and remarkable under the conditions you have suggested. We have just as many cloud-bursts in Washington as they have at Eureka or Denver. Let me explain further. Suppose there is a region of country the declivities of which will gather all the water that falls during a great storm suddenly; instead of days, it gathers in hours or minutes, as is the case at Denver. If the declivities are extreme and a great storm comes, the people call that a cloud-burst.

The CHAIRMAN. I have seen a great many of them. I have been in the sunshine, and have seen a dark cloud off over the mountains, accompanied by thunder and lightning, and have seen the people running to the mountains to escape what was inevitable, because they knew the place so well, and in half an hour the water would be 25 feet deep where they had been. The friction of the water on the bottom of the stream would make a column of water that was almost perpendicular; a wonderful sight.

Director POWELL. I have walked before such a one, where a wall of water nearly as high as my head came down a dry stream bed. The region of country most affected by those sudden storms on the face of the globe is the region which I first explored, that of the Colorado River. There the walls of the cañons are from 4,000 to 6,000 feet high, with a labyrinth of cañons running into it from either side. When the rain falls in that district of country the Colorado River is raised, sometimes many feet in one night. The great storms which occur at the headwaters of the river do not fill the cañon as full as the local storms do, because in the local storms the water falls on the declivities, which are like the roof of a house, and is discharged into the river in a few hours.

The CHAIRMAN. Would it be safe to build dams in those peculiar cañons at all?

Director POWELL. I think not. I am afraid the line of my thought is so broken that——

The CHAIRMAN (interposing). I will not interrupt you again.

Director POWELL. I am very glad to have you ask questions. I wanted to say that the topographic map, then, is the chief expense of the hydrographic survey, as the measurement of the roofs of the houses of Washington, which I used as an illustration, would be the chief expense of determining the rain-fall. My hydrographic survey is primarily a topographic survey. The selection survey is a topographic survey. I have to determine catchment areas, reservoir sites, and irrigable lands, and I have to determine the sites of diverting dams and lines of canals. All these are done by the topographical survey, and, in my judgment, in the cheapest possible manner.

Adjourned.

SEVENTH DAY'S SESSION.

WASHINGTON, D. C., *March* 18, 1890.

The committee met pursuant to adjournment.

Present: Mr. Stewart (chairman), Mr. Plumb, Mr. Moody, Mr. Casey, and Mr. Reagan.

FURTHER STATEMENT OF DIRECTOR POWELL.

The CHAIRMAN. Major, you can proceed.

Director POWELL. I attempted at the last meeting to explain the use of the topographic survey in carrying out the purposes of the statute in making the irrigation survey. The things which, under the law, we are compelled to discover are, first, the catchment areas and their declivities, in order that the amount of water can be determined and the method by which that water can be controlled and brought upon the land. It was shown that we not only need the area of the catchment basin, but its declivities, and the topographic survey economically discovers the area and the declivities. The higher declivities are determined in a more general way than the lower ones. The regions of the reservoirs, of the canals, and of the irrigable lands are surveyed topographically with a great deal more refinement than the others. We also have to discover the sites of the reservoirs, and, as I believe, of all practicable reservoir sites, for the purpose of selecting those which are best and most economic, and which serve the lands the best. The second purpose is to discover the sites of diverting dams along the streams, or service dams, as they are sometimes called, and the sites of canals. For this purpose, as there are a great many canal sites to be discovered in any one district, it is necessary to overlook the entire district in order that the best may be found and selected. Having discovered all possible reservoir sites, all possible diverting-dam sites, all possible canal sites, and all possible lands that can be irrigated, it becomes necessary, then, in view of all the facts, so that they may be correlated one to another, to make selections. The discovery of these by the use of trial lines, I stated, would cost at least three times as much as to discover them by topographic methods. They must be discovered by some method or other, and for the purpose of discovering them the most economic method is used. Further than that, it is necessary to determine the volume of water flowing in the streams, and for this purpose it is found, after a careful examination, that this stream-flow can be discovered by a combination of topographic and gauging methods with very much greater economy, and I illustrated that by showing how we would discover the amount of rain which could be gathered from the roofs of a city. I suppose that the hydrographic survey, if we had attempted to gauge each stream, would have cost from four to ten times more than by the present method; so that, altogether, the use of the topographic survey for discovering all these facts in relation to the hydrography—the reservoir sites, the canal sites, and the irrigable lands—very greatly reduced the cost of the work.

Senator MOODY. Will you please describe how you execute this topographic survey for such a purpose?

Director POWELL. Yes, sir; in the first place, we enter a hydrographic basin—we will speak of one basin, as that will illustrate them all.

Senator MOODY. Just select some place.

Director POWELL. I will take the Upper Arkansas, for example. There we measure a base line——

Senator MOODY (interposing). Did you carry on any topographic work there during this last year?

Director POWELL. Yes, sir.

Senator MOODY. Whereabouts?

Director POWELL. Through the basin, from the summit of the mountains in Colorado nearly down to the Kansas line, so that we have covered almost all of the Arkansas basin within the arid region.

Senator MOODY. In this connection, did you have any engineering work done outside of the topographic work?

Director POWELL. Yes, sir.

Senator MOODY. What was that?

Director POWELL. That was to measure the capacity of the reservoir sites, to make plans for dams, and the construction of reservoirs, to run lines of canals on the ground, and estimate their cost. That was the engineering part of the work.

Senator MOODY. How did the topographic work aid that engineering work?

Director POWELL. The topographic work practically discovered all of the reservoir sites and all the canal sites. It also discovered the hydrographic basin—the outline of the hydrographic basin and its slopes.

Senator MOODY. Please give in detail, if you will, the manner of executing that topographic work at one single point where you discovered reservoir sites.

Director POWELL. A base line is measured. From that base line a system of triangulation is projected, which is exceedingly inexpensive, costing, perhaps, at the rate of fifteen cents per square mile. That covers the basin with known points with far more accuracy than it could be measured with chains at a hundred times the cost. Then the topographer determines, at the bottom of the basin its altitude above the level of the sea. He proceeds up the main stream and up its lateral branches with a line of levels, so as to determine the gradients of the streams themselves. As he proceeds in this way up the stream and up the lateral streams, he locates himself from point to point by the known points which are already established by the system of triangulation, stops at this point or that point and finds out where he is at the moment, and plots that upon a plane table which he carries with him. From his station then with gradienters in part and alidades in part, and with other instruments, he determines the altitude of the hills and valleys about him and makes a map of the region on the ground then and there, passing from point to point along the streams, as I have mentioned.

Senator MOODY. What becomes of that map? Does he turn it over to the engineers, so that they can measure and determine the capacity of this basin?

Director POWELL. Ultimately with all the data gathered in its construction. As he goes along he runs grade curves in the valleys, in some places 10 feet apart, but in general in the valleys where irrigable lands are situated the grade curves are run 20 feet apart. Higher up in the mountains they are run 50, 100, or 200 feet apart. It is not necessary to do the work with a great degree of refinement in the mountain regions. Thus he constructs a map as he goes of that drainage basin. When that map is constructed he is enabled to outline upon the map, first, the area and declivities of the drainage basin, and, second, all possible reservoir sites—the topographer has discovered them—all possible irrigable lands, and all lines of canals from the reservoir sites and the streams to these irrigable lands.

Senator MOODY. Does he form one of a general party, including the engineers, who are running the actual levels and laying out lines?

Director POWELL. No, sir. The work is carried on by three parties—one a topographic party, one a hydrographic party, and one which is working upon the lines and canal sites, making plans and estimating cost of construction. Those are three different functions, which are pursued by three different classes of men. Shall I go on further with an explanation of how the maps are made?

Senator MOODY. Yes; until you show the connection between the topographic work and the engineering and hydrographic work.

Director POWELL. The topographers having discovered the reservoir sites, the canal sites, the irrigable lands, and the basins that are drained, the material is furnished to the engineers and hydrographers. The hydrographers do not go with the topographers, but we select in such a basin some point where one or two typical streams can be gauged, and the hydrographer stops at that station and measures the stream from time to time until he has determined the volume of water flowing in the stream at its various stages. Then he selects a series of points on a series of streams and arranges his instruments in such a way that he passes from one stream to another, visiting them once a day, once a week, or once a fortnight, as the case may be, having stationary instruments which record automatically for a part of the work. Finally the hydrographer has discovered the flow of the stream, and from an examination of the topographic maps which have been prepared, which give areas and declivities, he is able to say what water can be furnished for irrigation and what works are necessary to control it. Having these facts and the sites discovered and the lines discovered, the engineer now enters upon his duty, and he decides that out of fifty reservoir sites twenty of them, perhaps, are the best. Having determined that these twenty reservoir sites are good, having marked the general routes or lines of the canals which must be constructed from these reservoir sites to the lands to be irrigated, he then runs upon the ground the lines necessary to outline the basin with accuracy, cross-sections it to determine exactly how much water it will hold, he then examines the site for the dam, and determines its foundation, length, and height. Having these factors before him—the amount of water which can be supplied to that reservoir and the amount of water which in great storms it must be able to control so as not to be destroyed, all of which is furnished him by the topographers and by the hydrographers,—the engineer's duty now is to plan the works, mark their sites upon the ground, and estimate the cost of their construction.

Senator MOODY. Out of the appropriation of $250,000 how much was assigned to topography?

Director POWELL. About one-half—nearly one-half.

Senator MOODY. And how much to the engineering and hydrographic work?

Director POWELL. The other part—a little bit more than one-half.

Senator MOODY. Can you give the exact amount?

Director POWELL. I can not from memory, but I think, perhaps, I have the data here.

Senator MOODY. How much of the topographic assignment has been expended?

Director POWELL. About seven-eighths of each.

Senator Moody. That is, seven-eighths of $350,000?

Director Powell. Seven-eights of the part of the $350,000 which was assigned to topography. I have laid all those facts before this committee heretofore. In the statement I made some time ago I gave the cost per square mile, etc., as you will remember. That is all in my testimony.

Senator Reagan. One of the points made against this topographic survey is that you have assigned a great deal more money to that than to the hydrographic survey and the engineering work, and that you are making it cost more than it ought. I wish you would let us know how that is.

Doctor Powell. The engineering work of marking on the grounds the lines discovered by the topographic survey and the sites of the reservoirs and the computation of the cost of the work will, I suppose, require about three-fourteenths of the appropriation.

Senator Moody. That would be about $60,000.

Director Powell. Yes, sir; of the last appropriation of $250,000. A larger proportion was used this year because we had not the topography in every locality; but I am speaking of what the plan will be in the future. All this has been set forth to the Appropriation Committee of the House, and is on record. The hydrography will cost, if carried on by our present plan, about three-fourteenths, and the topography, as it is called, will cost eight-fourteenths of the money. That is about the proportion which it will be in the future. That has not been the proportion this year. We chanced this year to know of certain reservoir sites from previous studies of the country. These were already known, and we did not have to go to the expense of discovering them.

Senator Reagan. While you are on this branch of the subject I wish to present a point which I think will be of interest to the committee. It is alleged that by your plan of a topographic survey it will take many years to complete with a very large expenditure. I have heard the suggestion made before the committee that the cost will be $ 10,000,000, and that it will greatly delay the development of the project of irrigation. I would like to know what you have to say to that.

Director Powell. To complete the survey of the arid region, which is about 1,300,000 square miles, and which does not include the subhumid region where some irrigation is practiced, will cost $7,000,000 by following the methods which have been adopted. The time in which it can be completed will depend upon the rate of appropriations. If appropriations are made at the rate of $250,000 per year it will take twenty-seven years; if made at the rate of $1,000,000 per year, as I have recommended to Congress, it will take seven years. But if the methods which we have adopted are abandoned and the more expensive and less satisfactory methods are adopted, it will take five times that amount of money; and if the rate of appropriations should remain the same it will take five times as long. I have explained to the Appropriations Committee, and my statement is on record and I have it with me, that the topographic branch of the work will cost $4,000,000 in addition to what had been accomplished prior to the commencement of the present fiscal year; that the hydrographic survey, as I have planned it, will cost an additional sum of $1,500,000; and that the engineering survey will cost another $1,500,000, making in all $7,000,000.

Senator Reagan. What is it that will cost $4,000,000?

Director Powell. The completion of the topographic branch of the irrigation survey for the arid region, not including the subhumid region, for which no estimates have ever been made, will cost $4,000,000 more for the construction of the maps; but in the construction of the maps we discover all reservoir sites, all canal sites, all drainage basins, and also discover by the same method the data upon which we determine the amount of water which each basin will supply. That will cost for that region $4,000,000. The experience of this year shows that that was a liberal estimate. It was based upon the theory, as explained to the committee, that it would cost from $4 to $5 a square mile. The work this year has cost $3.78 a square mile, and that will carry us to the 1st of July and complete the office work; so that the estimate was not too small, but was quite within bounds. Then I estimated to the committee that it would cost $1,500,000 more to segregate the lands; that is, to run all township and section lines and discover, in Land Office terms, what lands should be segregated, so that we could report to the Land Office the particular lands which are selected under the law. The law compels us to segregate them. The measuring of the reservoir sites and the computation of the cost of works—all this for $1,500,000 more. Then $1,500,000 for the gauging of streams and the work of the hydrographic branch; which makes $7,000,000; $4,000,000 for the discovery of the facts——

Senator MOODY (interposing). That is the topographic work?

Director POWELL. Yes, sir; and $3,000,000 for the other.

Senator MOODY. For the engineering work?

Director POWELL. For the engineering and hydrographic work and segregations.

The CHAIRMAN. As I understand you, the topographic work precedes and is independent of the engineering work, and the engineers simply use the maps prepared by the topographers and obtain the information as to the flow of water from the hydrographers and then they proceed afterward?

Director POWELL. Yes, sir.

The CHAIRMAN. What connection is there between the topographic work and engineering work? Are the two classes of work done by separate forces or by the same force; that is, is the work done by separate divisions or one division? Do the engineers simply take the maps from the topographers when they are done and go on with their work alone?

Director POWELL. The engineers take the data which the topographers have prepared for them. They do not go over the ground to discover reservoir sites, they do not go over the ground to discover canal sites, they do not go over the ground to discover irrigable lands, they do not go over the ground to discover drainage basins or catchment areas. All these facts are determined for them, and they go to the reservoir sites, the canal sites, and the dam sites, and make their estimates of what it will cost to do the work, how the reservoir, the canal, and the dam shall be constructed, and what it will cost. That is the duty of the engineers.

The CHAIRMAN. Will the topography furnish them with data accurate enough to enable them to locate the reservoir sites and the canals without running over the ground with transit and level?

Director POWELL. Yes, sir; except on the lines selected, as I have explained to the committee. The reservoir sites themselves have to have a much more accurate survey, and the line which is selected to take the water from a reservoir site to the land has to have a much more accurate survey.

The CHAIRMAN. What is to hinder the engineer from going upon the ground and locating his reservoir site without the aid of topography? For instance, I go up into the mountains, and I find a stream of water; I follow that stream up, and I find upon it various flat places, without any engineering at all, and I can see with the eye that I can build a dam there. Then I find that an area of country below in the valley is irrigable. What is to prevent an engineer from first ascertaining about where the water could be taken out at the foot of the mountain, and determining what lands he could irrigate with his level, and without running any trial lines, and then going on up the stream and locating his dam site? After he has determined the location, he has used his level, and has the topographic part done. Why can he not do that without any previous topography—diagnose the stream, as it were, and construct his dam?

Director POWELL. I will explain that. I can make that clear. Here is a stream coming down from the mountain. We wish to store the water from that stream. We might go along that stream and dam the stream itself, and make reservoirs along its course; but when it is possible to avoid it, we never do that. We never build a reservoir on the course of the stream if it is possible to locate it anywhere else.

The CHAIRMAN. That is if it is a rapid stream?

Director POWELL. No matter what kind of a stream it is. To store the water upon the stream itself is to store it where the works have got to be constructed in such a manner that they will withstand the greatest storms. Wherever it is possible, and we find largely that it is possible, we store the water outside of the bed of the stream, making a low diverting overflow dam in the stream itself, and throw the water out on the mesa or valley to one side, so that a torrent coming down the stream can not destroy that reservoir; and the question you ask brings out one of the most interesting things relating to the subject of the storage of water—that is, never to build a reservoir upon the course of a stream when another site can be found. If you wish to construct a reservoir to store the water of a stream of great volume, take the water out by a diverting dam and a lateral canal, and store it in a basin on one side.

The CHAIRMAN. That our miners learned forty years ago in California; I among the rest. We found we could not make our storage reservoirs in the streams without great dams, and the water was diverted through ditches to storage reservoirs, built sometimes right above the placers or on the top of a knoll by throwing up banks around it, always where it would be protected from the floods. That has been the experience in the mining regions. Now, the engineer is a pretty good judge of what can be done in a torrential stream without any topography. I recognize, Major, the convenience in entering into a district of having the topography in advance, because you know then where to go to work, but I do not see so forcibly its practical necessity.

Director POWELL. Mr. Chairman, it is necessary for somebody to see all of that ground before the plan is made; somebody must see it. The engineer must see it, or somebody must see it for him. He must not only see it with his eye, but he must see it instrumentally. No man can properly estimate distances, altitudes, and slopes without instrumentation. Having seen it instrumentally, all that is needed after that is to put it on paper, and if he puts his notes on paper, makes a record and keeps a note-book, it takes just about as long as it does to make a map. The map is all made on the ground right then and there. The map is a note-book, the simplest and cheapest method of keeping the records. There it assembles the facts so that they can be seen as a conspectus and their relations known.

Senator MOODY. What is the difference between the topographic work done under the specific appropriation for topography and the topography connected with irrigation which you have carried on?

Director **Powell**. To the topography which we ordinarily do is added for irrigation a more careful determination of the declivities or gradients of the streams; that is all.

Senator **Plumb**. Is the topographic survey which you have been making from the Geological Survey appropriations suitable for the Irrigation Survey?

Director **Powell**. Yes, sir; except on one point; the gradients of the streams are not so carefully determined——

Senator **Plumb** (interposing). What is it suitable for without this addition you speak of?

Director **Powell**. For all purposes for which maps are used.

Senator **Plumb**. Then all the work you have done for the geological survey of a topographic character, in order to make it adaptable to irrigation has got to be supplemented by something else?

Director **Powell**. Yes, sir; but at a cost which is insignificant. Not over 3 cents a mile is to be added to what has been done.

Senator **Plumb**. Then you have been doing under this last appropriation practically what you were doing before?

Director **Powell**. So far as the topographic work is concerned; but we have added to that the gradients of the streams. The organization of the Geological Survey, prior to the foundation of the Irrigation Survey, provided that the Geological Survey should make a map of that country. When that map was authorized by Congress a statement was made by me—and the joint committee of the two houses has reported fully on the matter, and I have the report here—that it would take, at the rate at which appropriations were then in progress, thirty years to make that topographic map. When I presented the matter of the use of that topographic map to the committee I explained its importance, its value, for irrigating purposes, and the commission have reported upon that pretty fully, as you will see from a report which I have brought with me. When the matter of the irrigation survey itself was brought before Congress, session before last, I first was called upon, by a resolution of the Senate, to reply to certain interrogatories as to how this irrigation survey should be conducted, and I outlined in my report to Congress just what I have been doing and what I have explained to the committee, and my report has been published by Congress. I explained the use of a topographic map in relation to an irrigation survey as I had explained it years before, and appearing before the Committee on Appropriations to explain what would be done, I said to them that we would have to add something to what we have been doing for the purposes of estimating the cost and segregating the lands; and if appropriations could be made in such a manner that the time of the work could be shortened, and something more added to that—I said a million and a half for the hydrographic work and a million and a half for the engineering work—I said if $3,000,000 be added to the general estimate heretofore made, we can do the whole work, for we are already doing at this slow rate the topographic work necessary; and the committee on considering the matter understood very well—in their report you will see that it was understood—that they were anticipating the appropriation, that is, making larger appropriations to do what was already authorized, and in addition to that, making an additional appropriation to do these additional things. That was understood clearly by the Committee on Appropriations, and is all a matter of record. The topographic survey, therefore, is necessary, or something to take its place. If the trial-line system is to take its place, the total cost of the whole survey will be increased five times. The total cost of the discovery of sites only—that is, a part of it—will be increased three times, but the total cost of the whole survey will be increased five times; and then the topographic map will still have to be made for the Geological Survey.

It must be understood in this connection that I have submitted to Congress a plan for an irrigation survey of the arid lands, which contemplated an examination of the subject only so far as it related to the use of perennial streams; that it was not contemplated to make a survey relating to artesian waters, storm waters, or sand reservoir waters. If the scope of the survey is to be enlarged the estimates must be correspondingly enlarged. It should be further noticed that the estimate was made for the arid lands where irrigation is generally necessary, and not for the sub-humid lands where irrigation is necessary only in unusually dry years. If the survey is to be carried over these sub-humid lands the estimate must be correspondingly enlarged.

Now, gentlemen, the hour is nearly up, and I have hardly started on the subject; but I wish to beg of you one favor in this matter. You have heard two men connected with the Geological Survey who disagree with me, whose opinions are not my opinions.

Senator PLUMB. Who are they?

The CHAIRMAN. Captain Dutton and Mr. Nettleton.

Director POWELL. I have a good many men on the Survey. The men who are actually responsible for selecting the sites entirely disagree with the men who have appeared before your committee, and agree with me, and I want to beg of the committee to hear both sides of this question, and if you are going to interrogate me and my assistants, let those assistants be heard. Mr. Gilbert, who is practically the assistant director of the Survey, who has been associated with me for sixteen years in this work, and who joined me in the first report on the question of irrigation, has a better mastery of this subject, probably, than any other man in the country. Mr. Thompson, who has been with me twenty-one years in all the work, and who has charge of the map-making, is another whom I would like to have appear before you. I should like to have you call Mr. Gilbert, Mr. Thompson, Mr. Gannett, and Mr. Johnson, all of whom have thoroughly studied this subject, and know how to make maps and how to explain them, and are familiar with all branches of this work.

The gentlemen in charge of parties in each branch of the work have a tendency to exalt the importance of the special branch which they themselves are pursuing, and are apt to claim that the bulk of the appropriation should be given to them for their work. They are anxious to accomplish as much as possible, and to do it in the best possible manner, and urge their claims in what I think to be a very proper manner. I am not sorry that my assistants thus become interested in the work; but it is for me to co-ordinate it and to relegate to each branch its due and proportionate part. This is the error which I think Captain Dutton has committed. The magnitude of the work which he performs and its immediate presence before his eyes obscure his vision, and he fails to discover the magnitude and importance of the co-ordinate branches.

The CHAIRMAN. Could they not make their statements in writing?

Director POWELL. If so desired.

The CHAIRMAN. Have them make their statements in writing, and present them to the committee as soon as possible. We are occupying a great deal of time, and want to consider some other matters, and if the gentlemen you have named can make their statements in writing it will expedite matters.

Director POWELL. You sought the opinions of two men who never made a topographic map——

Senator JONES. (Interposing.) It seems to me like a one-sided affair to allow men on one side of this question to come here and answer questions, and now to have the men on the other side put their statements in writing, without giving the committee an opportunity to ask them questions. It is not right. I want to get the whole truth.

The CHAIRMAN. If there is objection to the written statements of course we will have the gentlemen come before the committee.

Director POWELL. I have been diverted from my line of thought by side interrogatories, and I would like to be heard further. The things which I intended to present are not presented yet.

The CHAIRMAN. We will have another meeting as soon as we can get the committee together.

Adjourned.

EIGHTH DAY'S SESSION.

Washington, D. C., March 21, 1890.

The committee met at 10.30 o'clock a. m.

Present: The chairman, and Senators Reagan, Moody, and Casey.

STATEMENT OF G. K. GILBERT, CHIEF GEOLOGIST OF THE U. S. GEOLOGICAL SURVEY.

Mr. GILBERT. Is it your desire that I make a statement, or that I shall answer some specific questions?

The CHAIRMAN. The committee desire to ascertain from you your opinion as to the connection between the engineering survey for the purpose of irrigation and the topographic survey, and whether the topographic survey is a necessity and must precede the engineering survey. You can go on and make a statement on that subject, giving the relation of the two surveys, the dependence of one upon the other.

Mr. GILBERT. It is my opinion that the information obtained by the topographic survey is essential to good results from the engineering survey. If the same information is obtained by other methods the cost will be relatively great; if it is not obtained the engineering survey will fail to achieve the best results. The topographic survey should precede in each locality.

The function of the irrigation survey, as a whole, is three-fold, as determined by the law. It has first to determine what land shall receive the scant water of irrigation; second, to plan the best system of works for distributing the water to the land, and third, to plan the best system of reservoirs for storing the water which falls in a drainage basin outside the period of irrigation. For each locality, for each drainage basin, as a rule, these three questions have to be considered together. They are so intimately related that they constitute a single complex question, which has to be determined for each locality; nevertheless each one of the questions is in itself complex.

In order to make the best selection of land it is necessary to know what tracts of land are available for the purpose of irrigation; that is, what tracts of land belonging to a district lie so level that the water can be conducted over them for the purpose of irrigation, and what are the areas of these tracts. It is necessary in selecting from among such tracts to consider their climatic conditions; in some cases there are great differences in climate. It is necessary to consider the soils and subsoils. It is necessary to consider the local duty of the water. It is necessary to consider the waste of water incident to transfer from the source of supply, that is, the distance from the source of supply with reference to the question of waste; and it is necessary also to know the amount of water which is available for some one or more of these districts, that is to say, the annual run-off of the drainage basin. In order to plan the best system of distribution it is necessary to know the positions of the tracts of land which may be irrigated with reference to the reservoirs in which the water for that purpose may be stored. These relations must be known horizontally and vertically, and the character of the intervening country must be known. It is necessary also to estimate the cost of constructing works for distributing the water, and the cost of maintaining such works. It is necessary to estimate the waste through evaporation and seepage by different systems of work, and it is necessary, in order to determine the magnitude of the works, to know the run off of the basin.

Speaking in a very general way, a reservoir can be made anywhere; but there is a great difference in expense, and the really available or practicable sites are those where a relatively small dam will create a reservoir containing a relatively large amount of water, and such sites may be scattered throughout the basin. In determining the question of reservoir sites it is necessary usually to consider whether there shall be a single reservoir or a small number of reservoirs low down in the basin or a larger number of reservoirs on the minor streams pertaining to parts of the basin. In order to make a comparison of these and to plan the best system of works it is necessary to estimate the cost of works, at least roughly, at the various places, and the cost of maintenance, and to consider the waste through evaporation or seepage; these differ with altitude and other conditions, and also with the form of the reservoir. It is also necessary for the other purposes; that is to say, where a reservoir site commands only a portion of the basin, the water which can be stored in that reservoir is only the water which flows through or past that portion of the basin. So, for the study of the problem of reservoir sites it is necessary to estimate with a good degree of approximation not only the run-off of the entire basin, but the run-off of parts of the basin.

Now, in this plexus of factors there is one which is very important; many of them are important, but there is one that is especially important and which is at the same time especially difficult; that is, estimating and determining the run-off. That may be determined, theoretically, at least, in various ways. In the first place, it can be measured directly; the streams can be gauged and their heights at various times can be observed for a period of years, and in that way the amount of water which runs off can be actually measured. For large streams the observations of one year give valuable information; the observations of two years may perhaps suffice for some purposes; but for small streams, in a region of very irregular precipitation, a greater number of years of observation is necessary. There are certain things besides the average annual run-off that need to be known. With reference to the determination of the amount of land it is advisable to put under ditch, the minimum run-off should be known. With reference to the construction of head-works and canals and dams that will stand against all floods that may come, it is necessary to know the maximum run-off, and it is especially necessary to know the maximum rate of run-off for this purpose. It is necessary to know separately the run-off of each stream that may be separately used in irrigation, and it is necessary to know separately the run-off of each catchment area the water of which may be separately stored.

The direct measurement of the run-off is, in my judgment, a very expensive matter. There must first be determined by a series of gaugings how much water runs off at each stage, and observations of the height of water must then be made and recorded for a series of years. For this purpose it is necessary to keep permanent observers, and such observers can not maintain continuous observations of any considerable number of streams. In my judgment the expense would be not far from $1,000 for each such determination, carrying it on for a sufficient number of years to make it of practical value.

Senator CASEY. What would you consider a sufficient number of years to make it of value?

Mr. GILBERT. That would depend upon the size of the stream.

Senator CASEY. Well, generally.

Mr. GILBERT. I think on an average three or four years would be necessary; but that would not suffice for a great number of small streams. In the case of large streams you could——

Senator CASEY (interposing). Would observations for three or four years determine the maximum and minimum?

Mr. GILBERT. No, sir; not in small streams. In the average run of streams the maximum and minimum occur only at irregular intervals, which may be short or long. That would be a matter more or less of estimation, even after a long series of observations.

Senator CASEY. You spoke of it as necessary a while ago.

Mr. GILBERT. It is important. It is necessary to determine the best works.

Senator CASEY. That would probably take eight or ten years' observation?

Mr. GILBERT. Yes, sir; it would bring the cost into competition with the gain to be acquired through the irrigation of the land.

The CHAIRMAN. It is now twenty-nine years since there was a winter similar to this last winter in California and the country west of the Rocky Mountains.

Senator CASEY. Does that remark go back to last summer and include the whole year?

The CHAIRMAN. Yes, sir; it includes the whole year. There was a very dry year twenty-nine years ago, 1861–'62, and this is 1889–'90.

Senator CASEY. So that if this information as to maximum and minimum run-off were ascertained, it would take a long series of observations?

The CHAIRMAN. What is the difficulty in allowing the inhabitants or inducing them to keep a sufficiently accurate gauge of the water for practical purposes? Could not some arrangement be made with the people living in that region to keep a record which would be sufficiently accurate?

Mr. GILBERT. That is the practical method of ascertaining the greater part of the run-off—to gauge the streams through experts and then employ local observers to watch the rise and fall. That is applicable only to the districts that are actually occupied by settlers now. There are great unsettled regions where the run-off would have to be determined in order to construct the best works, and these would have to be occupied——

The **CHAIRMAN** (interposing). Take, for example, the districts in Nevada that are actually occupied; are they not index localities that will do for the unoccupied districts?

Mr. **GILBERT**. I think so. I was coming to that——

The **CHAIRMAN** (interposing). So that the Government would not have to go to the expense?

Mr. **GILBERT**. I was speaking of the method of gauging the water in the streams. That method leads to large expense, in my judgment. The number of measurements that would have to be made in order to consider thoroughly the whole problem of land areas and of reservoir sites would be as much as twenty thousand, leading to an expense that would go into the tens of millions. Now, there are several indirect methods of reaching the result, and I would like to speak of three of these. In the first place, it is possible, usually, by an examination on the ground, to determine what is the magnitude of the flood channel of a stream, and then, by considering the cross-section of the channel in connection with its declivity, it is possible to estimate the rate of the maximum discharge.

The **CHAIRMAN**. An engineer can do that?

Mr. **GILBERT**. Yes, sir; and every one makes a crude estimate. When one sees a place where water has run, he thinks "Some time here has been a large stream." The engineer can measure the gradient and the cross-section, and can give an estimate of the rate of run-off in the time of the most severe storm, which will be valuable. In a humid region the rate of run-off is well related to the annual discharge. If we were dealing with a humid region instead of an arid region we might, by a consideration of the magnitude of the storm channels, make an estimate of the annual discharge which would be really valuable; but in the arid region the precipitation is so irregular that this is impossible. I have crossed on the Amagosa Desert a river-bed that is a mile broad. There was no water when I crossed it, and had probably been no water for many years, but at some time there was a great stream; yet that channel runs into Death Valley, and there is not enough water flowing through it annually on an average to keep the bottom of Death Valley wet.

The **CHAIRMAN**. I have been there.

Mr. **GILBERT**. So the study of channels in the arid region will not suffice for the determination of the annual run-off of the streams. Another indirect method is by analyzing the features that go to make up run-off, and then measuring the factors and putting them together by computation. We know that the run-off depends, in the first place, on the rain-fall. Now, if we can tell what percentage of the rain-fall escapes, and measure the rain-fall, we have our problem solved. The quantity that escapes depends particularly on two things—the declivity of the surface, or the rapidity with which the water runs, and the constitution of the surface or the soil. Some soils shed water; others hold it and yield it to evaporation.

Senator **REAGAN**. Now, this is all very interesting; but it is not the point we are trying to get at at all. We want to know, as I understand it, whether a topographic survey is necessary as a means of providing an irrigation system, or whether that can be done more cheaply and quickly by an engineering and hydrographic survey.

Mr. **GILBERT**. If the Senator will pardon me, I was intending to speak to that point.

The **CHAIRMAN**. Be as brief as you can.

Senator **CASEY**. We have been over all this two or three times, and have become very familiar with it, and the practical question Senator Reagan suggests is what we wish to consider.

Mr. **GILBERT**. The practical method depends on the third method of getting the run-off. The second method, which I have just alluded to, is impracticable, because of the difficulties of understanding the conditions and putting together the various elements.

The third method is one of analogy. In the same general district we have the same general rain-fall at the same altitudes; that is, the general rain-fall varies with the altitude in the same district of country. If we have two drainage basins in the same district of country at about the same altitude, having the same character of surface as to declivities and as to soil, then the run-off from those two basins will be proportionate to their areas; and working on that principle, it is possible to determine the run-off by, in the first place, actually measuring the run-off from certain basins taken as types, and then measuring areas and declivities and examining soil conditions of any other areas of which we wish to know the run-off.

The soil conditions are usually similar through wide belts of country, or, more strictly, their variation is in sympathy with the variation of declivity. Surfaces of gentle slope are more receptive, and steep surfaces less, so that classification of catchment areas by declivities is also largely classification by soil conditions. The measurement of areas and declivities and the determination of the general altitude are the functions of the topographic survey. In my judgment the division of the work into (1) a hydrographic survey which shall determine by gauging the run-off of types of basins, and (2) a topographic survey, has the additional advantage that it indicates the reservoir sites which are to be considered; that it indicates the tracts of land which lie in such shape that they are susceptible of irrigation, and that it indicates the alternative routes for canals and the alternative sites for the head-works of canals to be used in conducting the water to the irrigable lands.

The **CHAIRMAN**. If an experienced engineer, having general information with regard to the storms that occasionally occur in a given section of country, were to proceed into a drainage basin, follow up the streams, and ascertain the places that are suitable for reservoirs, etc., after having, of course, taken into consideration the general area of the basin by observation, its declivities, etc., what would prevent him from locating those reservoirs and segregating the irrigable lands from the other lands, and doing all that work, with the maps that are already collected, without waiting for the topographic survey to precede him?

Mr. **GILBERT**. There is a class of streams——

The **CHAIRMAN**. Could that be done at all?

Mr. **GILBERT**. It could be done with reference to a certain class of streams, in which the catchment areas lie so high that the climate is unsuited to agriculture, so that the streams will have to be handled low down on their courses, of necessity, and where there are existing good maps; but even in that case the engineer would need to go over the ground, in order to satisfy himself that he has the best system of reservoirs—that the system he adopts will not some time have to be reformed. He will have to go over the entire field thoroughly to discover the available reservoir sites, in my judgment. Where there are maps in existence exhibiting the available reservoir sites that is not necessary; he can discover those that need to be considered from the maps; but in general existing maps do not serve that purpose.

The CHAIRMAN. Are the topographic maps sufficiently accurate to locate the reservoir and estimate the quantity of water the reservoir would contain?

Mr. GILBERT. The topographic map would give only a crude idea of the quantity of water the reservoir would contain, not a sufficient estimate for final comparison; but it would give an amply sufficient estimate of the area of the catchment basin, and through that, with the aid of such a gauging system as I have mentioned of the amount of water which would come to that point, it would give a preliminary estimate of the reservoir.

The CHAIRMAN. Would it not be sufficient for general purposes to have a general estimate of the catchment basin, with a gauging system carried on by the inhabitants, after the first instance? Would not that be sufficient for ascertaining the amount of water for practical purposes?

Mr. GILBERT. In my judgment, for practical purposes it is necessary to examine the country tributary to each site or storage basin under consideration in order to ascertain the run-off, and such examination is most economically made by a general work which covers the whole hydrography——

The CHAIRMAN. (Interposing.) Can not an engineer make that examination?

Mr. GILBERT. Yes, he can make that examination, but he can not make it as cheaply as the topographic survey can. A differentiation of functions comes in here. The work of the topographer and the work of the engineer are, to a certain extent, the same. They use the same instruments; they make maps, contour maps; but they work on different scales, and when a man who works with one scale, be it large or small, is diverted to do a piece of work on another scale, he works at a disadvantage.

The CHAIRMAN. Which is the larger scale, that of the engineer or that of the topographer?

Mr. GILBERT. The engineer's is the larger scale. The engineer, in order to make his estimate of cost, etc., needs to go into minutiæ.

Senator REAGAN. What is meant by a smaller scale?

Mr. GILBERT. A smaller map for the same area.

The CHAIRMAN. Then, as I understand you, the topographic work would have to be done over again in order to get sufficient data for practical work?

Mr. GILBERT. Yes, sir. On every site of an irrigation works—every site of a reservoir, every line of a canal—a special survey would have to be run. A topographic survey, upon its small scale, and made in the rapid manner that belongs to a small scale, will not afford the data for final estimates as to cost. It serves as a reconnaissance for all those purposes.

The CHAIRMAN. What use would an engineer, locating reservoirs and laying out ditch lines, make of the topographic survey if it had preceded him, leaving the hydrographic survey out of the question?

Mr. GILBERT. He would, in the first place, know with a fair degree of approximation the height above the stream of the land to be supplied with water and the point of the upper portion of the stream at which the water would necessarily have to be taken out in order to be carried to that land. He would be enabled to consider alternate points for diverting the water without running trial lines. He would know where to direct his final survey and how to determine his general course.

Senator MOODY. Mr. Gilbert, is a topographic survey an observation survey in advance of the definite and particular survey that is necessary in order to locate practically these works that are indicated?

Mr. **Gilbert**. Yes, sir.

Senator **Moody**. A topographic surveyor is ordinarily and usually an engineer, is he not?

Mr. **Gilbert**. The two classes of work are branches of the same profession, but in general the topographer has a different range of information.

Senator **Moody**. In organizing an effort to put a certain region of country under water, that is to establish a system of irrigation, would you organize two parties, one to go in advance of the other and make these observations, or would you organize one party, who would make the observations—a topographic map, or what is its equivalent—and then proceed after they had done that to make the detailed measurements and observations and all that is necessary to locate the reservoirs and carry the water to the lands?

Mr. **Gilbert**. I would organize two parties, and let one precede the other, even if their work could be carried on together. Even if one did not need the work of the other I would organize two parties. It has been found in the history of Western exploration and survey (changing gradually from exploration to survey) that it was necessary to have different lines of work separately performed. In the original Pacific Railroad explorations all kinds of observations and surveys were carried on together. The resources of the country did not permit cutting up into small parties, and it was necessary to travel in one body. The topographers, the engineers, the naturalists, all went together; it was all reconnaissance. Afterward, when the Hayden, the Powell, the King, the Wheeler surveys were organized, those methods were adhered to at the start, but were finally departed from. Eventually there was one party for triangulation, another for topography, another for geology, traveling in the same district, but traveling independently, because it was advantageous to have the movements of each controlled by the particular work to be done.

Senator **Moody**. Supposing you were starting out originally to open up a drainage district, what would be your plan? Would you not first make these observations that you speak of, and then follow them up with a survey or measurements and the requisite engineering work, just as you would in locating a railroad through the country?

Mr. **Gilbert**. Yes, sir.

Senator **Moody**. In other words, you would select the general plan by observation, by certain preliminary measurements, and then carry it out by detailed work. Would that be it?

Mr. **Gilbert**. Yes, sir.

The **Chairman**. Have you any further observations to make?

Mr. **Gilbert**. I have not.

The **Chairman**. Before you go I wish to inquire what your profession is.

Mr. **Gilbert**. I am a geologist.

The **Chairman**. Are you engaged in the Geological Survey?

Mr. **Gilbert**. I have been engaged in the explorations and surveys of the Government since 1871. I have been mainly occupied in geological work, but have done some geographical work and some surveying, and I spent one year in the study of irrigation problems in Utah.

The **Chairman**. What position do you occupy in the Geological Survey?

Mr. **Gilbert**. I am Chief Geologist. I have charge, under the Director, of the geological work.

Director POWELL. Mr. Chairman, I would like to have you ask Mr. ilbert the relative cost of doing the work of the irrigation survey ith the aid of the topographic survey and without it.

THE CHAIRMAN. Mr. Gilbert may answer that question.

Mr. GILBERT. Mr. Chairman, I have not given sufficient considera- ion to that matter to give a quantitative estimate of the cost. It is my ecided opinion that the cost would be much greater, several times greater, if the determination of the sites, etc., were made by trial lines and by reconnaissances of the engineers, instead of being made by a general topographic survey.

Senator MOODY. Will you state, as briefly as you can, the difference between what you call trial work, the running of trial lines and observations by the engineers, and the topographic work?

Mr. GILBERT. That is easiest illustrated by considering a railway survey. The railway engineers, wishing to go from one point to another, inquire of the people as to routes, if they have no personal knowledge of the country themselves, and in that way learn of several routes that may be compared. They follow out each one, making a line survey, similar to the survey that they would make for the location of the road for the purpose of seeing where the opportunities are. Having done that they then select one line as best, modify it perhaps, and make a final survey. Now, in a country where there has been a topographic survey they run no trial lines. Take, for instance, the Appalachian regions when the topographic work of the Survey is in progress. Where these topographic surveys have been made the railway engineers study the maps, and by such studying are able to compare the possible routes, and usually to eliminate from consideration all but one and go to that directly.

The CHAIRMAN. Is there not a difference between a railway survey, which passes through the country over the lowest elevations, and a survey for the purpose of conducting water, which is arbitrary and which must be run where the elevations will permit? Does the engineer surveying for the purpose of irrigation require those comparative trial lines? Must he not go into a valley and ascertain by his eye and by his level where water will run around the valley, and is not that the trial line that he has got to run? He has got to follow that line if he is going to cover the land below with water; he has got to follow lines that are easily found.

Mr. GILBERT. In simple cases, but not by the eye. He must do it by levels. The eye always deceives. A ditch always runs up hill, apparently. But where the problem is to consider whether several streams shall be handled together for purposes of irrigation, or whether a stream shall be taken out at some low point on its course or at some higher point, by a route that offers better facilities for construction, then a reconnaissance of some sort is necessary. If it is not made, then the most economical route may not be the one that happens to be found.

The CHAIRMAN. In that case would the topographic survey show the engineer the levels and the difficulties of construction with sufficient definiteness to relieve him from the obligation of examining the route personally? If he is going to make estimates, has he not got to go over the ground anyway?

Mr. GILBERT. It will eliminate all the possibilities, except one or two.

The CHAIRMAN. Would it be very difficult, after you had the point where the water could be diverted, to ascertain the possibilities as to where the ditch might be run? Could not that be determined by levels very readily, without much expense, and could not all the possibilities of the stream be determined by levels at a minimum expense?

Mr. **Gilbert.** Yes, sir; but the topographic survey is a determination with a very small expense indeed. While it figures up in the aggregate to some millions of dollars, its rate per unit is very small.

The **Chairman.** Is not a great proportion of the expense of the topographic survey for work in countries where you can not utilize the land for irrigation and where you can not utilize the waters for that purpose? Is there not a great deal of surveying outside of the particular basins that can be utilized for irrigation purposes?

Mr. **Gilbert.** As I understand it, the future irrigation of our arid region is going to be distributed over its whole extent. It is going to include districts where a few years ago the thought of irrigation did not occur, but where storm waters can be used; and the general survey is going to be one of the means of indicating those districts.

Senator **Moody.** So that the topographic survey will get the whole country ready for irrigation in the future.

Mr. **Gilbert.** Yes, sir.

Senator **Reagan.** So far as you go, does the topographic survey include the whole country or select districts?

Mr. **Gilbert.** As I understand the work it has been begun in various States and Territories in basins where there is immediate need for the determination of these irrigation questions. The selection of tracts for initial work has been made with reference to the earliest needs of the greatest number of people.

Senator **Reagan.** And that may be extended as necessity arises?

Mr. **Gilbert.** Yes, sir. But at the same time complete blocks of country have been surveyed; not small areas of a straggling nature, but the general plan has been to complete the whole area. The beginnings of the work, however, have been made where the present need was most urgent.

The **Chairman.** Does your topographic survey leave marks on the ground indicating altitude and other signs which can be followed by the engineer?

Mr. **Gilbert.** No, sir.

The **Chairman.** They leave nothing on the ground?

Mr. **Gilbert.** They give the indications of altitudes of points which can be found; of points that are otherwise fixed; for example, the junctions of streams, the crests of hills, etc.

Senator **Reagan.** When you get that initial point you take the map and it shows you?

Mr. **Gilbert.** Yes, sir.

The **Chairman.** If it was not at the point where you wished to locate your reservoir or your ditch it would be necessary to have an engineering survey from that point to ascertain the location of hydraulic works, would it not?

Mr. **Gilbert.** I do not understand you.

The **Chairman.** When you get a fixed point you have got to go from that with the engineering survey to ascertain the other point, have you not?

Mr. **Gilbert.** If we have indicated on a topographic map a piece of plain country, indicated by contours far apart, and beyond that we have a steep hill, indicated by the contours close together, then the contour which skirts the bottom of that hill is the contour indicating the upper portion of that plane surface, the portion to be commanded by the ditch, and that is something of practical value, even if there is no absolute point fixed. It is the edge of that plain. I do not know that I fully understand you.

The **CHAIRMAN.** To determine a definite point at which to locate your reservoir you will have to find a known point. The map will not show you.

Mr. **GILBERT.** The expression of the map is through contours.

The **CHAIRMAN.** I know the expression; but does it not require actual engineering to find other given points definitely?

Mr. **GILBERT.** Yes, sir.

The **CHAIRMAN.** After you have the initial point from your topographic survey, it requires engineering to determine other points?

Mr. **GILBERT.** The topographic survey gives the position and height of definite points with the degree of precision of the map, whatever that may be, and if you compare any two of these points by means of the contours you have their relative heights. Take the upper edge of a plain that may be irrigated. You have the height of that with reference to the stream at various places, and by tracing the proper contour line you have an approximate idea of the course of the lowest possible canal route.

The **CHAIRMAN.** By what instruments do you ascertain altitudes?

Mr. **GILBERT.** That is ascertained in different parts of the country by a variety of instruments. In the present work of the Survey it is obtained chiefly by angles of elevation and depression; but it is also ascertained for altitudes that are not very essential to the work of irrigation by means of barometers. It is also ascertained along the lines of principal streams, I understand, in the present topographic work, by spirit leveling, but the other gentlemen present are better qualified to explain that than I.

STATEMENT OF ALMON H. THOMPSON, IN CHARGE OF TOPOGRAPHICAL DIVISION OF U. S. IRRIGATION SURVEY.

The **CHAIRMAN.** Mr. Thompson, what is your profession?

Mr. **THOMPSON.** I am a geographer, in charge of the topography of the Irrigation Survey.

The **CHAIRMAN.** Will you state to the committee whether a topographic survey is necessary to an engineering survey for the purpose of irrigation, confining yourself in as short space as you can to that exact point?

Mr. **THOMPSON.** A topographic survey is the cheapest and most accurate way of obtaining the facts necessary to plan a system of irrigation works for any natural district or drainage basin, and the results can be given to the people in the shortest time by this method. There are three well-defined phases or steps taken in engineering work.

The **CHAIRMAN.** Those steps have been explained a good many times to the committee. State what use an engineer would make of a topographic survey in a given district?

Mr. **THOMPSON.** It is supposed by the topographers and most engineers that it will furnish him all the data necessary for a reconnaissance; that he obtains in that reconnaissance most of the data for his lines, which he then runs. It is not supposed that it will furnish him data sufficient to make estimates of construction, such as cuts and fills. It is supposed that he will have to do that particular step of the work afterward. But it is supposed that it will furnish him with all information necessary for the first two steps, with the exception of now and then a single trial line.

Senator **Casey**. Suppose the data had not all been ascertained, what course would he pursue to obtain that data; would it be the same course that the topographic survey had already pursued?

Mr. **Thompson**. Yes, sir; if he wished to obtain it over an extended area of country. If he wished to obtain it as the topography is obtained in a line survey, for a few feet on either side of the trial line he might run, he probably would not cover the whole country with his map.

Senator **Casey**. He would cover only that region that he had particularly under his eye.

Mr. **Thompson**. Yes, sir. But the practice of the best engineers of the present day seems to be to obtain the topography of the whole country, especially in regard to irrigation work; and in other countries——

The **Chairman** (interposing). In what other countries do the topographers precede the engineers?

Mr. **Thompson**. In India, and to a certain extent in California, in cases that have come under my observation, and in countries where new irrigation works are located.

The **Chairman**. Have you any reports from the Indian surveys where they insist on topography preceding the engineering surveys?

Mr. **Thompson**. No, sir; I have no reports, but such reports are in the library of the Survey.

The **Chairman**. You have no reports showing that?

Mr. **Thompson**. No, sir; nothing in my hands. But there have been topographic surveys conducted in India for a long time, and these surveys are made use of by the engineers in constructing new works. The engineers of that country, as in this, I believe, obtain maps to begin with.

The **Chairman**. In southern California you say the topographic surveys precede the engineering surveys for hydraulic purposes. In what instances?

Mr. **Thompson**. I was trying to think of the particular instance. A year ago I was in San Francisco and an engineer came to me to ask me about the topographic work, stating that he had been employed by some company in San Diego County to construct works for irrigation purposes, and that his first step was to make a contour map of the area with intervals of 10 feet.

Senator **Casey**. He made that in the particular region in which he was working?

Mr. **Thompson**. Yes, sir. I think he said the area of his map was about 10 square miles.

Senator **Casey**. Was it any more expensive for him to do that work for the purpose he had in hand than it would have been if it had been done by a preliminary survey by the State?

Mr. **Thompson**. In my judgment it was much more expensive than a survey on a general plan.

The **Chairman**. Would he not make it more accurate having in view the objects to be attained, and would he not direct the survey to the attainment of those objects?

Mr. **Thompson**. That is a hard question to answer. If, on the general survey a map was made having the same contour interval and detail, I think it would be quite as accurate as he would make it.

Senator **Reagan**. Would not the answer to that depend upon whether the survey was made with greater or less detail?

Mr. THOMPSON. Pardon me. I said if the map was made with the same contour intervals, which means with the same details.

The CHAIRMAN. Would not the engineer, in making such a contour survey as he deemed necessary, locate marks on the ground which he could use in his survey, and which would not be found in a general topographic survey?

Mr. THOMPSON. It is possible that he might make some special marks with reference to his construction work. Our surveys are all connected with the Land Office surveys. The Land Office corners are marked every half mile, and our surveys are connected with the Land Office work; so that the Land Office lines can be drawn upon our maps, and the connection between the topographic work and the Land Office work be determined.

The CHAIRMAN. Are the Land Office marks extended into the mountains where there is no market for the lands?

Mr. THOMPSON. My remark relates to areas where the Land Office survey extends.

The CHAIRMAN. They do not extend into the desert lands?

Mr. THOMPSON. They do survey large tracts that are desert lands. The State engineer of California, when he was planning a system of works for that State, made topographic maps with contour intervals of 10 and 20 feet and carried the work over a portion of the State, although he was not planning a reservoir system but only canal lines to use the waters running in the streams during the time of irrigation.

Senator MOODY. Have you charge of the work of the Topographic Survey as well as the Geological Survey?

Mr. THOMPSON. Only of the irrigation branch.

Senator MOODY. In what regions of country has the work been conducted under last year's appropriation?

Mr. THOMPSON. In the Arkansas Valley, in Colorado; in New Mexico, on the Mora and Gallinas Rivers, in the region of Santa Fé and Las Vegas; and on the Rio Grande, in the region of El Paso; in California, in the region about Lake Tahoe, on the head-waters of the American and Uba Rivers, and the northern branch of Stanislaus, and the head-waters of the Truckee and Carson Rivers; in Montana, on Yellowstone Lake and along the Yellowstone River, and in southern Idaho along the Boisé and Snake Rivers.

Senator REAGAN. And on Sun River?

Mr. THOMPSON. No, sir. My work did not extend to Sun River. That was done under the engineers.

Senator MOODY. What work has been done by the Topographic Survey in connection with the engineering work under this irrigation scheme and appropriation?

Mr. THOMPSON. Over the same areas?

Senator MOODY. Yes.

Mr. THOMPSON. The engineers were working in the Arkansas River drainage basin in Colorado and about Lake Tahoe, in Nevada and California.

Senator MOODY. Was that in connection with the topographic work?

Mr. THOMPSON. The topographic work was not immediately connected with the engineering work. The engineers were engaged, as I understand, in surveying reservoir sites.

Senator MOODY. Where was the engineering party under Captain Dutton?

Mr. THOMPSON. He had general charge of the whole engineering branch.

Senator MOODY. Whereabouts did the engineers follow and use the topographic work?

Mr. THOMPSON. In no case that I know of. The topographic work had not been finished.

Senator MOODY. All that the engineers did under last year's appropriation has been done independent of topographic work?

Mr. THOMPSON. Of our completed work, as I understand it. They have called on us for our field-notes in many instances.

Senator MOODY. Were you able to furnish them any field-notes of your topographic survey?

Mr. THOMPSON. I think none that were worked up so that we would be willing to say that they were reduced the best we could do. We have furnished them preliminary notes, always stating that fact. We have been engaged on office work in the reduction of our observations but a short time. Of course the field-notes given were in a crude state.

Senator MOODY. Then, so far as the work has progressed under last year's appropriation, the topographic work and the engineering work for irrigation purposes have been carried on separately?

Mr. THOMPSON. Yes, sir; distinct organizations.

Senator REAGAN. Do you mean to be understood that the engineers have not made any use of the topographic survey in the engineering and hydrographic work?

Mr. THOMPSON. Under this last appropriation?

Senator REAGAN. Yes, sir.

Mr. THOMPSON. I do not know of instances, except information that they have obtained from our field-notes, from questions they have asked and photographs of field-work that have been given them. The maps have not been completed.

Senator REAGAN. Have you furnished them any?

Mr. THOMPSON. Not yet, sir; because they are not constructed. We have not finished them.

The CHAIRMAN. The hour is up.

Director POWELL. Mr. Chairman, I would like to have five minutes' time. Neither of the gentlemen who have been speaking has seemed to fully comprehend what the committee desire, and I would like to have five minutes of your time.

The CHAIRMAN. There will be another meeting as soon as we can get the committee together, and you shall be heard.

Director POWELL. That is satisfactory.

The committee thereupon, at 12 o'clock m., adjourned, subject to the call of the chairman.

NINTH DAY'S SESSION.

WASHINGTON, D. C., *March* 22, 1890.

The committee met at 10.30 o'clock a. m.

Present: Mr. Stewart (chairman), Mr. Moody, Mr. Gorman, Mr. Reagan, and Mr. Jones.

STATEMENT OF WILLARD D. JOHNSON, TOPOGRAPHER, U. S. GEOLOGICAL SURVEY.

The CHAIRMAN. What is your profession or occupation, Mr. Johnson?

Mr. JOHNSON. I am a topographer. Under the general direction of Professor Thompson I have charge of the topographic work in the Division of the Arkansas River Basin—of the portion of that basin lying west of the Kansas line.

The CHAIRMAN. The present inquiry will be directed to the question of the connection between the topographic survey and the engineering survey for purposes of irrigation, and of whether and, if at all, to what extent, the engineering survey is dependent upon the topographic survey. Please confine yourself to that exact question. We have been over the general ground sufficiently.

Mr. JOHNSON. So far in the Arkansas Basin, there has been little connection between the topographic and the engineering surveys because the engineering survey has entered upon its work in this field in advance of the completion of work by the topographic survey. The outcome of a topographic survey is a map and every step toward that end has its place in a system. The data of field work, if considered separately, necessarily appear fragmentary and incomplete. The parts must be adjusted and co-ordinated by office work. In such work we are now engaged. The area surveyed was large—22,000 square miles, and the map sheets covering all of that area are now nearing completion. The topographic work began in the fall of 1888, and was carried uninterruptedly, with gradually increasing field force, through the following winter, the following spring and summer, and well into the succeeding winter—the winter just ended. Office work then began, five months ago, upon the whole mass of this material. Engineering surveying was entered upon early in the summer of 1889.

In this basin I had charge of the topographic survey only, under the direction of Professor Thompson; within the same limits there was also an engineer—a division engineer—in charge of the engineering survey, under the direction of Captain Dutton.

The CHAIRMAN. Who was the engineer in charge of that work?

Mr. JOHNSON. Mr. Bodfish. From beginning to close of his work I was in continuous receipt, from this division engineer, of requests for maps, for topographic maps, or for map data of any character. These calls upon me for map data were continuous, urgent, and annoyingly persistent—annoying for the reason that I have mentioned, that such data as I had must, until we should have fitted together the mutually dependent parts in office work, necessarily appear to others fragmentary, scarcely intelligible and misleading.

Mr. Bodfish understood this, yet insisted, very reasonably I think, that he nevertheless must have maps, that without them he could do little, and that little at a disadvantage. I was finally directed to furnish him with photographs of certain unadjusted pieces of map work. I regretted the necessity for this as I knew that he could not fully understand them, that only those to whom they were of the nature of memoranda could understand them, and finally adjust them. I wish to emphasize the fact that I was repeatedly urged to furnish the engineering surveyors with topographical map data as a guide in their special work.

The CHAIRMAN. Is Mr. Bodfish in town now?

Mr. JOHNSON. Yes, sir. This unfinished material, covering about 1,000 square miles on the plains of Colorado, the engineering surveyors, as I expected, could not interpret. Thereupon pending the final completion of the maps, they entered upon work in the mountains, where they had the benefit of the old Hayden survey maps, at least. To do this was comparatively easy, for in addition to the Hayden maps, this region afforded opportunities for several good sites, of which every one knew. In every great river basin, as well settled as that of the Arkansas, out of the great number of opportunities for storage and for conveyance of water, to be discovered only through systematic study of the grades of the ground over its entire surface, there naturally will be certain obviously good sites, or seemingly good sites, about which there will be general knowledge. To such spots Mr. Bodfish went and there ran his careful levels and made the accurate and necessarily expensive special surveys. Aside from such work as this he engaged in what Captain Dutton, in an earlier letter, of June the 10th, pressing me for maps, described as reconnaissance work. Captain Dutton said: "Mr. Bodfish's work during the present season can hardly be more than the reconnaissance work. Ultimately, of course, we must have the thoroughly completed map."

Over the mountainous area covered by the old Hayden survey we did revision work merely, adding only what would be necessary for republication on the larger scale proposed. Here, when my principal assistant, Mr. Bien, found himself carrying his general surveys over the region in which Mr. Bodfish was making precise local surveys, we were again met with calls for map data, and we again, of necessity, furnished the unadjusted data. This, though confessedly incomplete, was found a useful guide, and at other points in the same region similar data were afterwards furnished at intervals.

Mr. Bodfish was even here working at a disadvantage, and it was, and in my opinion, everywhere must be, only over such limited areas, where the problems are of simple character, that such work can be conducted with even limited success without that full knowledge of the entire area under examination, which only a topographic map can give—make it by what method you will, and call it by what name you will. Next summer, as Captain Dutton wrote me, they must have the thoroughly completed map, and by July they may have it—more than 20,000 square miles of it—an area nearly three times that of Massachusetts.

They have now, to be sure, the Land-Survey maps, but these maps do not show the topography, and even as horizontal plans, they are imperfect and misleading. It is the topography—the vertical departure from the ideal level surface, that is all-important. A map becomes topographical only when it shows this surface form; furthermore, it is now generally agreed that the most satisfactory method of representing topography is by means of contours, which have something of the graphic effect of shading, and at the same time convey information in regard to elevation and depression that is both definite and quantitative. It is a topographic map of this character that this survey is making.

The CHAIRMAN. The land-survey maps are of the plains regions?

Mr. JOHNSON. Yes, sir; and of the valley areas in the mountains also.

The CHAIRMAN. You had nothing to do with the topographic work of other divisions?

Mr. JOHNSON. No, sir. We did no work outside of the Arkansas River Basin. The rim of that basin on the north, west, and south, and eastward to the one hundredth meridian constituted the limits of our area. We have surveyed the greater portion of it, and much the more difficult portion. Within these limits I conducted the general survey, and within the same limits the engineers conducted here and there their special and unconnected surveys of high precision (by comparison with which the topographical work is approximate)—by widely different methods, at relatively great cost, and yet surveys merely, none the less. I deem it important to the general question, to which you ask me to confine myself, that it be understood that all of this work is of the nature of preliminary surveying. The several names for what are virtually one thing and directed to a common end are here, I think, more misleading than useful. In field work they serve in the division of labor. The expensive trial-line work is conducted with a special object directly in view. The general and comprehensive survey, which achieves a topographic map as its result, aims only indirectly to convey this special information. For whatever purpose it may be made, to whatever purpose it may be applied, such a survey accomplishes nothing more nor less than what I have described as a topographic map. Whether by an irrigation survey, or by a geological survey, or by a rail-road-lands survey, it answers to that definition—a map showing the form of the surface, as a rule by contours—and to each it is practically indispensable, as it directs attention, without waste of energy, to such special details as require minute investigation; and to each, as well, it affords a graphic base for the record of multitudinous additional facts in natural groupings.

The CHAIRMAN. Is it not possible for the engineers, in the mountains, to follow up the streams, and to make locations by observation, and with their instruments, without having the topography in advance?

Mr. JOHNSON. It is possible, especially in the mountains, and along the main stream lines; but even under such simple conditions the engineer may, here and there, fail to discover important facts. Expensive mistakes must inevitably, in my opinion, follow a course which appears, in view of the magnitude of the work contemplated, dangerously loose and unsystematic. And I am speaking of the trial-line method under favorable conditions. The best sites for storage will frequently lie to one side of the main streams, and to these the waters must be led; the great canals and the minor canals will run across the barren spaces between the main streams; and here also will be found the lands to be irrigated. Failure to carry examination over these interstream areas must occasionally result in wasteful work, and discreditable blunders. The topographic map shows all the possibilities and all the impossibilities.

The CHAIRMAN. Is there any difficulty in having an engineer pass along an ordinary stream and determine the possible and impossible sites with his instruments in a short time—in a few days, for instance?

Mr. JOHNSON. Yes, sir; to determine all the possible sites for a given stream basin; not simply the flat places along its immediate valley, but in the adjoining and higher valleys as well; to determine the lines—the best lines—of getting the water there, and away from there, on to lands in some less watered basin or unwatered table-land; to do these and other complex things, and at the same time to be sure that no fact has been overlooked, would, without a topographic map, or its more expensive equivalent, be more than difficult—it would, in my opinion, be impossible.

The CHAIRMAN. If you were going to locate a reservoir would it not be necessary to run trial lines for that particular place?

Mr. JOHNSON. After the topographic map had been made?

The CHAIRMAN. Yes.

Mr. JOHNSON. After the topographic map had been made it would still be necessary to resurvey, by relatively precise and expensive methods, all actual sites chosen for reservoirs and canals, or provisionally chosen with a small margin of doubt. These areas over which resurveys would of necessity be made would, however, appear in the great breadth of country represented by the map as spots merely. But the map is the indispensable and unerring guide to these spots. It says: Here spend your money; it will be wasted elsewhere.

The CHAIRMAN. The engineer has his levels with him, and can easily make experiments and make his locations without spending much time with trial lines?

Mr. JOHNSON. The area of country that a man can cover in that way, at a fairly reliable distance from his base, is exceedingly small, although it may appear to him large when on the ground. I find that, in criticising and examining in the field the work of my assistants, map in hand and merely by eye, the area thus revised by me is insignificant as compared with the body of land surveyed. The arid lands are of great extent. Such rapid work as the engineer may do by his general oversight, the topographer does also at wonderfully small expense, and much better and more rapidly, because his work is part of a system.

The CHAIRMAN. Suppose we take a river that has a great many tributaries. Each tributary, whether you have a topographic map or not, must be examined to see if you can store its waters, and the engineer follows up the tributary to its source. Would he not necessarily be guided to the localities where there will be flat places, where he can make reservoirs?

Mr. JOHNSON. He would not, with the map, need to do all this work in the first place; and without the aid of maps, he would not be sure to discover all the complex possibilities and impossibilities of the case to which I have called attention. He could not be sure without much more work than you refer to.

The CHAIRMAN. Take a mountain stream. Do they carry the water out on a table-land from the heights where they store it, or do they let it run down the channel, as a usual thing, to be taken out where it opens out in a valley?

Mr. JOHNSON. It is not so much a question where the water shall be taken out, as where it shall be stored. In many cases they might do as you describe; but my point is that years afterwards it might, in some cases, be found that great blunders had been made, involving the expenditure of vast sums, and that these blunders might have been avoided by the early expenditure of a very small, relatively insignificant, sum.

In the Arkansas Valley we began work in the vicinity of Pueblo. There irrigation work is actively carried on. Local engineers—men practically familiar with irrigation problems—had run trial lines all over that country. There had been much talk of taking the Arkansas out at some point far above Pueblo, to supply a large ditch and irrigate the country along its course by tap-lines, but it appeared impracticable to do so.

Many thousands of dollars had been spent, however, upon trial lines for various purposes over this same region, and had not discovered what our maps revealed immediately. My assistant, Mr. Hays, after working for a week or more in that region, said to one of the prominent engineers of Pueblo, "Why do you not take out a ditch at this place, and run it across here, and here, and store your water on the top of this tableland?" It had not appeared before that such a route was practicable. Appearances were against it. The gentle grades of that country are frequently misleading as to their dip. Mr. Hays urged, "Our maps demonstrate that it can be done." He showed the maps, rough preliminary drawings, but they gave, after an expenditure of a few hundred dollars only, what the local engineers had in vain spent thousands for. The Teller Ditch Company, so-called, was at once organized. A special survey, costing several thousand dollars, verified the prediction of the maps. This carefully surveyed line does not in detail coincide with that furnished by Mr. Hays, but it does coincide with fair approximation. It was enough that he had given them the general line. Construction work on this great ditch, to be the largest in Colorado, has already begun.

The CHAIRMAN. Do you mean to say it would have cost many thousands of dollars to have gone above, where it was suggested the water might be taken out, and to have run a random level to ascertain the practicability of doing so?

Mr. JOHNSON. No, sir; I do not. It would have cost very much less than the sum actually spent, and spent to no purpose. It would have cost less, because Captain Dutton's assistants would have gone about the work in a more systematic manner; but perhaps even they would not have thought of the line at all without the map to point it out. I claim for the topographic survey that we are doing it for the whole country. The engineer accomplishes the same result, but only here and there, and even then in a roundabout and expensive way. As we have the whole country to cover our methods belong to a unified system. I have here [indicating] a finished map showing the area covered by the preliminary sketch referred to. Here appears the ditch line as finally surveyed, practically coinciding with the line of the original, and demonstrating in this particular case the usefulness of such topographic data.

Senator GORMAN. Do I understand you to say that it is absolutely necessary, in your judgment, that this topographic survey shall be made before the engineers go upon the ground to determine this question?

Mr. JOHNSON. I am convinced, after a year of work among a people to whom irrigation questions are of vital importance, that it is in the highest degree economical, even essential, that the topographic survey precede the elaboration of plans for extensive and systematic storage irrigation. I am convinced that the topographic survey is the most economical means for ascertaining the necessary facts.

Senator GORMAN. How much more economical? Take the Arkansas basin. What would be your estimate of the additional cost of obtaining this information through the engineers without a topographic map?

Mr. JOHNSON. In my opinion it would be several times more expensive.

Senator GORMAN. Then it follows, in your judgment, in view of economy and results, that the special surveys should be suspended until after the completion of your topographic work.

Mr. JOHNSON. For the engineer to undertake his special examinations within a given area, in advance of the completion of the topographic map of that area, can only lead, it seems to me, to confusion and waste of money.

Senator JONES. Will you please explain your method of work?

Mr. JOHNSON. It has been so modified away from the prevailing methods of the text books as to be practically new. It is, in the main, that of triangulation—at first with the transit, by trigonometrical methods, but eventually, and chiefly, with the plane-table, by graphic methods. By this triangulation distances are determined indirectly, but more accurately than by direct measurement. Yet the work is initiated by a direct measurement—by the measurement of one line, the initial base line; and this initial base is measured with extraordinary care. One line, several miles in length, is thus determined, and from this line the triangulation scheme is expanded. The first triangle is obtained by measuring the angles from either end of the base to a third point previously marked. By means of the only known distance and the two known angles the two remaining sides of the triangle are found. This triangle is the unit of the system, hence the name triangulation. Such triangles are multiplied by computing additional sides, or distances between points, by measuring the angles only, and computing the distances. Such a system may be expanded over an area of 50,000 square miles perhaps, such as that of the Arkansas basin, and the final triangle with its computed distances may lie several hundred miles away from the initial base. The last computed distance it then becomes necessary to test by actual measurement, and the test of the last link is a test of the whole chain. This second measured line is called the verification base. I have indicated only the principles of procedure. The actual practice is somewhat more complex.

Upon the points located in this net of triangles the detailed map-work is based. The map is not made in one great sheet, but the total area is cut up into atlas-sheet areas, as in the case of the Arkansas basin, of about 1,000 square miles each. Speaking more accurately, the positions and boundaries of these atlas sheets are determined by the half-degree lines of latitude and longitude. Now, under the best conditions, upon each of these atlas-sheet areas, of nearly 1,000 square miles each, three of the precise locations of the primary triangulation should fall. The positions of these points must be furnished, to the map-maker proper, in terms of latitude and longitude, so that he can plot them accurately on his map sheet. This map sheet, mounted on a drawing board, and this again on a suitably constructed tripod, is then taken into the field and the map is made directly upon it, and upon similar, but smaller supplementary sheets. The drawing board, with its tripod of special construction, is called a plane table, and the method thereafter is, throughout, the plane-table method—a graphic method—the most direct and simple method for making a map, which is, itself, a graphic product.

The three points plotted upon the map sheet are termed its primary control. From these a secondary triangulation or control is spread directly upon the paper until many small triangles affording, perhaps, two hundred secondary locations, are determined within the area of the single primary triangle formed by the three primary points. This work is done by means of a telescope, with attachments similar to those of the transit, but mounted on a flat plate or broad ruler base, and resting directly upon the plane-table map sheet. Elevations are carried forward from point to point by means of vertical angles—a method of vertical triangulation.

So far, however, we have no visible map, merely control. The smaller, supplementary sheets, are now furnished to traverse men, as they are termed. The points of the secondary or graphic triangulation are plotted upon these traverse sheets, as the points of the trigonometric triangulation were plotted upon the larger sheet, and at these numerous control points the traverse men start and close. The elevation above sea-level of each of these points is also written on the smaller plane-table sheet, at a fine pricked hole, representing the located point. The method of the traverse man, as the name implies, is that of traverse, or meander—the same in principle with that of the trial line, but far less precise, and astonishingly rapid. The precision of detail, such precision as may be required, is attained by means of the check points. By the trial-line method, also a map may be made, but at relatively great cost, with great nicety in detail, but with gross inaccuracy in general proportion. These check points furnish with accuracy, and at a minimum of cost, that which line surveying, however carefully executed, can not furnish at all—the skeleton plan. By this method of triangulation a degree of closeness, in the determination of horizontal position and of elevation, may be reached, beyond the possibilities of the map to express, on the scale adopted. In estimating the cost of such topographical maps, per square mile, that of the primary control, though executed with great care, will be hardly more than 1 per cent., that of the secondary control perhaps 20 per cent. The traverse man, as stated, starts his line from a known point, and runs to other known points, checking and adjusting backward his error. The distribution of control points is, or should be, such that the probable error, after such adjustment, will be inappreciable or unimportant on the scale of the map.

In running his lines the traverse man depends for distances upon automatically counted revolutions of a wheel of his vehicle, and upon a further graphic triangulation, which he carries down even into this detail; for directions he depends upon his compass, and also upon this rough triangulation; and for elevations—for the detail of the grades of the surface, he depends upon the aneroid barometer. All of these approximate means are directly dependent upon the control locations, and errors are not cumulative. By running his lines close together and locating by intersection—by his rude triangulation, intermediate points, and by getting heights at such intermediate points by rude levels across between his lines, he surveys area and makes a map. I have here on this map, or large progress diagram, the area of an atlas sheet of 1,000 square miles, exhibiting the primary locations, the secondary locations, and the lines followed by the traverse men. You here [indicating] see the whole method graphically displayed. I have ruled this area into squares, representing square miles, on the scale of one inch on the map to one mile on the ground. It will be seen by following these red lines, which stand for the meandered lines, how well they are distributed for the control of area, as we say, and also the curious influence of the topographic configuration of the country upon this distribution. Within this area the traverse men have meandered, covering by their intersections belts of country on either side, a total distance of more than 3,000 miles. The total area must be covered by these belts and no blanks left. No blanks can be left, because, the method being a graphic one, a blank will appear as such on the map.

Senator MOODY. What has been the total cost of this topographic survey within the Arkansas basin?

Mr. JOHNSON. The total expenditure to date, for topography, in the Arkansas Basin, since I began work in the fall of 1888, has been $57,000. We surveyed 22,000 square miles, and, when completed, the maps will have cost $3 per square mile. This statement includes the heavy expenditure for equipment. I had about fifty animals, and seven or more separate camping parties. This expense for equipment, in this new field, will not have to be incurred again. Omitting this large item, the cost per square mile has been about $2.

Director **POWELL**. Let me add to Mr. Johnson's statement of topographic methods an explanation of the manner in which we get starting points for elevations. There is a plexus of railroads all over the United States. Lines now meander from the Atlantic to the Pacific coast, and from city to city of the interior, and these lines are connected at their termini, and they cross one another in various ways and at various places, forming altogether a net-work of roads. In their construction levels have been run, and by connecting their lines altogether we are able to discover discrepancies in these levels. The roads of the country have been very generous to us and have furnished us their profiles, so that we have in the Geological Survey nearly all the profiles of all the railroads in the United States. Whenever discrepancies between levels of the different roads are discovered we report them to the engineers of the roads, and the errors are soon detected. Having in this manner a vast system of level lines run all over the country, we have a basis from which the levels of the topographic survey can be reckoned.

Senator **JONES**. You select a height from which you desire to start a system of elevations, and then you run a level from the railroad to determine its elevation.

Director **POWELL**. Yes, sir; and check on other railroad levels from time to time.

Senator **MOODY**. Mr. Johnson, you are, I understand, the topographer for the Geological Survey?

Mr. **JOHNSON**. Not exactly; a topographer of the Geological Survey assigned to special duty on the Irrigation Survey for irrigation topography.

Senator **MOODY**. Is there any distinction between the expenditure for topography in the Geological Survey and for topography in the Irrigation Survey?

Mr. **JOHNSON**. I know little about that, sir.

Mr. **THOMPSON**. (Interposing.) The expenditures are kept entirely separate. Mr. Johnson's work was on the Irrigation Survey.

Senator **MOODY**. How do you keep the expenditures separate?

Mr. **THOMPSON**. The money allotted is drawn by requisitions on the Treasury, and the account kept separately.

Senator **MOODY**. How do you keep it separate?

Mr. **THOMPSON**. There was no geological work going on in that region.

Senator **MOODY**. Can you tell me where this topographic work was going on for purposes of irrigation?

Mr. **THOMPSON**. In Montana, Idaho, Colorado, California, Nevada, and New Mexico.

Senator **MOODY**. All for irrigation?

Mr. **THOMPSON**. Yes, sir.

Senator **MOODY**. In putting your work on topographic maps do you make any distinction between the irrigation topography and the general geological topography?

Mr. **THOMPSON**. In this case it was all for irrigation. There was no distinction, because it was all for one purpose, the Irrigation Survey. Had we been making it for geological purposes it would have been substantially the same.

Senator **MOODY**. What distinction do you make when you come to make maps? Do you have to go over the ground again for geological purposes?

Mr. THOMPSON. No, sir; the same topographical map answers for the geological survey.

Senator MOODY. Then the geological survey answers for the irrigation survey.

Mr. THOMPSON. Yes, sir. As the geological survey was previously conducted——

Senator MOODY (interposing). I mean as it is now in that country.

Mr. THOMPSON. I had charge of similar work of the geological survey before being assigned to this. The work was in principle precisely the same. It is simply an extension in methods of the geological survey topography.

Senator MOODY. That is, you add this specific detailed information as to elevations, etc., for irrigation purposes to your topographic surveys for geological purposes.

Senator JONES. Let me understand that. I understood Senator Moody to ask you, if, as a matter of fact, there is a geological survey for a given part of the country, this irrigation survey is made to supplement the geological survey.

Mr. THOMPSON. If the geological survey maps had been made in this region we would not have had to go over it again for the maps of the irrigation survey; but the geological maps had not been made.

Senator MOODY. Is it the intention to complete that whole country in one map eventually?

Mr. THOMPSON I can not speak as to what the intention is.

Senator MOODY. What I want to ascertain is this: Is it necessary, in your pursuit of geological information, for you to go over this ground again, after you have made this sort of topography?

Mr. THOMPSON. No, sir; not to make the map.

Senator MOODY. Now, can you put those divisions of the country together, where you have a map of one region on a scale of 1 inch to 4 miles and a map of another region, adjoining, on a scale of 1 inch to 2 miles?

Mr. THOMPSON. If we were to join these two maps, this map [indicating] would show the country more in detail. Every other one of the 100-feet curves represented on the large scale would exactly join with the 200-feet curves on the small scale, which covers 4 miles to the inch. They would join there. If the 4-mile map were photographed up so that it would be on a 2-mile scale, they would join.

Senator MOODY. Is it not sufficient, for engineering operations in irrigation, to take this geological survey map instead of making this irrigation topography?

Mr. THOMPSON. In my judgment, it would be sufficient.

Senator MOODY. You have this information, but you have to go on the ground and locate with more detail?

Mr. THOMPSON. Yes, sir. It is a mere matter of revision, quite rapidly done, because we take the map right into the field and draw the contour lines upon it.

Senator MOODY. Now, in your irrigation topography you do precisely the same thing in the first instance. That is the first work you do—what may be called the reconnoissance, the preliminary or observation work. You do precisely the same thing in both cases, for irrigation and geological topography.

Mr. THOMPSON. The same in method, but we obtain more refined determinations in relation to the streams.

Senator MOODY. It is important that we should understand what is essential in the way of appropriation for actual irrigation purposes and what is essential for geological purposes, that is, for the geological observation and survey that is going on, and what I want to know is whether we can use in this irrigation work the topographic maps that you have already made or are ready to make.

Senator JONES. As I understand, they are already made.

Director POWELL. This whole discussion is proceeding on a mistaken notion on the part of Professor Thompson of the import of your question. May I explain it?

The CHAIRMAN. Certainly.

Director POWELL. We have been doing work for a number of years, making topographic maps in the arid region. The ones that we have been making——

Senator MOODY. Did you make any topographic maps of this region where Professor Thompson had charge?

Director POWELL. No, sir; this is new work. I wish to speak of the relation of one to the other. A topographic map must be made for the geological survey and one for the irrigation survey, but they are one and the same, not two maps. The same map serves both purposes. There are certain areas of country where we need it on a scale of 4 miles to the inch; other regions on a scale of 2 miles to the inch. In the regions we have surveyed heretofore we have gone farther into the mountains. There we have made the maps on a smaller scale, but sufficient for our work in geology and irrigation alike.

Senator MOODY. What is the difference in paying the expense of this sort of topography out of your geological survey appropriation?

Director POWELL. None at all, if Congress makes a sufficient appropriation. It makes no difference.

Senator JONES. If Congress makes a specific appropriation for a geological survey the director would be obliged to expend it for that, and if there was a specific appropriation for an irrigation survey he would have to expend it for that, but he can make a map for both.

Director POWELL. The cost of the map necessary for irrigation over the cost of the map necessary for the geological survey is a trivial thing. It is involved in the running of the gradients of the streams.

Senator MOODY. We have secured for actual irrigation purposes $89,000 out of the $250,000, it seems, and the expense has gone toward this topographic work.

Director POWELL. What I am trying to get at is——

Senator JONES. I should think that objection would lie to the whole amount. The engineering and hydrographic work are no more important to the irrigation survey than the topography. They are all a means of finding out what is essential to the location of reservoirs and dams. It seems to me if you object to one, you must object to the other.

Senator GORMAN. Take this survey you have made. What would be the difference in the cost to the Government between using your topographic map for geological purposes and the one which includes irrigation as well as topography?

Director POWELL. One map serves both purposes.

Senator GORMAN. What is the difference in the relative cost of producing those two maps?

Director POWELL. That which is necessary to be done for irrigation purposes, over and above what is necessary for geological purposes, would not exceed 1 per cent.

Senator GORMAN. It would not be more than 1 per cent?

Director POWELL. No, sir.

Senator REAGAN. All that would be necessary would be to narrow the contour lines?

Director POWELL. No, sir; that is not necessary. The only additional work is the running of the gradients of the streams with accuracy.

Senator GORMAN. So that in this arid country you think it would be wise to make the appropriations to include both?

Director POWELL. Yes, sir. I do not think we ought to do the work twice. By my method when it is done for one purpose it is done for all.

Senator GORMAN. I would like to ask you, in view of what Mr. Johnson has said, why is it, in pursuing this inquiry, if the geological survey was absolutely necessary to economy and results, that you put the engineering parties into the field prior to the completion of the topographic work?

Director POWELL. I have explained that to the committee heretofore, but I will explain it again. Four or five weeks ago I explained to the committee that in the Arkansas Valley I knew of some reservoir sites, so that it was not necessary to have a topographic survey to discover what was already known. I knew that Twin Lakes was a reservoir site, and I knew of others. I had been studying that country for twenty-two years. I was at Twin Lakes twenty-two years ago.

Senator JONES. You had a topographic map of that country in your head.

Director POWELL. Yes, sir; I knew certain sites, and I said to my engineers, "We will not wait a year for a topographic map, but take the sites we now know, and examine them while the topographic corps is discovering the remainder." So I sent a small engineering party to make plans of those reservoirs, the sites of which were already known or supposed to be known.

Senator GORMAN. Is that the case with every engineering party that you sent out?

Director POWELL. Yes, sir. When we sent out an engineering party we knew much of the special ground it was going on.

Senator MOODY. Then for irrigation purposes you could have saved this $57,000.

Director POWELL. No, sir. Only a few sites were known and many had yet to be discovered; the topographic work had to be done to discover them and to find out how much water could be furnished by the several catchment areas, and to discover canal sites, dam sites, etc.

The CHAIRMAN. This engineering work for the purposes of irrigation only needs to proceed as the settlement of that region requires it. It does not need to be done in a day, because the land can not all be occupied in a day. As I understand you, the engineering party proceeds in advance of the topographers where reservoir sites are already known. Now, what is the difficulty in allowing the topographic survey to go on, and permitting the engineering to proceed independently of it? Must the engineering survey, particularly in localities where they want the water immediately, be retarded by waiting for the topographic survey, or may the engineers go on, using what topography you already have, and survey the known basins, make estimates, and let the people use them?

Director POWELL. Let me explain. There are two things that must be determined before the ultimate plans for construction of works can be approved and published to the people. We have got to know what water is to be controlled. If we make an error in that the whole thing is disastrous. If we plan a reservoir site and have not the data before us so as to know how much water has to be controlled for that reservoir site, the reservoir may be constructed, and the first great storm that comes along will destroy it, sweep it out. We must know what that drainage area is, what the supply of water is. That can not be determined by any other method than the one which I have adopted in less than ten to twenty years. I have done it by topographic methods in part. I have explained to the committee how I determined that. It is impossible to do it in any other way as quickly or as cheaply. Second, if we do not make a topographic map, we can not make reports until the end of a series of years after the streams have been gauged. Then, by taking the other method we make it cost five times as much, as I have already told the committee.

The CHAIRMAN. Do you mean to say that nothing can be done until the topography is complete in each?

Director POWELL. Let me illustrate. We can not put on the roof [illegible] a house until the walls are built. We can not erect the walls until the foundation is laid, but while we are laying the foundation we [illegible] haul the bricks and cut the shingles. For each particular basin or reservoir we must have the complete topography before we can report upon it. Suppose there is a little stream which will furnish 10,000 acre-feet of water in a year. I must know the drainage basin of that stream before I can plan that reservoir and know that there is 10,000 acre-feet of water to be controlled.

The CHAIRMAN. That is the work of your engineer, is it not?

Director POWELL. No, sir. No railroad manager would put the freight system, the passenger system, the ticket system all under one man. A house-builder does not employ the same man as a mason, a carpenter, and a plumber. My men are all engineers, but I have classified them, putting one class of work into one man's hands, and another class of work into another man's hands, so as to get the best work from each.

The CHAIRMAN. Then, I understand the work you have done in those localities where the topography has not preceded will be useless?

Director POWELL. No, sir. I shall have the topography ready for those districts before the plans are completed and the reports made. In two or three months the topography will be ready, and we can then tell what water the works will have to control by using the gauging of typical streams. The final report on the reservoirs of a stream can not be made until they have the topography. The engineers can not make their recommendations until they have. The work done in splitting the shingles for a roof is not lost, though it be done while the workmen are laying the foundations.

Senator GORMAN. Was the destruction of the dam in Arizona the other day caused by a disregard or lack of knowledge of these things?

Director POWELL. Yes, sir; the same as at Johnstown. They had miscalculated the amount of water they had to control, and when the storm came the dam would not hold the water.

The CHAIRMAN. Do you not think it was because there was not a sufficient waste-weir?

Director POWELL. My idea is that the dam at Johnstown was a good dam.

The CHAIRMAN. Had it a waste-weir?

Director POWELL. It had one but it was not large enough, for they had improperly computed the amount of water which had to be controlled.

The CHAIRMAN. Is it not easy to make an ample allowance

Director **POWELL**. Yes, sir; if you know what that ample allowance should be, but suppose you do not know.

The **CHAIRMAN**. In torrential streams it would seem to be best to leave as much waste-way as before the dam was constructed.

Director **POWELL**. There is something more on that point. There is no use of building a dam to control 50,000 acre-feet of water if the basin is not going to supply it. I want to know how much water is going to come down, and the way to get that hydrographic information is by using the topographic survey. There is no other way of doing that except at great expense. Every gentleman who has spoken on that point here has said it would cost from four to ten times as much to do it by other methods than that adopted by me. My own judgment is six times.

The **CHAIRMAN**. In gauging streams you gauge the actual amount of flow?

Director **POWELL**. Yes, sir.

The **CHAIRMAN**. You take the gauge of one stream and use that as a basis for other streams in the same locality?

Director **POWELL**. Yes, sir.

The **CHAIRMAN**. You do not use any topography in gauging streams?

Director **POWELL**. No, sir.

The **CHAIRMAN**. And the gauging of streams under any system would be expensive.

Director **POWELL**. If I want to know how much water will run off of twenty-five roofs, I find how much runs from one roof, and then multiply——

The **CHAIRMAN**. Your explanation of that was very good, and I appreciate the advantage of that method. Would not the experience of people living on a stream indicate——

Director **POWELL**. It is a very dangerous thing to depend upon the experience of people for the data necessary to plan engineering works. Ignorant guessing will not do.

The **CHAIRMAN**. You can not rely upon it; but you can see the marks from floods, and gain some information from the experience of the people who live on the stream. As I remarked yesterday, the storms in that country have had no parallel since 1861-'62, twenty-nine years ago.

Director **POWELL**. We are very fortunate in having a wet and a dry year together, and all over that country I have taken advantage of that, and have been gauging the typical streams. Something was said the other day by Professor Thompson about the maps made by other engineers in California and I have brought the maps of California with me.

Senator **GORMAN**. I would like to have, for my own information, a little more light on the question the topographer in charge of the Arkansas Basin brought up, as to the administration of office details. He states distinctly that in that case, where the engineers were put into the field to locate the reservoirs and so on, their work was retarded, and its expense greatly added to, because the topographic survey had not been made. Now I understand you to say that you had general knowledge of that particular locality. I would like to have further information about it, and I will ask you whether it is not an absolute necessity to stop the engineering surveys until the topographic map is made.

Director **POWELL**. The actual surveys of the reservoir sites themselves should follow the topography. Last year they could have done so, for I had topography in other districts; but they did not go into th districts in which I had topography already collected for a very potent reason.

Senator MOODY. What is that reason?

Director POWELL. I am proceeding to give it. The people of the Arkansas Valley were in conflict about water rights. It is a country that is densely settled, and they were suffering for water, and I thought it was wise to go and give speedy relief. So I went to the Arkansas Valley. The legislature of Nevada had made an appropriation to construct irrigation works, and they wanted to know where to put them, and I went there to solve the problem as soon as possible. So, in all the work I did, I went into densely populated districts, where the problem was pending over the people, believing the people were anxious for the information at once; and I attempted to get that information in the best way.

Senator GORMAN. Then it was the local pressure that made you pursue a course which was not economical?

Director POWELL. Yes, sir; not the solicitation of individuals, but the pressure that came from a knowledge of urgent wants of the people. But these urgent wants were represented by governors, by members of legislatures, by boards of trade, and leading men of the country. There are certain districts of country in the arid region already highly developed by settlement, and where the water supply of the smaller streams is already used during the season of irrigation. In these districts the people desire to know how to control the greater streams, and especially how to store the surplus water, which is very great, and I went into those districts where the problems were pressing for immediate solution. In those districts I already knew some of the facts, but not all, and I acted upon the basis of facts known. I knew certain reservoir basins, and I said, "We will go on and get the information about these basins and supplement our work by the topographic information which we are already collecting," for the topographic survey preceded the engineering survey by about seven months.

For a year or two past there has been excessive drought in the arid region and large areas of crops have perished by reason of them. In those districts the people wanted early information and I believed it was wise to give them that information and adjusted the work to the conditions existing. In entering upon the work I believed that some loss would be entailed, but that it would be entirely insignificant in comparison with the good that would be done. One of the places which I entered upon was the valley of the Rio Grande above El Paso, because the people in the valley had had their agriculture destroyed. The values involved amounted to millions, and I took up the problem to see what could be done to save those people, and have discovered a practical solution, and it has already been presented to this committee and to a committee of the House, and that conclusion has received the approval of both committees and they have introduced bills in both Houses to apply the remedy proposed. I might have proceeded by the other method to solve the problem in the same manner with a saving of $1,000 or $1,200, but a speedy solution of the problem seemed desirable and I shouldered the responsibility.

Senator GORMAN. Then, I understand that in the administration of this trust, if appropriations are made hereafter, you will complete the topographic maps before putting the engineers at work.

Director POWELL. Yes, sir. I shall have enough topography this year to employ my engineers for the next year.

Senator **JONES**. Has there been any waste of money in the location of such reservoirs as you have located?

Director **POWELL**. If we had had our topographic survey finished we would have had less lines to run and would have saved something thereby.

Senator **GORMAN**. What was the difference in the Arkansas Basin between the cost of making the survey in the way you made it and making it after you had the topography?

Director **POWELL**. It cost $1,500 or $2,000 more than it would have cost if done the other way.

Senator **GORMAN**. What was the total cost of the engineering party in that basin?

Director **POWELL**. I think about $19,500.

The **CHAIRMAN**. Has the work been completed?

Director **POWELL**. Only on certain reservoirs. The great body of the engineering has yet to be done, and the engineers will proceed with it with the maps in their hands, and do it right, and reach results that can be given to the people with confidence because all the facts will be discovered by the topographic survey.

The **CHAIRMAN**. I mean the topographic survey of the Arkansas Valley.

Director **POWELL**. It has been completed nearly to the one hundredth meridian.

Mr. **THOMPSON**. It is completed to 101.30.

The **CHAIRMAN**. What proportion of the Arkansas Valley has been completed?

Mr. **THOMPSON**. I am speaking hastily, but I should say that of the Arkansas Valley out to the State line, about four-fifths has been completed.

Director **POWELL**. Now, Mr. Chairman, you have seen that we are making topographic maps for the irrigation survey, and the reasons for making them have been given. It has also been explained that the same maps are to be used in the geological survey. The maps are made once, and only once, and serve both purposes. In other regions we are making the same kind of maps on the same scale for geologic purposes and the geological survey is going on in some regions where irrigation is necessary and the maps which are made for the geological survey serve both purposes. The irrigation-survey maps are all that is necessary for geology as well as irrigation; the geological-survey maps are all that is necessary for the geological survey and the irrigation survey. In another region of the plains we are making topographic maps for the geological survey, and I have brought them with me. You will see, as I spread them before you, that they are made on the same plan as the others and on the same scale, and in like manner reveal the storage basins. Here in Kansas is one of the finest storage basins we have ever discovered on the plains, and it has been discovered by the topographers of the geological survey. The topographic work had to be done for the geological survey, and in making these discoveries they added substantially nothing to the cost of the work. I wish, Mr. Chairman, to make it clear that the topographic survey is done but once, and then done for both purposes. I have explained this matter to the appropriations committee and you will find it in the report of that committee which I hold in my hand.

The **CHAIRMAN**. Was that map made previous to the irrigation survey?

Director **POWELL.** It was made last summer, at the same time that the irrigation topography was in progress in another region.

Senator **MOODY.** You are making maps by the irrigation survey which can be used in the Geological Survey?

Director **POWELL.** Yes, sir. All the maps made by the irrigation survey will serve for the Geological Survey, and all maps made for the Geological Survey will serve for the irrigation survey. [Refers to map.] You see here is the Arkansas River. Here is a little basin, 5 miles from the Arkansas River, at about the ninety-ninth meridian. This is in the subhumid region. We are pushing the topography for the Geological Survey in the subhumid region and pushing the irrigation survey in the region to the west.

Senator **MOODY.** [Indicating on map.] Is the water taken out there?

Director **POWELL.** Yes, sir; it is taken out there. We can create a lake there [points], and there is low land lying along there to which the water can be conducted.

The **CHAIRMAN.** Is there anything else you wish particularly to present?

Director **POWELL.** I have not yet had twenty minutes in which to make a clear statement of the case. If I could have twenty minutes I would like very much to have it. I have been so frequently interrupted that I have drifted everywhere.

Senator **MOODY.** Still you have given us much information, and it is always a good thing for us to suggest questions, because then you know what is running in our minds.

The **CHAIRMAN.** Could you condense what you have to say and send it in writing?

Director **POWELL.** I can.

The **CHAIRMAN.** Do that, and bring it in.

Director **POWELL.** I will attach it to my statement. If the committee want opinions about this matter I should like to have the Superintendent of the Coast Survey brought here. I want to say to you that I had selected the present Superintendent of the Coast Survey to take charge of this work. He had the matter under consideration when the President offered him the position he now occupies. He is one of the best hydrographers in America.

The **CHAIRMAN.** What is his name?

Director **POWELL.** Mendenhall. He is familiar with the problem, and has discussed it with me.

The **CHAIRMAN.** I think we will call him. I would like to hear what he has to say.

Director **POWELL.** If you will address him a letter, asking him whether my method, with which he is familiar, is the most economic, most thorough, and most speedy, I think he would answer.

Senator **MOODY.** Is there any necessity for topography for the surveys you make out on the plains?

Director **POWELL.** Whenever I am allowed I want to present to you the question of what kind of a survey is needed on the plains; it needs a slightly different survey from that of the mountain region.

Senator **MOODY.** Can you state, in a general way, whether there is any necessity for the topographic survey?

Director **POWELL.** Yes, sir; it is chiefly topography on the plains. Professor Thompson told you that the British Government has made a topographic survey in India. That government has covered much of India with a topographic survey, and I can bring you many volumes of the reports of that survey. Everywhere in the civilized world, with-ut any exception, they make topography the basis of an irrigation survey—in Italy, in Spain, in France, the French in Algeria, the Russians n their arid regions, and the British Government in India and the French and English engineers in Egypt, and I have specimens of the naps which they made with me if you wish to see them.

The CHAIRMAN. Suppose the engineers took the same instruments hat you use, what would be the difficulty of their making the topographic survey that would be necessary for their work in the same nanner that you make it preliminarily, but on a smaller scale, to ascertain where to locate their ditches, and all that?

Director POWELL. None at all if on the same scale; if on a smaller scale it would not serve the purpose. But I would not take the man who is to stand by the river gauging the water and break up his work by sending him away to discover reservoir sites or canal sites or the area and declivity of drainage basins. He has all the work that he can do on the rivers in measuring their flow. I would not take the man who is to plan the dam and have him measure a river 20 or 30 miles away, and hunt a canal site perhaps 20 or 30 miles away in another direction. I would divide the work among skilled men, so that each one should do his part in the most economic and thorough manner. All the men are engineers, all doing work of the irrigation survey, but the work is divided among them on the economic principle well known as the division of labor. On a railroad one man is not ticket agent, freight agent, engineer, brakeman, and surveyor, but the work is divided among the men, and each takes his proper part. So in the irrigation survey, the work is divided among the men and each takes his proper part, one to do topographic work, one to do hydrographic work, and one constructive work.

Mr. Chairman, you have already received statements from myself and my assistants of the amount of money allotted at the beginning of the season to the topographic work, the hydrographic work, and the engineering work, and you have learned that a sum of money was reserved for subsequent contingent expenses. That reserve fund has been chiefly used in two ways: the engineering and hydrographic work has been strengthened in some places, and a small amount has been used in that manner; but the principal part of the reserve fund has been used in making segregations of land as required by the statute. Everywhere throughout the country it has been found that the people were anxious that these segregations should be made at the earliest possible date.

The statute reserves them from the 2d of October, 1888, the date of the signing of the act, even though the selections are not made until some time later. Whenever they are made the date of reservation is the 2d of October, 1888, and there were two reasons why the people wanted these segregations made rapidly, first, that they might know what lands were withdrawn from occupation and sale under the desert land act, timber land act, and pre-emption act, and which could be settled only under the homestead act; second, they are exceedingly anxious that reservoir sites and canal sites should be withdrawn from sale that they might not fall into the hands of individuals for speculative purposes, and a great pressure was brought upon the Director of the Survey to make these segregations speedily, and the work was carried on with all the vigor possible. A great number of reservoir sites, such as mountain lakes, etc., already known, were re-examined through the aid of the Land Office plats and from the general geographic information in the possession of the Survey; and such sites were certified to the Land Office as being reserved under the provisions of the statute. The general information in the possession of the Survey also indicated that certain great tracts of land should be reserved under the statute. A reconnaissance of such lands has been made, the Land Office plats examined, and 30,000,000 acres of land have been selected for final examination in the Land Office, so as to exlude all lands on which legal filings have been made. In one case, on Bear River, in Idaho and Utah, the people were in conflict, and the governors and people petitioned the Secretary of the Interior asking that lands in that region should be protected from occupation at the earliest date as important reservoir and canal sites were being occupied, and the Secretary of the Interior, while I was in the field, telegraphed me a peremptory order to send officers to that region and make the necessary segregations, and it was done.

For more than twenty years I have been conducting explorations and surveys in the arid lands. During the first year of my work in that region my attention was directed to the arid land problem, and from that day to this it has been my chief study. My field of study has been threefold: First, I have studied the lands themselves and the waters which are to supply them, and the forest areas on which they are dependent. Then I have studied carefully the practice of irrigation in the United States, and much of it has grown up under my eye until 8,000,000 acres of land are now under canals in that region. Then I have provided myself with the literature relating to irrigation, especially the engineering literature. From all of these sources, and aided by counsel and advice from my assistants who are able men, I have gradually developed a system of survey of the arid lands. More than fifteen years ago I commenced the gauging of streams. More than fifteen years ago I commenced the selection of irrigable lands tentatively, and thousands of people—scores of thousands—have settled on lands selected by myself and under my advice, given through the agency of maps and reports.

The conclusions which I have reached are not hasty, for I have given to the subject the best thought and energy of my life. In the solution of these problems two men have been most intimately associated with me and they have been considering them to a greater or less extent for many years. I refer to Mr. Gilbert and Mr. Thompson. We have sometimes disagreed about practical methods, but ultimately we have arrived at substantially the same conclusions. And the plan which I have submitted to the committee and which I previously submitted to the Congress is the outcome of all that study. The theory was to make a practical survey at the smallest expense which would give the greatest amount of information to the Congress and to the people actually engaged in irrigation, and to do the work not in the interest of particular individuals or of corporations, but for all of the people; so that if the farmers were to control the waters for themselves they would know how to do it in a thoroughly economic manner, and if they were to engage corporations to do the work for them they would have the necessary information to make their contracts with intelligence.

I have witnessed the wasteful expenditure of much labor and money aggregating millions of dollars. I have witnessed the granting of rights to companies to furnish water that were improvident and I have witnessed the reaction from these unwise contracts expressed in conflict with the water companies and expressed in unfriendly legislation and local regulation by which improvident rights once granted were destroyed. It has been in view of all these facts that the establishment

water rights where they were improvident and wasteful, the growth
the vast system of conflict from water rights which now exist, the
pairment of the catchment areas of water by the destruction of
rests, and the many other problems which I have already presented
the committee, that the legal, industrial, and engineering problems
ve all been considered, and I have for years been gathering all these
cts and from time to time have been presenting them to the Congress.
nd the survey which I have gradually developed has been the chief
gency for the accumulation of facts for the people, and as finally organ-
ed, was intended to assemble them completely and thoroughly in
ch a manner as to be of the greatest utility to the farmers them-
lves and to be of the greatest value to the States and to the General
overnment in the regulation and establishment of rights under this
ew industry.

It has seemed to me that by far the most important thing to be done
the interest of the people was to make a topographic map on which
ould be assembled in a graphic manner the principal tracts to be con-
dered. I have, therefore, in the management of the early explora-
ons and surveys, and later in the conduct of the geological survey,
oroughly represented the purpose and importance of the topographic
ap, and the subject has been examined by a joint committee of the
wo Houses and met with its approval. It has also been considered
om time to time by the appropriation committees and moneys have
een granted for its construction. When a more speedy and special
urvey was demanded and the statutes required that the lands and sites
hould be segregated and the works planned and the cost thereof es-
imated, I stated that the basis of the work would be a topographic
ap; that the map which we were making in the geological survey
r its purposes would serve the purpose of the irrigation survey as
rdered by Congress, but that to wait for these maps much time would
e consumed; that as the work was then in progress it would take
bout thirty years to complete it, and that if it were desirable to prose-
ute the irrigation survey speedily it would be necessary to do the top-
graphic work for the irrigation survey, and that the maps then con-
tructed would serve the purposes of the geological survey; that topo-
raphic work must be done for each and both purposes, and if done for
ne would be done for both.

With this understanding the appropriations for the irrigation survey
vere made in terms requiring the preparation of the maps used—in the
ame terms that required the preparation of the map for the geological
urvey. The law, therefore, authorized the survey on the plan which I
ad recommended to the Congress and it has been faithfully pursued
according to that plan. I represented, before the appropriation was
made, that the map was necessary and the appropriation was made in
terms authorizing its preparation. The question now arises, Was that
plan wise? Is it the most accurate, the most economic, and will it give
results to the people in the shortest time? My views on this matter
have already been presented in part, but in a desultory manner from
the fact that they appear in interlocutory form and often complete answers were not possible. I therefore desire to make a summary statement of the necessity for a topographic survey as the basis of an irrigation survey.

Under the survey I have to discover diverting dam sites, reservoir sites, irrigable lands, and canal sites from streams to reservoirs and from reservoirs to lands. All these are called for in the act. Some method of discovery, then, must be adopted. To guess at them by riding over the country and then testing the guesses by trial lines is a very expensive method. It costs on an average $25 per mile to run a trial line on the ground. Altogether hundreds of thousands, perhaps more than a million of miles of trial lines would have to be run if this method were to be adopted, and the average expense of running a trial line, as shown by the experience of railroad companies in this country, is about $25 per mile. But I had already demonstrated that a cheaper method could be used. I had superintended the conduct of topographic surveys for several hundred thousand square miles and found that railroad engineers could use those topographic maps and save the expense of trial lines. They could take a topographic map and select a line and survey that one alone for construction purposes, and this is now the practice of railroad engineers everywhere throughout the country where our maps are made.

Let me illustrate the economy of this method by a single instance: The Canadian Pacific Railroad ran trial lines which cost $3,000,000, and then built the road along a route which was not the best, and then changed the route over part of its course; and it is now discovered that the best route was still not found. Had a topographic map of the country, 200 miles in width from the eastern terminus to the western terminus, been made it would have cost much less money and the best line would have been revealed and a great saving would have accrued, and the map thus constructed would have served the purpose of all the tributary lines within the district and the purposes of a geological survey and everything else for which topographic maps are needed.

I have stated to the committee, and have made the statement after a careful consideration and years of study of the special problem, that the trial-line system for the discovery of lands and sites would cost three times as much as a topographic map system and when completed it would be less satisfactory. But if the topographic system were adopted it would not only be cheaper and more satisfactory for the purpose, but it would also serve the purpose of the geological survey and all other purposes for which topographic maps are used.

But the use of the topographic survey does not end here. There is yet another use of the topographic branch of the work equally important with the one already given and which would require it to be done were there no other reason for it. I refer to its use in the hydrographic survey. The arid region is naturally divided into many thousand distinct drainage areas, each one of which must be considered separately in planning irrigation works, as each one is a catchment area for the water which is to be controlled and used in irrigation. That the waters in each basin must be measured in some manner is manifest for the following reasons: First, if works are to be planned the amount of water to be controlled by the works must be known in each case. The dams to divert water should not be too great, nor too small; if too great an unnecessary expense is incurred, if too small the entire catch may not be secured. For the planning of dams also it is necessary to determine the volume of the maximum flood. All this requires a knowledge of the mean annual volume, the minimum annual volume, and the maximum annual volume, and the maximum flood volume. Again, if canals are planned they should be neither too small nor too large; if too small they can not perform the service, if too great they are made too expensive. Again, the gradients of the canals must be determined, and this depends upon the amount of water which they are to carry. If the volume is small the gradient must be large, if the volume is large the gradient must be comparatively small. Then the reservoirs are to be planned.

For this it is necessary to determine the amount of water which can be stored. It would be unwise to plan reservoirs unnecessarily large for the service, or ~~so~~ small that they would not perform the service. How, then, shall these waters be measured? Now, experience and long observation make it manifest that the gauging with meters and nilometers of the waters of each of the many thousand districts could be done only at a great expense.

But a careful investigation of the subject had already revealed another method, and when its cost was computed it was believed by myself to be about one-sixth of the cost of direct gauging. This method has already been fully explained to the committee. It is proposed to use the facts gathered in the topographic survey necessary for the other purposes, and to gauge a few typical streams with great accuracy and to derive from these factors and the general rain-fall tables in differing latitudes, longitudes, and altitudes a system of formulæ by which the water supply can be computed for each district. Thus it is proposed to solve the problems in part by experimental demonstration and in part by computation. I believe that by this method hydrometric results can be obtained superior to the results by direct gauging, and it can be done for a very much smaller amount, making a saving equal to twice the cost of the topographic map. It is thus that the topographic method of doing the work as compared with the trial line and direct gauging method will cost only about one-fifth of the amount which those methods would cost. If, therefore, it is considered that it is the most accurate and the most economic method, it remains to be shown that it is the most expeditious. This will appear from a consideration of the following conditions: A number of typical streams are gauged, the maximum rain-fall of any special stream may not be found without taking the observations for a long series of years, but of a large number of streams widely distributed throughout the country. Maximum and minimum volumes will be repeated now here, now there, now elsewhere, from time to time. We thus are able to get this maximum and minimum in a few places in a comparatively short time, and by the use of the method which we have adopted of measuring catchment areas and their declivities we can easily determine the general extreme conditions in each case without waiting for the long period of time to elapse. It is thus clear that results can be obtained in a much shorter time by the method adopted. It was therefore believed to be more accurate, more economic, and more expeditious.

It must, then, be remembered that the topographic work must be done anyhow for the geologic survey. That question has already been examined at great length by Congress and approved, and the law directs it. Whatever is done for the irrigation survey is thereby saved for the geologic survey. But it seemed to Congress that the irrigation survey should be pushed forward more rapidly than the geologic survey, and therefore the expense of the map is charged to the irrigation survey and paid for out of the appropriations made for that work, except in those regions where the geologic survey is in progress: there the maps constructed are used for the irrigation survey.

There is yet one other question in this connection which has been raised in the committee and which deserves complete answer. It is this: Would it not be possible to do a little work in each district from year to year, just enough to meet temporary wants, but to supply those wants fully? Of the thousands of districts which I have mentioned, there is no one which is not already settled, there is no one which does not already require the information which this survey will give. It is not possible to do a part of the work in any one district and leave the whole unfinished and properly utilize that work. The entire district must be understood, surveyed, all the facts obtained, before any proper plan can be presented. Each such district must be completed before results can be reached which will be of value to the people and serve their needs. But more, it is sometimes the case that two, three, or more adjacent districts which lie in one great river system are interdependent; that is, they are so related that the problems in one can not be solved without at the same time solving the problems of the others. There will, therefore, be many cases where several districts, each having a distinct system of works, will have to be completed together. As the work of the whole arid region can not in all probability be done all at one time—because it can not be hoped that appropriations will be made for it in that manner, and if made it would be difficult to find the trained necessary officers and difficult to administer—there remains only the policy which has already been inaugurated, of selecting those districts where the problems are most pressing for immediate solution and of taking them in their order according to the best judgment of the officer who has charge of the work and administers the trust.

In conclusion, Mr. Chairman, I crave permission to earnestly urge the importance of doing this irrigation survey work in the most thorough manner. The extent of the area to be redeemed is involved in the question. If the work is well and properly done the greatest area can be brought under agriculture; if carelessly and badly done a much smaller area of agriculture will ultimately be developed. The relative cost of the construction of these works is also involved in good or bad work. If the work is badly done it may easily cost two or more times what it would if properly planned. This means ultimately differences of many hundreds of millions of dollars in all; and there is yet another consideration: All the waters of 1,500,000 square miles are to be used in irrigation; all the rain that falls from the heavens above those lands; all the waters that run in the brooks, creeks, and rivers. These waters are enormous, almost inconceivable powers, and they are to be controlled. It is possible to store these powers so that they will forever be a menace to the people whose agriculture will depend upon them. India, in which the waters have been stored for many centuries, is covered with breached reservoirs; and the problem of making these reservoirs safe for the people is considered the most important problem presented to the British engineers in India. That same problem is committed to the survey under my charge, and I think I have some realization of its magnitude. The officers associated with me in the work feel like responsibilities, and I must beg of you not to diminish that responsibility by prescribing methods of procedure in the work which must necessarily result in the preparation of plans with insufficient data, and in leading the people who construct the works astray, and submitting their property—their fields and homes—to imminent destruction and putting them in peril of their lives.

Mr. Chairman, for the long and patient hearing which you have given me I can only express most profound thanks.

NINTH DAY'S SESSION.

WASHINGTON, D. C., *March* 28, 1890.

The committee met at 10.30 o'clock a. m. Present, Mr. Stewart (chairman), Mr. Plumb, Mr. Moody, Mr. Jones, and Mr. Reagan.

STATEMENT OF SUMNER H. BODFISH, DIVISION CIVIL ENGINEER, U. S. IRRIGATION SURVEY.

The CHAIRMAN. What is your occupation, Mr. Bodfish?

Mr. BODFISH. I am an engineer in the Geological Survey, engaged in the irrigation division.

The CHAIRMAN. Were you engaged during last year in the irrigation work?

Mr. BODFISH. Yes, sir; I was engineer of the Arkansas division.

The CHAIRMAN. Will you state what use you were able to make of the topographic survey in the surveys which you made in the Arkansas division last year, and also state what necessity there was for such a survey in connection with your survey?

Mr. BODFISH. I have had no maps of the topographic survey in condition to use yet. The party has not yet finished its maps, as I understand.

The CHAIRMAN. Are topographic maps necessary for your engineering work in surveying for irrigation?

Mr. BODFISH. They are not absolutely necessary. If I had good topographic maps they would be very useful.

The CHAIRMAN. Can the engineering survey be carried on in advance of the topographic survey? In other words, can an engineering party do what topographic work is necessary for the purposes of irrigation?

Mr. BODFISH. I think it can. I think the topography should be under the immediate direction of the engineer, and such limited topography as——

The CHAIRMAN. What topographic work is necessary for irrigation purposes? Explain briefly how you carry on your engineering operations, to what extent you go into topography, and what use you make of it.

Mr. BODFISH. The irrigation problem, as I understand it, is simply stated: The first step is the discovery of a location for storage; second, the amount of water that you can store at that locality; third, the cost of storing that water, building reservoirs, etc., and fourth, the means of distributing the water over the country below and the cost of distributing it. In determining the location of a reservoir, if good topographic maps were in existence, they could be utilized, first, in a negative way, by keeping one from looking for a reservoir where there is great improbability of finding it; but as most of the reservoirs must be found on the streams and not off of them, it is better, in my opinion, for the engineer to search all streams, because unless a topographic map is made with great detail it is not possible to delineate everything in that map that might be utilized as a reservoir; this would be true, especially of a small one. The engineer himself should search every stream for the reservoirs, and having ascertained where they are, then make the necessary surveys for determining the amount of water that can be stored, and for estimating the cost of construction. Then he has to determine the amount of water that can be obtained there. If he knows the rain-fall, the topographic map would be of some assistance to him; but from the map alone it is impossible to positively determine the run-off; the true way to determine the run-off would be to measure it at the point where the reservoir is to be located.

The **CHAIRMAN.** Must you necessarily go into detailed measurements at all places you build reservoirs, in order to ascertain the run-off? Is it necessary to obtain the details with that degree of accuracy?

Mr. **BODFISH.** No, sir; because the necessities of the reservoir site would not require it. He can judge from the appearance of the stream at the time he is visiting it, by the high-water marks, or by talking with the inhabitants, or by comparison of the drainage areas above that reservoir site that he finds on maps, whether it is possible to build that reservoir. If it is a doubtful case, whether he shall build a great or small dam, it is a question he must make a careful examination to determine.

The **CHAIRMAN.** With regard to the construction of reservoirs on streams that are violent and torrential in flood times, what circumstances does the engineer take into consideration to determine what kind of a dam it is safe to build?

Mr. **BODFISH.** In almost all of those streams that are torrential there are high-water marks, because the torrential currents are so swift that they leave a mark; so he can determine whether it is a stream of that character.

The **CHAIRMAN.** Can he, from the declivities of the surrounding hills, without actual measurement, approximate the rapidity with which water will be forced against the dam in flood time?

Mr. **BODFISH.** I do not think he can.

The **CHAIRMAN.** He can not do that?

Mr. **BODFISH.** Not very accurately.

The **CHAIRMAN.** Then it is not ordinarily safe to build dams in these large torrential streams?

Mr. **BODFISH.** No, sir.

The **CHAIRMAN.** When you go into a stream like the Arkansas to build a dam high up, where it is torrential in flood time, how do you avoid the danger, and when you do build one, what precautions do you take?

Mr. **BODFISH.** If you do build one, the precaution would be to make it an overfall dam. The building of the dam would depend on the amount of water it would have to carry. If the stream is a rapid-falling stream, as is usually the case in those regions, the chances are very few of finding a good reservoir site; but you might find a gorge with a comparatively flat basin above, where you could store the water at a sufficiently low cost to warrant the construction of a high overfall dam.

The **CHAIRMAN.** Is it not sometimes possible to build dams in such places and turn the water over the rocks and give it as large a waterway as it originally had?

Mr. **BODFISH.** Sometimes; but I should say it is rarely possible.

The **CHAIRMAN.** In that country will not most of the dams necessarily be built out of the main stream?

Mr. **BODFISH.** In the Arkansas Valley?

The **CHAIRMAN.** Yes.

Mr. **BODFISH.** As far as I have become familiar with the Arkansas drainage basin, the reservoir sites are found on the streams.

The **CHAIRMAN.** Are there lakes on the streams which indicate reservoir sites?

Mr. **BODFISH.** Most of those I have found on the Upper Arkansas have been caused by glacial action. They have been caused by the terminal moraines across the original drainage lines. They have been natural basins in the past. Farther down the stream there are a few small ones that have been made by the washings-in from side gorges into the larger cañon, making banks between which you might build. Those are dangerous localities to build in, however; the foundations are precarious, and the large cañon, as a general rule, falls rapidly.

The CHAIRMAN. In utilizing these rivers, which class of reservoirs do you recommend the construction of first?

Mr. BODFISH. Those built on the streams.

The CHAIRMAN. They are much more expensive, are they not?

Mr. BODFISH. Well, that is to be determined. I have not seen the others yet.

The CHAIRMAN. You have not seen any except those which are on the streams?

Mr. BODFISH. No, sir; all I have found are on streams.

The CHAIRMAN. If you could find sites higher up, where the reservoirs could be constructed cheaply and safely, would it not be well to commence there and make your cheap reservoirs first?

Mr. BODFISH. I must say here, that the area that I have prospected over lies within the mountainous district.

The CHAIRMAN. I am speaking of the mountain district.

Mr. BODFISH. In the Arkansas Valley mountain district reservoir sites off the streams do not exist. It is a rapid-falling stream, and all of its tributaries are rapid-falling streams.

The CHAIRMAN. When you have surveyed and finished your work in the mountain regions, what surveys do you make for the purpose of ascertaining ditch lines, so as to show what lands will be under water when the works are constructed?

Mr. BODFISH. If the water is taken out of the streams directly below the mountain region, a trial line—what I would call a "fly" line—would be run from the point from which we wished to take the water out.

The CHAIRMAN. Would a topographic map be sufficiently accurate to enable you to dispense with that "fly" line or trial line?

Mr. BODFISH. If it was a good topographic map, well constructed, we might in some places dispense with the trial line.

Senator MOODY. You mean if it was a topographic map that was constructed under the supervision of an engineer, as an engineer would construct it?

Mr. BODFISH. Yes, sir.

Senator MOODY. It would have to be such a map, and not a mere topographic map—a map of the surface?

Mr. BODFISH. A general map of the surface may be good for general purposes, but not for specific purposes.

The CHAIRMAN. What proportion of the work on the Arkansas, for example, would be dispensed with if you had a good topographic map to begin with? How much cheaper would it be to make the irrigation survey if that preceded it?

Mr. BODFISH. I do not think it would be any cheaper, sir, in the Arkansas drainage basin.

The CHAIRMAN. You would have to do about the same amount of work at any event?

Mr. BODFISH. Yes, sir.

Senator REAGAN. If you had a topographic survey, would you have to make trial lines the same as you do without a topographic survey, in order to ascertain the extent and character of a drainage basin and to establish the lines for ditches?

Mr. **Bodfish**. No, sir; not necessarily.

Senator **Reagan**. If you would not, how do you make out that it would cost as much to make the irrigation survey with a topographic survey as without it?

Mr. **Bodfish**. As I understand it, a topographic survey means a survey of the whole district within the boundary lines of the drainage area.

Senator **Reagan**. That is what I mean, the drainage area and the country to be supplied with water and irrigated.

Mr. **Bodfish**. Even having a topographic map of the entire area, and even with the rain-fall given, I would not know the quantity of absorption or evaporation on the surface.

Senator **Reagan**. Would you know that by an engineering survey?

Mr. **Bodfish**. I could not determine the run-off of any stream.

Senator **Reagan**. You could not determine that in any way except by hydraulic experiments.

Mr. **Bodfish**. I could determine, by measuring the streams, the amount of water that runs off.

Senator **Reagan**. What I am trying to obtain from you is an explanation of the answer you made to the chairman, that it would not save any expense to have a topographic survey precede your irrigation survey.

Mr. **Bodfish**. If I had to do the same work after the topographic survey was made that I had to do before, it would cost more.

Senator **Reagan**. But would you have to do it?

Mr. **Bodfish**. Yes, sir. As I explained to you just now, I would have to weigh the amount of water that passes a certain point, any way, even if I had a topographic survey of the area.

Senator **Reagan**. If you had a topographic survey, would you not know the drainage basin from that?

Mr. **Bodfish**. Yes, sir.

Senator **Reagan**. Would you not know where you could fix your dam from that?

Mr. **Bodfish**. Not necessarily. It would depend upon how well the map was made. I mean by that, that a map showing 20-foot contours would not necessarily——

Senator **Reagan**. Would you not know the country that would be supplied by irrigation from a topographic map?

Mr. **Bodfish**. Not until I had located the reservoir. If I could not locate the reservoir from the map, I could not tell you what country I could cover.

Senator **Reagan**. How do you get the information as to where you shall locate the dam and reservoir?

Mr. **Bodfish**. By personal inspection on the ground.

Senator **Reagan**. And not a survey.

Mr. **Bodfish**. Yes, sir.

Senator **Jones**. I understood you to say a while ago that a topographic survey would save you from making examinations where it would be impossible to find reservoir sites.

Mr. **Bodfish**. It will in some cases, sir.

Senator **Jones**. Then there would be at least that shadow of difference between the cost of locating works with and without a topographic survey.

Mr. **Bodfish**. If the topographic map shows me the water flows over a drainage line that falls a hundred feet to the mile, it is very little use for me to go there to find a reservoir site.

Senator JONES. It would be no use to go there to look for a reservoir site?

Mr. BODFISH. No, sir.

Senator JONES. If you found that out from a topographic map, even if you could find it without the topographic map, then you would save something by the use of the topographic map?

Mr. BODFISH. Yes, sir.

Senator JONES. Then you do save something by the use of a topographic map in such a case as that?

Mr. BODFISH. I stated that ——

Senator JONES. I understood you to say that there would be no saving in having a topographic map.

Mr. BODFISH. I referred to the entire work of examination and construction and not to special cases. If I have a map of the entire area, and by examining that I can ascertain that there is one-fourth or three-fourths of that area that I need not consider, so much of my time is saved, and even if I had to examine all of those streams, I think personal inspection would cost less than a topographic survey of the whole drainage basin.

Senator REAGAN. If you should make a topograhpic survey on a stream, would you not know from that topographic survey where the narrowest gorge was?

Mr. BODFISH. Certainly.

Senator REAGAN. The facts as to the character of the soil, of course, you get by inspection?

Mr. BODFSH. Yes, sir.

Senator REAGAN. If you know the location of the narrowest gorge which will create the largest basin, is that not where you will locate your reservoir dam?

Mr. BODFISH. Not necessarily.

Senator REAGAN. What would be the exception to that?

Mr. BODFISH. The fall of the stream above, or other facts—whether it will hold a sufficient quantity of water——

Senator REAGAN. You do not take my whole question. I say after you have ascertained your basin by the survey is it necessary to go over that again, or do you suggest the idea of guessing at it?

Mr. BODFISH. I would not send an engineering party there to make a special survey of that reservoir site without having personally visited and examined it to see whether it was represented right on the map.

Senator JONES. If you were making an examination of a given watershed for reservoir sites, without a map of any sort or of any description, would you have to make a personal inspection of the entire territory?

Mr. BODFISH. Yes, sir.

Senator JONES. How would that be made?

Mr. BODFISH. First, by myself riding over the country, or by having some intelligent assistant, to whom I could delegate part of that work, do it for me.

Senator JONES. By simply examining it with the eye?

Mr. BODFISH. Yes, sir.

Senator JONES. Then, when you found the location, approximating, according to your judgment, the conditions required, what more particular examination would you have to make to ascertain the facts in the case?

Mr. BODFISH. I send one of my parties there to make the actual survey and ascertain what different heights of dam are required—how much water different heights of dam will contain.

Senator JONES. What does the party do?

Mr. BODFISH. They make a minute contour map, showing 10 feet of elevation, and they make a careful topographic survey of the immediate location of the dam.

Senator JONES. How would the topographic survey which you would have made by that party differ from the topographic survey as made now under the direction of the geological survey for the purposes of irrigation?

Mr. BODFISH. It is made in the same manner, but with a great deal more detail.

Senator REAGAN. More detail as to the actual place of the reservoir?

Mr. BODFISH. The contour of the basin is shown more in detail.

Senator JONES. The principal work would be at the particular place where you intended to locate the reservoir?

Mr. BODFISH. Yes, sir.

Senator JONES. And the examinations of the outlying ground would be less minute?

Mr. BODFISH. Yes, sir.

Senator JONES. Would those outlying examinations be more minute than the geological survey?

Mr. BODFISH. Yes, sir.

Senator JONES. And you would examine the whole drainage basin?

Mr. BODFISH. No, sir; the whole storage basin—the storage basin caused by the dam.

Senator JONES. You misunderstood my former question. I asked you in the beginning as to whether your examination of the storage basin would be more minute; then I asked you if your examination of the outlying region would be less minute.

Mr. BODFISH. That would not be examined at all.

Senator JONES. You would not examine anything except the area of the lake you intended to make?

Mr. BODFISH. No, sir; but if I could not ascertain from the land office survey the boundary lines of that drainage basin, I would meander it in a crude manner sufficiently to determine what the drainage area was; but I see no necessity of making a topographic survey over that entire area, showing the contour.

Senator JONES. It would make no difference whether that was steep or level, or slightly rolling or anything of that sort?

Mr. BODFISH. Nothing more than my eye would show.

Senator JONES. Then, as I understand you, your idea is that the topographic examination made in connection with the geological survey for irrigation purposes is entirely useless?

Mr. BODFISH. It is not absolutely necessary at all, sir.

Senator JONES. And in the location of the reservoirs, you think all that is necessary is to survey exactly and particularly the location of the lake and nothing else, except to get, in a rough sort of way, a general idea of the size of the drainage basin?

Mr. BODFISH. Yes, sir.

Senator JONES. Without regard to its topography?

Mr. BODFISH. Yes, sir. If I weigh the amount of water passing that point, I can weigh it more cheaply, I can measure its flow and quantity more cheaply there than I could make a survey of the reservoir basin, and then I would know the amount of water passing that point——

Senator JONES. Have you any definite idea what caused the destruction of the Hassayampa dam?

Mr. BODFISH. I have never seen the place, or any good maps of it, and I have no opinion as to the matter.

Senator REAGAN. In the construction of a dam is it a matter of any moment to know whether the drainage basin from which the water is to be collected is precipitous or level?

Mr. BODFISH. Yes, sir.

Senator REAGAN. Do you get that information by the eye or by a topographic survey?

Mr BODFISH. By the eye, sir.

The CHAIRMAN. Is there anything further?

Senator JONES. I would like to ask a question or two. In locating these reservoir sites as you indicate, after you get them located, you then, in selecting a route for ditches to take the water to the land, run trial lines to ascertain the relative elevations of the country, do you not?

Mr. BODFISH. I have to determine approximately the fall per mile that I can give that ditch when making the final survey.

Senator JONES. And would you not also have to find out where it ought to be located?

Mr. BODFISH. That would be part of the preliminary work, to discover that point.

Senator JONES. Would a topographic survey save any part of that expense?

Mr. BODFISH. That would depend upon the accuracy of that survey.

Senator JONES. Of course an inaccurate and worthless survey would not be of any value in any way or anywhere. I was asking with reference to the topographic survey made by the Geological Survey in this matter. The object of this inquiry is this: It has been stated here by certain gentlemen that that portion of the money appropriated by Congress for furthering this survey of the arid lands that has been used for a topographic survey has been wasted and thrown away, and that only that part has been valuable that has been put into the hands of the hydrographers and those doing engineering work as such. Now, what the committee want to know is the opinion of the gentlemen engaged in this work as to the relative cost of obtaining this information by the two different methods. Your way, as I understand you, is to secure the information by going onto the ground and making trial lines. Others think that a topographic map of the entire country facilitates matters. What we want to know is the relative importance of these different branches of the work, and my immediate purpose in asking the question I did was to find whether there would be a saving of cost to your work or the work you did if you had such a map as is being constructed in this matter, to indicate to you where you should locate your lines from the reservoirs to the lands to be irrigated, or whether it would be cheaper to ascertain that by making trial lines; that is, by making a survey yourself.

Mr. BODFISH. I should prefer to make the trial lines.

Senator JONES. That does not quite answer my question.

Mr. BODFISH. Even with the maps in existence I should rather make the trial lines for my own personal——

Senator JONES. I was asking about the relative cost. The point I intended to ask you was whether the topographic survey would enable you to make a correct and proper location of the ditch lines without making all these trial line surveys?

Mr. Bodfish. I understand the question, sir, and when I said i would depend upon the quality of the map I stated the whole matter.

Senator Jones. What is the quality of the maps——

Mr. Bodfish. I do not know the quality of the maps made in th Arkansas district. I have not had a chance to test them.

Senator Jones. You know the quality of the maps being made by th Geological Survey, do you not?

Mr. Bodfish. I know what kind of maps they make elsewhere, bu I do not know what they have made there.

Senator Reagan. This does not apply to any particular locality. I is a general proposition.

The Chairman. You say you know the quality of the maps made b the Geological Survey elsewhere than in your district. State what th is.

Mr. Bodfish. I know the quality of the maps made by the Surve in the East and I know the quality of some of the coarser maps of th West, but I do not know what they are doing on this irrigation surve work in making topographic maps.

Senator Jones. If you are not familiar with the maps, of course yo can not answer.

The Chairman. Have you examined any topographic survey maps East or West, that would be sufficiently accurate to be of practical us in locating ditches?

Mr. Bodfish. I do not think I have, sir.

The Chairman. Have you examined many?

Mr. Bodfish. I mapped, with my assistants, a fourth of the State o Massachusetts.

The Chairman. Made a topographic survey?

Mr. Bodfish. Yes, sir.

The Chairman. Then you have been engaged in that work?

Mr. Bodfish. Yes, sir; for ten years.

The Chairman. And were none of the maps constructed under you supervision or by you sufficiently accurate to select ditch lines by?

Mr. Bodfish. No, sir.

Senator Jones. Of what value are those maps?

Mr. Bodfish, They are of general value.

Senator Jones. Tell me something they can be used for.

Mr. Bodfish. You could locate a preliminary railroad line by one.

Senator Jones. Then why could you not locate a preliminary ditch-line by it?

Mr. Bodfish. Because a ditch-line is a rigid line. A railroad line i not a rigid line; it is covered by a variety of grades, steep and light A ditch line is comparatively a rigid line and can not be determined b anything but the lightest grades.

Senator Jones. Do you not run a preliminary line for a ditch lik you do for a railroad and then make the permanent location of th ditch?

Mr. Bodfish. No, sir.

Senator Jones. You make the permanent location at once?

Mr. Bodfish. We make an approximate location by running a comparatively rigid line first.

Senator Jones. So that no secondary work is necessary.

Mr. Bodfish. Except for cross-sections and cost of constructio For instance, if I am to run a preliminary line as I did in Kansas starting from near the Kansas and Colorado line, I ran a preliminar line to see where ditches could be run to take water from the Arkansa

River just west of the Colorado and Kansas line. A grade of about a foot and a half to the mile was determined upon before the line was run and a line leveled out and meandered out on that grade to see where it would go, how soon it would get on top of the bluffs, and where it would pass through those bluffs—whether through bad or good cuttings—and the deviation on the grade from one foot and a half was very little.

Senator **JONES**. If you had a similar survey to that you made in Massachusetts for that particular section of country you went over could you have determined with approximate certainty whether or not that ditch was feasible, without making your survey?

Mr. **BODFISH**. I should not have assumed to use my Massachusetts work for that purpose without running a random line over the ground.

Senator **JONES**. Then if there had been just such a survey of that country as you had made in Massachusetts, it would have been of no practical use or value in determining whether or not that ditch line was feasible?

Mr. **BODFISH**. No, sir; it would not have been of much value.

Senator **MOODY**. In your surveys in the Arkansas River district did you make use of any topography that had been executed in that district?

Mr. **BODFISH**. No, sir.

Senator **MOODY**. Then whatever work the engineer corps has done with reference to irrigation has been done entirely independently of any topography?

Mr. **BODFISH**. It has in the Arkansas division.

Senator **MOODY**. Do you know of any other division where topography has been used?

Mr. **BODFISH**. I do not know anything about what has been done in the other divisions, sir.

Senator **MOODY**. Of course I understand that you want to answer accurately; your mind runs in that direction; but do you know, in a general way, of any use that has been made of the topography that has been going on under the geological appropriation or under the irrigation appropriation?

Mr. **BODFISH**. I do not know of any use that has been made of it.

STATEMENT OF GEORGE E. CURTIS, METEOROLOGIST AND HYDROGRAPHER U. S. IRRIGATION SURVEY.

The **CHAIRMAN**. Mr. Curtis, what is your occupation?

Mr. **CURTIS**. Meteorologist and hydrographer.

The **CHAIRMAN**. Where have you been engaged in that occupation?

Mr. **CURTIS**. In the Geological Survey.

The **CHAIRMAN**. How long?

Mr. **CURTIS**. In the office since last June; in the field since the preceding December.

The **CHAIRMAN**. What section of the country were you in?

Mr. **CURTIS**. Colorado and New Mexico.

The **CHAIRMAN**. What are the duties of a hydrographer?

Mr. **CURTIS**. The duties of a hydrographer are mainly to measure the discharge of steams.

The **CHAIRMAN**. What particular duties did you perform? Were you measuring the streams?

Mr. **CURTIS**. While I was in the field my duties were in connection with a camp of instruction for hydrographers, and after having finished those duties I returned to the office.

The CHAIRMAN. What is a camp of instruction?

Mr. CURTIS. It is for the instruction of young hydrographers who are about to take the field in different parts of the West. My duties were to give instruction in meteorological and hydrographic observations.

The CHAIRMAN. Explain, in brief, how you ascertain the flow or discharge of water in a stream at a particular point.

Mr. CURTIS. A cross-section is selected at which the river has a uniform slope, and which is a region both of minimum deposition and of minimum corrasion. Soundings are made, and the cross-section is divided into partial sections whose area is computed. The average velocity of the current is then measured with the current meter in each partial section. From its known area, and from the average velocity of the current, the discharge through each partial section is computed, and the sum of the partial discharges is the total discharge of the stream.

The CHAIRMAN. Can you tell from what the velocity is when the water is low what it will be when the water is high?

Mr. CURTIS. No accurate determination can be made except by actual measurement.

The CHAIRMAN. The velocity of the water is influenced by the water coming into contact with the land, either on the sides or on the bottom of the stream?

Mr. CURTIS. The friction and the slope.

The CHAIRMAN. When the river is high the middle of the stream has less friction than the sides and bottom. How can you estimate for that?

Mr. CURTIS. The velocity is determined in different sections of the stream at every gauging, and gaugings are made at as many different stages of the stream as possible.

Senator JONES. How do you determine that? By actual measurement?

Mr. CURTIS. By actual measurement with the current meter.

The CHAIRMAN. Then you must examine the stream at flood times?

Mr. CURTIS. Yes, sir; at all heights.

The CHAIRMAN. That would take a great many years?

Mr. CURTIS. No, sir; in a usual year the——

The CHAIRMAN. There have been several great floods on the Pacific Coast. There was one in 1849, another in 1861, and one this year—a great flood, overshadowing the others. How do you ascertain the facts for such years?

Mr. CURTIS. Those are unusual cases.

The CHAIRMAN. But they must be obtained.

Mr. CURTIS. If not measured, the discharge at such times can only be estimated, but frequently estimated with considerable precision.

Senator JONES. Do you find that the same amount of water is discharged at the same flood-height at all times? For instance, if you have a gauge in a river, would the discharge at the 20-foot mark be the same at all stages?

Mr. CURTIS. Not necessarily; in fact, in some large rivers, as for example the Mississippi, it has been found that the discharge is different in rising from what it is in falling water.

Senator JONES. Is there a difference at different periods of a rise as to the amount of discharge at a given point?

Mr. CURTIS. If I understand you, those are fine questions that are of little economic value; they are principally of scientific interest or important in connection with river hydraulics.

The CHAIRMAN. What use do you make of the topographic maps in hydrography?

Mr. Curtis. None, in the actual conduct of the work.

The Chairman. You rely upon your measurements of the streams?

Mr. Curtis. Entirely.

The Chairman. Are you a practical engineer?

Mr. Curtis. No, sir.

The Chairman. You are simply a hydrographer?

Mr. Curtis. Yes, sir; and meteorologist.

URTHER STATEMENT OF EDWIN S. NETTLETON, SUPERVISING CIVIL ENGINEER ROCKY MOUNTAIN REGION, U. S. IRRIGATION SURVEY.

The Chairman. I believe you have already given your opinion that t is not necessary that a topographic survey should precede the engineering survey for irrigation.

Mr. Nettleton. I have.

The Chairman. How much use could you make of an ordinary topographic survey in the engineering work?

Mr. Nettleton. To an engineer entirely unacquainted with the country a good map would be somewhat of a guide to study in his office before entering the field, but after that I do not think it would be of much or any value to him; that is any topographic map that I have seen made in this country.

The Chairman. Have you examined the topographic maps that have been made by the Geological Survey?

Mr. Nettleton. Yes, sir.

The Chairman. Pretty extensively?

Mr. Nettleton. Yes, sir. I have lately looked over pretty nearly all of the maps, including all the western ones that are published.

The Chairman. When they make a topographic survey of a section and then of another adjoining section, how do they join their work together?

Mr. Nettleton. I am not familiar with the way only from what I have been told and from some work I have seen in the office. The work of making these surveys is done by a great many different small parties who are sent out into the field. Their work is sent into the office in sheets, covering small areas, and the sheets are adjusted one to another; and it has been found in practice, I think, that different topographers will not complete the contours on their sheets so they will join. Many times there are considerable errors, and those have to be adjusted in the office.

The Chairman. They average them?

Mr. Nettleton. Yes, sir.

The Chairman. Bring the lines together?

Mr. Nettleton. They are made to represent a picture with a reasonable degree of accuracy.

The Chairman. That is done for the purpose of learning the general geography and topography of the country?

Mr. Nettleton. Yes, sir.

The Chairman. Made up in that way, as I understand you, they would not be of any practical use in the accurate survey needed for irrigation?

Mr. Nettleton. I consider the work of locating and surveying reservoirs and establishing lines of canals as being work that requires greater refinement than it is possible to secure with a topographic survey like we are doing or can afford to do. For instance, in the mountains the contour lines are supposed to be 50 feet, vertically, apart. In computing a gradient of less than 50 feet in a mountain country, in order to establish reservoirs or ditch lines, it is necessary to make observations and computations of which no note can possibly be taken from a topographic map. Contour lines 50 feet apart might omit to show a proper reservoir site, because the reservoir site might be only 40 feet high.

Senator **REAGAN**. You mean 40 feet of altitude?

Mr. **NETTLETON**. Yes, sir; vertical height.

The **CHAIRMAN**. That is the scale, I believe, on which they are making their topographic maps in the mountains?

Mr. **NETTLETON**. Yes, sir; 50 feet.

Senator **REAGAN**. Do you know what scale is employed generally by the topographic survey on the lower lands?

Mr. **NETTLETON**. I think 20 feet is the smallest scale they are working on, but I am not certain about that. I think the scale is 20 feet on the plains and 50 and 100 feet in the mountains. I am not positive as to the exact scales.

Senator **REAGAN**. If the maps were made on a scale of 10 or 12 feet, would that make a difference, in your opinion?

Mr. **NETTLETON**. I do not think that even would be sufficient.

Mr. **REAGAN**. I am not talking about the details.

Mr. **NETTLETON**. It would be of greater assistance. Ten or 12 feet contours in the mountains would show the possible existence of a great many more reservoir sites than 50-feet lines would.

The **CHAIRMAN**. But after knowing the possible existence of sites, what would be necessary to know actually what could be done in each particular case?

Mr. **NETTLETON**. To make what we call the engineering survey, or a topographic survey sufficient in detail to determine the area and holding capacity of that reservoir.

The **CHAIRMAN**. Do you invariably visit and inspect the ground before you make any survey?

Mr. **NETTLETON**. Yes, sir. In regard to reservoir sites in the mountains, a practiced engineer can generally determine with his eye, without the aid of instruments, what is a possible reservoir site and what is not; but generally the engineer looking for reservoir sites or making preliminary examination has a hand-level. He can get onto a suitable point and tell very nearly with his hand-level where the water line will be; and standing on one side of a dam site he can trace pretty near the water line. If that shows an area sufficient, and the dam can be made without too great expense, then he orders a survey. That survey is made accurately enough to determine quantities in the dam, the cost of making the dam, and also the holding capacity of the reservoir.

The **CHAIRMAN**. Where you construct reservoirs sufficiently strong to withstand floods, what elements or facts must be taken into consideration?

Mr. **NETTLETON**. There are two ways of providing against floods. One is by an overfall dam, which must, of course, be made very secure on its back side and on its foundation. Another is, where the floods are not very torrential and where the discharge of the stream can be provided for by making a waste-way lower than the crest of the dam, leading off to one side or one end of the dam.

The **CHAIRMAN**. Where you use a waste-way the question will be in getting it large enough for all possible contingencies?

Mr. Nettleton. Yes, sir. The experience of the last year or so eads me to believe that that matter has not had sufficient study; that ve have not paid sufficient attention to the occurrence of heavy storms ind sudden floods; but the destruction of the two dams that have reently occurred ought not to be used as an argument against constructng reservoirs.

The Chairman. Why not? That is a question that concerns the ublic very seriously.

Mr. Nettleton. In the case of the Johnstown disaster, the waste-ray was evidently large enough to carry off the flood that caused the lestruction of that dam; but that was an unprecedented storm—seven nches of rain fell within a few hours on that drainage area. The reservoir was used for fishing purposes, and in the waste-way a grating f iron rods an inch in diameter, set very close together, had been put n to keep the fish from running down the stream. This tremendous torm brought down leaves and brush, and one large log, which lodged gainst this grating. The man in charge, or the only man who was here having any authority, was a young engineer, who, instead of lowing out the waste-way with dynamite or some other explosive, comnenced to raise the embankment of the dam, which had settled and ras low in the middle. He commenced putting loose earth on the top, nd the water raised faster than he could raise the dam; at the same ime the outlet was partially choked up with this rubbish. It is my pinion that if that grating had been taken out and the waste-way kept lear there would have been no disaster.

The Chairman. Then, in ordinary dams you would not have those ish-traps?

Mr. Nettleton. No, sir. I would do just the opposite. There are laces in the old country where they put the waste-way very considerbly below the crest of the dam. Then if they want to utilize nearly he whole capacity of the dam, they put up posts and some kind of temorary wicker work of straw, that will hold the water until it gets to a ertain height. When it gets to that height it will break away—go out efore the water rises to the top of the dam, and that leaves a very large pening for the protection of the dam——

The Chairman. Have you any knowledge of this other disaster rhich occurred in Arizona?

Mr. Nettleton. Nothing except what reports I have seen in the ewspapers. But that was evidently caused by an insufficient waste-ray, causing the water running over the top of a loose-rock dam.

The Chairman. It was constructed for an overflow dam?

Mr. Nettleton. No, sir; it was not so designed——

The Chairman. And the waste-way was not sufficient to let the water o by?

Mr. Nettleton. No, sir.

The Chairman. Do you not think that is one of the things you have ot to examine with great care?

Mr. Nettleton. Yes, sir. I think one of the most important things n locating dams in running streams is in the first place to get the hisory of the stream, and if you can not get information in relation to the reatest floods that have occurred, observe the highest water-marks hat can be found.

The Chairman. Mere gauging will not give you that information?

Mr. Nettleton. No, sir, except in an exceptionally high stage of he water. I would provide for the greatest discharge ever known on he stream, and that to make it safe, I would double that capacity, in case there was a great deal of property or many lives depending on th breaking of the dam. Such things do not cost very much.

The Chairman. You can in no stream make the waste-way sufficientl large to take a flood through.

Mr. Nettleton. A waste-way is not always the best way to get ri of floods. Sometimes the best way is to take the water over the cres in whole or in part.

The Chairman. The overflow dams are very expensive, are they not

Mr. Nettleton. If you have solid rock for the foundation of you dam, and rock for the overflow water to strike on, a masonry dam is no very expensive.

The Chairman. Are there not some streams in the West where an dams, even masonry dams, would be unsafe; for instance, those stream where they have landslides in consequence of cloudbursts, which brin down immense bowlders?

Mr. Nettleton. There are places in the mountains where I think i is unwise to try to dam those torrential streams. In the first place, the dams are of no use after you get them, filling up with sand and debri and making an over-fall dam without any holding capacity.

The Chairman. Do those mountain streams carry evidences on the ground that such floods have occurred, as a usual thing?

Mr. Nettleton. Yes, sir. An engineer can generally find high-water marks.

The Chairman. And large bowlders which have come down the stream?

Mr. Nettleton. Yes, sir. Especially where there is timber growing, you will frequently find the trees scarred and flood-wood lodged in the crotches of the trees, high above where one would suppose water ever could have reached, but yet it is there.

Senator Moody. You are acquainted with these topographic maps that have been made by the Geological Survey?

Mr. Nettleton. Yes, sir; I have seen them.

Senator Moody. What use can be made of those in the Land Office in fixing the boundaries and the area of the reserved lands provided for?

Mr. Nettleton. These topographic maps show only the topography of the country, without any reference to or connection with the Land Office surveys; and they give no information as to the character of the soil, whether or not it is a timber or rock covered country or irrigable and agricultural lands. They just simply show its slopes, and what the character of its slopes are. While a topographic map might show a fairly good looking country, still the land might not be worth segregating.

Senator Moody. What use has been made of any of those maps in the selection of irrigable lands in the Land Department?

Mr. Nettleton. I do not know that any use has been made of them.

Senator Moody. What sort of maps do they have to have, and what sort of work do they have to do, in order to segregate the lands under this last appropriation of 1888?

Mr. Nettleton. The only use of any map that I know of is one on which to make note of the lands segregated, the sections, etc.

Senator Moody. Do those segregations have to be made entirely independently of any topography?

Mr. Nettleton. Yes, sir; the segregations have to be described by township, range, section, and fraction of section, and have no connection whatever with topographic maps.

The **CHAIRMAN**. In order to make the segregation, it is necessary to make an actual survey on the ground, is it not?

Mr. **NETTLETON**. Yes, sir.

Senator **REAGAN**. Segregation for what purpose?

The **CHAIRMAN**. To ascertain what are and what are not irrigable lands. In order to accomplish that you would have to run a line on the ground any way?

Mr. **NETTLETON**. To connect that land with the present surveys?

The **CHAIRMAN**. With the Land Office surveys.

Mr. **NETTLETON**. Yes, sir.

The **CHAIRMAN**. If the topography were ever so accurate, it would not indicate the character of the soil, would it?

Mr. **NETTLETON**. No, sir.

The **CHAIRMAN**. And a line would have to be run to determine that?

Mr. **NETTLETON**. Yes, sir.

Senator **MOODY**. Would a topographic map indicate the character of the ground where the ditch has to be run?

Mr. **NETTLETON**. Only as to the slopes, but not as to whether it is sandy or alluvial soil.

Senator **MOODY**. It would not indicate whether the soil was rocky?

Mr. **NETTLETON**. It shows nothing except the slopes and the natural water courses.

Senator **MOODY**. In running the line of a ditch to carry water from a reservoir, would you or would you not take into consideration the character of the soil as to rocks and so on through which that ditch would run?

Mr. **NETTLETON**. Certainly we would have to consider that.

Senator **MOODY**. Would you not avoid, if possible to do so, in your engineering determination a region of country where the soil is composed of rocks, broken up or loose?

Mr. **NETTLETON**. I would avoid any country that would prevent the building of a practical ditch.

Senator **MOODY**. What use could be made of one of those topographic maps in locating the line of a ditch?

Mr. **NETTLETON**. In the actual location of the lines of ditches it would be of no use whatever.

Senator **MOODY**. In locating a reservoir, would you not take into consideration the character of the foundation of the banks?

Mr. **NETTLETON**. Yes, sir; certainly.

Senator **MOODY**. What use can be made of a topographic map for that purpose?

Mr. **NETTLETON**. It furnishes no information whatever in regard to the practicability of a dam site, or the character of its sides or bottom, which is one of the most important things to be considered in the construction of a dam. It simply shows what the slopes of the country are.

Senator **MOODY**. Can you not ascertain by the eye, with a sufficient degree of accuracy for engineering purposes, the location of reservoir sites preliminary to the actual and accurate survey?

Mr. **NETTLETON**. An engineer with good judgment can very closely estimate what is a reservoir site and what is not. He may not be able to determine whether it is entirely practicable. Perhaps the dam may cost too much for the amount of water it will hold. He can not determine those questions finally unless he makes a survey.

Senator **MOODY**. I mean, would you gather those facts by observation, preliminary to the actual and accurate detail survey?

Mr. **NETTLETON**. Most certainly.

Senator MOODY. Of what service would a good topographic map be in making those examinations?

Mr. NETTLETON. As I stated in the beginning, it might be of some assistance to an engineer who was a stranger in the country, by enabling him to get a general idea of the country; but in actually locating reservoirs, I do not think the topographic maps I have seen would be of any assistance.

Senator MOODY. Neither in locating reservoirs or in the line of ditches, nor in the segregation of the irrigable lands.

Senator JONES. Nor in the ascertainment of the sites for reservoirs.

Mr. NETTLETON. There are some reservoir sites that might be shown by such a map; for instance, take the one at El Paso. If there had been a topographic survey of that, with 20-foot contour lines, it would have shown without question that there was a reservoir site there; but there are thousands of other localities where 50-foot contour lines would not show nearly all the reservoir sites.

Senator MOODY. Will you please state any instance where the irrigation engineering service has reaped a benefit from the use of the topographic survey that has been going on?

Mr. NETTLETON. Well, I have had something to do with the starting out of two or three of the engineers on this survey. In the first place I sent to Washington (I was then at Denver) for all the maps of the country that was in my division. I had the Hayden Atlas, which survey covered Colorado, and I got some topographic maps of Arizona and New Mexico, and a few of Montana up about the Yellowstone. Now, I do not claim that I can read topography on a map as readily as some, but I looked those all over, and with one or two possible exceptions I could not find on any of them what I could safely say was a reservoir site, so that I could direct or recommend an engineer to examine it.

Senator MOODY. In the process of exploring and developing the possibilities of irrigation through the means of artesian wells, of what use will be the topographic work which is being carried on by the Geological Survey?

Mr. NETTLETON. I think that perhaps in connection with artesian wells it would be more useful than in the engineering work of selecting reservoir sites and dam sites, because those maps show approximately the elevation above the sea, and in studying an artesian country it is quite desirable to know the altitude of the surface of the country above the sea-level within a reasonable degree of accuracy.

Senator MOODY. In making those explorations and investigations what would the engineer have to do?

Mr. NETTLETON. Without a topographic survey he would naturally get the profiles of the railroads crossing the country, all of which have the elevations above the sea-level. From the railroad profiles it is possible to get the elevations at every mile, but you can always get them without a great deal of trouble at every town along the line of a railroad. These furnish a good basis to work on. I did a good deal of that work in 1868. Commencing in southern New York I carried it down through the oil region in Pennsylvania, and I worked up my surveys from the railroad elevations of the different stations.

Senator MOODY. Is that not entirely sufficient for making examination in regard to irrigation by means of water obtained from the artesian basins?

Mr. NETTLETON. If you had a series of contours carried all over the country, with benches established, that would be of great advantage over the railroad elevations.

Senator **Moody**. Is it essential in regard to practical demonstration?

Mr. **Nettleton**. No, sir.

Senator **Moody**. Can it not be done very much more cheaply without it?

Mr. **Nettleton**. Yes, sir.

Senator **Moody**. It would be a very expensive process to undertake to carry contour lines all over that semi-arid region 50 or 100 feet apart, would it not?

Mr. **Nettleton**. I do not know what the cost would be per square mile for such work. Do you, Mr. Bodfish?

Mr. **Bodfish**. From $1 to $5 per square mile.

Senator **Jones**. It would cost that for a topographic survey?

Mr. **Bodfish**. Yes, sir.

Senator **Moody**. Do you regard it as essential in making the examination for artesian basins throughout North Dakota, South Dakota, Nebraska, Kansas, and Texas, to have a topographic survey?

Mr. **Nettleton**. No, sir; I have been considering that subject, and have looked up the railroad lines crossing that country, and I find a great number of railroads, especially near the Missouri River, through the eastern part. There are several lines running east and west which give an excellent opportunity of getting the profiles of that region.

Senator **Moody**. So that you can make a pretty good guess as to the depths at different points of this artesian basin?

Mr. **Nettleton**. Yes, sir.

Senator **Moody**. Now, has it not been your experience, after all, that it requires the actual sinking of wells at different points to ascertain accurately the facts as to the depth of that basin?

Mr. **Nettleton**. Yes, sir; whatever data you find by a bore you know to be true; whatever you theorize on you do not feel so sure about.

Senator **Moody**. Is it not a fact that the roof of this artesian basin is very irregular, so that in some places you would have to sink very much deeper than in others, although at the same altitude?

Mr. **Nettleton**. In my study of the oil country I found a very uniform character of rocks 1,000 or 2,000 feet below the surface, but nearer the surface they were more broken.

Senator **Reagan**. If you were going to use the water of a particular stream to irrigate a particular plain, supposing there was no topographic survey or anything else to aid you, what steps would you take in order to apply the water to the land?

Mr. **Nettleton**. The first thing to be done is to determine what land you want to irrigate; the next thing to be done is to determine whether you have water that can be carried onto that land.

Senator **Reagan**. Determine the irrigation basin?

Mr. **Nettleton**. Yes, sir. Then, if there is more land than water, and money saving is an object, we seek the cheapest line, because the amount of irrigation that can be done is limited on account of the amount of water; so we pick out the most economical canal. But if it is the other way, if there is more water than land, and it is desirable to cover every acre of land, then we try for the highest line possible to get onto that land, without so much regard to expense.

Senator **Reagan**. What steps do you take to ascertain the extent and character of your catchment basin from which you get your water?

Mr. **Nettleton**. We generally take the maps of the country. That is one guide. Another is a knowledge of the character of the stream, obtained by observations or by inquiring of people who have known the stream for years, and who know about what its discharge is. For irrigation purposes it is not so much the size of the drainage area as i character that we rely on.

Senator **Reagan**. Do you regard it as essential to the success of suc an undertaking that you should know the extent of the drainage area

Mr. **Nettleton**. Yes, sir.

Senator **Reagan**. How would you get that?

Mr. **Nettleton**. I think in nearly the whole country in the ari region we have maps of some kind that give very closely the drainag system of the region. They are compiled, as far as they have been mad by the Wheeler, the King, the Powell, and the Government land su veys. These maps show quite closely the areas of the drainage basi of the streams.

Senator **Reagan**. Now, if there was a topographic survey made in th way that it is being made by the Geological Survey, could you not tak those maps and locate the drainage areas and the lands that are to b covered by water?

Mr. **Nettleton**. It would be relocating it. It would be simply con firming what has already been mapped; but I do not think that as t the areas it would change very much the areas of the drainage basin of the maps already made. It would give more information, perhaps, i regard to the slopes of the various parts of the country within thos drainage basins; but the exterior lines of the drainage areas would no be changed very much, I think, by a topographic survey such as is no being made.

Senator **Reagan**. Would you regard it as important, in determinin a drainage basin, whether it was a level or precipitous country, wit reference to the construction of your dam?

Mr. **Nettleton**. It would if a man went into that kind of work without looking before and around him, and if he had no idea of his own a to the country he was in; but when an engineer is sent into a country he can generally see pretty well its general character.

Senator **Reagan**. You think a good engineer could judge of the country without the assistance of the map?

Mr. **Nettleton**. He ought to.

Adjourned.

STATEMENTS OF CHEMISTS REFERRED TO BY ASSISTANT SECRETARY WILLITS.

UNITED STATES DEPARTMENT OF AGRICULTURE,
DIVISION OF CHEMISTRY,
Washington, D. C., February 3, 1890.

Hon. EDWIN WILLITS,
Assistant Secretary:

SIR: In addition to the information contained in the letter of May 7, which I hereby return, I would desire to call the attention of the committee to the fact that the character of the water used for irrigating purposes has much to do with the ultimate influence of irrigation upon the soil. If the water used for irrigating purposes contain much mineral matter, there would be a tendency for this matter to accumulate in the soil in such quantities as to become injurious to the growing crops. In many places where irrigation has been attempted with water charged with alkali it has had to be abandoned on account of the effect of the alkali mentioned above. Any attempt, therefore, to store water for irrigation purposes or to irrigate on a large scale should be preceded by a preliminary study of the nature of the water supply to be used.

The records of the Geological Survey abound in material of this description, that institution having made a systematic examination of the waters in the region embraced in the description contained in the committee's letter.

If the water, which is to be stored for irrigation purposes, come in the rain-fall it would usually be pure enough for irrigation purposes, provided it did not fall upon land already saturated with alkali. It is easy to see, however, that a body of water collected from the rain-fall descending on lands thoroughly charged with alkali might be wholly unfit for irrigation purposes. On the other hand, waters which are derived from large rivers and other streams are usually pure enough for irrigation purposes and could be used a long time on land without appreciably increasing the mineral constituents thereof.

Respectfully,

H. W. WILEY,
Chemist.

UNITED STATES DEPARTMENT OF AGRICULTURE,
DIVISION OF CHEMISTRY,
Washington, D. C., May 7, 1889.

Hon. EDWIN WILLITS,
Assistant Secretary:

SIR: Your communication of the 4th instant, addressed to Dr. Wiley, chief chemist of this division, has been referred to me for a reply, Dr. Wiley's trip to the West in the interest of the sorghum experiments preventing him from taking up the subject to which you refer.

I have examined the letter of Senator Stewart, which I return herewith, and have the honor to make the following report thereon:

That portion of the inquiry included under the character and constituents of soils seems to be the only point which falls within the province of this division. In order to enable you to furnish the committee with information which would be useful to them on this point, I have examined all the literature which is here available for information in regard to the constituents and character of soils west of the hundredth meridian of west longitude. I find several extensive investigations upon soils in this area and considerable information upon their character, and will make reference as follows to the sources where it can be found:

(1) The soils of the different districts in California have been made the subject of a very complete and important investigation by Prof. E. W. Hilgard, State chemist of California and professor of agriculture in the University of California. This investigation was undertaken for the Superintendent of the Tenth United States Census, and is embodied in volumes 5 and 6 of the Tenth Census under the head of "Cotton production." The investigation was intended especially to make comparison of the soils of California with those of the Southern cotton-growing States, with a view of investigating the adaptability of the California soils to cotton production. It comprises a large number of analyses of California soils taken from various localities, and a very complete and able discussion not only of the character and composition of these soils, but also of their geological sources and formation. The composition of soils of the various cotton-producing States is included in the investigation; also a

large number of analyses of soils in the Indian Territory. Further elaboration and discussion of the subject of California soils by Professor Hilgard will be found in the different reports made by him to the president of the University of California, notably in the reports for 1882 and 1884. Appendix No. 7 to the report for the year 1886 contains a valuable treatise by Professor Hilgard upon "Alkali lands, irrigation and drainage in their mutual relations."

I can commend the general plan and character of this investigation to the Senate committee as a model of the manner in which such an inquiry may be profitably carried on.

(2) The annual reports of the United States Department of Agriculture contain considerable information upon the subject of the composition of soils, and I have searched them through to obtain all the data upon soils in the region which forms the subject of the investigation by the Senate committee. The annual report for 1870 contains, on page 100, the analyses of three samples of soil from western Nevada. A special report of the Department of Agriculture, issued in 1882, entitled "Investigation of Sorghum as a Sugar-Producing Plant," contains on pages 58 and 64 analyses of a number of samples of soil from the Arkansas Valley in Kansas, namely, Great Bend and Hutchinson, Kans., and from Rising City, Nebr. In the year 1886 Bulletin No. 10 of the chemical division of this Department was issued, having for its subject "Principles and Methods of Soil Analysis," by Mr. Edgar Richards, assistant chemist. This publication contains the analyses of a number of soils, including prairie soils from Dakota, and also soils from Washington Territory.

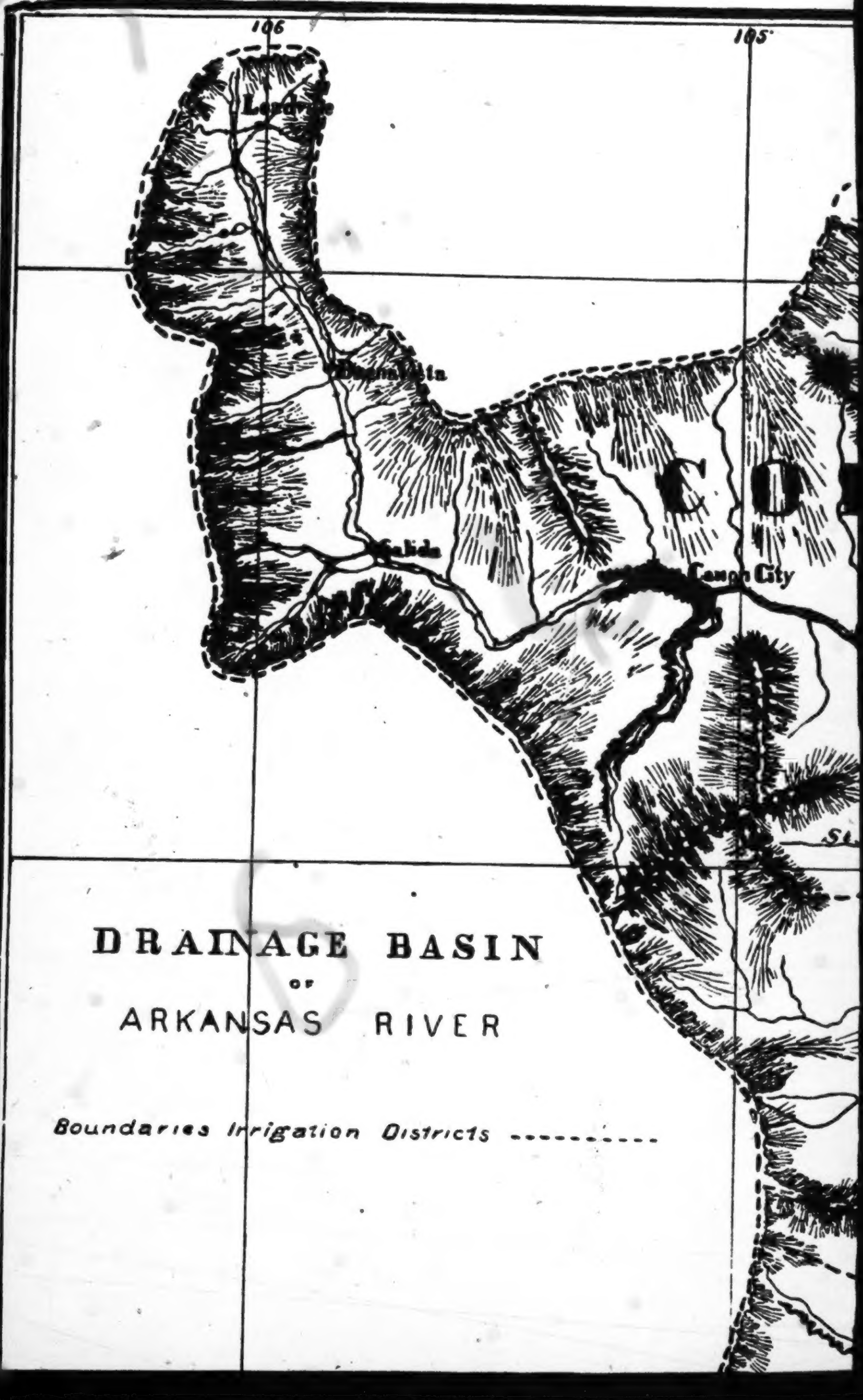
Besides the above I would state that the chemical division is at present engaged upon the analysis of a large number of soils collected from different parts of the country, among which are included four samples of soil from Arizona, one from California, and three from the Territory of Wyoming. These analyses will be completed some time during the course of the present year, and the results can be communicated to the committee if they so desire.

(3) In addition to the above information on the subject of the character and composition of the soils within this region, it might not be improper to suggest to you that the attention of the committee be called to the sorghum plant as one peculiarly adapted to certain portions of the region which forms the subject of the committee's investigation. It might be well to forward to the committee, as part of the information to be furnished from this Department, the special bulletins containing the results of the experiments of the Department upon sorghum as a sugar-producing plant. Some of the best results in the growth of sorghum were attained last year in the southwestern portion of Kansas at the station of this Department at Conway Springs. Both these and previous experiments by the Department would seem to show that the sorghum plant is peculiarly adapted to the arid or subarid regions of the West. It resists drought much better than corn or the other cereal crops, and seems, moreover, to attain a higher percentage of sugar in these dry regions.

I would also respectfully call your attention to the report, upon which, however, I can give you no exact information, that the tropical sugar-cane is said to have been raised with considerable success during the past season upon irrigated lands in Arizona.

Respectfully,

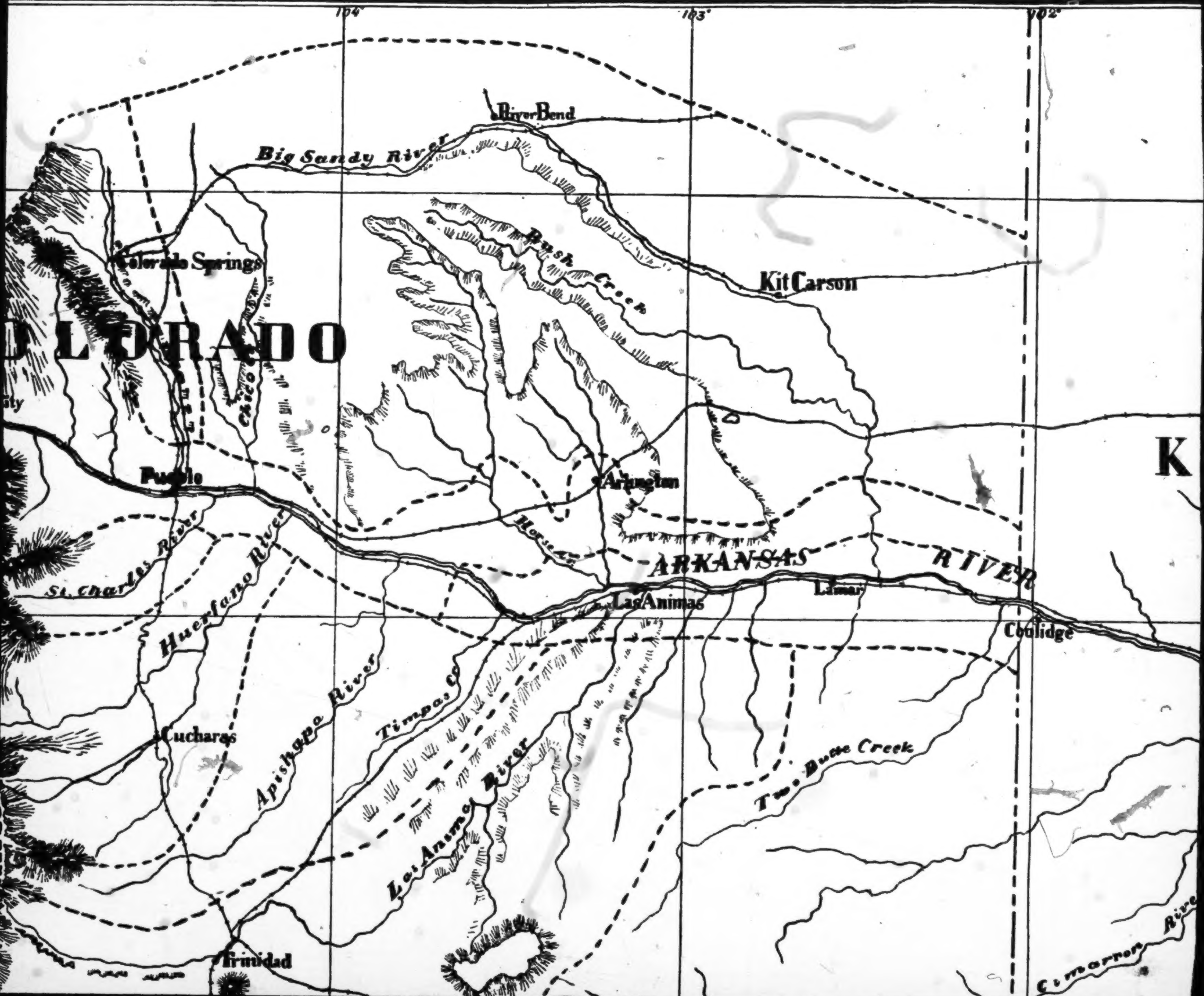
C. A. CRAMPTON,
Acting Chemist.

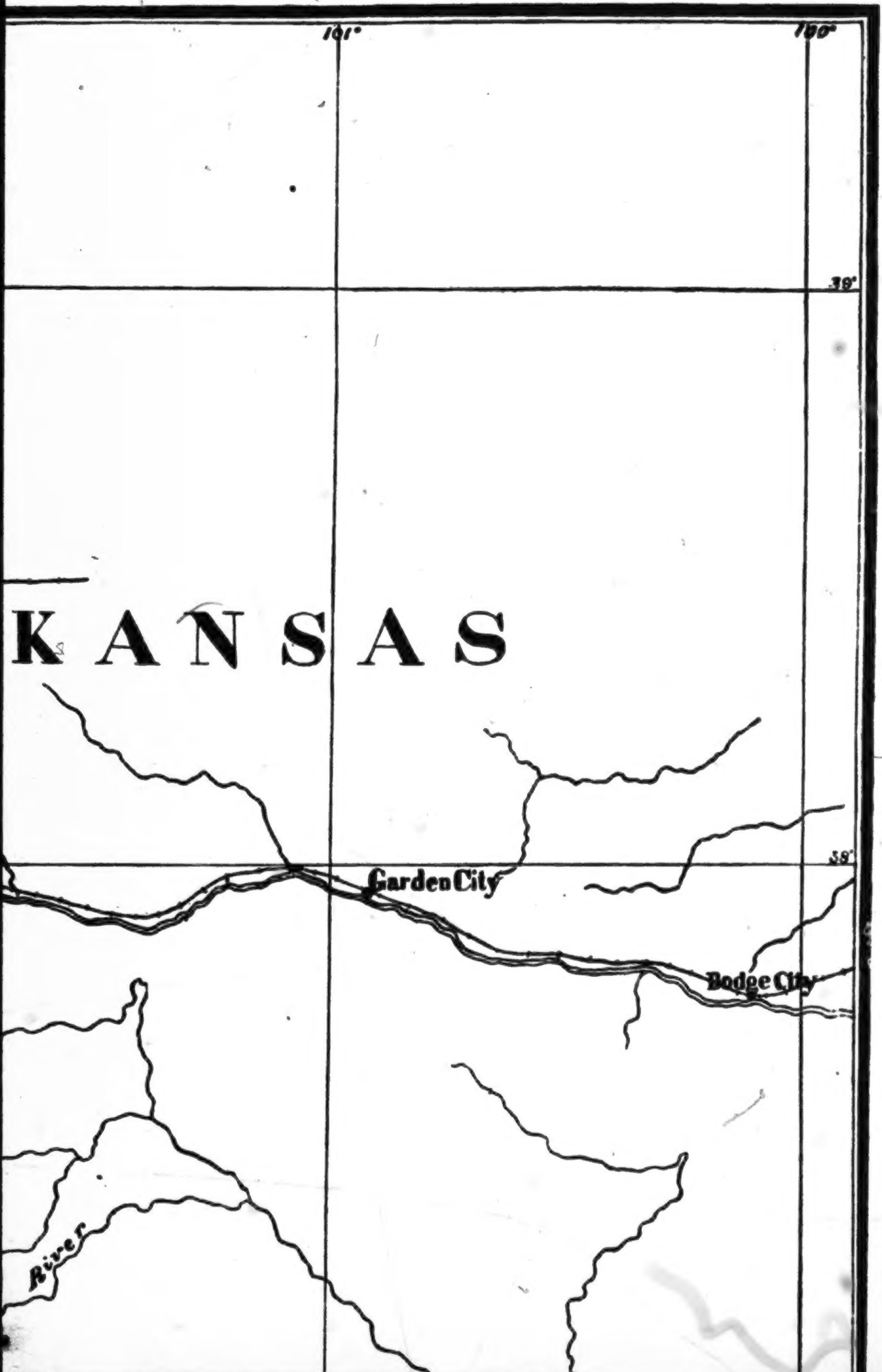


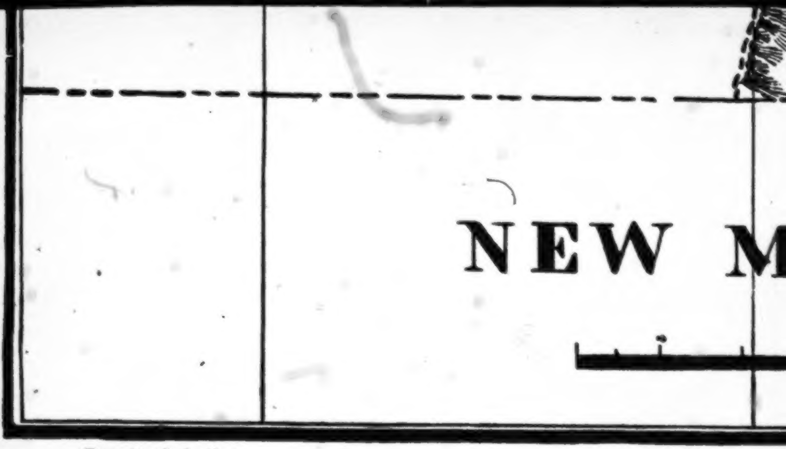
DRAINAGE BASIN OF ARKANSAS RIVER

Boundaries Irrigation Districts ----------

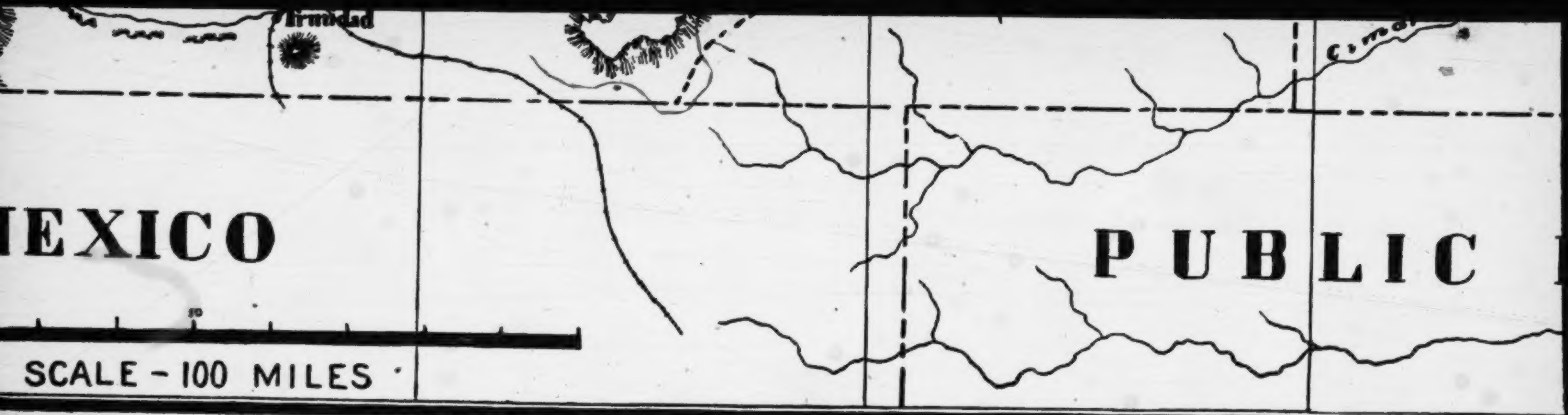
106
105°
Leadville
Buena Vista
Salida
Canon City
CO
St


104°
103°
102°
River Bend
Big Sandy River
Colorado Springs
Bush Creek
Kit Carson
OLORADO
Chico
sty
K
Pueblo
Arlington
Horse
ARKANSAS
RIVER
Las Animas
Lamar
Coolidge
St. Charles River
Huerfano River
Apishapa River
Timpas Cr.
Cucharas
Las Animas River
Two Butte Creek
Trinidad
Cimarron Rive

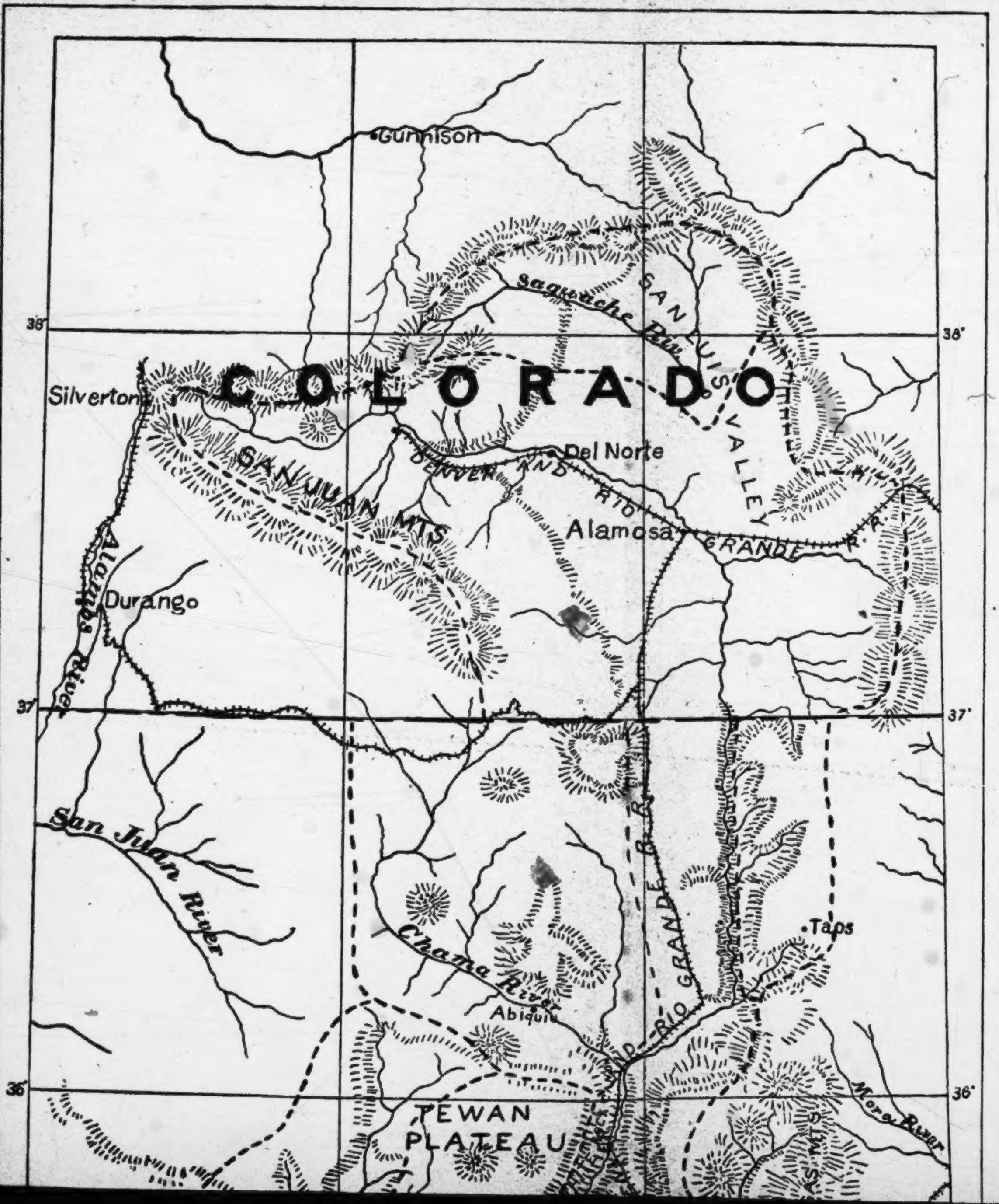

101°
100°
38°
38°
KANSAS
Garden City
Dodge City
River



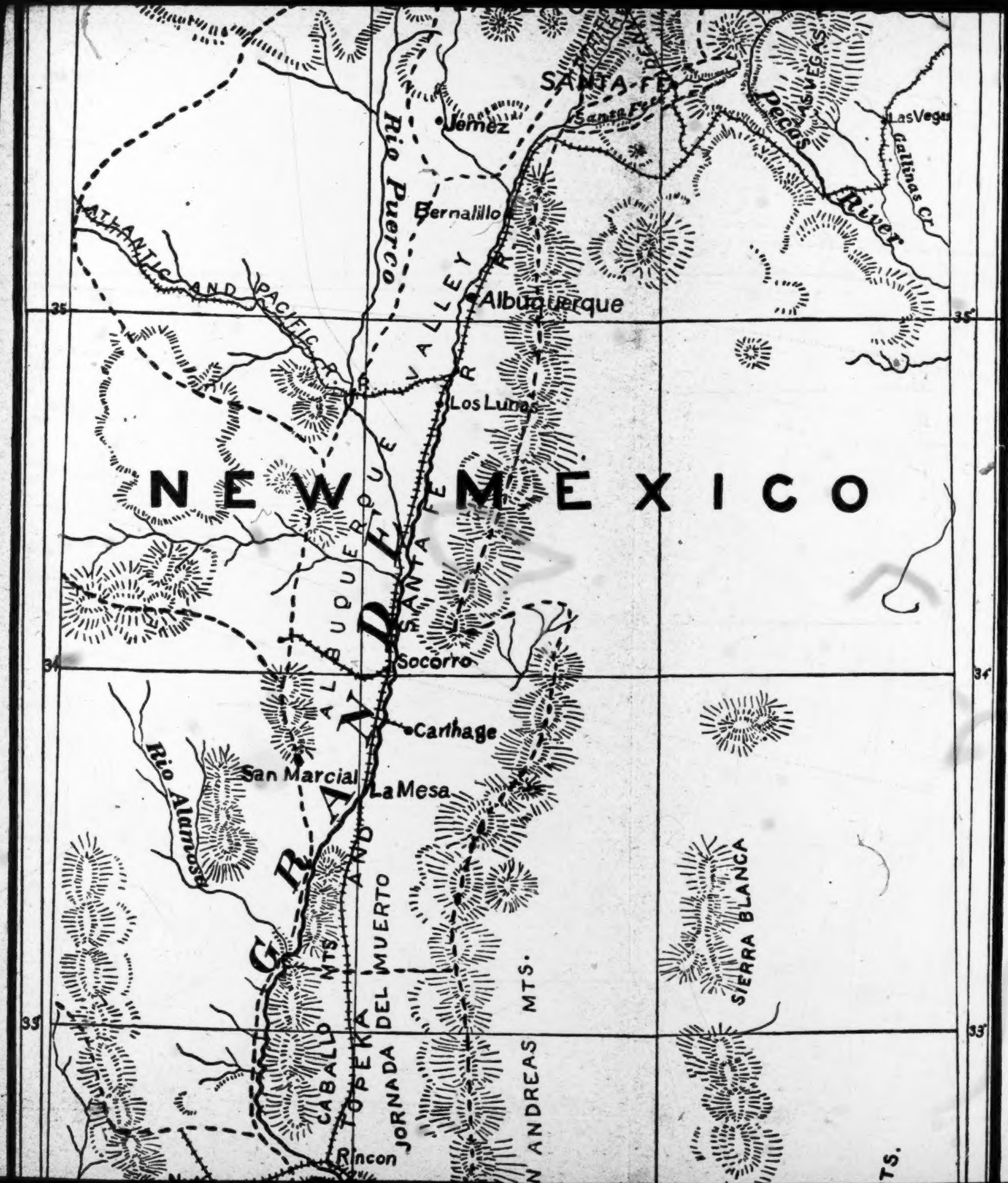
Report on Irrigation.

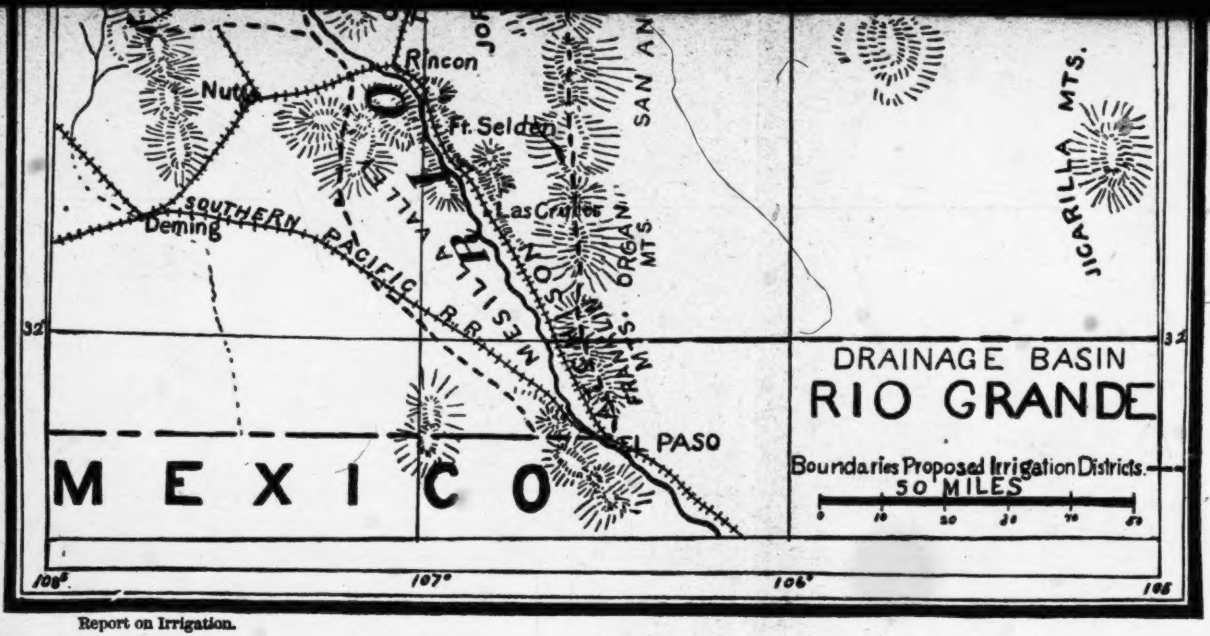

Trinidad
Cima
IEXICO
PUBLIC
50
SCALE - 100 MILES

37°
C LANDS

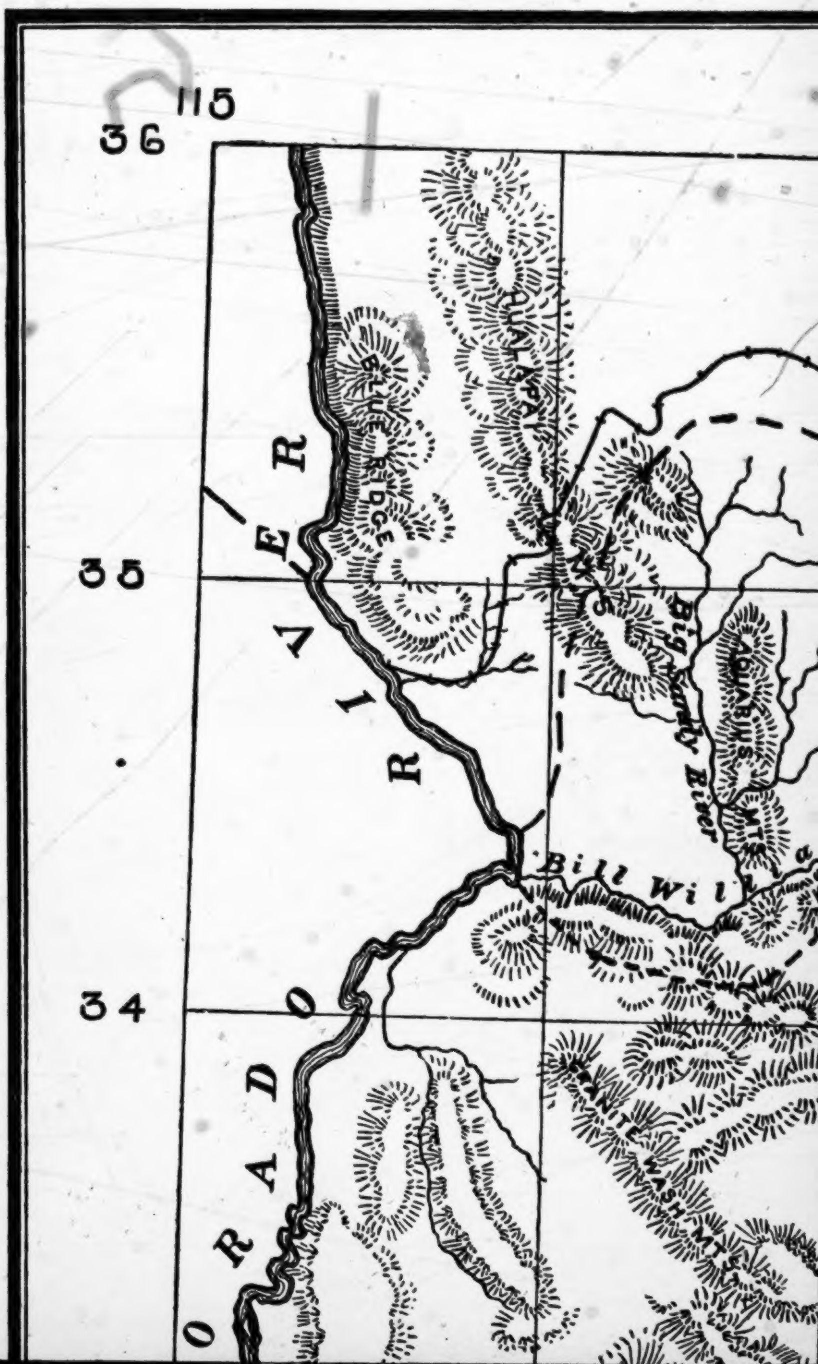


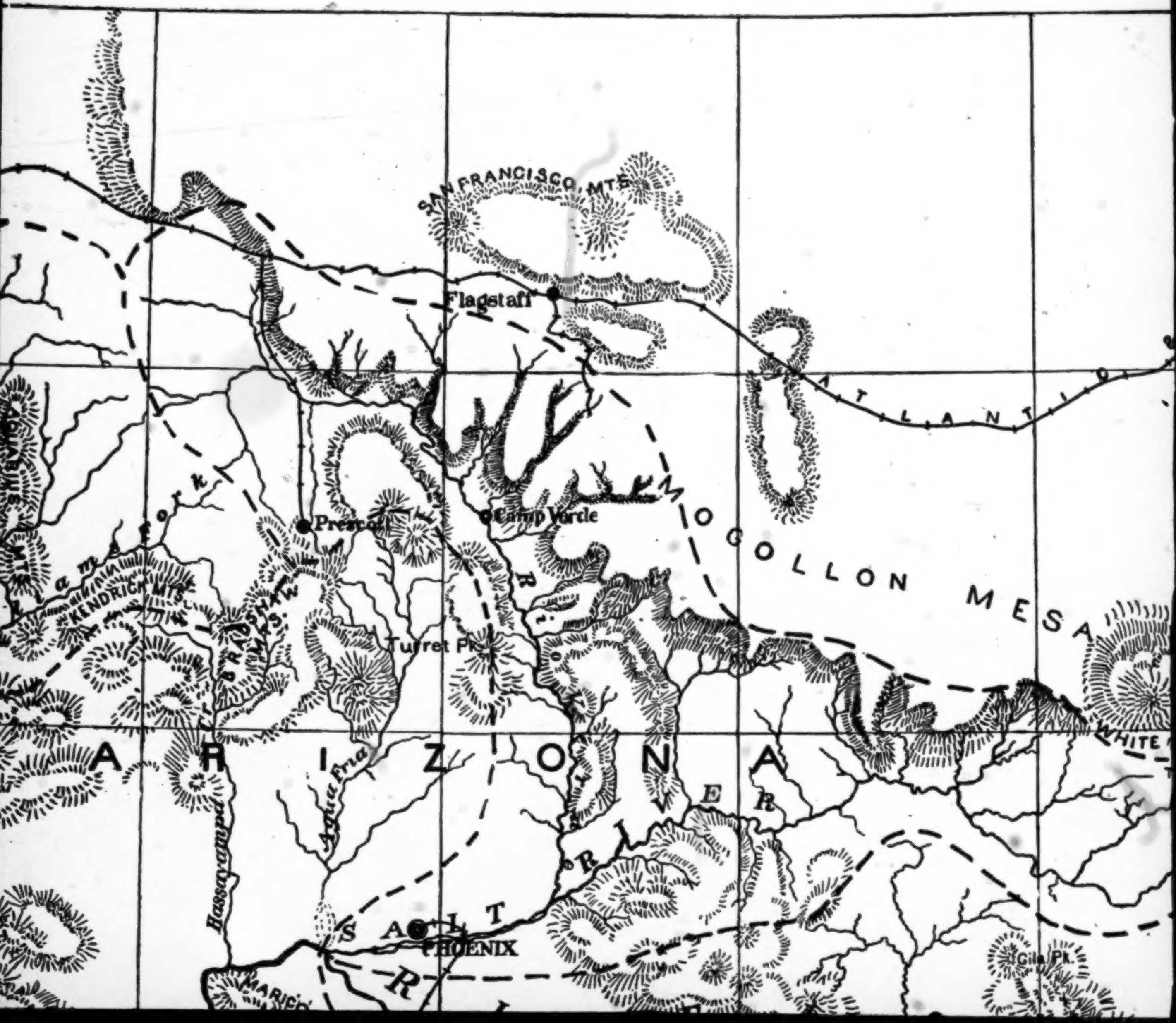
COLORADO
Gunnison
Saguache Riv.
SAN LUIS VALLEY
Silverton
SAN JUAN MTS
DENVER AND RIO GRANDE R.R.
Del Norte
Alamosa
Durango
Alamos River
San Juan River
Chama River
Abiquiu
RIO GRANDE
D. & R. G. R.R.
Taos
TEWAN PLATEAU
AS MTS
Mora River
38°
37°
36°

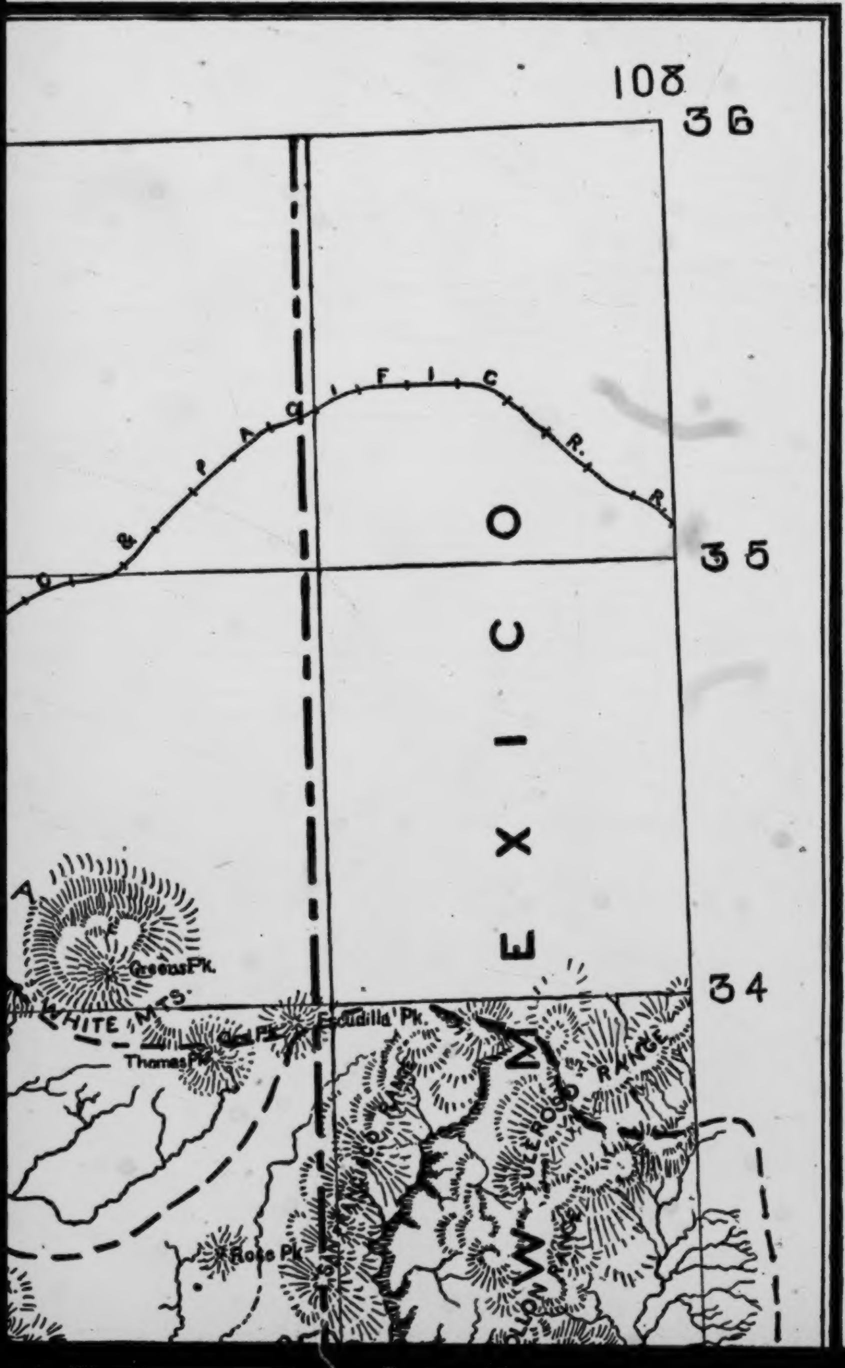

SANTA FE
Santa Fe
Jemez
Rio Puerco
Pecos
River
LAS VEGAS
Las Vegas
Gallinas Cr.
Bernalillo
ATLANTIC AND PACIFIC R.R.
VALLEY
Albuquerque
35°
35°
Los Lunas
NEW MEXICO
ALBUQUERQUE
SANTA FE
R.R.
GRANDE
Socorro
34°
34°
Carthage
Rio Alamosa
San Marcial
La Mesa
AND
TOPEKA
CABALLO MTS.
JORNADA DEL MUERTO
SAN ANDREAS MTS.
SIERRA BLANCA
33°
33°
Rincon
TS.

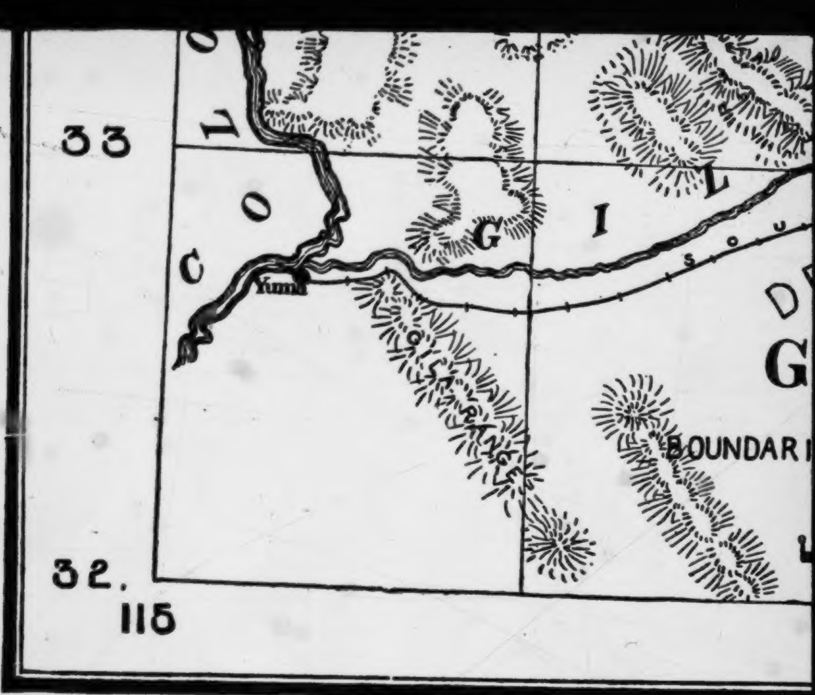

Rincon
Nutt
Ft. Selden
Las Cruces
Deming
SOUTHERN PACIFIC R.R.
MESILLA VALLEY
SAN AN
ORGAN MTS.
FRAN MTS.
JICARILLA MTS.
EL PASO
MEXICO
32°
32
DRAINAGE BASIN
RIO GRANDE
Boundaries Proposed Irrigation Districts.
50 MILES
0
10
20
30
40
50
108°
107°
106°
105

Report on Irrigation.

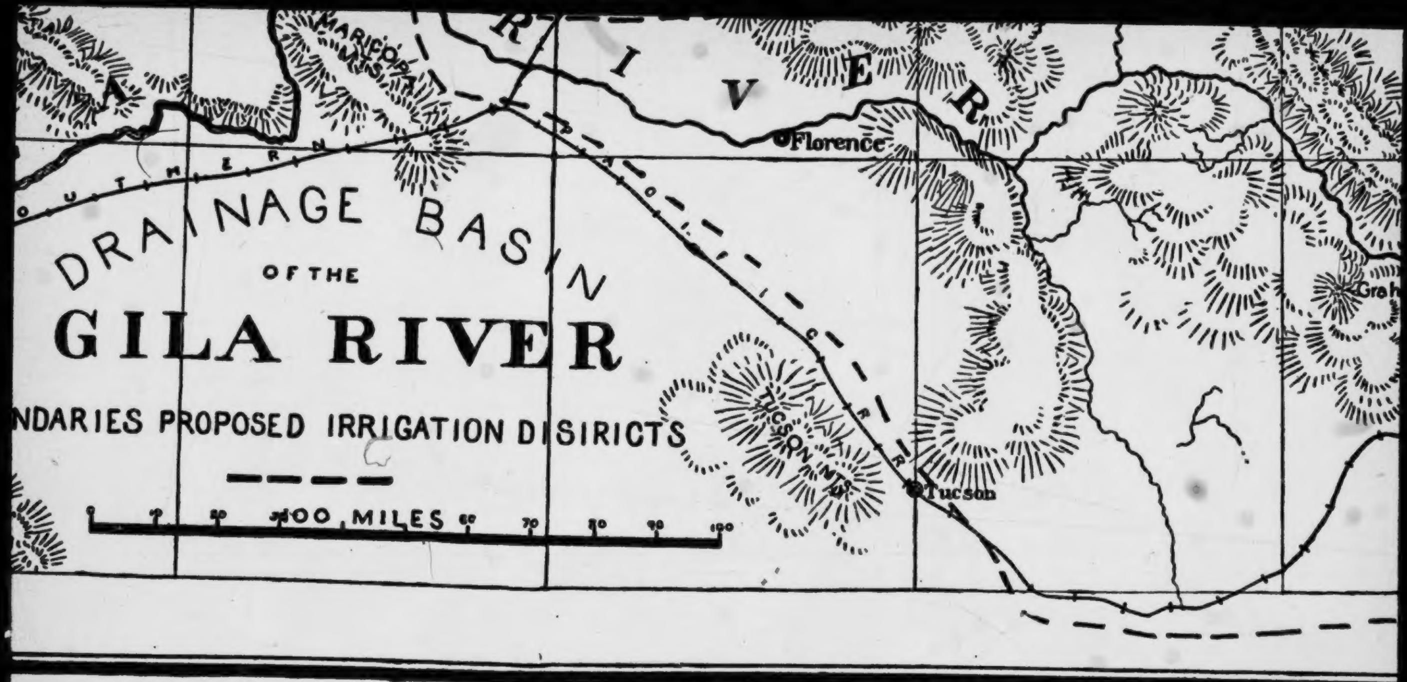
115
36
35
34
COLORADO RIVER
BLUE RIDGE
UALAPAI
MTS
Big Sandy River
AQUARIUS MTS
Bill Wil
RANTE WASH MTS

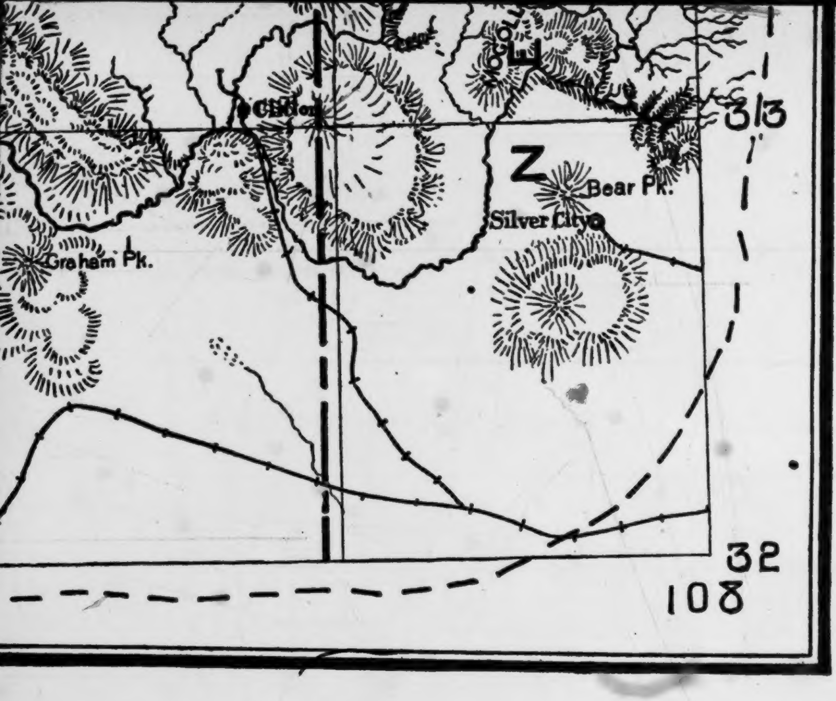

SAN FRANCISCO MTS.
Flagstaff
ATLANTIC
MOGOLLON MESA
Camp Verde
Prescott
AQUARIUS MTS.
KENDRICK MTS.
BRADSHAW MTS.
Fork
Turret Pk.
ARIZONA
Agua fria
Hassayampa
SALT RIVER
PHOENIX
MARICO
Gila Pk.
WHITE

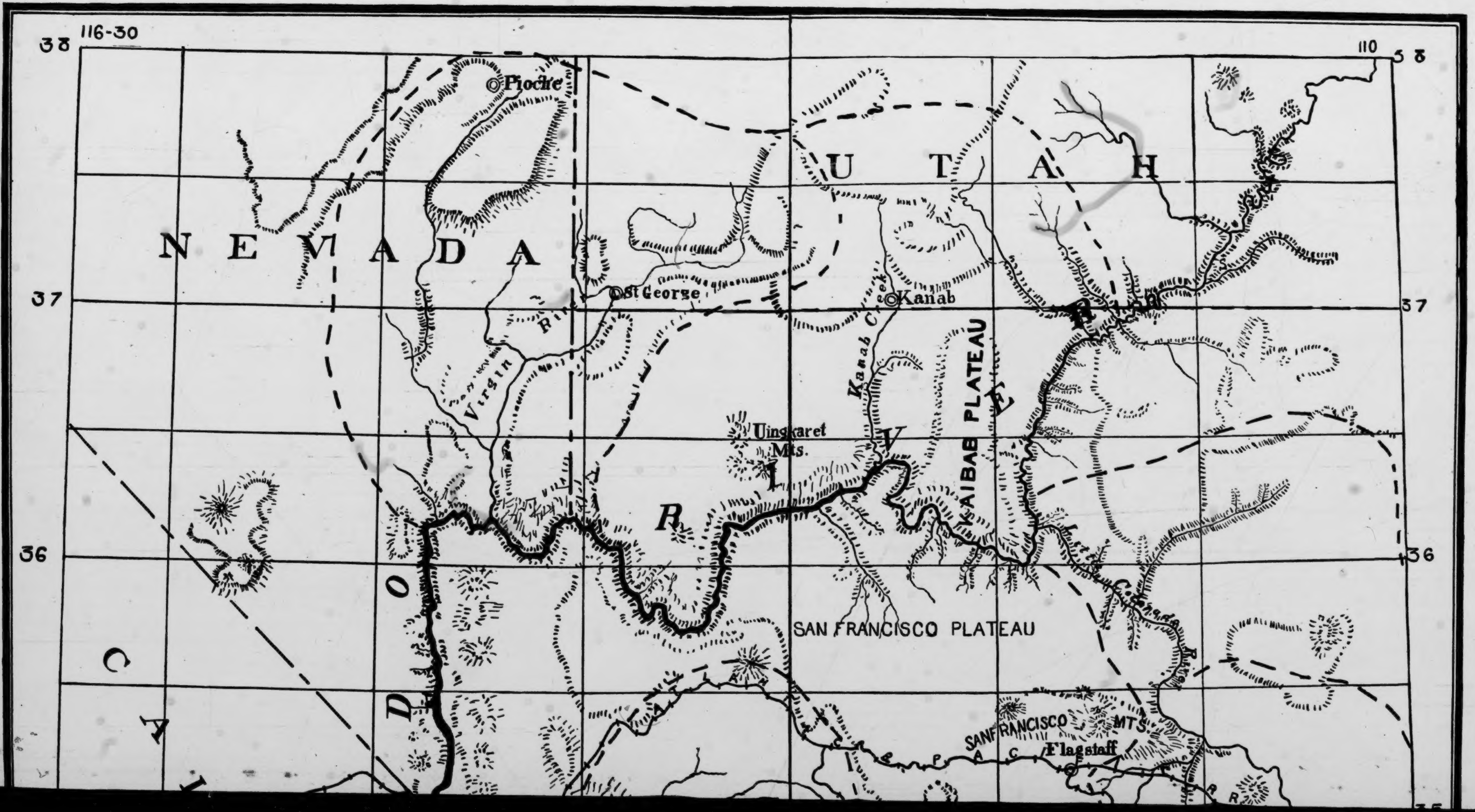

108
36
35
34
O & PACIFIC R. R.
MEXICO
A
Greens Pk.
WHITE MTS.
Escudilla Pk.
Ord Pk.
Thomas Pk.
SAN FRANCISCO RANGE
TULEROSO RANGE
MOGOLLON RANGE
Rose Pk


33
C O L O
G I L
Yuma
S O U
D
G
GILA RANGE
BOUNDAR
32.
115

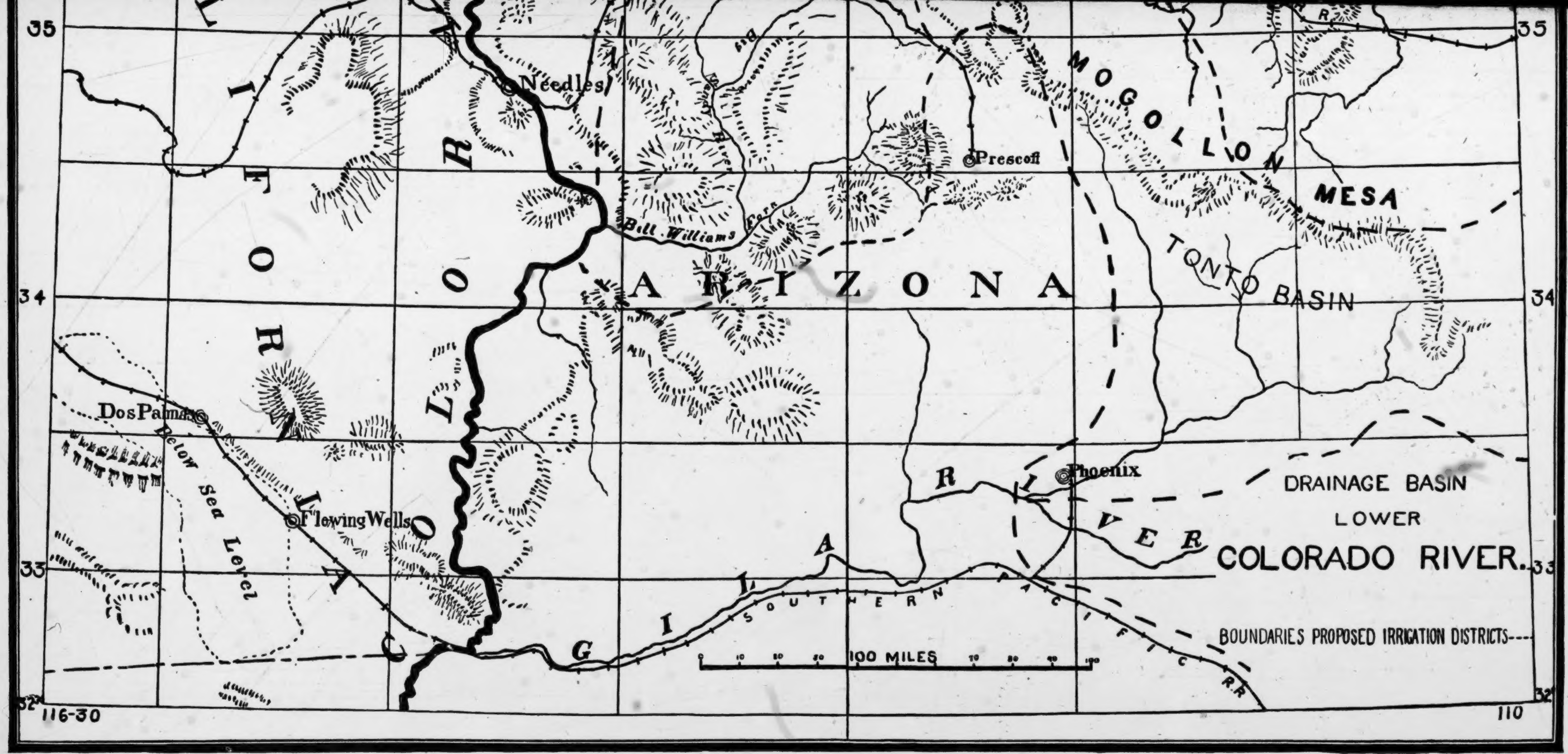
Report on Irrigation.


R I V E R
MARICOPA MTS.
Florence
SOUTHERN
PACIFIC R.R.
DRAINAGE BASIN
OF THE
GILA RIVER
NDARIES PROPOSED IRRIGATION DISIRICTS
TUCSON MTS.
Tucson
Grah
0 10 20 30 100 MILES 60 70 80 90 100

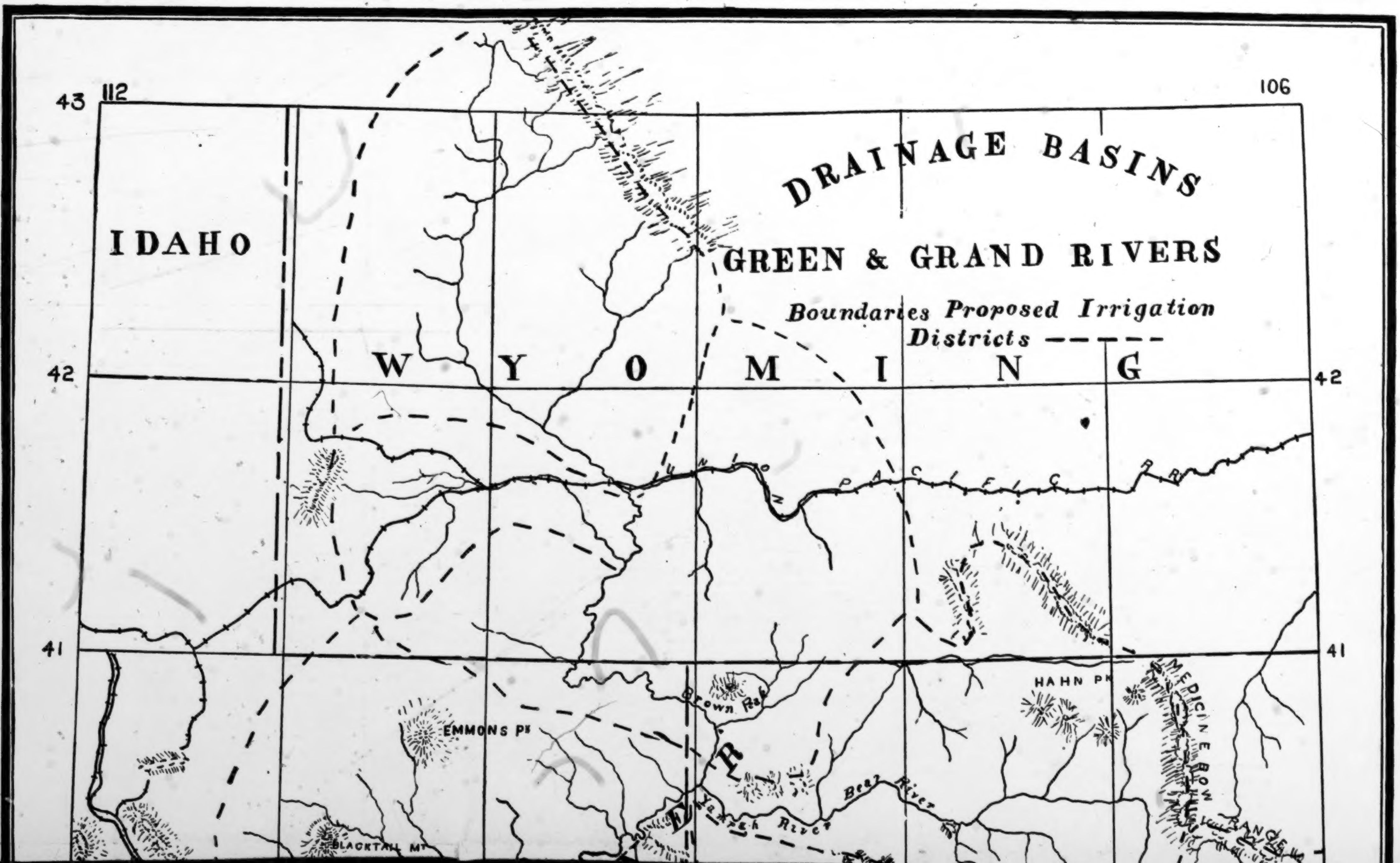

Clifton
E
33
Z
Bear Pk.
Silver City
Graham Pk.
32
108

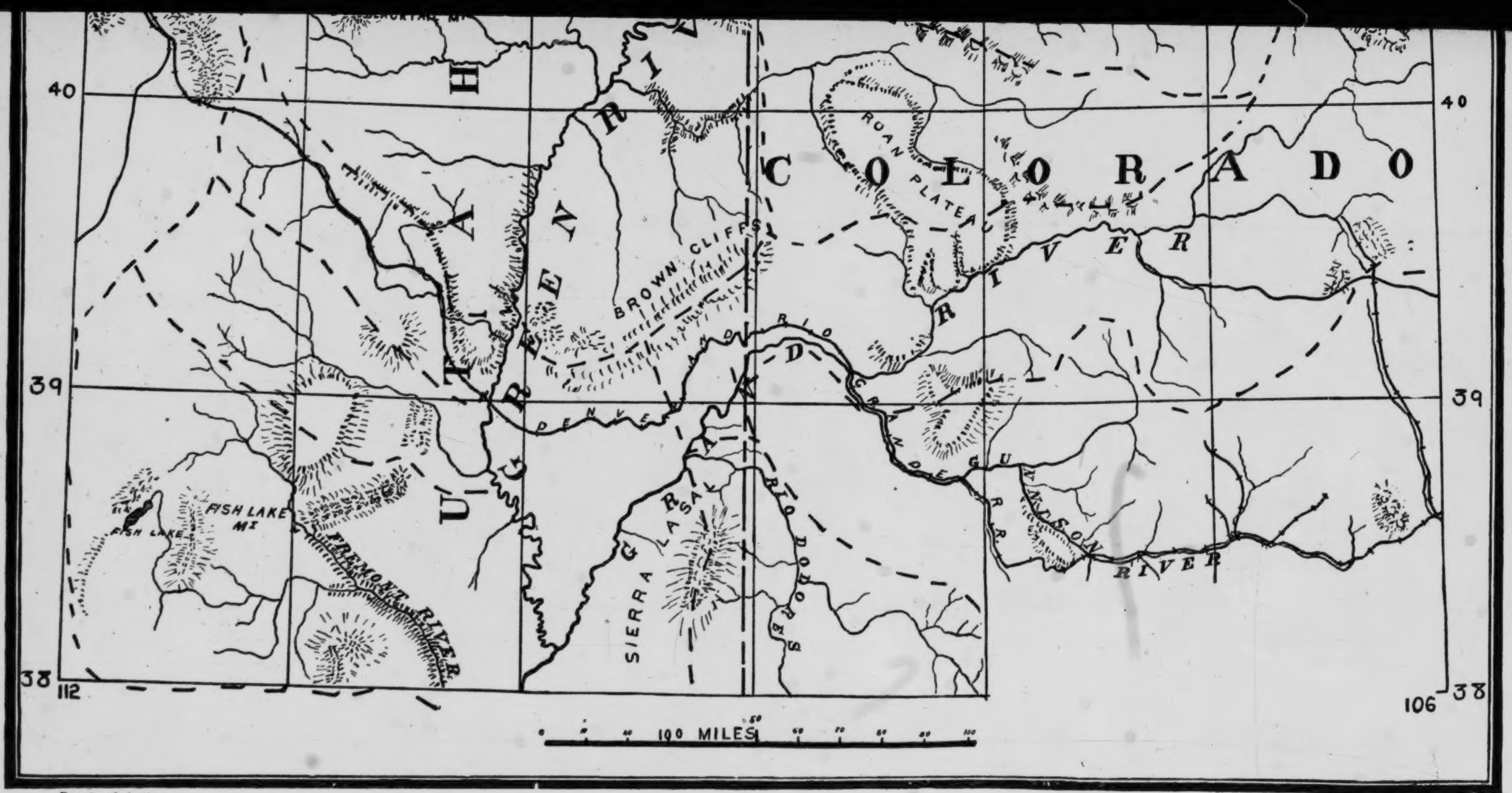


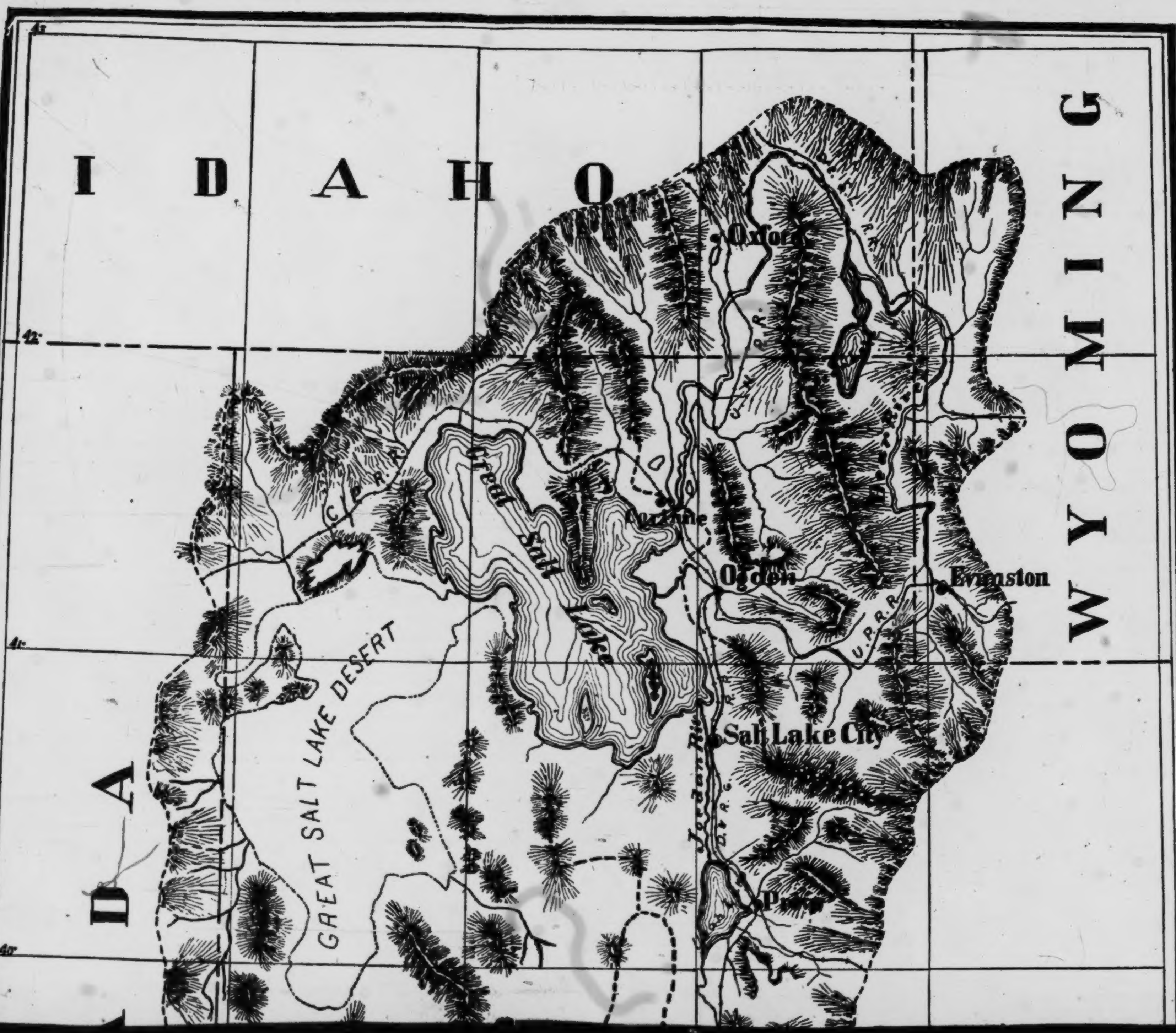
116-30
38
110
38
NEVADA
UTAH
Pioche
St George
Kanab
Kanab Creek
Virgin R
Uingkaret Mts.
KAIBAB PLATEAU
COLORADO RIVER
37
37
36
36
SAN FRANCISCO PLATEAU
Colorado R
SAN FRANCISCO MTS.
Flagstaff
CAL
PAC R R


DRAINAGE BASIN
LOWER
COLORADO RIVER.
BOUNDARIES PROPOSED IRRIGATION DISTRICTS
ARIZONA
CALIFORNIA
COLORADO R
GILA RIVER
MOGOLLON MESA
TONTO BASIN
Bill Williams Fork
Needles
Prescott
Phoenix
Dos Palmas
Flowing Wells
Below Sea Level
SOUTHERN PACIFIC R.R.
0 10 20 30 100 MILES 70 80 90 100
35
34
33
32
116-30
110

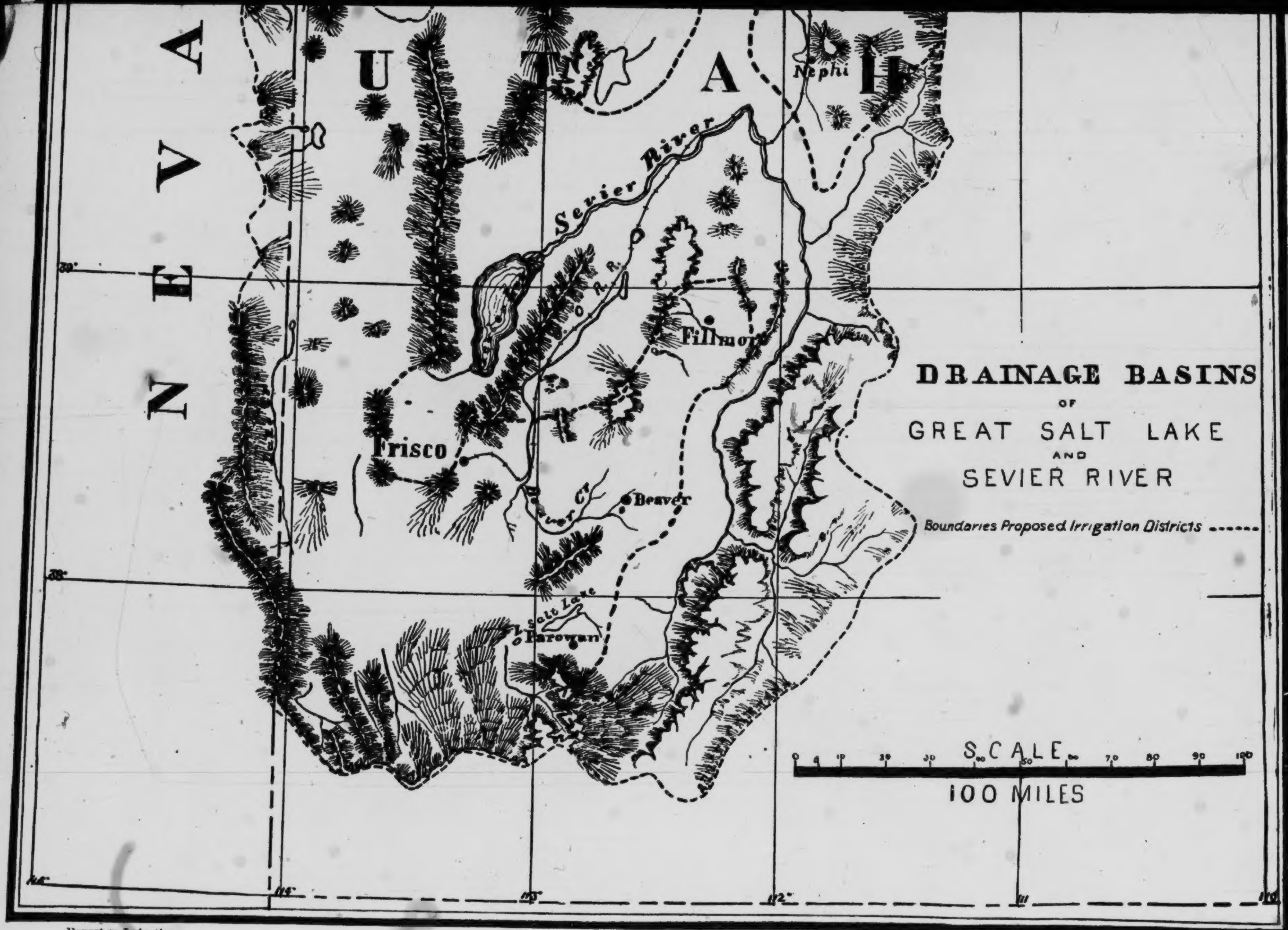
Report on Irrigation.


DRAINAGE BASINS
GREEN & GRAND RIVERS
Boundaries Proposed Irrigation Districts
43
112
106
42
41
IDAHO
W Y O M I N G
UNION PACIFIC R R
EMMONS Pk
BLACKTAIL Mt
Brown Park
HAHN Pk
MEDICINE BOW RANGE
Yampah River
Bear River
R
E


40
40
COLORADO
ROAN PLATEAU
GREEN RIVER
U T A H
BROWN CLIFFS
RIVER
RIO GRANDE
GRAND R.R.
DENVER
39
39
FISH LAKE MT
FISH LAKE
FREMONT RIVER
SIERRA LA SAL
RIO DOLORES
GUNNISON RIVER
38
112
106
38
100 MILES



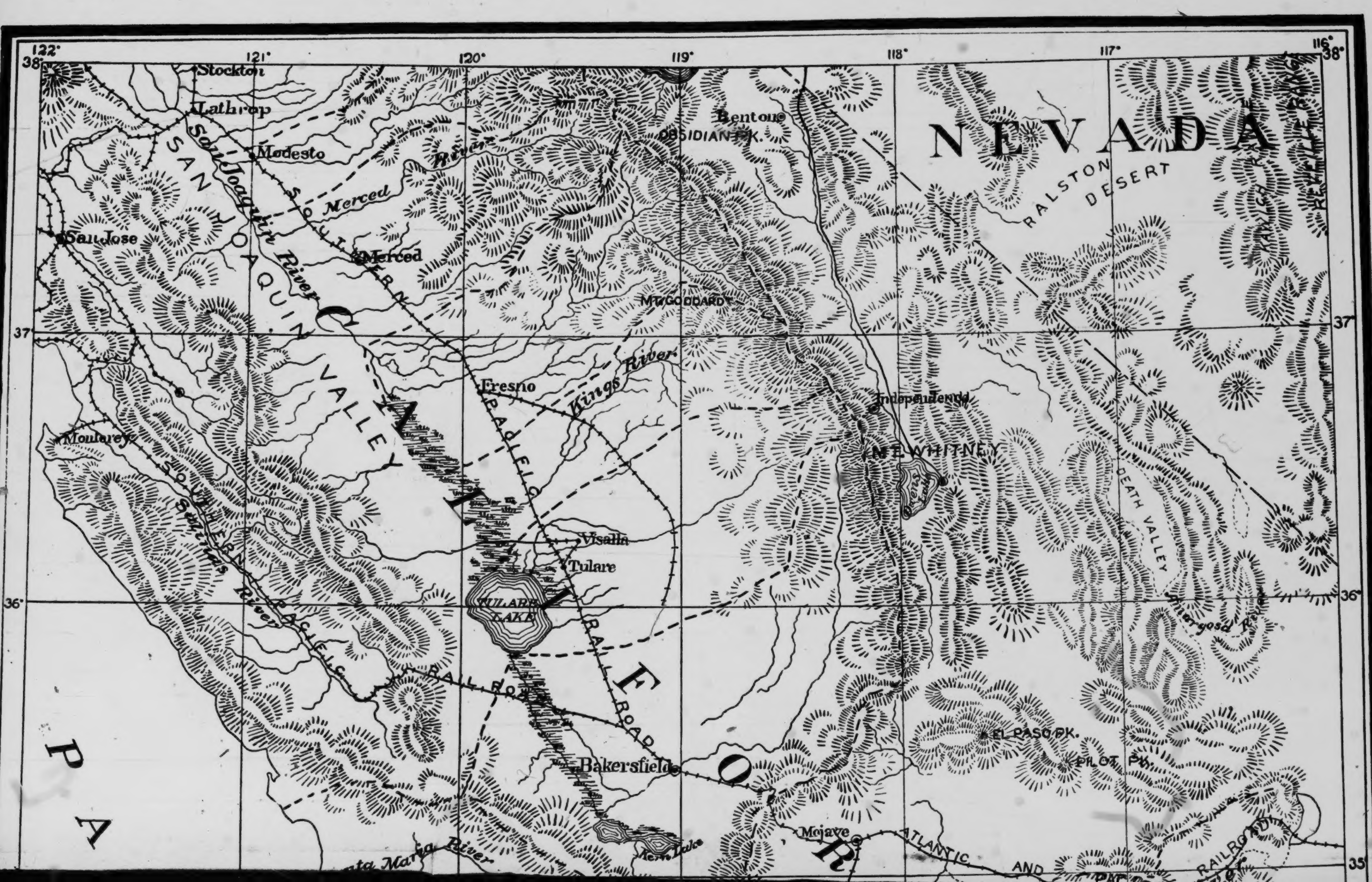
IDAHO
WYOMING
D A
42°
41°
40°
Oxford
Corinne
Ogden
Evanston
Salt Lake City
Provo
Great Salt Lake
GREAT SALT LAKE DESERT
C.P.R.R.
U.P.R.R.
U.N.R.R.
Jordan Riv.
D.& R.G.

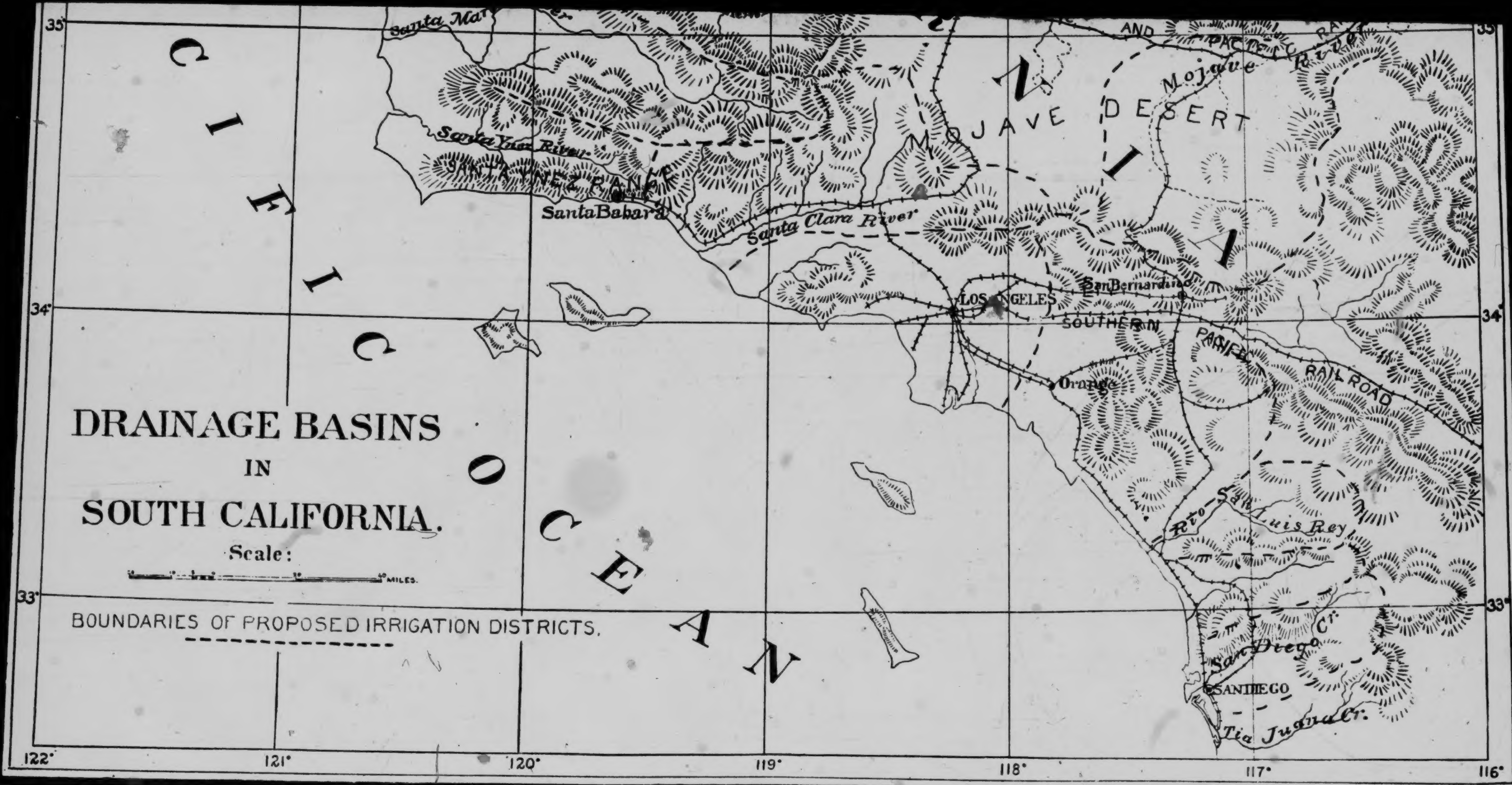


DRAINAGE BASINS
OF
GREAT SALT LAKE
AND
SEVIER RIVER

NEVA
UTAH
Nephi
Sevier River
O.R.R.
Fillmore
Frisco
Beaver
Beaver Cr.
Salt Lake
Parowan
39°
38°
115°
114°
113°
112°
111°
110°
Boundaries Proposed Irrigation Districts
SCALE
0 5 10 20 30 40 50 60 70 80 90 100
100 MILES

Report on Irrigation.


122°
121°
120°
119°
118°
117°
116°
38°
37°
36°
35
NEVADA
RALSTON DESERT
KAWICH RANGE
REVEILLE RANGE
Benton
OBSIDIAN PK.
Stockton
Lathrop
Modesto
San Joaquin River
SAN JOAQUIN VALLEY
Merced River
Merced
San Jose
SOUTHERN PACIFIC RAILROAD
MT. GODDARD
Fresno
Kings River
Independence
MT. WHITNEY
Owens Lake
DEATH VALLEY
Monterey
Salinas River
Visalia
Tulare
TULARE LAKE
Amargosa River
CALIFORNIA
EL PASO PK.
PILOT PK.
Bakersfield
Kern Lake
Santa Maria River
Mojave
ATLANTIC AND PACIFIC RAILROAD
PA



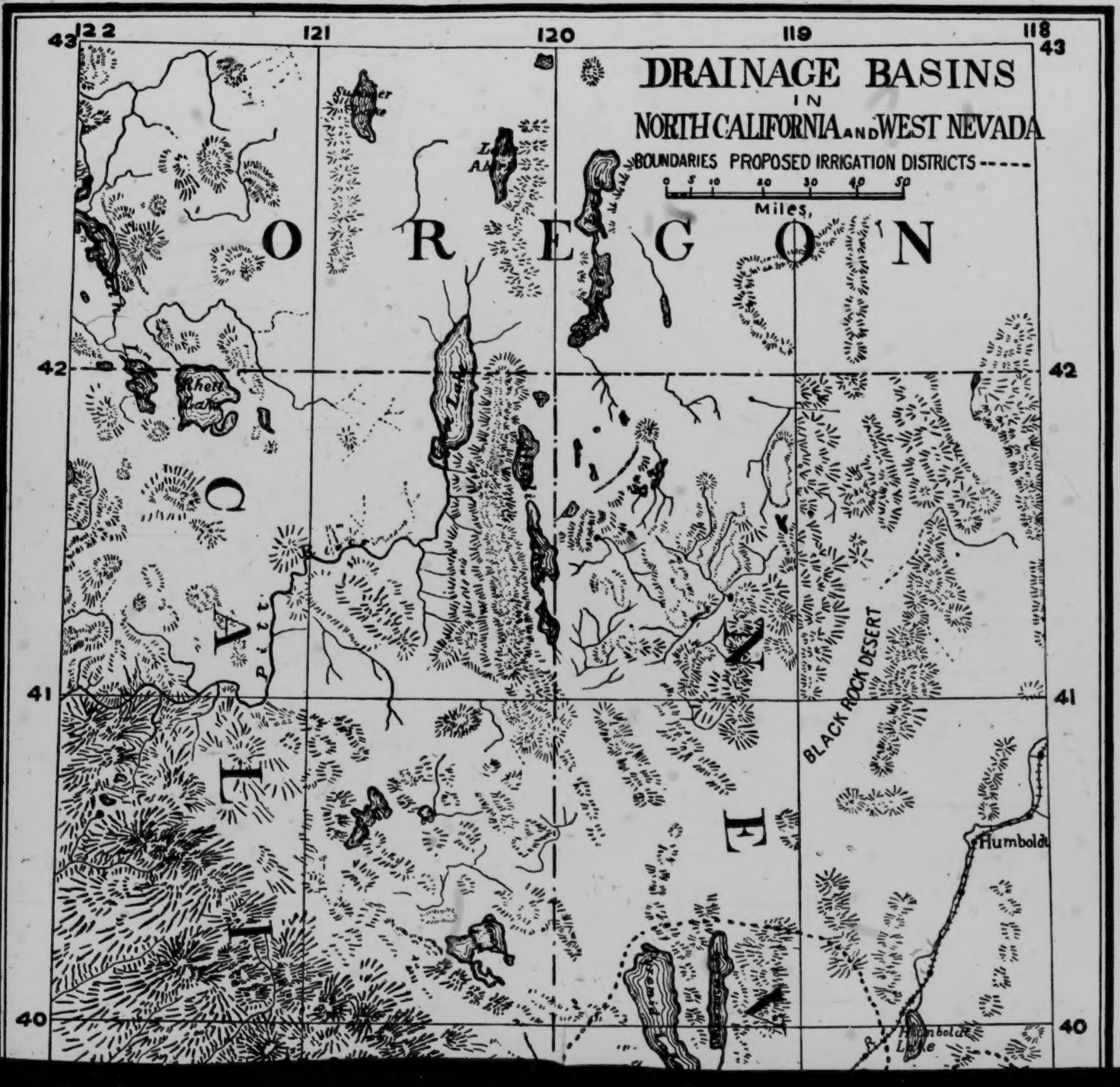
DRAINAGE BASINS
IN
SOUTH CALIFORNIA.

Scale:

BOUNDARIES OF PROPOSED IRRIGATION DISTRICTS.

MILES.
Santa Mar
Santa Ynez River
SANTA YNEZ RANGE
SantaBabara
Santa Clara River
CIFIC
OCEAN
N
I
A
MOJAVE DESERT
Mojave River
AND PACIFIC RAI
LOS ANGELES
San Bernardino
SOUTHERN PACIFIC RAIL ROAD
Orange
Rio San Luis Rey
San Diego Cr.
SANDIEGO
Tia Juana Cr.
35°
34°
33°
122°
121°
120°
119°
118°
117°
116°

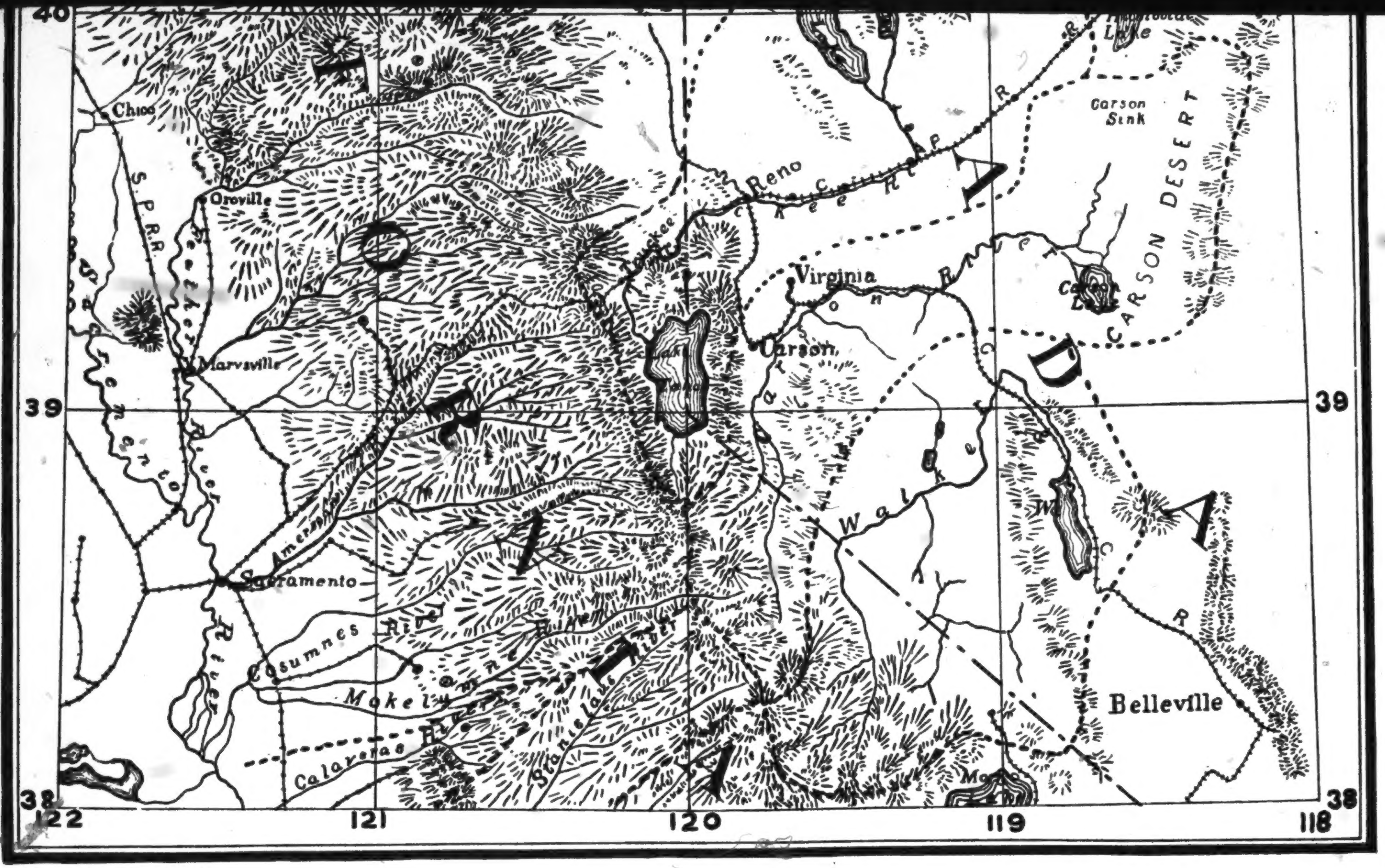
Report on Irrigation.



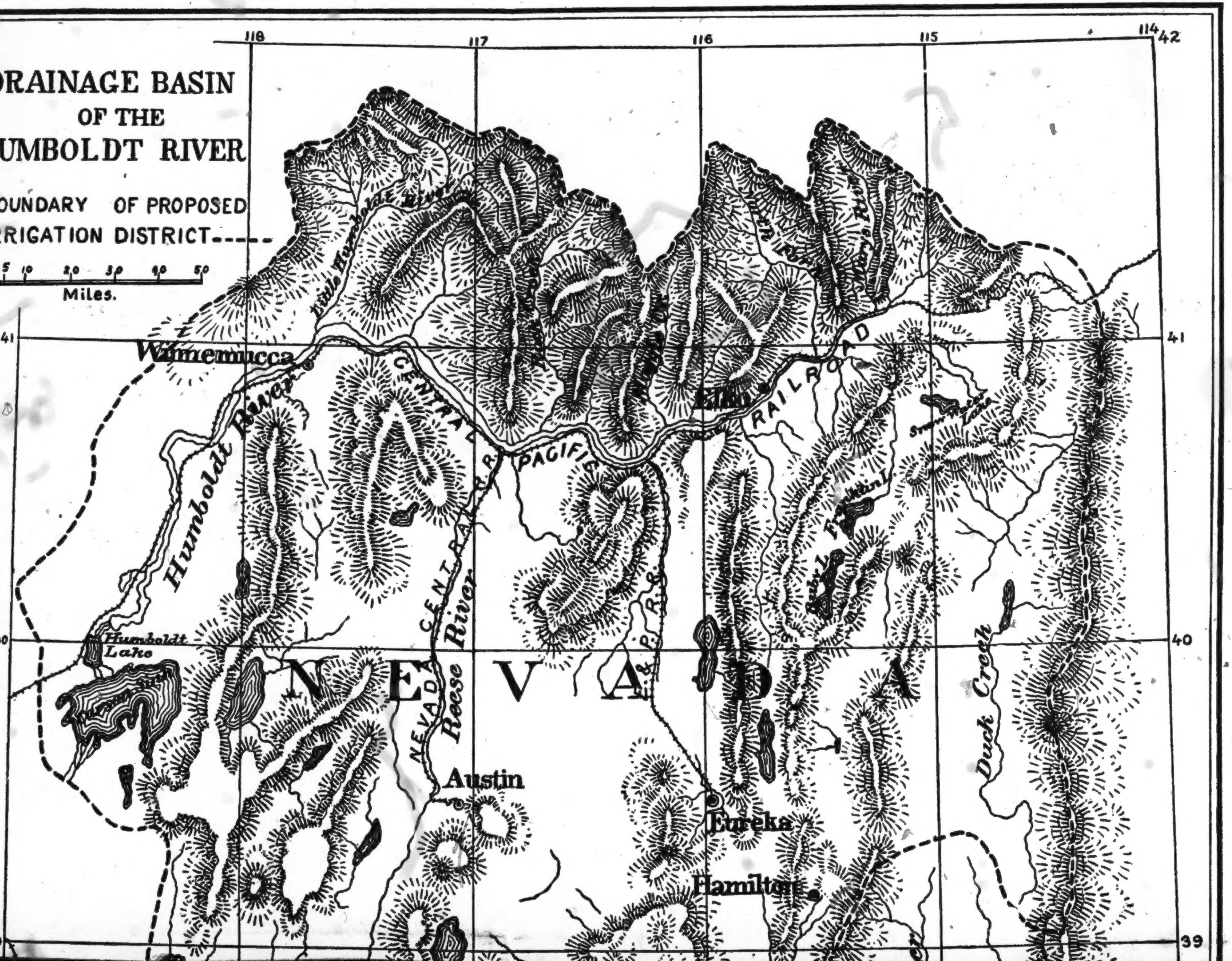
DRAINAGE BASINS
IN
NORTH CALIFORNIA AND WEST NEVADA

BOUNDARIES PROPOSED IRRIGATION DISTRICTS - - - - -

0 5 10 20 30 40 50
Miles,
122
121
120
119
118
43
42
41
40
O R E G O N
C A L I
N E V
BLACK ROCK DESERT
Summer Lake
Lake Abert
Rhett Lake
Pitt R.
Humboldt
Humboldt Lake

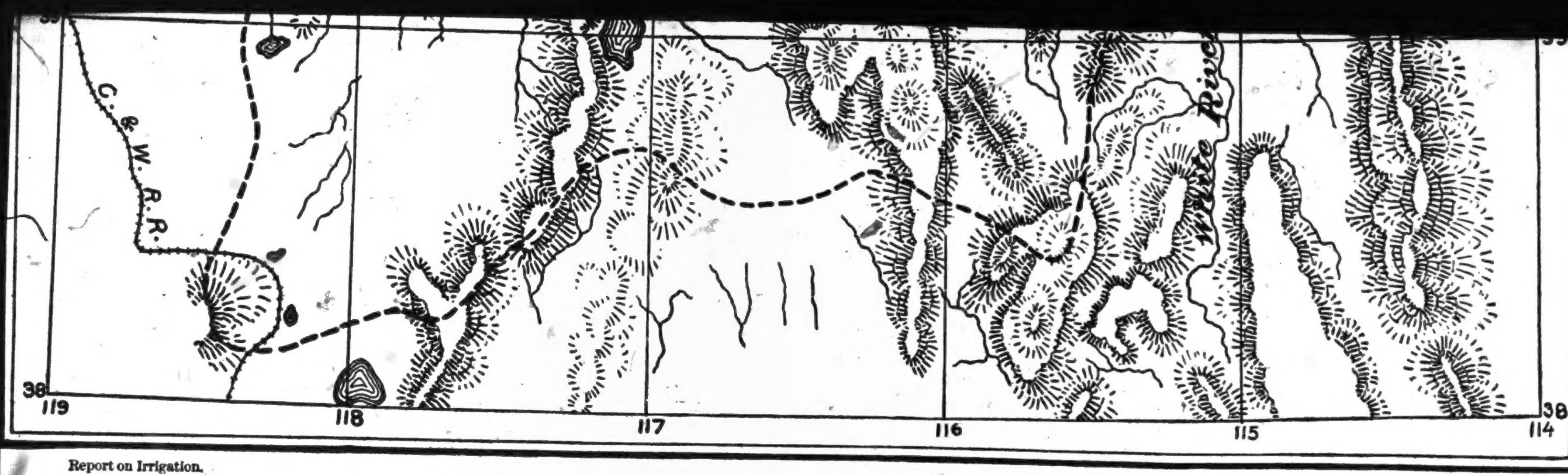

40
Chico
S.P.R.R.
Oroville
Marysville
Feather River
Sacramento River
Sacramento
American River
Cosumnes River
Mokelumne River
Calaveras R.
Stanislaus River
Reno
Virginia
Carson
Carson Sink
CARSON DESERT
CARSON DESERT
Carson Lake
Walker River
Belleville
C.P.R.R.
Lake
39
38
122
121
120
119
118
C
O
R
N
I
F
I
A
A
D
A

Report on Irrigation.

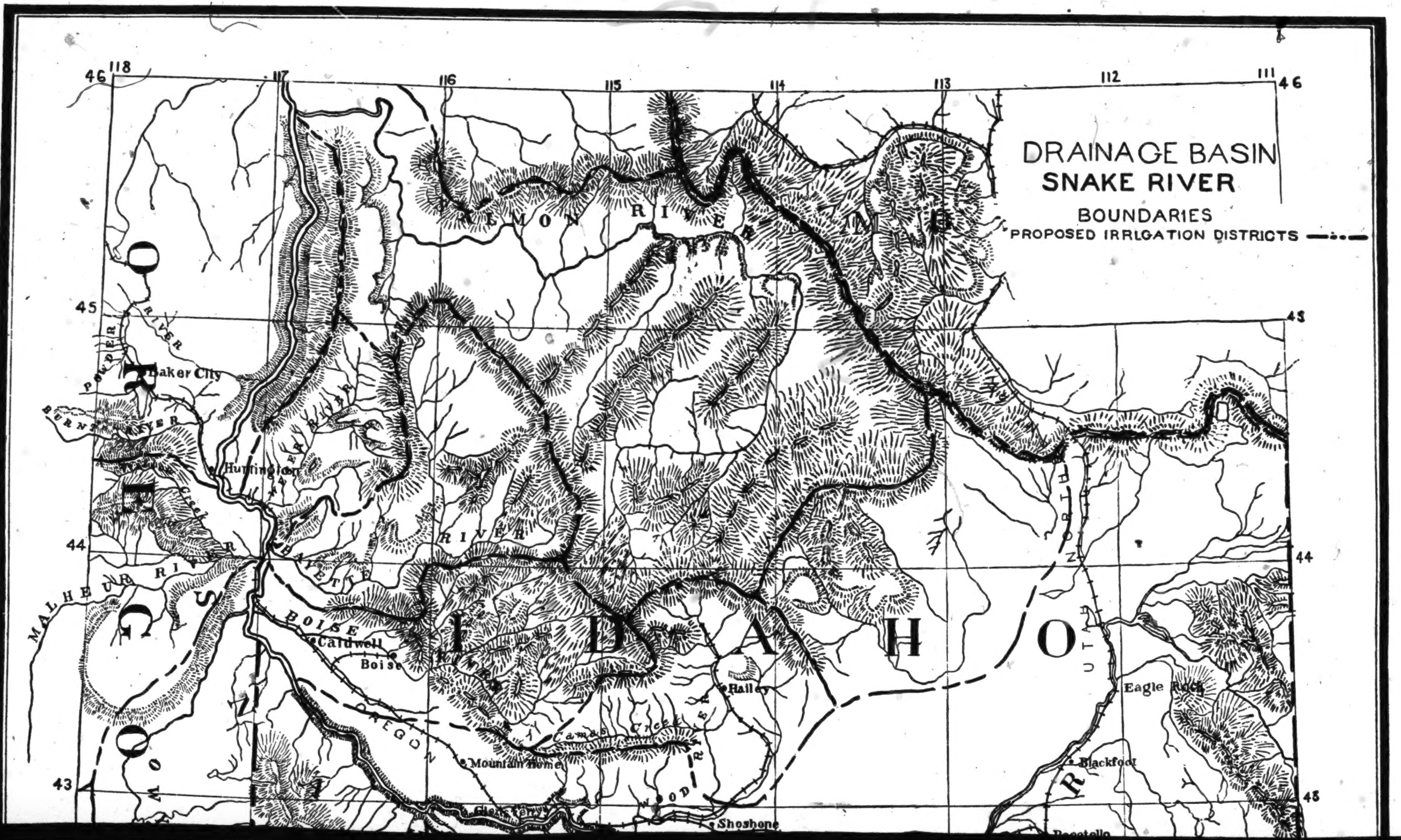


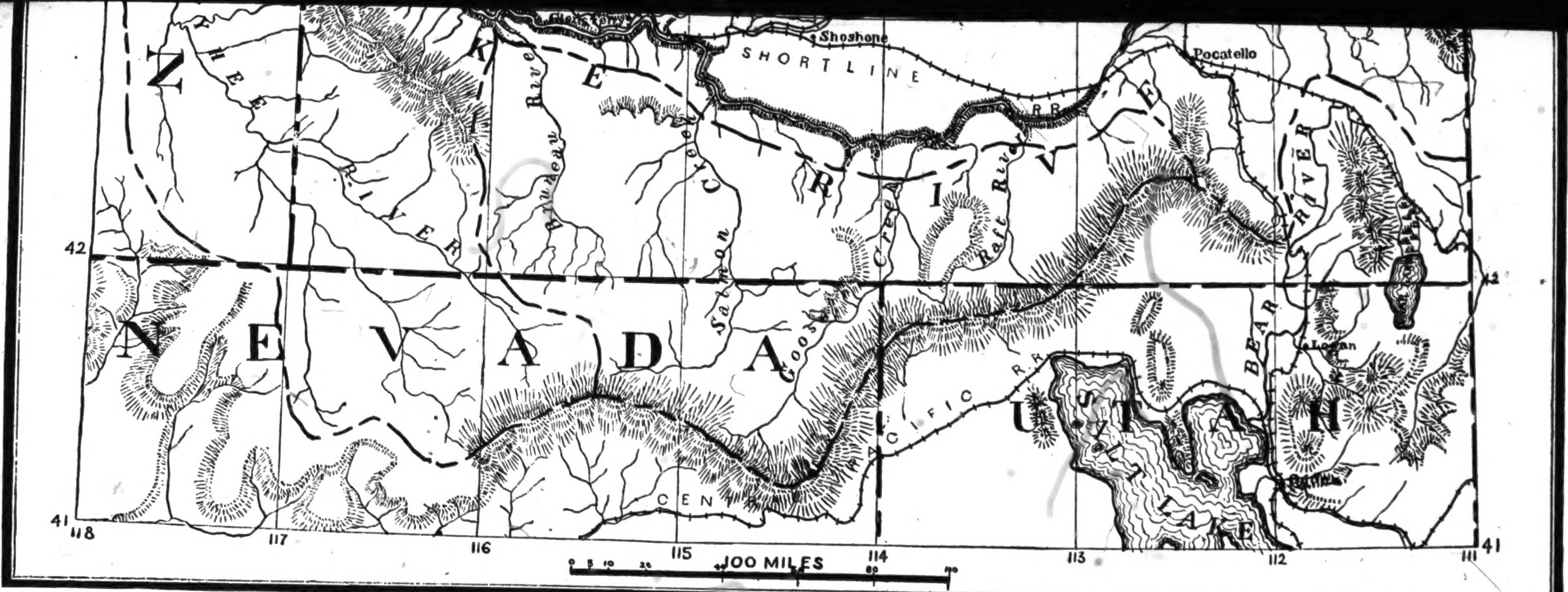
RAINAGE BASIN
OF THE
UMBOLDT RIVER

OUNDARY OF PROPOSED
RRIGATION DISTRICT
5 10 20 30 40 50
Miles.
118
117
116
115
114
42
41
40
39
Little Humboldt River
Winnemucca
Humboldt River
CENTRAL PACIFIC RAILROAD
Elko
Humboldt Lake
NEVADA
NEVADA CENTRAL R.R.
Reese River
E. & P. R.R.
Franklin L.
Snow Water Lake
Duck Creek
Austin
Eureka
Hamilton

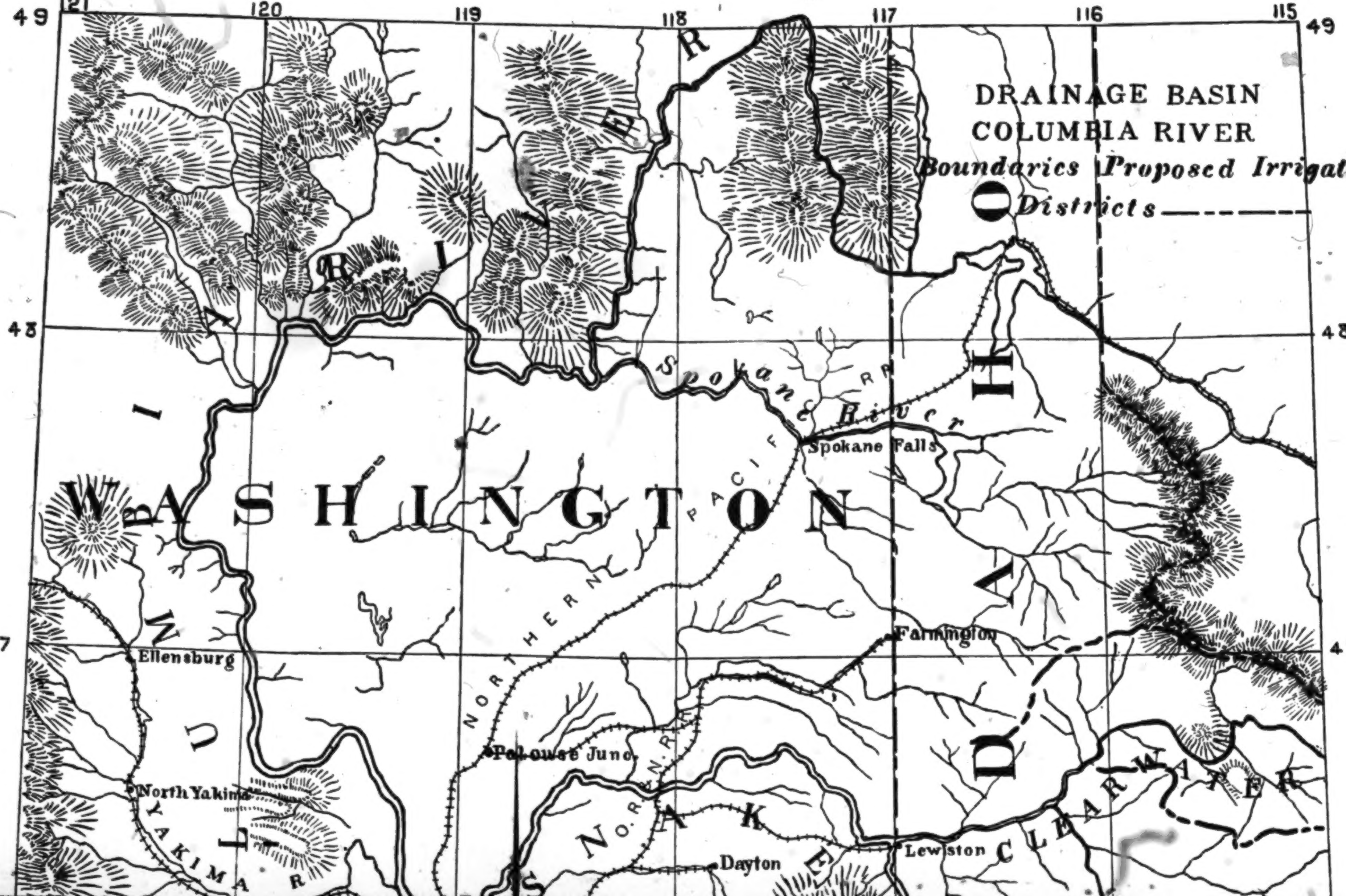

C. & W. R.R.
VII
White River
38
119
118
117
116
115
114
38
39

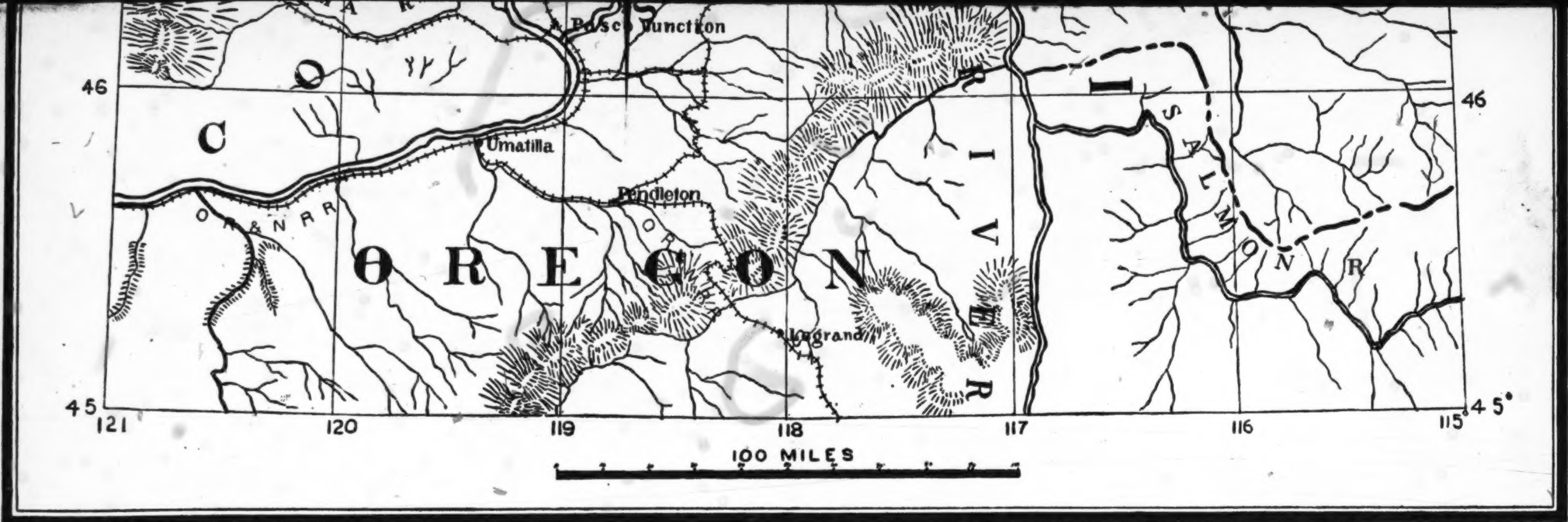
Report on Irrigation.


DRAINAGE BASIN
SNAKE RIVER
BOUNDARIES
PROPOSED IRRIGATION DISTRICTS
118
117
116
115
114
113
112
111
46
45
44
43
OREGON
IDAHO
MONTANA
UTAH & NORTHERN
SALMON RIVER
POWDER RIVER
BURNT RIVER
Baker City
Huntington
PAYETTE
RIVER
MALHEUR RIVER
BOISE
Caldwell
Boise
OREGON SHORT LINE
Mountain Home
Camas Creek
Hailey
WOOD RIVER
Shoshone
Glenns Ferry
Eagle Rock
Blackfoot
Pocatello

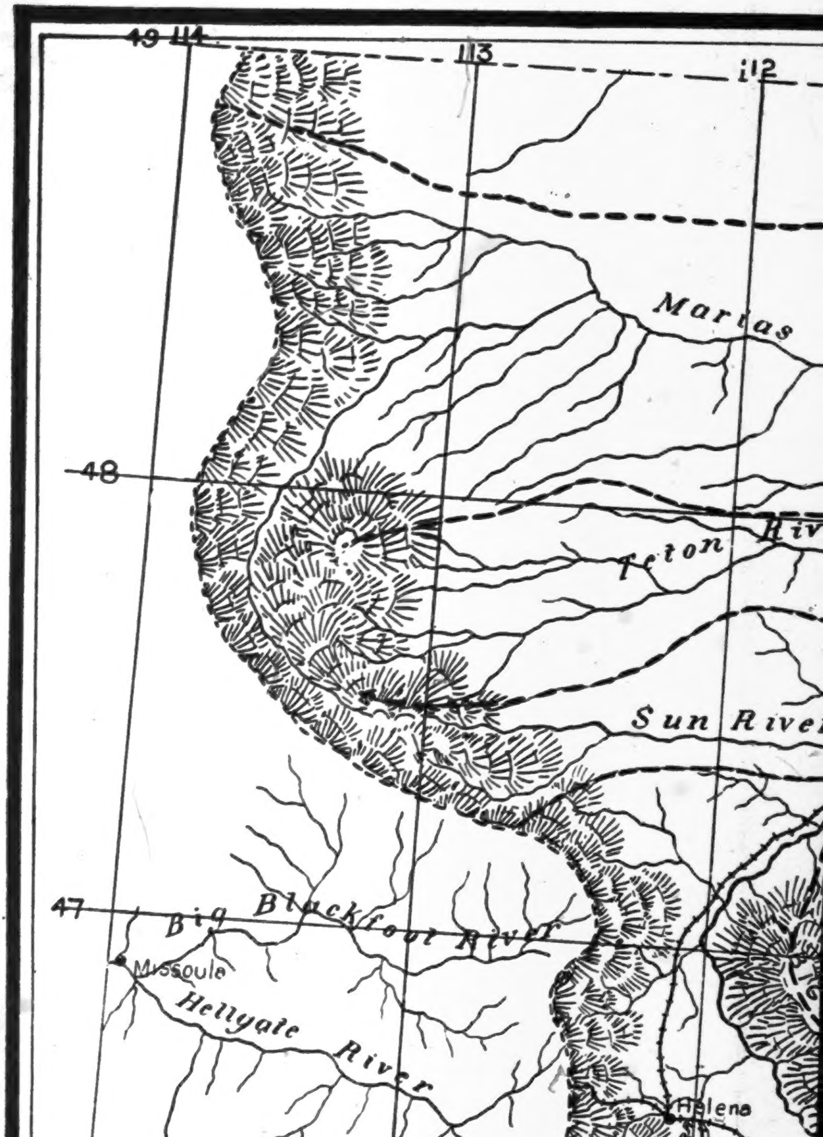

Glenn's Ferry
Shoshone
SHORT LINE R.R.
Pocatello
SNAKE RIVER
OWYHEE RIVER
Bruneau River
Salmon Creek
Goose Creek
Raft River
BEAR RIVER
NEVADA
UTAH
Logan
Ogden
SALT LAKE
CENTRAL PACIFIC R.R.
42
41
118
117
116
115
114
113
112
111
0 5 10 20 40 60 80 100
100 MILES

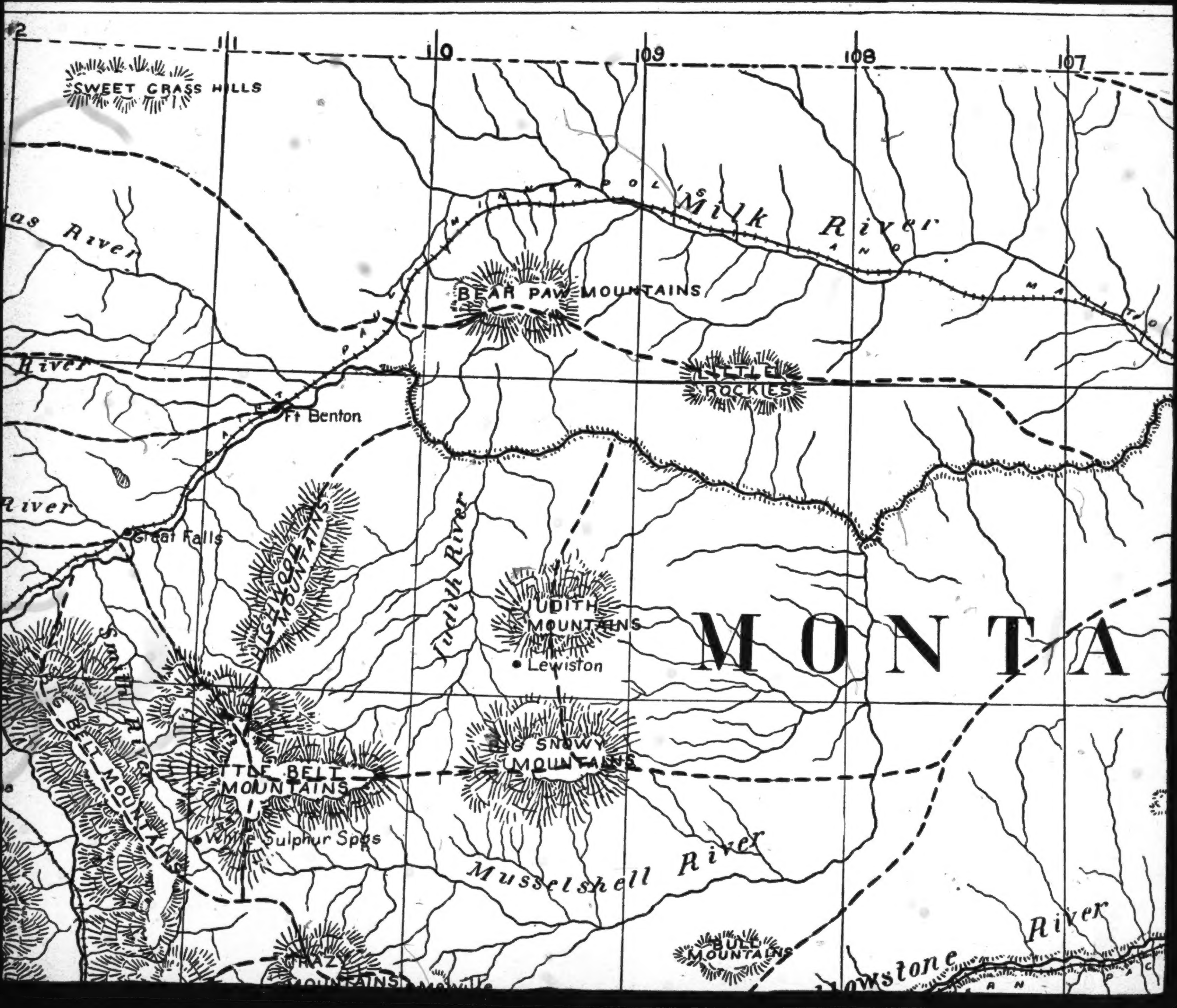
Report on Irrigation.

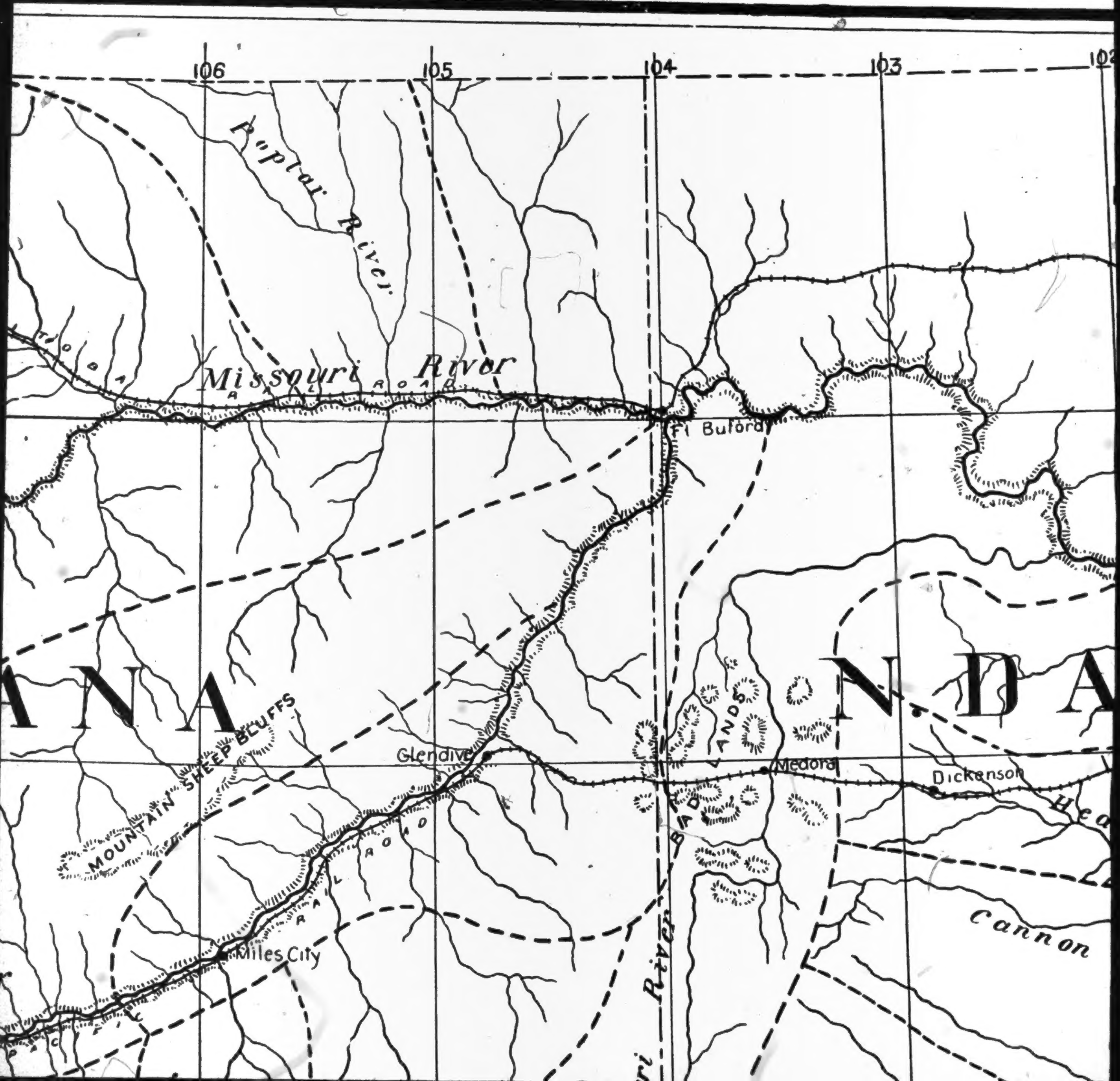

121
120
119
118
117
116
115
49
48
47
DRAINAGE BASIN
COLUMBIA RIVER
Boundaries Proposed Irrigation Districts
WASHINGTON
IDAHO
Spokane River
Spokane Falls
NORTHERN PACIFIC RR
Farmington
Ellensburg
North Yakima
YAKIMA R
Palouse Junc
N.P.R.R.
Dayton
Lewiston
CLEARWATER
SNAKE

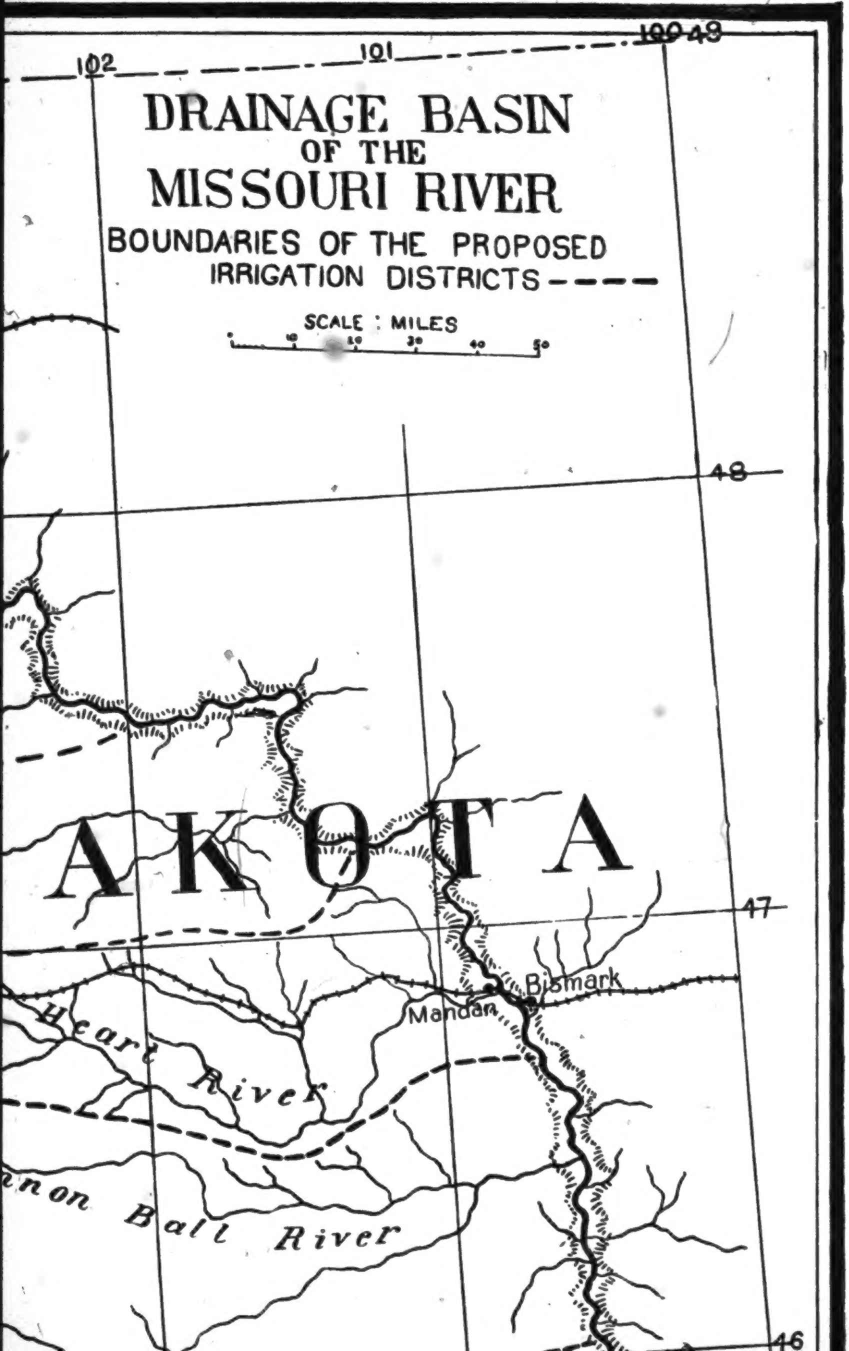

Pasco Junction
Umatilla
Pendleton
Lagrand
O R & N R R
C O
OREGON
RIVER
I
SALMON R
46
45
121
120
119
118
117
116
115°
100 MILES

Report on Irrigation.


49
114
113
112
Marias
48
Teton Riv
Sun Rive
47
Big Blackfoot River
Missoule
Hellgate River
Helena
Deer Lodge
Phillipsburgh
Anaconda
Boulder
Butte
Montana Central
46

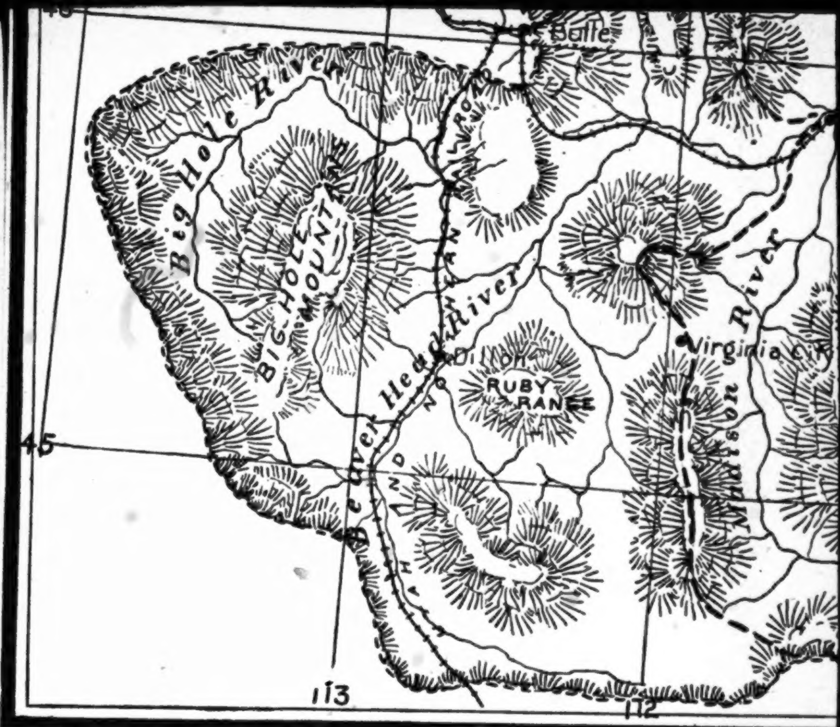

112
111
110
109
108
107
SWEET GRASS HILLS
as River
Milk River
BEAR PAW MOUNTAINS
LITTLE ROCKIES
River
Ft Benton
River
Great Falls
HIGHWOOD MOUNTAINS
Judith River
JUDITH MOUNTAINS
Lewiston
MONTA
Smith River
BIG BELT MOUNTAINS
LITTLE BELT MOUNTAINS
BIG SNOWY MOUNTAINS
White Sulphur Spgs
Musselshell River
CRAZY MOUNTAINS
Melville
BULL MOUNTAINS
llowstone River


106
105
104
103
102
Poplar River
Missouri River
RAILROAD
Ft Buford
ANA
N. DA
MOUNTAIN SHEEP BLUFFS
Glendive
BAD LANDS
Medora
Dickenson
Hea
RAILROAD
Cannon
Miles City
River
ri
PACIFIC

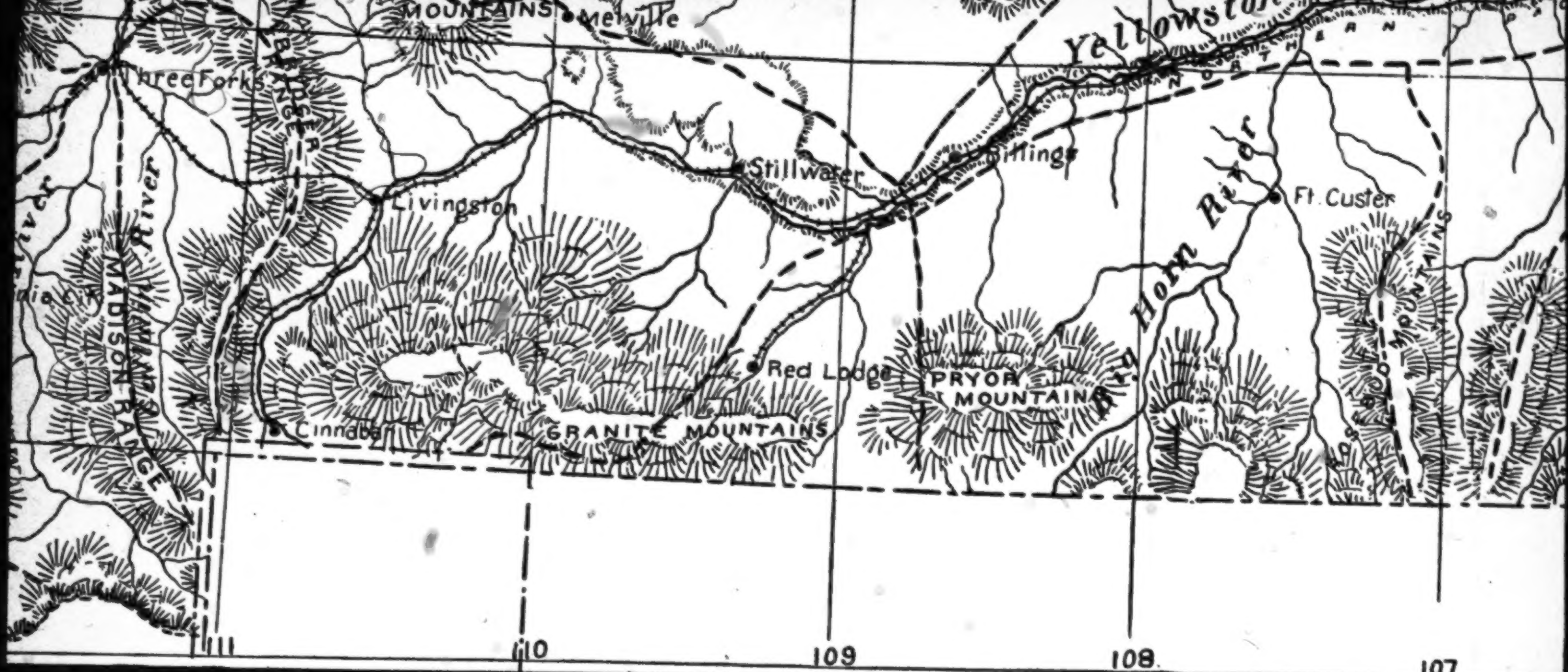


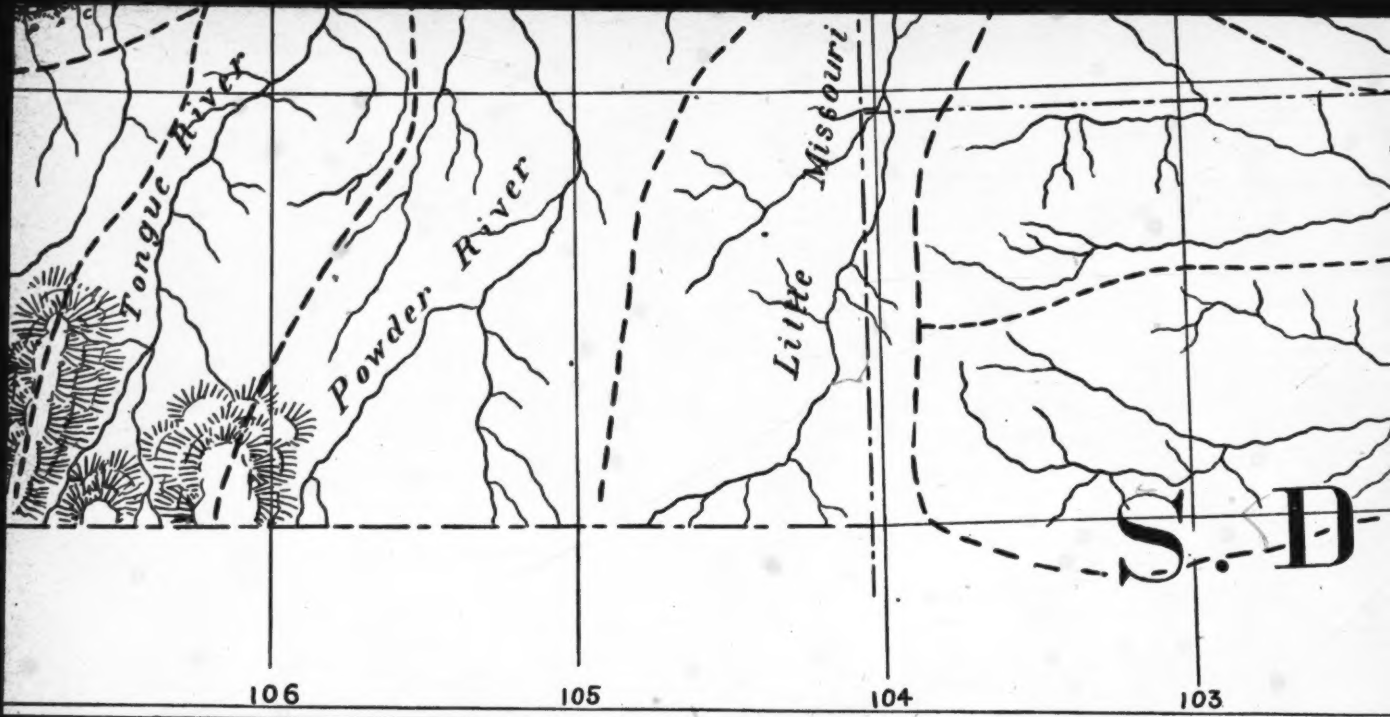
DRAINAGE BASIN
OF THE
MISSOURI RIVER

BOUNDARIES OF THE PROPOSED
IRRIGATION DISTRICTS ----
SCALE : MILES
0
10
20
30
40
50
102
101
100
48
48
47
46
AKOTA
Bismark
Mandan
Heart River
non Ball River

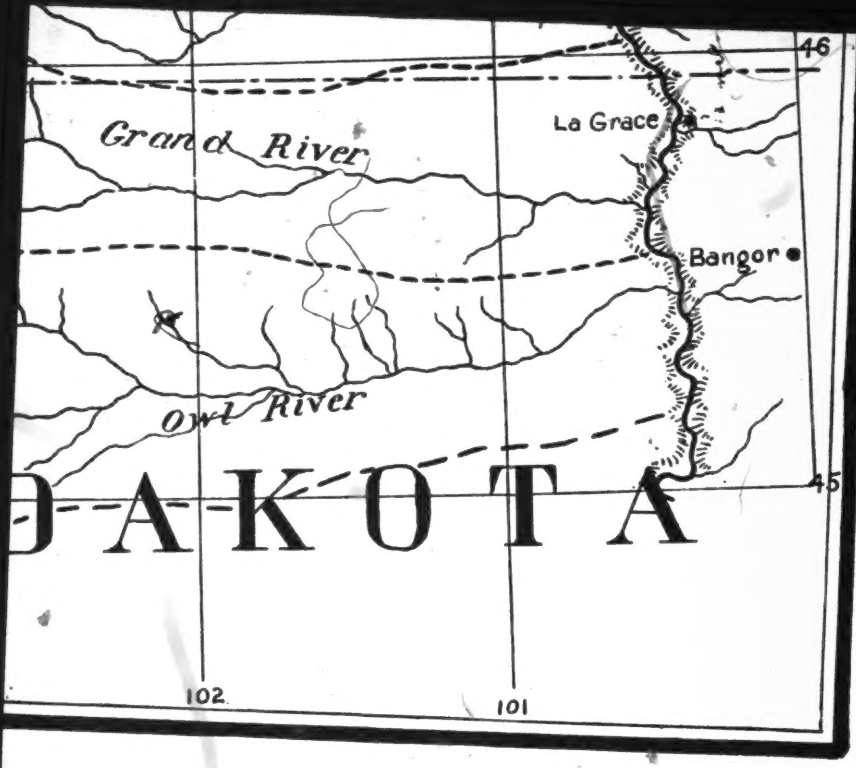

Butte
Big Hole River
Big Hole Mountains
Beaver Head River
Dillon
Ruby Range
Virginia City
Madison River
45
113
112

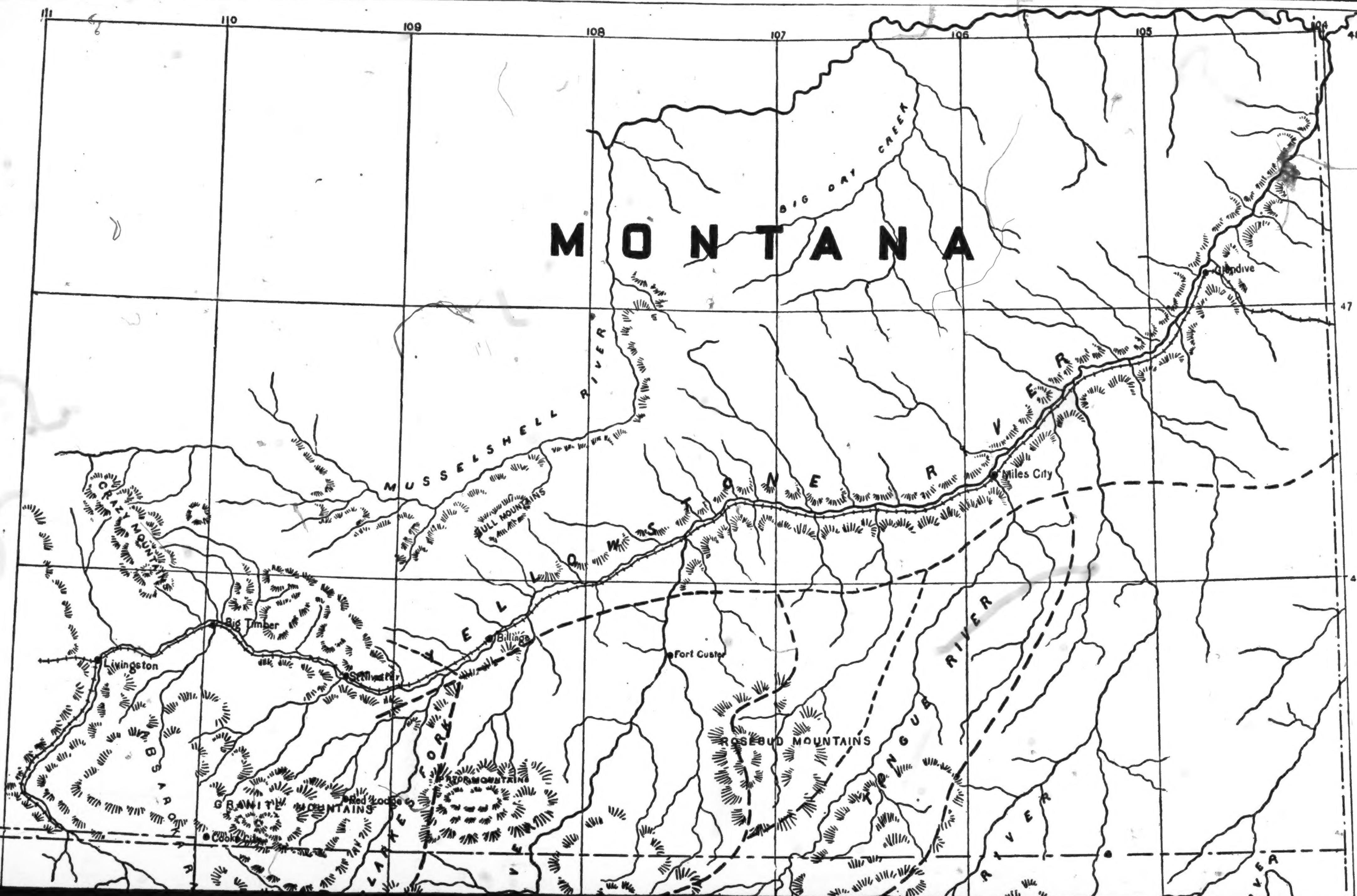
Report on Irrigation.

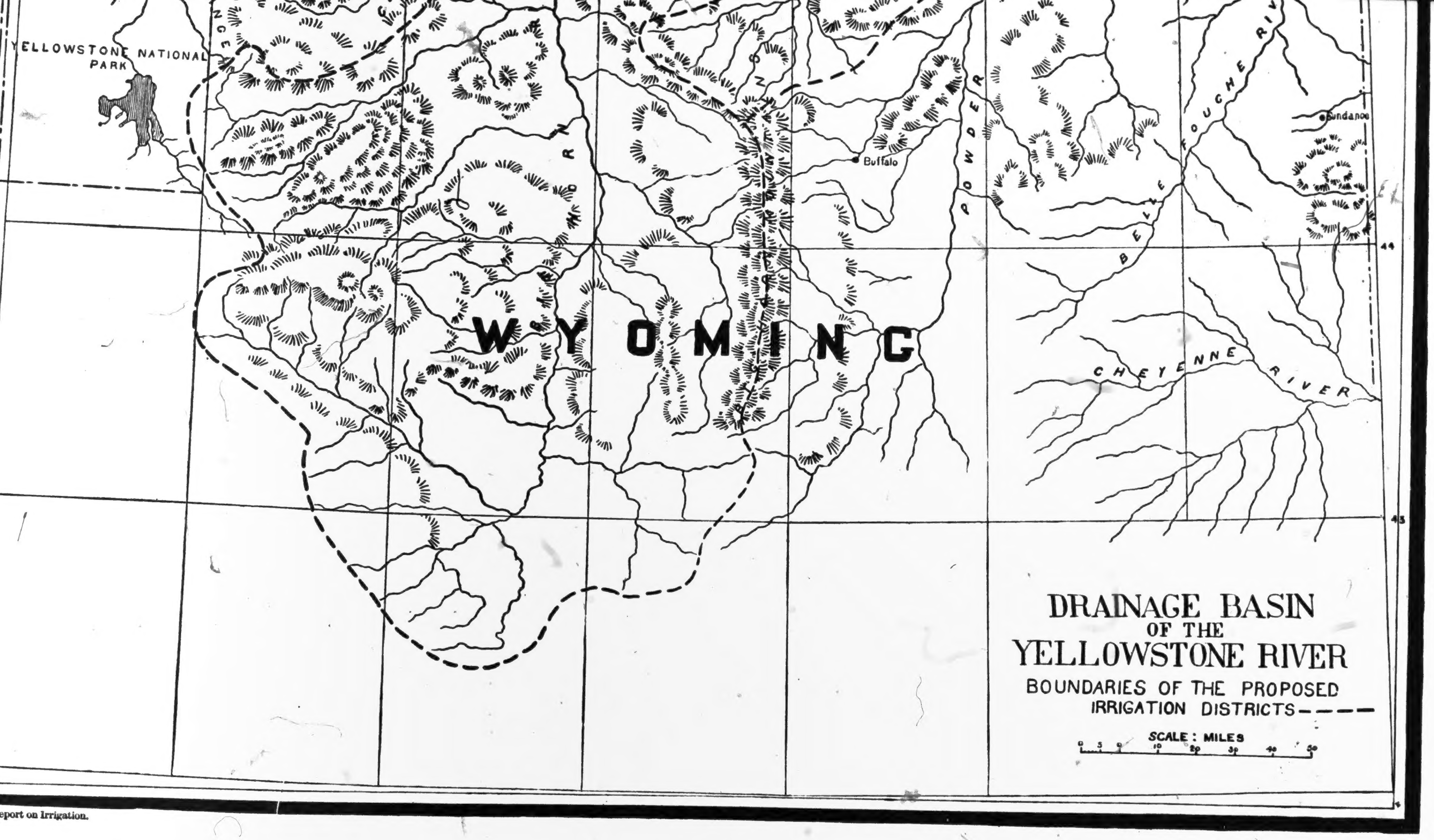

MOUNTAINS
Melville
Yellowstone
NORTHERN
Three Forks
Madison River
MADISON RANGE
Livingston
Stillwater
Billings
Ft. Custer
Big Horn River
Red Lodge
PRYOR MOUNTAINS
GRANITE MOUNTAINS
Cinnabar
MOUNTAINS
111
110
109
108
107



Tongue River
Powder River
Little Missouri
S. D
106
105
104
103


46
La Grace
Grand River
Bangor
Owl River
45
DAKOTA
102
101

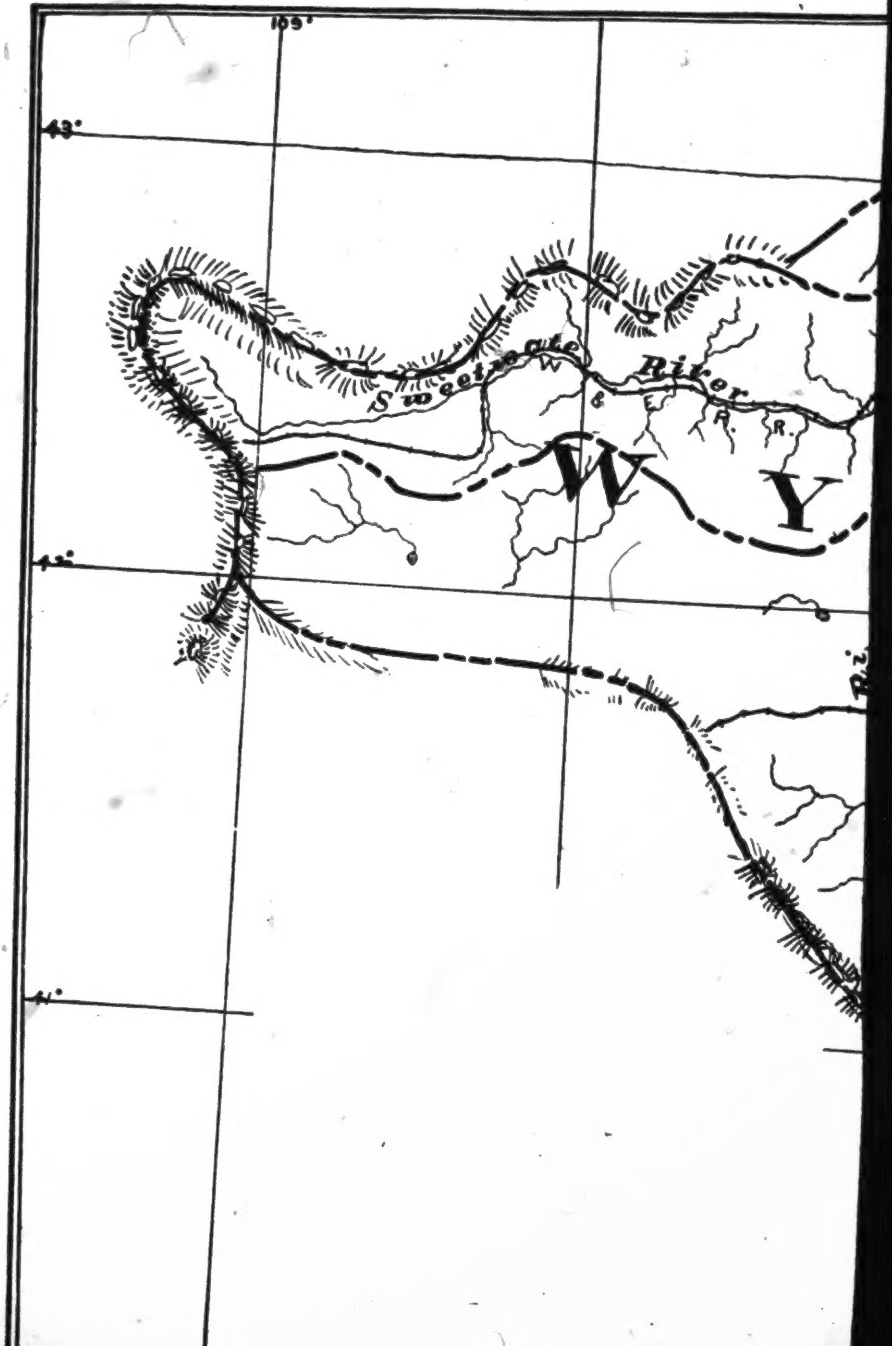

111
110
109
108
107
106
105
104
48
47
46
45
MONTANA
BIG DRY CREEK
MUSSELSHELL RIVER
YELLOWSTONE RIVER
Glendive
Miles City
CRAZY MOUNTAINS
BULL MOUNTAINS
Big Timber
Livingston
Stillwater
Billings
Fort Custer
ROSEBUD MOUNTAINS
TONGUE RIVER
RIVER
ABSAROKA
GRANITE MOUNTAINS
Red Lodge
Cooke City
PRYOR MOUNTAINS
CLARKE FORK

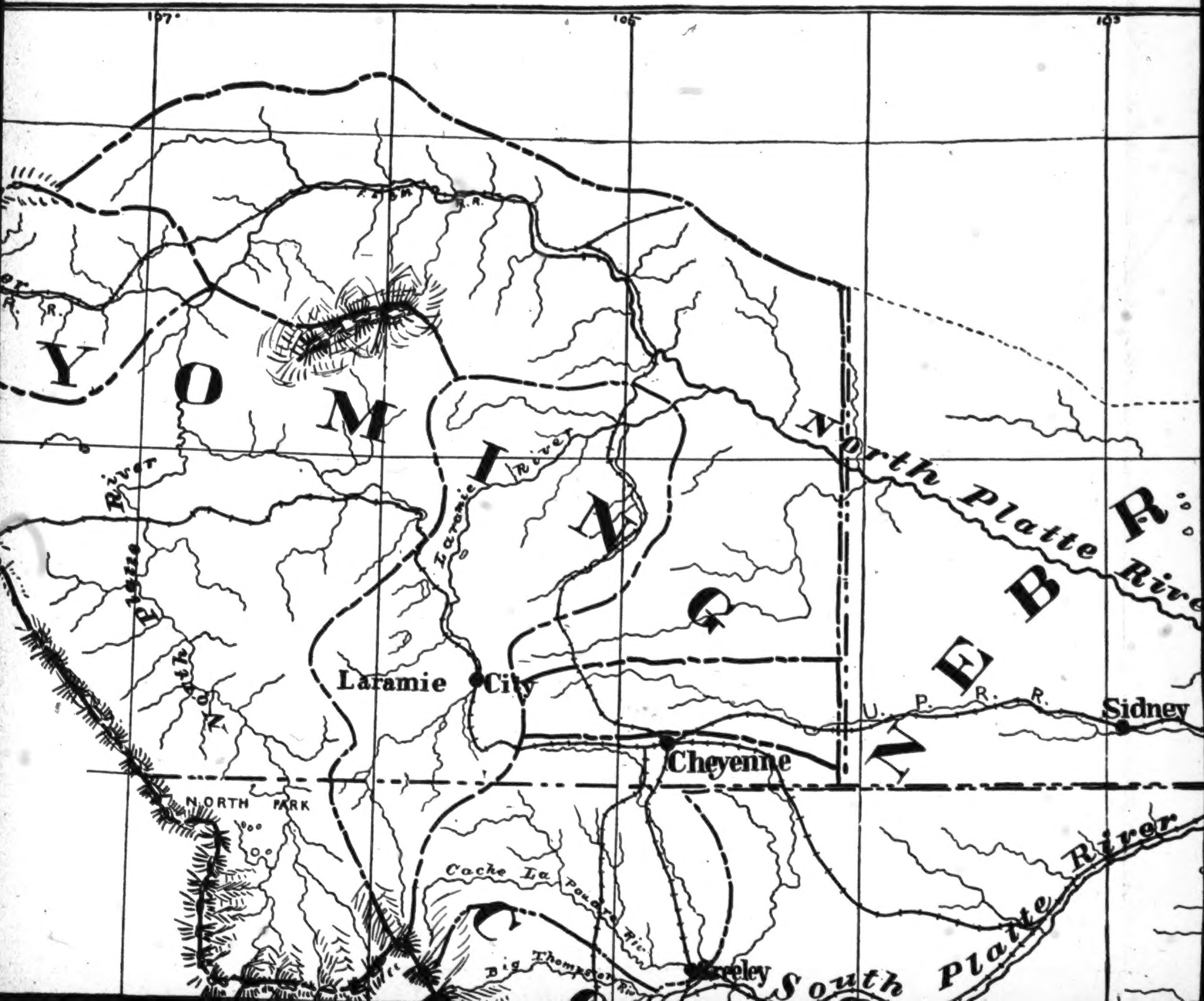

YELLOWSTONE NATIONAL PARK
Buffalo
Sundance
POWDER R
BELLE FOUCHE RIVER
CHEYENNE RIVER
WYOMING
44
43
SCALE : MILES
0 5 0 10 20 30 40 50

DRAINAGE BASIN
OF THE
YELLOWSTONE RIVER

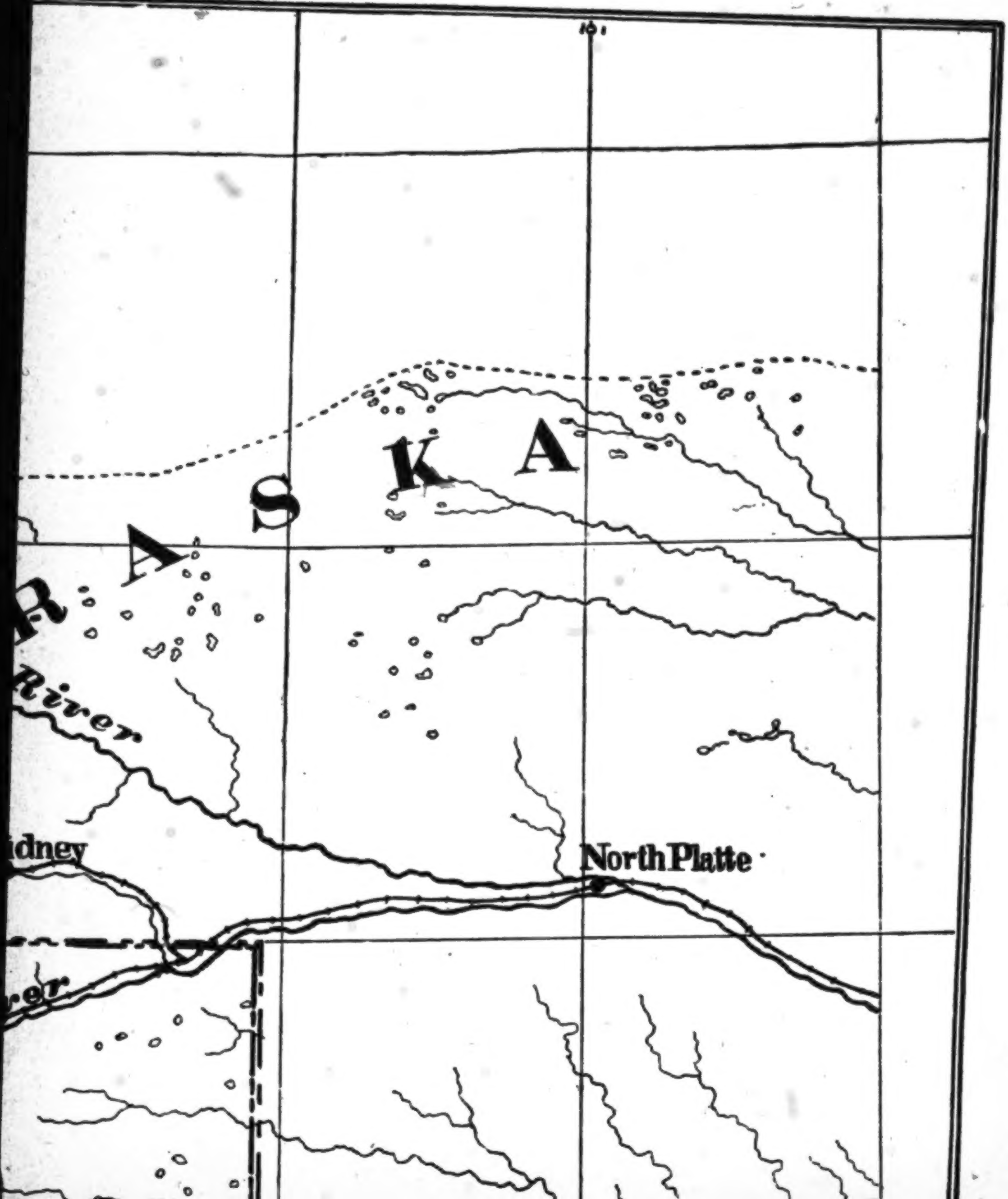
BOUNDARIES OF THE PROPOSED
IRRIGATION DISTRICTS – – – –

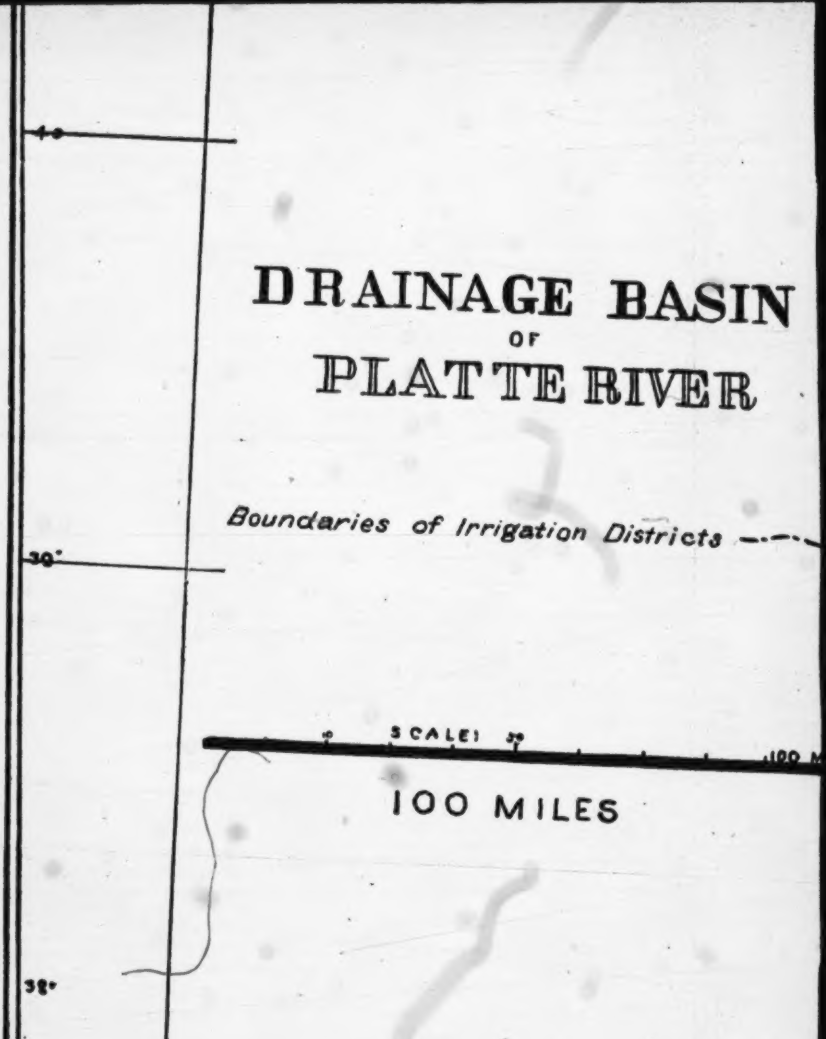
eport on Irrigation.


109°
43°
42°
41°
Sweetwater River
W & E R. R.
W Y
Ri

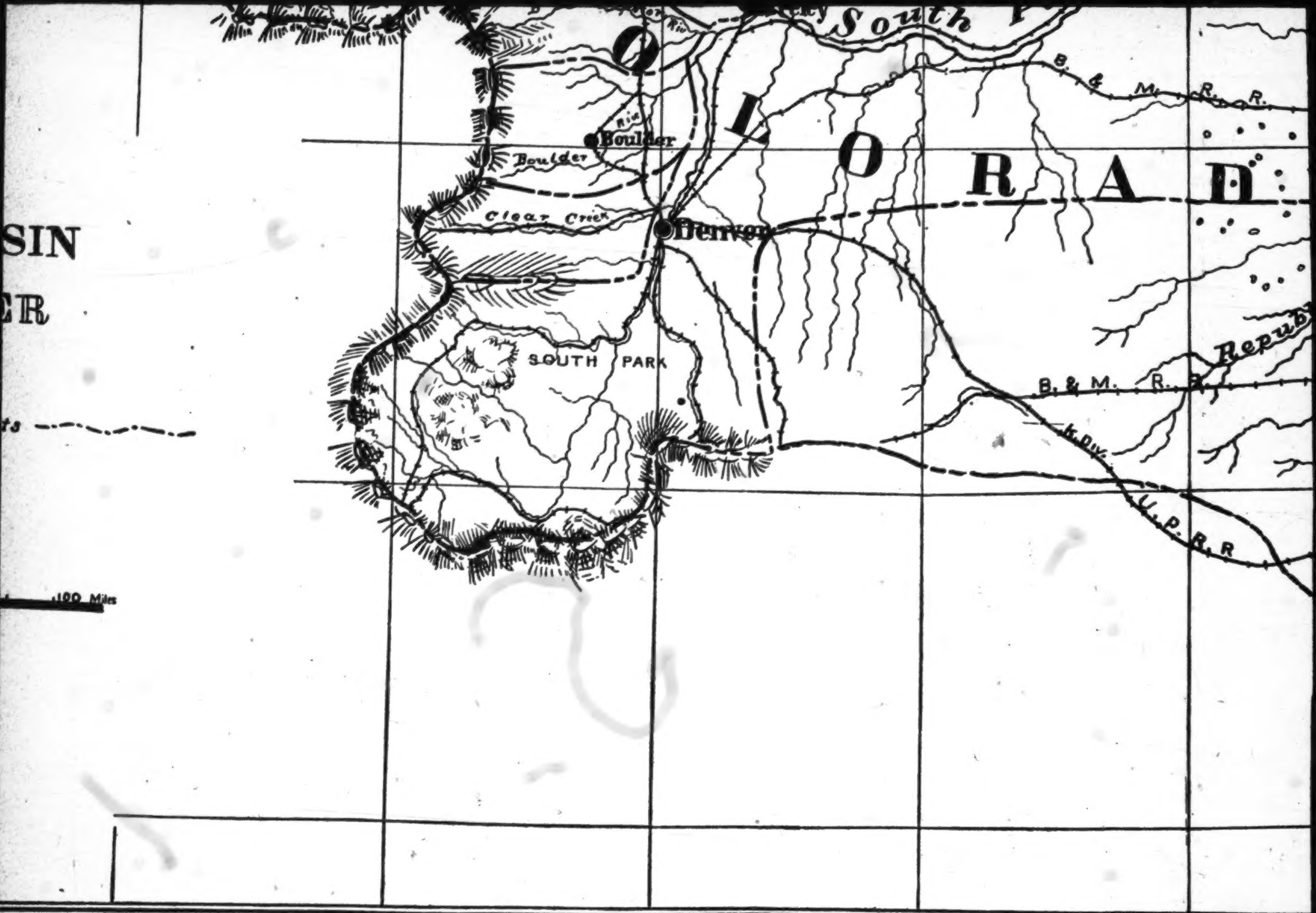


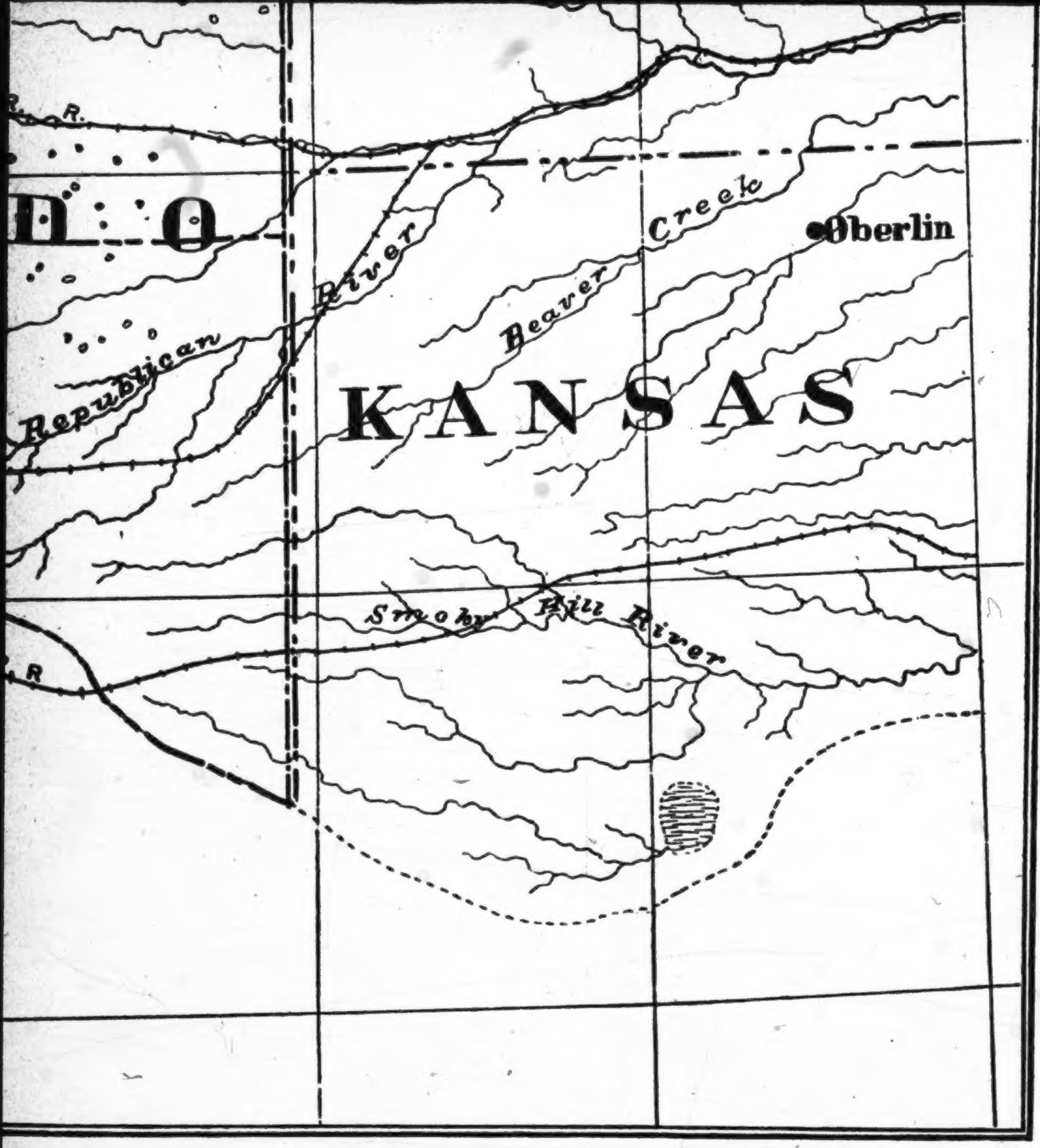
107°
106°
105°
R. R.
R. R.
W Y O M I N G
River
North Platte
Laramie River
North Platte River
N E B R
Laramie City
Cheyenne
U. P. R. R.
Sidney
NORTH PARK
Cache La Poudre Riv.
Big Thompson Riv.
Greeley
South Platte River
C


101
R A S K A
River
idney
North Platte
ver


40
39°
38°
DRAINAGE BASIN
OF
PLATTE RIVER
Boundaries of Irrigation Districts
SCALE:
10
50
100 M
100 MILES

Report on Irrigation.


SIN
ER
South P
B. & M. R. R.
C O L O R A D
Boulder
Boulder
Clear Creek
Denver
SOUTH PARK
Repub
B. & M. R. R.
K.P.
U.P.R.R
100 Miles


R. R.
D O
Republican
River
Beaver
Creek
Oberlin
KANSAS
Smoky
Hill River
R

MISCELLANEOUS PAPERS.

ESTIMATE FOR EXPENDITURES OF SURVEY.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
Washington, D. C., February 7, 1890.

DEAR SIR: Agreeably to a promise made you I herewith submit for your consideration an estimate of the cost of the field work of the Irrigation Survey for the fiscal year ending June 30, 1891, which includes the cost of doing the work and collecting the information that in my judgment is required by the law making appropriations for this specific work.

The estimate does not include the salaries of administrative officers above the Chief Engineer, nor the expenses connected with the publication of the necessary maps and reports, or the expenses for office rent in Washington and incidentals connected therewith.

After a careful consideration of the question regarding the time required to complete the surveys, and the ultimate cost thereof, I am of the opinion that five years will be ample time in which to cover the whole country with the necessary field work. Another year will be required to finish the office work and make the final field reports. In placing the time at five years I have endeavored to consider the immediate necessity for pushing the work with due regard for securing good results and with minimum expenditure of money.

I have designated the allotments for each State and Territory, but this may not be considered as at all arbitrary. This can also be said in reference to the total amount.

The semi-arid portion of our country needs something more than is contemplated in the present law. This section requires artificial water many times to tide over a few weeks of scanty rain-fall. There are no "waters in sight," and grave engineering difficulties present themselves when undertaking to supply it with the common methods for irrigation. There are several theories as to how the waters not "in sight" can be utilized. It is probably wise for the Government to undertake the solution of some of the most reasonable of these theories.

If the subject of climatological observations are to be taken up by the survey, as was suggested to the Senate committee at its last meeting, I would add at least $10,000 for this purpose.

If deemed wise, the appropriation could be made in bulk and then, if other considerations were to be taken into account, the expenditures could be locally changed.

I should suppose $75,000 would cover fully all unprovided salaries, office rent, the printing of maps, reports, etc., making in all $470,000. The appropriation for the first year will be larger than that for subsequent years on account of the purchases of instruments, field outfits, etc.

E. S. NETTLETON,
Supervising Engineer U. S. Irrigation Survey.

Hon. W. M. STEWART,
Chairman Senate Special Committee
on Irrigation and Reclamation of Arid Lands.

Estimate of the cost of the necessary surveys in compliance with the act of October, 1888, for the fiscal year ending June 30, 1891.

California	$50,000	Wyoming	$25,000
Oregon	15,000	Montana	25,000
Washington	15,000	Dakota (North)	10,000
Idaho	30,000	Dakota (South)	10,000
Nevada	30,000	Nebraska	10,000
Utah	40,000	Kansas	10,000
Arizona	20,000	Texas	5,000
New Mexico	50,000		
Colorado	50,000		395,000

GENERAL INSTRUCTIONS FOR HYDROGRAPHERS.

[The following instructions were issued by the chief engineer of the United States Irrigation Survey.]

The duties which devolve upon the hydrographers will be at once of a highly scientific and practical character, and will consist in ascertaining by systematic observations and measurements the values of numerous factors or qualities which must be known in order to fully carry out the purposes of the law, which requires an investigation of the extent to which the arid lands can be redeemed by irrigation. They may be mentioned in the following order:

(1) Measurements of water supply.
(2) Measurements of the loss of water by evaporation.
(3) The investigation of the climatology of the arid region with reference to agriculture by irrigation.
(4) Measurements of sediments transported by streams.
(5) The duty of water.
(6) Collection of general information.

(1) The measurement of water supply will consist primarily in the gauging of streams. For this purpose the methods developed at Embudo will be followed for the present, but with time and experience it is hoped that improvement will come. For this purpose stations will be established on streams to be gauged at points selected, and a systematic record will be kept of the rise and fall of the streams by means of inclined graduated rods, and the stations will be visited by the hydrographers so as to gauge repeatedly at different stations of the water until a sufficient number of stages have been gauged to admit of a formula for the stream and the s a tion. The stream beds will be plotted and the slopes ascertained by leveling. Full records will be kept by the hydrographers of all their gauging work and the results reported monthly to this office.

(2) This evaporation will also be measured by the general methods employed at Embudo. The quantity to be ascertained is the evaporation from water surfaces. Wherever practicable it is desirable to combine station work by placing evaporizaters at the same stations as river gauges; but this must be influenced by considerations of economy and the intelligence of the observers.

(3) The study of the climatology of the West will be mainly the work of the central office, as the data upon which it depends are of regional extent, and most of them are collated by the Signal Service, whose records are accessible only in Washington; but hydrographers are expected to furnish some accessory data, and to cultivate in their divisions the interest of volunteer observers and to promote the organization of meteorological societies. They are cautioned, however, not to duplicate the work of the Signal Service, but to maintain a most cordial and co-operative attitude towards the observers of that bureau and to conform to its methods.

Rain gauges will be placed at stations not occupied by Signal Service observers, and for the present localities at higher altitudes especially need investigating as to the amount of precipitation, and as a general though not invariable rule preference should be given to higher altitudes in choosing rain-gauge stations. It is deemed unadvisable to use the sling psychrometer except in cases where the observer is known to be a man of exceptional intelligence and skilled in the use of meteorological instruments.

(4) The measurements of sediments transported is a subject which must await future development, and no instructions can be given for the present with reference to it.

(5) Care should be taken to ascertain the duty of water in all localities where irrigation is practiced whenever opportunity occurs. The subject should be investigated personally, and too much reliance should not be placed on the mere statements of farmers unsupported by careful measurement. As the duty will vary, much inquiry is necessary to ascertain upon what causes such variations attend. The following factors seem to be of prime importance: (1) Method of flooding lands, (2) climate, (3) character of soil and subsoil, and (4) kind of crop raised.

(6) The central office will be frequently called upon to furnish information not only to Congress but to thousands of individuals throughout the country upon the subject of irrigation. In short, it must constitute itself a bureau of information. The hydrographers are expected to have their eyes open to all facts relating to irrigation and to keep the central office advised of everything of interest.

Reports must be made monthly, embracing a full account of all operations during the month. Records of gaugings, with the plates of the section at the station, and records of soundings and leveling must be kept by the hydrographers and copies of them furnished to this office at such times as will hereafter be stated and upon such forms as shall be prescribed. They will also collate the reports of the rain gauge and other observers and consolidate them, forwarding the consolidated report to this office.

EQUIVALENTS OF UNITS USED IN MEASURING WATER FOR IRRIGATION PURPOSES.

[Prepared by E. S. Nettleton, supervising engineer U. S. Irrigation Survey.]

UNITED STATES GALLONS.

100 gallons per minute equals—
.44 acre foot in 24 hours.
13¼ " feet in 30 days.
40 " " 3 months.
160 " " 1 year.
1 " foot in 55 hours.
.223 " " 1 second.
11⅛ California (miner's) inches.
8½ Colorado (miner's) inches.
1 United States gallon equals 231 cubic inches, or 1.748 cubic foot.

COLORADO INCHES.

100 Colorado inches equals—
5⅙ acre feet in 24 hours.
1 " foot in 4.2 "
155 " feet in 1 month.
465 " " 3 months.
1,860 " " 1 year.
19½ gallons per second.
1,170 " per minute.
2.6 cubic feet per second.
130 California inches.

CALIFORNIA INCHES.

100 California inches equals—
4 acre feet in 24 hours.
1 " foot in 6 "
120 " feet in 30 days.
360 " " 3 months.
1,440 " " 1 year.
15 gallons per second.
900 " per minute.
77 Colorado inches.
2 cubic feet per second.

CUBIC FEET.

1 cubic foot per second equals—
2 acre feet in 24 hours.
60 " " 30 days.
180 " " 3 months.
720 " " 1 year.
7.48 gallons per second.
449 " per minute.
50 California inches.
38.4 Colorado inches.

THE SEEPAGE OF WATER.

EXTRACTS FROM THE REPORT OF THE STATE ENGINEER OF COLORADO FOR THE YEARS 1885 AND 1886.

[Filed by E. S. Nettleton.]

Seepage is a subject which is beginning to assume definite importance in connection with the economic use of water for irrigation; but it is only within the last year or two that any observations have been taken to accurately determine the volume in the stream above when canals are taken out and at a given point below. The amount returned to the stream by seepage through the soil was merely a matter of conjecture.

It is a well established fact that before irrigation became so universal in Colorado the water in the streams was greatly decreased in volume as it found its way out upon the plains. This was more particularly observed in the time of low water during the spring and fall season. Those who came up the South Platte Valley a few years ago will remember crossing the river in the eastern part of Weld County on the dry sand.

Within the last ten years at Platteville the river has vanished utterly at times, so that people could cross and recross dry shod. But there has been a change in this respect, and it has evidently been caused by the building of irrigating canals and the distribution and suspension for a time of the water upon and in the uplands adjacent to the streams. Observation and experience prove conclusively that seepage water is an important factor and adds largely to the volume of water flowing in the channel.

The increase in the lower valley of the South Platte has been a matter of notice, and becomes so distinct and certain that new canals have been constructed to take advantage of this interesting and important condition of affairs.

It is well known that the bed of Cherry Creek, once utilized as a thoroughfare for business in the city of Denver, has now a constant stream of water coursing through it, which is unquestionably the resultof seepage from what is commonly known as the High Line Canal of the English company.

In October, 1885, I instituted a series of measurements of seepage water in the Cache la Poudre, in order to obtain some accurate information upon this subject.

Five points of observations were selected, the uppermost being at the measuring flume in the cañon and the lowest at a point east of the town of Greeley, the two points being about thirty-five miles apart. A request was issued to the canal owners to close down the head-gates of all the canals, and so exclude all water; but in consequence of head-gates leaking, it was found necessary to measure the quantity which found its way into each canal and add this amount to that found flowing in the river in order to obtain the total discharge.

The following table shows the results of the measurements made October 12 and 13, 1885:

[Cubic feet per second.]

Places where measurements were taken.	Water in river.	Water diverted from river by canals.	Water in the river at the points measured plus that diverted by canals between those points.	Increase in volume of the river between the points measured.	Increase in river from the cañon to point measured.
First river measurement	127.06				
Pleasant Valley and Lake Canal		1.75			
Larimer County Canal		0.58			
Jackson Ditch		0.27			
Cache la Poudre Ditch		1.00			
Larimer No. 2 Canal		0.54			
New Mercer Canal		0.23			
Fort Collins Canal		1.14			
Second river measurement	134.00		130.47	11.88	11.88
Larimer and Weld Canal		1.73			
Judge Howes' Ditch		2.60			
Josh Ames' Ditch		0.69			
The Lake Canal		1.25			
Cache la Poudre No. 2		3.22			
Third river measurement	150.00		159.47	25.50	37.40
The Whitney Ditch		1.58			
Cache la Poudre No. 3		5.87			
Fourth river measurement	161.86		169.32	19.33	56.69
Ogilvy Ditch		38.96			
Fifth river measurement	153.12		192.07	30.21	86.90

The following table is made up from measurements made of the same river but four years later, or in October, 1889. These last measurements show that the seepage has been increasing since 1885.

Table of measurements of seepage water in the Cache la Poudre River, Larimer and Weld Counties, Colo., October 14 to 17, 1889.

[Cubic feet per second.]

Where measurements were taken.	Water in river.	Water diverted from river by canals.	Water in river at the points measured plus that diverted by canals between those points.	Increase in volume of river between points measured.	Increase in volume of the river from the gauging station at cañon to point where measured.	Increase in volume from gauging station at cañon to point where measured.
						Per cent.
Gauging station at cañon	68.7					
Larimer County Ditch		0.8				
Pleasant Valley and Lake Canal		14.8				
Jackson or Dry Creek Ditch		5.3				
Cache la Poudre Ditch		7.0				
Taylor & Gill Ditch		2.6				
Larimer County Canal, No. 2		12.4				
Fort Collins water-works		0.9				
Fort Collins Canal		0.6				
Larimer and Weld Canal		8.0				
Second river measurement below dam of Larimer and Weld	32.6		80.0	11.3	11.3	16.4
Howe or Pioneer Ditch		1.7				
Josh. Ames Ditch		1.4				
Lake Canal		1.5				
Fort Collins Irrigation Ditch		1.5				
Box Elder Ditch		6.6				
Cache la Poudre Canal		55.2				
Third river measurement below dam of Cache la Poudre Canal	1.5		116.8	30.8	48.1	70.0
Whitney Ditch		2.3				
B. H. Eaton Ditch		0.3				
Union Colony Canal, No. 3		9.8				
Ogilvy Ditch		30.1				
Fourth river measurement below dam of Ogilvy Ditch	3.5		161.3	44.5	92.6	134.7
Fifth river measurement near junction with Platte River	9.9		167.7	6.4	99.0	143.8

Table of measurements of seepage water in the South Platte River, Colorado, October 18 to 25, 1889.

[Cubic feet per second.]

Where measurements were taken.	Water in river.	Water diverted from river by canals.	Inflow from natural tributaries.	Water in river at points measured plus that diverted by canals and minus the inflow from tributaries.	Increase in volume of river between points measured.	Decrease in volume of river between points measured.	Increase in volume of the river from the gauging station at cañon to point where measured.	Increase in volume from gauging station at cañon to point where measured.
								Per ct.
First measurement—Gauging station at cañon	130.8							
Little Granger Ditch		4.8						
High Line Canal		112.0						
Platte Cañon Ditch		0.2						
Last Chance Ditch		0.3						
Deer Creek			2.6					
Nevada Ditch		10.4						
City Ditch (Platte Water Company's Canal)		9.8						
Plum Creek			3.3					
Marcy Gulch			1.4					
Lee Gulch			9.3					
Brown Ditch		1.5						
Second measurement—South Platte River at Littleton	13.4			135.8	5.0		5.0	3.8
Big Dry Creek			3.6					
Little Dry Creek			0.9					
Bear Creek			3.1					
Farmers and Gardeners		0.2						
Third measurement—South Platte at Denver	66.0			181.0	45.2		50.2	38.3
Clear Creek			0.6					
Fulton Ditch		57.7						
Brantner Ditch		16.1						
Brighton Ditch		11.9						
Fourth measurement—South Platte River at Brighton	7.8			207.9	26.9		77.1	58.9
Lupton Bottom Ditch		6.0						
Platteville Ditch		7.9						
Ellwood E. Wheeler Ditch		6.4						
Big Dry Creek (seepage from Brantner)		3.4						
Fifth measurement—South Platte below Ellwood E. Wheeler Ditch	26.1			249.9	42.0		119.1	81.1
Beeman Ditch								
Meadow Island Ditch		2.9						
Buckers' Ditch		9.0						
Farmers' Independent Ditch		18.2						
Sixth measurement—South Platte River below Platteville	10.3			264.2	14.3		133.4	101.9
St. Vrain Creek			18.1					
Big Bend Ditch		4.2						
Union Canal		30.9						
Seventh river measurement—South Platte, below dams of Union Canal	6.8			277.7	13.5		146.9	112.3
Big Thompson Creek			6.6					
Mayfield Ditch		17.8						
Eighth river measurement—South Platte, below dam of Mayfield Ditch	5.2			287.3	9.6		156.5	119.6
Ninth river measurement—South Platte, at head of Latham Ditch	45.7			327.8	40.5		197.0	150.6
Cache la Poudre			14.8					
Tenth river measurement—South Platte, at Hoover Ditch	120.1			387.4	59.6		256.6	196.1
Hardin Ditch		1.0						
Eleventh river measurement—South Platte, at head of K. and Big Ditch	139.6			407.9	20.5		277.1	211.8
Small ditch (no name)		2.0						
Putnam Ditch		30.9						
Twelfth river measurement—South Platte	105.8			407.0		0.9	276.2	211.0
Fort Morgan Canal		131.9						
Thirteenth river measurement—South Platte, below Fort Morgan Canal	3.6			436.7	29.7		305.9	233.8
Bijou Creek			3.6					

Table of measurements of seepage water in the South Platte River, etc.—Continued.

Where measurements were taken.	Water in river.	Water diverted from river by canals.	Inflow from natural tributaries.	Water in river at points measured plus that diverted by canals and minus the inflow from tributaries.	Increase in volume of river between points measured.	Decrease in volume of river between points measured.	Increase in volume of the river from the gauging station at cañon to point where measured.	Increase in volume from gauging station at cañon to point where measured.
								Per ct.
Fourteenth river measurement—South Platte, at Denel	8.3			437.8	1.1		307.0	234.6
Denel and Snyder Ditch		3.6						
Platt and Beaver Canal		25.0						
Lower Beaver Ditch		17.5						
Beaver Creek			7.0					
Smits's or Island Farm Ditch		8.4						
Tetsal Ditch		2.3						
South Platte Ditch		24.1						
Pawnee Ditch		4.4						
South Platte, at Merino	8.5			516.4	78.5		385.5	294.7
Schneider Ditch		12.6						
Springdale Ditch		3.6						
Sterling Ditch No. 1		10.1						
Low Line Ditch		1.8						
Smith and Henderson		6.8						
South Platte, at Sterling	6.4			549.2	32.8		418.3	319.8
Sterling Ditch, No. 2		1.9						
Arnette Ditch		8.9						
South Platte, near Iliff				553.6	4.4		422.7	323.1

NOTE.—The following are the distances, in an air line, from the different points of measurement:

	Miles.		Miles.
First to second	11½	Ninth to tenth	10
Second to third	11	Tenth to eleventh	4½
Third to fourth	17¾	Eleventh to twelfth	7½
Fourth to fifth	9	Twelfth to thirteenth	4½
Fifth to sixth	7	Thirteenth to fourteenth	7
Sixth to seventh	7½	Fourteenth to fifteenth	18
Seventh to eighth	5	Fifteenth to sixteenth	7¾
Eighth to ninth	2	Sixteenth to seventeenth	4¾

STATEMENT BY CHARLES W. GREENE ON FINANCIAL POLICY.

[Made by request.]

CHICAGO, ILL., *January* 20, 1890.

Hon. WM. M. STEWART,
United States Senator, Chairman Special Committee on Irrigation:

DEAR SIR: When in Washington a few days since you asked me to present in writing, for the consideration of the committee, my views in reference to the employment of private capital for the development of irrigation in the arid region.

You suggested that I should wholly discard the idea that the Government shall undertake the construction of any comprehensive and extensive system of reservoirs and canals, and that I should present—

First. The inducements necessary to enlist private capital.

Second. The practical safeguards against the monoply of the public domain by individuals or corporations.

Third. The protection which should be accorded to such investments.

Whatever value may attach to my opinions on these several subjects will be wholly due to the experience gained in almost two years of constant and reasonably successful effort to secure capital for corporate irrigation enterprises, and to the careful study of the subject which has been inseparable to such effort.

As to the first topic. The chief inducement to the investment of capital is the profit which may be directly derived from it. The first question asked is, Will it pay?

Those undertakings, considered as a class, which are proven by experience in different places and under varying conditions to have a reliable earning power, can command almost any sums of money that may be asked, at a rate of interest gauged by the risks incurred.

There must be, however, a public knowledge of such undertakings among the investing classes to command attention. While many investors insist on having personal knowledge of the management, or that it must be under their own eyes, others will take greater risks, provided the margin of profit is sufficient to justify. It is the latter class who will make most of the investments until a better knowledge of irrigation has been disseminated.

To state the difficulties may best suggest the requisites for success. The arid district is localized west of the ninety-eighth meridian, distant from money centers. It is but thinly settled and comparatively little known. There is a wide-spread prejudice, owing to the formerly prevalent idea that it was a "desert," unfit for cultivation and practically worthless.

There is not much of it that is inviting to the casual observer. The natural products are of slow growth; but few of them have any value as food for either man or beast. The tree-growth is shrubby and furnishes no desirable building material and but little fuel. The natural grasses, though nutritious, grow so slowly that as much as 30 acres is required to feed each animal ranging on them. It requires some courage, born of knowledge and experience, to invest money in the reclamation of such lands. Transportation facilities are limited. Settlements are few and far between. There is no inducement for settlement, indeed it is impossible until a water supply is provided.

It follows, then, that a first necessity is to let investors know the truth in regard to these lands. That they are exceptionally fertile. That the application of water makes them wonderfully productive. That the 30 acres which will now support only one animal becomes capable, when a water supply is provided and it is seeded with tame grasses, of feeding from sixty to one hundred animals. That the choicest fruits, and all the cereals, reach the highest perfection upon these apparently barren lands. That agriculture or horticulture becomes there an exact science. That water, sunshine, and soil may be combined by the intelligent cultivator for the production of as certain results as the manufacturer can attain from the combination of labor and the raw material in the various processes of industry.

Your committee has gathered a vast amount of reliable information that proves the value of these lands and the falsity of the popular impression, and which proves, too, the certainty of satisfactory returns for capital judiciously employed. The publication and general distribution of this information will, in my humble opinion, exert a most potent influence to secure the investment of private capital. It is a lack of knowledge which greatly delays such investments.

No greater inducement can possibly be offered than a statement of facts in regard to this region. The term "desert" is a misnomer as applied to such lands as water can be supplied for.

When compared with the granite hills of the East, with a scanty soil and a bleak climate, or even with the prairies of the central West, it has manifold advantages. There is a wealth of natural resources but little comprehended. There is money in the bright warm sunshine; there is money in the water wherever it can be brought and applied to the soil; there is money in the fertile surface soils; there is money in the clays; there is money in the timber; there is money in the vast coal-fields, in the extensive deposits of iron; there is money in the gold mines, in the silver mines, in the copper mines, in the lead mines; there is literally money in the underlying rocks. There is health and comfort in the dry, mild climate, in the mountain air, in the freedom from malaria and pulmonary ailments. These are among the inducements for investing money in irrigation and which will invite settlers to occupy every irrigable acre.

The area under discussion is of vast extent. It includes seventeen degrees of latitude and twenty-four degrees of longitude. The altitude varies from sea-level to about 8,000 feet. The temperature ranges from 40° below zero to 120° in the shade. The products embrace all those of the temperate zone and the subtropical fruits and grasses.

The sources of water supply are from running streams, from springs, and wells, from artesian wells, from tunnels into the mountains, from reservoirs retaining flood waters, etc. The distribution is by gravity through open canals and acequias, through cement and iron pipes at various pressures, or water may be raised or forced by wind, steam, or hydraulic power. The cost of water supply may range from a single dollar per acre to a hundred dollars or even more, and under certain conditions the latter cost may be justified by the returns.

Each locality has its specific advantages and favoring conditions. Experience has proved that irrigation enterprises have been successful in every part of this great area and under all of the varying local circumstances. But very few have been unsuccessful, and those were generally so from faulty management.

They are not all equally profitable. Some localities offer far greater advantages than others, and the most signal successes, as to financial results, have been achieved where the seasons are longest, where the sun shines hottest and most constant, and where vegetable growth is rankest.

The inducements to be presented to investors will necessarily be suggested by the conditions existing in each separate locality.

With a general knowledge of the underlying principles of irrigation, considered as an industry, widely disseminated, each undertaking will commend itself by its own peculiar advantages. These may be a specially fertile soil, a favorable climate, adaptation to particular products, a good local market, the facilities for transportation, cheapness of construction, an active demand for water which makes it command the higher prices, etc.

The security for such investments is exceptional. The increase in value of the land reclaimed is so positive and so rapid, and these values are so substantially based upon land with its earning capacity, that deferred payments and annual charges, as well as reasonable bonded indebtedness, are safe beyond all question. As compared with railroads, water-works, gas-works, or other corporate undertakings where the growth of traffic or patronage is comparatively slow and is contingent upon so many uncertainties, irrigating enterprises increase the values of land reclaimed often many fold within the brief time devoted to construction, and each item added to the income account becomes permanent and practically perpetual at agreed rates.

It will be very difficult to adapt general legislation to all the varied conditions which exist within the arid region of the United States. In Egypt the Nile is the one source of irrigation, and legislation may readily control every detail. In Spain or Italy the area is comparatively small in each, the climate is uniform, and all the conditions are similar, yet in these countries irrigation has presented many difficult problems for solution. It may be here noted that it is everywhere successful and profitable, and when once undertaken is never abandoned.

While the Wright law of California is admirably adapted to the needs of that State, where the lands are nearly all owned by individuals, the titles perfected, and all subject to taxation, where transportation facilities are excellent, and where all industries are well organized and specialized, it is wholly impractical for many localities, and particularly where there are large areas of unoccupied lands. In such localities the investment of capital must precede general settlement. The settler can not occupy or cultivate the land until provision is made for supplying water. The homesteader is not generally wealthy, and most of the localities where it is within the capacity of individual or community effort to secure and distribute water are already occupied and under improvement.

It is those districts where large streams must be diverted, where engineering difficulties are to be overcome, or where the water supply must be stored in expensive reservoirs which are now requiring large sums of money for their development. These are wholly out of reach for the land locator, and all the profit which could be derived under the most favorable circumstances from 100 or 200 acres of land would be small inducement for any man to inaugurate such undertakings. They are clearly beyond the capacity of individuals or communities. The individual can not live there, nor the communities be formed, until the large expenditure has been made and the water supply is actually provided.

Again, the municipal or public corporation system is impractical for such districts, because there is little, if any, taxable property. The homestead is not taxable until final proof is made, and that requires five years of actual residence. Pre-empted land is not taxable until a final receipt is issued, and that may be more than two years after settlement; and so with land taken under the timber-culture law or under the "desert" act, the title remains vested for a longer or shorter time in the Government, and the land is not subject to taxation during that time.

Whatever inducements may be offered to private investors to reclaim and make these lands inhabitable by direct legislation, it appears to me, must be in the way of providing some practical method by which capitalist and settler may co-operate. While the one shall make available a water supply he must be entitled to a fair and reasonable compensation, and the lands deriving a benefit should be held responsible for the payment. This regardless of whether the title remains in the Government after entry or has been perfected by the occupant.

A literal compliance with some of the present laws—which were never designed for the conditions under consideration—would render the construction of irrigation works almost impossible, and of necessity these laws have been construed with some liberality to the settler.

The embarrassments which must attend such legislation are manifold. It is variously estimated that from $80,000,000 to $120,000,000 are already invested in irrigation plants. They have been created under existing statutes, generally State or Territorial enactments. Though any proposed legislation should not be retroactive, any radical change might seriously affect present investments, as these undertakings require years of time for their development, and most of them are just at the beginning. Based upon enactments now in force and calculated upon existing conditions, they may be crippled or destroyed by adverse national legislation. Further investments would certainly be discouraged by injury to present investors.

Popular clamor denounces corporations and demands a scaling of the profits to be allowed capital; but such clamor is not always reasonable or just. The undertakings are too large for single individuals, and the aggregation of capital is only possible under the corporate or company system which has been devised for its concentration and employment and for the determination of personal liability.

Because there have been abuses of corporate powers is no good reason for the denunciation of a system which has accomplished so much that is beneficial.

A law which shall limit the profits of one party where the facilities are specially good and all conditions favorable, would destroy another less fortunately situated.

I shall therefore summarize as to the first topic:

There should be a general dissemination of reliable information to enable investors to judge intelligently as to the merits of the industry as a whole and as to particular localities. To this end the hydrographic and topographical surveys should be hastened. This is clearly within the province of the Government to provide. They need not be accurate and complete surveys, but rather preliminary, only presenting such general data as will determine the relative location of suitable dam sites, sufficient storage capacity and available arable lands, and as to what reservations are actually necessary. The extent of drainage area and average rain-fall should also be determined. There are not so many of these favorable locations as may be supposed. Indeed, they are comparatively few.

The area to be reclaimed is of such vast extent and there is such a variety of soil, climate, productions, of transportation facilities, of water supply and distribution, that national legislation may easily prove prejudicial.

The land laws should permit of co-operation between capital and settler. There should be positive assurance that the Government will not compete with nor embarrass private undertakings, though it may adopt all proper safeguards against the abuse of granted privileges.

With national legislation to protect the public land while providing for its occupancy; to determine as to suitable dam and reservoir sites; to prevent the occupancy of sites adapted to reclaiming and utilizing a large area by parties who only improve a fraction of it; to definitely determine the rights of appropriation of water limited to its use only; to grant the use of designated reservoir sites and right of way for canals and ditches on public lands, I submit that the legislation suited to each locality for the inducement and protection of investors can be properly and safely intrusted to the States and Territories.

The second topic: What are the practical safeguards against the monopoly of the public domain by individuals or corporations?

So much more is heard of the abuses of granted privileges than of the benefits derived that it is not unnatural if it creates an unfavorable opinion as to public honesty.

Yet it is quite safe to assert that the great mass of investors are really desirous of acting within the law. Obedience to and regard for the law is a necessity to the stability of investments. It is a small minority who are disposed to take advantage of their associates or of the Government. With the experience of the past as a guide it ought surely to be possible to guard against the schemes of the evil-minded without unduly restricting the operations of those who in good faith are willing to aid in creating wealth from the vast undeveloped resources of the region in question by the use of their capital.

There are four prominent methods under existing laws of acquiring title to the public lands.

The homestead law provides for a long bona fide residence and the payment of only nominal fees to acquire title. As I have before suggested, a homestead settlement can not very well precede a permanent water supply, and is only possible where the annual rain-fall will permit of some cultivation or will produce partial crops. It is, therefore, impracticable to adapt the present law to many large areas which it is possible and desirable to irrigate.

The pre-emption law requires a shorter term of actual residence on the land, but exacts $1.25 an acre in payment for it. This law has been taken advantage of and abused more than any other. If repealed as to the irrigable region it could probably be substituted by a better enactment.

The timber-culture law is objectionable in many respects, yet nowhere is there greater need to encourage the growth of trees for timber and fuel. If such encouragement could be provided for in some other way, or if it should be required of canal-builders, perhaps, as a condition to the granting right of way to plant trees along the main canals and principal laterals and on the margin of reservoirs, it would be of inestimable advantage to the public welfare. It would fully compensate the expense to the builders or owners of the canals by direct benefits.

The desert act has many good features and some bad ones. It gives inducement for the reclamation of the land by allowing the acquirement of a full section to each individual. It does not require residence either before or after the water is provided. The entryman may not be a resident either of the State or Territory. It does not stipulate as to what use shall be made of the land or how much shall be put under cultivation. It only requires that permanent water shall be carried to each 40 acres, and evidently assumes that when such expense has been incurred the self-interest of the entryman will prompt him to cultivate it. Under this law great abuses have been perpetrated, and yet it has some commendable features.

Can not a law be framed that will contain the good features of all these several laws and be the only one under which these lands may be acquired?

It may provide:

(1) For a reasonable limit of area.

(2) Prohibiting more than one entry to each individual, and defining the qualifications of an entryman.

(3) That the entryman may mortgage it to secure a water supply to a certain limit and to insure its maintenance.

(4) For a time limit within which the water supply may be secured.

(5) For actual residence and cultivation after water is obtained.

(6) For the perfection of title when certain improvements have been made or when a stated proportion has been brought under cultivation.

(7) For encouragement to tree-planting, not by the acre of solid growth, but by the number of thrifty trees, permitting the planting along ditches or fence rows and to include either fruit or forest trees.

(8) Severe penalties for the violation of its provisions.

As to the limit of area, it must in great measure depend upon the class and locality of the lands. While 5 acres of orange orchard, or other semi-tropical fruits, may afford a handsome income, 5 acres of land only adapted to grain or a single crop of grass would not be worth having. Whether the lands shall be classified, and who shall be authorized to make the classification, will require careful consideration.

The importance of rapid settlement and improvement of the reclaimed lands, and the advantage of having it occupied by the greatest number of occupants, is so great to a company providing water supply that it almost insures the exertion of every energy to that end. If, then, there shall be a limitation put upon the acquirement of extensive areas to be held for speculative purposes without improvement the returns to capital will be made dependent upon legitimate efforts.

A combination of the irrigable and pastoral lands has been strongly urged by Major Powell. Whether it can be practically accomplished throughout the entire region and under all circumstances is a question for very careful consideration. A limited area immediately adjoining a small tract of irrigated land could have no great value. Take the gramma grass districts as an instance. After each rain-fall the stem of this grass freshens and renews its growth. As the surface moisture is evaporated it dries and growth ceases until the rain falls again. It is equally nutritious, dry or green. It requires three years for a growth of 6 to 12 inches. If cut or fed close it may be months before it will again furnish pasturage. Under the present system of range feeding cattle can feed at any time over a range of 5 miles or more from permanent streams or springs. As soon, however, as a heavy rain or snow fall permits them to leave such permanent water they travel for long distances upon the plateaus or into the mountains. When one section is covered with snow they drift to another, it may be one side of a mountain where the snow melts soonest, so that localities many miles from permanent water are now utilized for pasturage. That these cattle must have access to the permanent water goes without saying, and the fencing in of such waters can not be permitted. If they are prevented from reaching the river they must have access to the canals or reservoirs. But if the pasturage shall be confined to the tract immediately adjacent to the irrigated lands many districts of plateau and mountain will be wholly worthless.

The third topic: What protection shall be accorded to such investments:

(1) A definite determination as to the rights which may be acquired in the use of water.

(2) Legal protection against subsequent locators who may seek to divert water supply where provision has already been made for its distribution for such reasonable time as will permit the settlement and improvement of the lands.

(3) A lien against the lands benefited to secure the payment of a just compensation for constructing the works and for their maintenance and for the use of the capital

invested, such lien only to apply as against the private ownership as acquired under the laws.

(4) Protection against malicious injury to the works and against the improper use or waste of water by the occupant of the land or others.

(5) Power to adopt and enforce such rules and regulations for the distribution of water as may be necessary to conserve and to facilitate its economic use.

The subject is very broad and of great importance, and I appreciate that in the brief time at my disposal and under the pressure of business engagements I have not been able to do it full justice.

REPORT BY E. M. McCLELLAN, C. E., ON ELKO COUNTY, NEV.[*]

Elko County, situated in the northeastern part of Nevada, is 155 miles in width, east and west, and 120 miles in length, containing 16,670 square miles of land.

About 30 miles south of the north boundary, extending across the county from east to west, is the water-shed, separating the waters of the Columbia and Snake Rivers from those of the great basin.

This water-shed is composed of several different parallel mountain ranges which trend north and south, having an elevation of 8,000 to 10,000 feet above the sea-level.

In many places the valleys between these ranges have such an even slope both ways from their highest part that it is only by close observation a person can determine when they have crossed the water-shed. At other points the ranges are connected by cross mountains, nearly as high as the main mountain.

On the north side of this water-shed are six main streams, viz: Goose Creek, in the east, Salmon River, Bruneau River, and the east, middle, and west forks of the Owyhee River. In the northwest corner of the county, lying between the east and west forks of the Owyhee River, is the Owyhee Desert, containing over 1,000,000 acres, 750,000 acres of which is fine agricultural land.

Four of the rivers now flow north, viz, the Salmon, Bruneau, and east and middle Forks of the Owyhee, which show distinct traces of having once discharged their waters in the opposite direction, and in the valleys at their heads can to-day be traced the shore-line of old lakes. At that time also the water-shed was farther north than now, and its course northeast and southwest. Subsequently the vast lava field, which covers Oregon, Washington, and Idaho, flowed up to and in some places over the divide. The consequent settling of the earth's crust beneath the weight of the lava caused an elevation of the country a few miles away from the edge; and also the convulsion which broke apart the mountain near by, and which are shown to-day by the deep, narrow cañons through which the rivers flow.

Upon leaving these cañons the rivers have worn away the lava to a great depth, and now flow across the desert in precipitous gorges from 200 to 3,000 feet in depth. Where the mountains end and the lava field commences, the rivers are very near the level of the desert and can be readily carried over it. And in each of these cañons, which are not over 100 feet wide at the bottom, dams can be placed turning the valleys again into lakes, and the water, now running to the ocean, will be utilized in reclaiming land, which is the richest and most productive in the world, but, as it now lies, is worthless.

As most of the agricultural lands lying below the old lake beds on the Salmon and Bruneau Rivers and Goose Creek are in Idaho I will not report on them, but will mention a small lake bed, near the head of the Salmon (No. 18), which can be reflooded and 20,000 acres reclaimed in this State, and one on Goose Creek (No. 19) which will irrigate 10,000 acres.

Upon the east fork of the Owyhee are two reservoir sites, Nos. 16 and 17, on appended plat.

No. 17 is at the upper end of the ancient lake bed and can be utilized in irrigating 4,000 acres of land below it, which will not be covered, by a reservoir 100 feet high at No. 16.

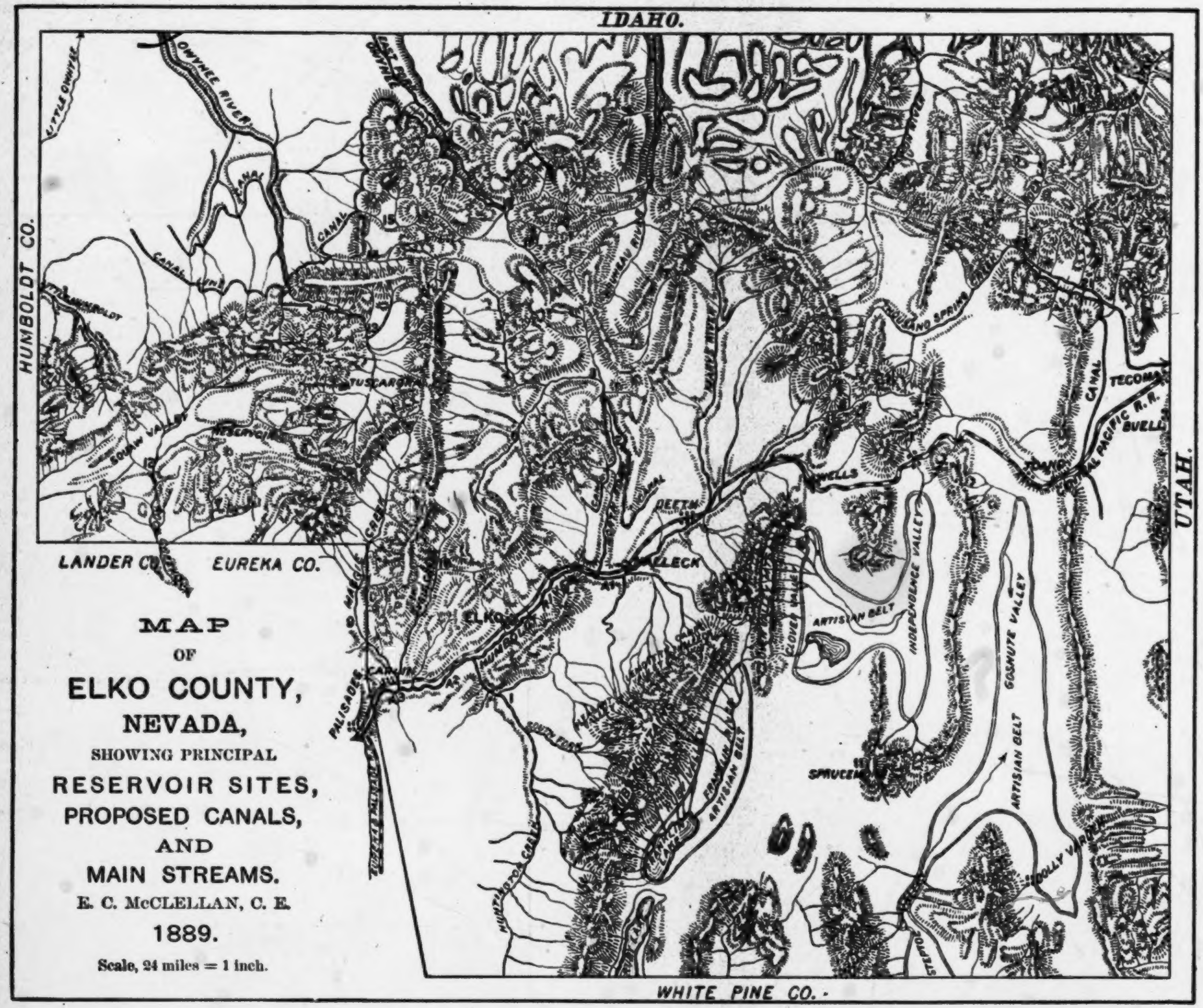
No. 16 will flood about 10,000 acres at the lower end of the old lake bed and store sufficient water to irrigate 150,000 acres of land. It has 220 square miles of natural water-shed, some of the mountains being 10,000 feet high.

No. 15 is an old lake bed, now called Bull Run Basin, and is the finest small reservoir site in the country. It has about 50 miles of water-shed, is surmounted by high mountains, and water can be stored for 50,000 acres.

---

[*] This report did not reach the committee in season to be inserted in the third volume of testimony.

MAP "C" 16.


IDAHO.
OWYHEE RIVER
LITTLE OWYHEE
CANAL
HUMBOLDT CO.
TUSCARORA
SQUAW VALLEY
RESERVOIR
LANDER CO.
EUREKA CO.
PALISADE
CARLIN
ELKO
HUMBOLDT
DEETH
HALLECK
WELLS
INDEPENDENCE VALLEY
CLOVER VALLEY
ARTISIAN BELT
GOSHUTE VALLEY
SPRUCEMONT
STEPTOE
DUCK VALLEY
TOANO
TECOMA
BUELL
CENTRAL PACIFIC R.R.
UTAH.
WHITE PINE CO.

MAP
OF
ELKO COUNTY,
NEVADA,
SHOWING PRINCIPAL
RESERVOIR SITES,
PROPOSED CANALS,
AND
MAIN STREAMS.
E. C. McCLELLAN, C. E.
1889.
Scale, 24 miles = 1 inch.

No.	Location.	Watershed.	Land covered.	Location of land.
A1	Humboldt River	2,400 square miles	1,000,000 acres	Eureka, Lander and Humboldt Co's.
A2	" "	3,400 "	" "	" "
A3	" "	4,000 "	" "	" "
1	South Fork	700 "	" "	" "
2	North Fork	720 "	50,000 "	Elko County.
3	" "	700 "	" "	" "
4	" "	250 "	" "	" "
5	" "	150 "	" "	" "
6	Pie Creek	270 "	" "	" "
7	Hanks Creek	50 "	100,000 "	" "
8	Bishop Creek	40 "	" "	" "
9	Maggie Creek	320 "	10,000 "	" "
10	Susie Creek	30 "	5,000 "	" "
11	Rock Creek	650 "	40,000 "	" "
12	" "	400 "	" "	" "
13	Main Owyhee River	280 "	500,000 "	" "
14	Deep Creek	20 "	" "	" "

11	Rock Creek	650	"	....	40,000		....		
12	" "	400	"	....	"	"	....	"	"
13	Main Owyhee River	280	"	....	500,000	"	....	"	"
14	Deep Creek	20	"	....	"	"	....	"	"
15	Bull Run Basin	35	"	....	"	"	....	"	"
16	East Owyhee	220	"	....	"	"	....	"	"
17	" "	20	"	....	5,000	"	....	"	"
18	Salmon River	280	"	....	20,000	"	....	"	"
19	Goose Creek	30	"	....	5,000	"	....	"	"
20	1,000-Spring Creek	470	"	....	125,000	"	....	"	"
21	" " "	250	"	....	"	"	....	"	"

Report on Irrigation.

No. 14 is in the southern part of the State; same lake bed as 15, the mountain having been broken open in two places, but the site for a reservoir is not good. It is separated from 15 by a ridge 100 feet high.

No. 13 is the old lake bed near the head of the main Owyhee, and has a drainage of 270 square miles. The storage capacity and water supply is amply sufficient for 250,000 acres.

The Little Owyhee, heading west of Elko County and flowing across the northwest corner, has a small lake bed near its head, not shown on the accompanying map. The waters stored in these reservoirs, Nos. 13, 14, 15, and 16 and on the Little Owyhee, can by canals be conducted upon the lava field at the highest places and conveyed over all the land which water can be collected for. The necessary canals leading out from the cañons and constructed along the base of the mountains would also gather all the water coming from the mountains in the small streams which flow down. The early spring flow from these streams alone will irrigate at least 50,000 acres during the flow, which lasts till July.

Heading in the water-shed and flowing south into the Great Basin are a large number of fine streams, the largest of which flow through ancient lake beds, which can be converted into reservoirs. Commencing on the west, the first one is the Little Humboldt River, which rises upon the southern crest of the lava belt, flows north 18 miles, then west and southwest. There are no lake beds along its course until after it enters Humboldt County.

Rock Creek flows south through two old lake beds, each of which will be easily flooded. The first, No. 12, at the lower end of Squaw Valley (the present name of the old lake bed), has a drainage of 400 square miles. There are only about 10,000 acres of agricultural land in Elko County below this reservoir site. The second, No. 11, 12 miles below the first, in Rock Creek Basin, and partly outside this county, has an additional drainage of 200 square miles.

About 200,000 acres of good agricultural land lies below these two in Eureka, Lander, and Humboldt Counties, a part of which can be reclaimed by these reservoirs.

No. 9 is another lake bed, situated just outside of this county. It is not as good a reservoir site as any of those so far named, but has a fine water-shed of 250 square miles on Maggie Creek. About 10,000 acres can be reclaimed by this.

No. 10, on Susie Creek, is a small reservoir point; has a water-shed of 50 square miles, with 3,000 acres of good agricultural land below.

The north fork of the Humboldt, with its tributaries, flows through five old lake beds. Nos. 2, 4, 5, and 6 are comparatively small, and will flood about 2,000 acres with dams 30 feet high. No. 3 is the largest and most important in the county south of the water-shed. The old lake bed covers nearly 10 square miles, drains 750 square miles of territory, and will irrigate 100,000 acres of land which lies below it.

No. 7, near the head of Mary's River, on Hanks Creek, is also an important reservoir site. It has 50 square miles' drainage of mountains 9,000 feet high, and nearly 200,000 acres fine agricultural land below it.

No. 8, at the head of Bishop Creek, is a second-class reservoir site, with a drainage of 75 square miles.

No. 1 is the only lake bed that can be used on the south side of the Humboldt River, and a very important one, as into it can be put the drainage of 700 square miles, covering the highest mountain range in the State of Nevada (the Ruby Mountains, which are 13,000 feet high). A dam here 100 feet high would cover 10 square miles, but it would take one at least 200 feet high to hold all the water now going to waste. There are at least 1,000,000 acres of agricultural land below in the Humboldt Valley.

These lake beds, from Nos. 1 to 12 inclusive, lie in the Humboldt Basin. In addision to these, which are away from the main river, there are three places in this county where the river has broken through mountain ranges—at A1, A2, and A3—where are fine sites for large reservoirs but impracticable on account of the railroad and towns in the valley. They also mark the sites of old lakes which were several hundred feet in depth.

A1, at the junction of the north fork with the Humboldt River, is the largest. A2, below the mouth of the south fork, is second in size. A3, in the western part of the ounty, at the mouth of Maggie Creek, is third in importance. The break through he mountains below A3 forms the Palisades, noted as the finest bit of scenery along he overland railroad.

Below each of these reservoir sites is sufficient land to be irrigated with all the water that can be stored in it.

The Humboldt River is the most important river in the Great Basin, having nearly ,500 miles of water channel. The entire water-shed of this river lies in Elko County, xcept two tributaries of the Little Humboldt in the northern part of Humboldt ounty, and Reese River, in Lander County, which flows north through the central art of the State.

The river in its course southwest, after leaving Elko County, flows across one ther larger lake bed than any of those above, and breaks through another chain of mountains at Iron Point, between Battle Mountain and Winnemucca. Battle Mountain is built within this lake bed, and contains the only artesian wells that have been sunk in the eastern part of the State. Reese River enters the Humboldt Valley at this point.

Through Elko County the Humboldt River bottom is about a mile wide. On each side are bluffs from 50 to 100 feet high, and extending back from these bluffs to the foot of the mountains on both sides lie table lands, upon which the few farmers in our county are located, and where all crops raised in the temperate regions can be grown and harvested with far less work than in the countries not irrigated. At the present date the farms are located along the small streams where they come from the mountains, and where the only work necessary for reclaiming the land was to clear off the brush at a cost of $2 an acre and run a plow furrow from the creek upon it.

Only one reservoir has been built in the county. It is located in Squaw Valley, in the western part of the county, and a canal in connection with the reservoir has reclaimed 5,000 acres. The company expect to irrigate as much more by it as soon as the land can be cleared off. This land without the water was worthless, now it is worth $100 an acre. The cost of constructing the dam and canal was $200,000. Cost of 5,000 acres of land cleared and planted was $25,000, which leaves a gain of $275,000.

The cost of the next 5,000 acres will be only $25,000 which will net the company owning it $475,000.

The reservoir site, utilized by them, is poorer than any which I have mentioned as yet, being the only one which the company could utilize for their land. There are a large number of reservoir sites throughout the county as good as the one utilized in Squaw Valley.

In the northeast corner of the county the water-shed has turned north to within 12 miles of the north boundary, and on the south slope is the headwaters of Thousand Spring Creek. The north branch, called Rock Creek, heads here 25 miles west of the Utah line and flows south 20 miles. The South Fork, or main Thousand Spring Creek, heads 35 miles south and 25 miles west of the head of Rock Creek, flowing northeasterly to the junction.

Just below the junction the mountain has been broken through, and above it is the reservoir site, marked No. 20 on the appended map. These creeks drain 450 square miles of water-shed, one-third of which is mountain land. Twelve miles below this, one, at No. 21, is another lake bed, which can be utilized, but the opening where a dam would be built is nearly 300 feet wide. It has 125 miles of additional water-shed. Below these two reservoir sites is 125,000 acres of fine valley land.

The waters of Thousand Spring Creek and all east of the Ruby range of mountains belong to the eastern part of the Great Basin in which Salt Lake is situated. In the southeastern part of the county the mountain ranges are lower than elsewhere and the precipitation of moisture far less. The prevailing storms are all brought from the Japan current in the Pacific Ocean, northwest of us, and the water-shed on the north and Ruby Mountains on the west catch most of the moisture as the clouds go over them.

There are two ranges of mountains in this section, with valleys between, which have no outlet and were lake beds at some period of greater precipitation than now.

Between the Ruby range and the first range east the valley is divided into two parts. The southern part, lying close to the Ruby Mountains, is called Ruby Valley. It is 5 miles wide at the lower end and 12 at the upper. At the south are two lakes—Ruby and Franklin. The Ruby range is low at the south, furnishing comparatively little water, and Ruby Lake is fed by numerous springs which overflow from the artesian belt beneath, created by the ancient lake. Franklin Lake, just north, and about the same level as Ruby lake, is supplied from the surface streams which flow into it and Franklin River.

Ruby Valley is 50 miles long. Northeast of Ruby Valley is the northern part of the main valley, which is subdivided into two valleys, called Clover Valley and Independence Valley.

Clover Valley lies on the east of the mountains, which is here generally called Clover Mountains. The valley is 20 miles long and 10 miles wide. East of Clover Valley is Independence Valley, 40 miles long and 10 wide.

These two valleys once formed a lake of greater extent, but have now less precipitation of moisture than Ruby Valley.

Just south of Independence Valley is Spruce Mountain, which has an elevation of 10,000 feet but is only 3 miles long on the summit. East of the south end of Ruby Valley are the north ends of Long and Butte Valleys; across the mountains lies Steptoe Valley. It is divided into two parts, the northern part lying in this county and being 60 miles long and an average width of 10 miles; it is called Goshute Valley. The ancient lake bed in this valley is more extensive than in the valleys west of it, but at the present day the precipitation of moisture is far less. All of these valleys show the presence of artesian belts beneath, but no wells have ever been sunk and it is not known what supply they will furnish.

There are no good reservoir sites in this section of the county, and although there are over 1,000,000 acres of fine agricultural land in these valleys, not over 200,000 acres of this can be irrigated without a large expenditure for storage. The Ruby and Clover range have sufficient snow and rain-fall to irrigate all the land in the valleys if it was stored.

The reservoir sites thus far described are the largest and best in the county, will need an average expenditure of $100,000 each, and the work can only be done by the Government or capitalists. Twenty of the twenty-one mentioned have an outlet where the dam would be placed less than 100 feet wide, and a dam 100 feet high would not be over 700 feet long at the top.

The bottom and sides of the cañons are, in all cases, solid rock, and stone for building can be quarried on the spot. The land to be irrigated below them still belongs to the Government. Nearly all the land in this county taken up is on the low bottoms along the rivers and streams that were natural meadows, where the ground is too damp and cold to raise anything but grass.

Owing to our poor transportation facilities and an unjust discrimination against the whole State by the only through line of railroad in it, the farmers have been only able to raise cattle for the markets abroad. The consequence is that in selecting land the first necessity for the settler was to find a piece of meadow where he could at once raise hay for his stock. Then if by a little work he could clear off and cultivate a small garden to raise enough vegetables for his own use he had to be contented.

Before the railroad was built connecting the mining town of Eureka, in Eureka County, with the Central Pacific Railroad the people had a good market for their produce, and farms were taken up and vegetables and cereals grown for that market along the slope of the Ruby Mountains. Upon the construction of the railroad and a combination of the two roads produce of all kinds were shipped from California and the East cheaper than the farmers could land it in town. For a number of years grain was shipped from California to Eureka for $10 a ton; at the same time if a Nevada farmer living near the railroad wished to ship his grain to Eureka he would have to pay $30 a ton. On all other farm produce the same unjust discrimination is used.

This has nothing to do with the amount of agricultural lands and reservoir sites in our State, I know, but it accounts almost entirely for the lack of advancement we have made. Neither capital nor settlers are attracted to a place where they know exorbitant rates will be charged them for everything that can not be raised but must be shipped in; where, when anything is raised, the rates for importing the same thing is lowered till it can be sold within a few miles at a less price than it can be raised and landed to the market for; and where, when a market for the produce is found away from home, the rates are raised till it will not pay to ship it. These are the actual facts in this State, and because of this the people have been confined to the raising of cattle and horses, which could be sent to market without depending upon the railroad.

The interstate law has helped us some, but there still remains high rates which only a competing line of railroad will overcome.

A close estimate of the land in this county shows that we have nearly 2,500,000 acres of No. 1 agricultural land and about 1,500,000 acres of this can be reclaimed by a proper storage and distribution of water. In doing this the reservoirs so far mentioned only form the principal points for storage. There are hundreds of small reservoir points where a small expenditure of capital and work will create a storage of waste waters capable of irrigating from 100 to 10,000 acres of land each.

In calculating the agricultural acres I have only put in my estimate those lands in the county where it appears the best results could be had. I have left out nearly 1,000,000 acres which have a rich soil but which lie in small tracts not easily reclaimed compared with the rest. When this State has the population which its vast mineral wealth and unrivaled climate will some day bring to it, most of this land will also be utilized.

As I have stated before most of the lands taken up lie along the river and creek bottoms and are too cold and damp to raise anything but hay. Along the Ruby Mountains is the largest exception to this rule, and it is here that most of our farmers have settled. Here at an elevation of nearly 6,000 feet above the sea-level can be raised all the products of the temperate regions, including grapes, peaches, cherries, apples, and small fruits as well as all the vegetables and cereals.

The climate is so healthy that there are only four doctors in the whole county, and most of the cases they have are caused by accident and not from disease.

Of this 2,500,000 acres of good land, only 90,000 acres is under irrigation to-day, and 60,000 of this is natural meadow, leaving only 30,000 acres actually farmed. All lands that are to be reclaimed are farming lands, being dry and warmer than the bottoms. A very liberal estimate to be placed upon the cost per acre for storage of the water and canals for conveying it upon the lands would not be over $20. The cost of clearing it off ready for cultivation would not be over $5 per acre more, making a total cost of $25.

In the northwestern part of the United States, along the Pacific coast, where immigration is now directed, the actual cost of clearing the land and getting it ready for cultivation is $135 per acre. The land is no richer, the climate far inferior, and the amount of work to harvest a crop nearly double what it is in this State.

There is also in all non-irrigating regions the liability every few years of drought with consequent loss of crops or excessive moisture with equally bad results. Here the farmer can tell before planting, even without storage, exactly how many acres can be irrigated each year, and, supplying the growing crops himself with just the amount of water needed for each product, he never misses a harvest, and the produce of his fields and orchards is fully equal and in many cases superior to those of non-irrigating countries.

The traveler crossing our State sees only the worst sections of the eastern part. The line of the railroad along the river bottom under the bluffs is 50 feet or more in elevation.

Looking from the car window he can see in the distance the mountains covered with perpetual snow, and can imagine that there must be streams flowing from them, but he does not see the miles of rich table lands intervening, across which flows from April to June sufficient water to convert every acre of it into productive farms if held in reservoirs until needed.

No measurement of the annual flow of water in the numerous streams in the county of Elko is known, but the farmers who have been in the country the longest state that they are positive the quantity of water flowing to waste every year is amply sufficient to irrigate every acre of agricultural land in the county. If this be true, it would bring 3,500,000 acres under cultivation instead of 1,500,000 as I have estimated.

The agricultural land and the water to irrigate it lie in close proximity in this northern part of the State. The only thing necessary to create a fertile and populous county out of the seeming desert, is wise legislation founded upon a just appreciation of the needs of an irrigation district.

All enactments of our law-makers, since the organization of the United States, have been founded upon the English common law, acknowledged to be the best in the world, and as long as we had only a country to make laws for which did not need irrigation the English riparian act was the one needed for that country. But now we have a vast empire of arid lands for which an entirely different code of laws is required, and to successfully meet these requirements it is absolutely necessary to frame laws of a character wholly unprovided for by English common law. To do this it is not necessary that experimental enactments be passed as though irrigation was a new thing in the world.

The experimental stages of law-making for the successful reclamation of arid lands have been passed through by other governments, both in the new world and the old, and all we have to do is to adopt the best of these, or compile a code of laws from the best parts of all or some of them with the very slight changes which might be necessary to their introduction into a free country.

The main point upon which the successful solving of the irrigation problem depends is the absolute ownership and control by each State government of all waters, storage points, and right of way for main feeding and distributing canals. The State could then construct the canals and reservoirs and rent the water (as done by other governments) at rates determined by the cost of constructing and keeping in repairs the necessary works.

No time should be lost by the Government in securing all the water and storage points in the arid regions. The history of other irrigating communities should be sufficient for us to be assured that only evil will befall any section of our country where one of the main elements of life is the property of any individual or corporation and can not be controlled by the people.

Our agricultural lands lie at a general elevation of 5,000 to 6,000 feet above the sea-level. Our mountain ranges have varied elevations of from 7,000 to 13,000 feet in height. Very few observations have been taken of the amount of rain and snow fall at different elevations in the country, and at only one place have we any data for a Series of ten years past.

At this place (Camp Halleck), situated at an elevation of nearly 6,000 feet, the main precipitation for the ten years was 10.5 inches annually. That is the general average of precipitation also over a large part of the agricultural lands of the same general elevation, but it nearly all falls in the winter and spring and has mostly disappeared before the irrigation season is over. This amount of precipitation is greater than in many places in the United States where irrigation is unknown.

The precipitation in the mountains can only be estimated, but it can not be less than three times that of the valleys.

STATEMENT OF ARNOLD HAGUE, GEOLOGIST, U. S. GEOLOGICAL SURVEY, IN RELATION TO THE NATIONAL YELLOWSTONE PARK AS A WATER RESERVATION.

In the organic act of 1872, establishing the Yellowstone Park, Congress declared that the reservation was "dedicated and set apart as a public park or pleasure ground for the benefit and enjoyment of the people." The wisdom and foresight of those who at that time urged the withdrawal from settlement of this tract of land from the public domain has never been questioned.

The necessity for the protection of the geysers and hot springs and other unrivaled scientific curiosities of the region, the importance of utilizing the park as a game reservation for the larger Rocky Mountain animals rapidly becoming extinct with the settlement of the country, and the natural advantages of the place as a sanitarium and health resort, have since been recognized by the steadily increasing crowds of visitors who annually visit the place.

From these æsthetic points of view alone the value of the Yellowstone Park to the nation have amply repaid for all cost of maintenance. Its advantages to the nation in the future has scarcely begun to be realized even by those most familiar with its charms and natural advantages. Notwithstanding all that may be urged in favor of a liberal maintenance of the Park based upon sentimental considerations, the most forcible argument for its preservation is an economic one far outweighing all others in benefits to the people.

In my opinion the object of first importance in maintaining the Park is the conservation and regulation of its water supply. By the natural configuration of the country the Park is singularly adapted as a catchment basin for the storage of water. It is doubtful if any region of the same extent in the arid regions of the Rocky Mountains offers so many favorable conditions for receiving, storing, and distributing through a few main drainage channels so large an amount of water.

The Park is situated in the extreme northwest corner of Wyoming, and covers an area approximately 50 by 40 miles. The central portion of the Park is an elevated volcanic plateau between 7,000 and 8,500 feet above sea-level, with a mean altitude of 8,000 feet. The surface of the plateau is diversified by undulating basins of varied outline cut by numerous deep cañons and gorges. Strictly speaking, it is not a plateau in the popular acceptation of the word; at least it is by no means a level plain, but a rugged country presenting bold escarpments, the edges of mesa-like ridges. Rising above this plateau on the south, east, north, and northwest occur mountain ranges whose culminating peaks tower from 2,000 to 4,000 feet above the inclosed table-land.

The Gallatin Range shuts in the Park on the north and northwest. Spurs and outlying ridges of the Gallatin connect it with the Snowy Range, an elevated mountain mass which bounds the Park on the north and pours a large share of its water into the Yellowstone River. The Absaroka Range borders the Park along the entire eastern side and presents for more than 80 miles an unbroken barrier to all western progress. It is an exceptionally rugged region with volcanic peaks and table-topped masses rising from 10,000 to 11,000 feet in height. Only a few adventurous hunters and mountaineers cross the range by one or two dangerous, precipitous trails, known to but few. The early trappers found it a forbidding land; prospectors who followed them, a barren one. The Absaroka Range, however, furnishes one priceless treasure: from its western slope it sends numerous torrents into the Park, many of them running directly into Yellowstone Lake. On the east side of the range an equally large water supply make up the Stinking Water and Clark's Fork, which ultimately flow into the Yellowstone River. The Absaroka Range is intimately connected with the Wind River Range, which shuts in the plateau on the south. To the westward, and separated only by the broad valley of the Upper Snake, lie the Teton Mountains, whose northern outlying spurs project into the Park. On the southwest side of the Park is situated the Madison Plateau, which stretches northward until it abuts against the southern end of the Gallatin.

From this incomplete sketch it will be seen that the Park country, although a high table-land, stands relatively low to the rugged mountains which surround it on all sides. From this outer rim of mountains innumerable streams pour their waters into the Park.

Across the plateau from the southeast to the northwest, but with a very irregular course, runs the Continental Divide separating the waters of the Atlantic from those of the Pacific. On both sides of the Continental Divide and within a few miles of the line, lie a number of large bodies of water which form so characteristic a feature in the scenery of the plateau that the region has received the appellation of the lake country of the Park. Hundreds of smaller lakes lie dotted over the surface, filling irregular depressions in the lava flows or occupying shallow basins scooped out by glacial ice. Many of these lesser lakes are found as natural reservoirs higher up in the mountains. In addition to these are found numerous ponds, marshes, and meadows everywhere scattered over the country. So numerous are they that the water held by them adds a very considerable amount to the total water supply. Two rivers, the Yellowstone and Snake, receive the greater part of this water, the former draining more than one-half the area of the Park and the latter the entire western side of the Continental Divide. Falls River, a very considerable stream in the southwest corner of the Park, empties into Henry's Fork before its waters join the main Snake River. On the north side of the Divide both the Madison and Gallatin drain large areas of the Park, the former, running westward, cuts through the Madison Plateau, while the Gallatin, although receiving none of its water from the Park plateau, still carries off a large amount of water precipitated upon the reservation. Both these latter streams unite with the Jefferson in Montana to form the Missouri.

Let us examine a little more closely into this water supply. I can not do better than to quote from an article on the physical features of the Park which I published not long since.

"Yellowstone Lake, the great reservoir for the river which gives its name to the Park, is a body of water of great beauty, measuring 20 miles in length, with a breadth across its greatest expanse of 15 miles. It has a very irregular outline, with an indented shore of nearly 100 miles, and an area of 140 square miles. Not only is the Yellowstone by many times the largest lake in North America at so high an elevation above sea-level (7,741 feet), but it ranks among the first in the world at high altitudes. Upon the western side of the Divide, less than 6 miles from the Yellowstone, and separated from it by a ridge not more than 200 feet in height, lie Shoshone and Lewis Lakes; the former with an area of 12 square miles, and the latter 4½ square miles. Heart Lake, at the eastern base of Mount Sheridan, measures 3 square miles. These three smaller reservoirs pour their waters into the Snake, which also finds its source near the southeast corner of the Park.

"In the autumn of 1886, with a view of obtaining some data upon the amount of discharge, the largest bodies of water were accurately measured. Not only was the time selected the driest period of the year, but all lakes and streams stood at a lower level than at any time during the previous five years. Yellowstone Lake stood 20 inches below the high-water mark of early summer. The measurements may be said, therefore, to have been taken at the minimum discharge. Measured just below the outlet of the lake the discharge of the Yellowstone River was found to be 1,525 cubic feet per second, or, in other words, 34,000,000 imperial gallons per hour. The out-flows from Shoshone, Lewis, and Heart Lakes combined yielded 104 cubic feet per second. The Lamar, Firehole, Gibbon, and Madison Rivers were gauged, and careful estimates made of the Gallatin and Falls Rivers, based upon the size and flow of the streams and the area of the country drained. According to estimates of Dr. William Hallock, of the U. S. Geological Survey, who kindly undertook the gauging of the streams, it was found that the minimum discharge was equal to 1 cubic foot per second per square mile over an area somewhat more than 4,000 square miles, and that the amount of water running into the Park and leaving it through the five main drainage channels would make a river 5 feet deep and 190 feet wide, with a current of 3 miles per hour. While this may not indicate a large supply as compared with certain highly favored areas, yet it is for the arid region of the West an exceptional amount."

While there are many conditions governing both the amount of snow and rain fall in the far West, two important factors are found in the Park region which influence in a large measure the precipitation of moisture. These are the great elevation of the culminating peaks surrounding the Park, and the exceptional broad mountain mass. From Madison Valley eastward across the Park and the Absaroka Range the country attains an elevation unsurpassed by any area of equal extent in the northern Rocky Mountains. For 90 miles in an east and west line the country rises in a solid block far above the adjacent country, admirably situated to act as a condenser for the moisture-laden clouds. Meteorological records taken for a number of years show a climatic condition unlike that observed elsewhere in the Rocky Mountains, the amount of snow and rain fall being higher and the mean annual temperature lower. Rain-storms occur frequently throughout the summer, while snow is quite likely to fall any time between September and May. In an arid region and one of unequally distributed rain-fall, forests and moisture maintain reciprocal relations. The abundant precipitation over the Park exerts a favorable influence upon forest growth, 84 per cent. of the area being timber-covered. This forest in turn protects the snows and marshes from the intense heat of the sun and the dry westerly winds. By means of this protection the deep snows of winter lie upon the plateau well into midsummer, while at still higher altitudes in sheltered places it remains throughout the year, slowly supplying the springs and streams.

By its topographical structure the Park is designed by nature as a reservoir to collect an exceptional water supply. By its geological structure it is well adapted to store this water, both on the surface and in the deeply buried rocks. From beneath the lavas of the plateau numerous streams and underground springs pour their waters into the lakes and out upon the land surfaces.

For these reasons the present area should be enlarged to the east and south so as to take in a dense forest region useless for agricultural purposes and destitute of mining resources, but embracing a rough, mountainous country abounding in streams—the real sources and feeders of Snake River, Yellowstone Lake and River. The area proposed to be added to the Park would extend the boundaries about 25 miles to the eastward and 9 miles to the southward of the present ill-defined limits which were established at a time when the region had been but little explored. The proper control and distribution of the water is a necessity to the people of Montana, Dakota, Wyoming, and Idaho. The protection of the forests, game, and marvels of the reservation should be the desire of every one looking to the welfare of the country. The interests of the Park should be zealously guarded by the nation.

REPORTS ON IRRIGATION

FROM

CONSULS OF THE UNITED STATES

CORRESPONDENCE WITH STATE DEPARTMENT.

UNITED STATES SENATE,
Washington, D. C., April 23, 1889.

SIR: Referring to your letter of the 2d instant, in which you state that "our consuls will be instructed to prepare reports covering such phases of the subject (namely, irrigation) as you may be good enough to intimate," I inclose herewith a draught of a letter which if you will have sent to our consuls in the countries mentioned in the inclosed memorandum where irrigation is practiced, will greatly oblige the Senate Committee on Irrigation and Reclamation of Arid Lands.

Please forward all reports received by you to Mr. R. J. Hinton, Engineer, U. S. Geological Survey, Washington City.

Yours, respectfully,

WM. M. STEWART,
Chairman Committee on Irrigation, etc.

The SECRETARY OF STATE.

DRAUGHT OF LETTER IN REGARD TO IRRIGATION TO BE SENT TO CONSULS.

WASHINGTON, D. C., *April* 23, 1889.

The questions connected with irrigation and the reclamation thereby of arid lands are now attracting public attention. Congress has recently made appropriations for surveys of reservoir sites, ditches, canals, etc., and the United States Senate has created a special committee to thoroughly investigate the general questions involved. The Department, in response to an inquiry from the special committee, desires to aid in its investigations, and therefore requests as early as practicable a report on the subject of irrigation as practiced in the country in which you are stationed. Your inquiries should be directed in the main to the following points:

(1) Areas of land under irrigation; compare with the non-irrigable and cultivable areas when possible. Also quantity and quality of crops grown.

(2) Sources of water supply, whether from rivers, streams, springs, lakes, wells, reservoirs, catchment basins, or tanks, etc.

(3) Character of works used for storage and distribution of water. Forward published reports, if obtainable, in regard to any important irrigation and storage works.

(4) The system of water distribution, whether governed by laws, rules and regulations, or customs. Give duty of water per acre, *i. e.*, the amount used per acre and per season, the cost or rental to user;

tenure of ownership of water, and whether the same be public or private, national or community.

(5) Character of climate in irrigated region and nature of soil, annual rain-fall or other precipitation.

(6) Antiquity or otherwise of irrigation systems within the section treated of, and whether the same are maintained at public or private expense.

The Department desires to obtain maps and any publications obtainable bearing upon this subject for the use of the Senate committee.

The committee states that it desires to place itself in communication with competent experts and authorities on irrigation. These investigations should be conducted diligently, and reports made as early as possible.

MEMORANDUM FOR DISTRIBUTION.

All Asiatic countries: Egypt, Tripoli, Tunis, Morocco, Algiers, Senegambia, Orange Free State, Colonies of Cape of Good Hope and Natal, Madagascar, etc. Also, Madeira, the Azores and other islands, the Australian Colonies, Hawaii, South and Central American Republics, the Empire of Brazil, Mexico, and European Colonies of South America. The principal countries of Europe in which irrigation is practiced are France, Italy, Spain, Portugal, Holland, Turkey, Greece, Austria; also Russia in Asia.

MEXICO.

REPORT BY UNITED STATES CONSUL JOHN WOESSNER, OF SALTILLO, ON IRRIGATION IN COAHUILA, MEXICO.

A part of this section of this large and rich State is irrigated from springs which generally rise in the mountains; the water is carried in many cases and often many miles from these springs to level, fertile land by means of narrow ditches. Other parts of this State, the lands can not now be irrigated on account of no water, and the total absence of the necessary implements for boring and the proper practical labor to accomplish the required result. Where there are springs the water should be carried through iron tubes; farther away from here, where there are no springs, but "haciendas" of importance, the artesian well, it seems to me, is what is needed. I would advise manufacturers in the United States who desire to build up a trade of this kind to do so with a direct representative who speaks the language, establishing an office centrally located in the Republic, where attention may be given to the wants and demands of such a trade.

Water is worth a great deal more than land in this country, and the right to use it is fixed by laws. Much good land is not used because of lack of water, and to depend on rain in some parts is too much of a risk. With a good water supply much of the rich soil of this State would produce abundantly of nearly all kinds of products, which at present are not enough to support the population.

There are very few windmills used at present in this State, though I think they might be successfully used, for the reason that good winds blow nearly all the year. There is considerable water-power unused, which, according to law, can be acquired by denouncement. If a spring of water rises in the property of any one, the owner of the property also owns the spring. Rivers are owned and controlled by the State through which they pass. Rights and privileges to public waters are sold by the State.

The system of water distribution is as follows and is generally acquired by purchase: A stream of permanent water is called thirty days of water and the owner may sell the right to any one to use this water for any length of time; say, for example, one day in every month, which is called one day of water, worth very often as high as $1,000 per day. It is an understood right between all land owners that parties owning any right or privilege in the water can pass same to their land through the lands of adjacent owners by means of narrow ditches. This system often causes many difficulties, particularly when the owner of a day or two of water dies and leaves some fifteen or twenty heirs, each of whom receives his share in hours, being an equal division under the same right of the day or two of water inherited. The formation of artificial lakes has already awakened attention, and a foreign company of capitalists agitates at present the question of making a lake with the waters of the Rio Grande, to be used for industrial and agricultural purposes. This project, however, involves difficulties, arising from its international character.

REPORT BY U. S. CONSUL A. WILLARD.

UNITED STATES CONSULATE,
Guaymas, Mexico, August 14, 1889.

Up to the present time the lands cultivated in Sonora (this consular district) are confined to the bottom or valley lands on the small streams and rivers.

For the purpose of irrigating said lands dams of simple construction of stone and earth, or brush and earth, are erected on the sides or in the streams, and ditches are dug to convey the water to the lands cultivated. These dams, as a rule, require repairs and some reconstruction each year.

The ditches require cleaning and repairing yearly, but are not expensive to maintain.

REPORT BY U. S. CONSUL-GENERAL C. C. MORE, CITY OF MEXICO, ON IRRIGATION IN MEXICO.

The system of irrigation has become very generally practiced in various portions of this republic, having been in vogue more or less ever since the days of the conquest of the country by the Spaniards in 1521.

It may be stated as a general proposition that the natural supply of water in Mexico is very limited as compared with that of other countries. The traveler in this republic notices the great scarcity of rivers, running streams, lakes, and springs. In the mountains of the country many small streams take their rise, but soon after reaching the plains they become absorbed in the sandy soil and sink into the ground. Again, in Mexico during the rainy season there is a great abundance of water (said rainy season may be stated, in a general way, as extending from June 1 to October 1), but for the remainder of the year the rain-fall is very scant, water becomes very scarce, and the whole country becomes very dry, except in the regions along the sea-board (the

Pacific Ocean, the Gulf of California, the Gulf of Mexico, etc.), in which localities the dews are very heavy and refreshing showers much more frequent than in the upland regions.

I will now take up the six points of interrogatory mentioned in your circular, and incorporate in my replies the information obtained from the said department of public works and from other sources:

(1) "Areas of land under irrigation; compare with the non-irrigable and cultivable areas when possible, and quantity and quality of crops grown."

Answer. The department aforesaid assured me that they had no statistics upon which to frame an answer to the first part of this question, and that it would take months to collect the information in proper shape.

The principal crops grown here with the assistance of irrigation are sugar, coffee, corn, wheat, oats, barley, beans, cotton, and tobacco; also oranges, bananas, and other fruits. Without irrigation, except near the coast, the yield would be very meager; with irrigation said crops are excellent, and will compare favorably with those of other countries, especially when consideration is had of the primitive agricultural implements used and the inefficient cultivation as contrasted with that practiced in the United States, England, France, and Germany.

(2) "Sources of water supply, whether from rivers, streams, springs, lakes, wells, reservoirs, catchment basins, or tanks, etc."

Answer. The water supply for irrigating purposes is drawn principally from rivers, streams, and natural lakes. In some instances bold springs gush from the earth and furnish a constant, never varying supply for irrigation of thousands of acres, as in the case of "Atlacomulco," in the State of Morelos, a large, beautiful "hacienda," or plantation, at one time owned and operated by Cortez, the Spanish conqueror, and still belonging to decendants; on the hacienda of "Coakinstla," one of the finest sugar plantations in Mexico, near the city of Cantla. Sometimes also large dams of solid masonry are constructed at great expense, which, however, form large reservoirs of water during the rainy season, and which during the remainder of the year furnish the necessary supply for irrigation. Artesian wells supply some of the water used for irrigation; also wells from which the water is raised and poured into the irrigating canals by means of windmill pumps and buckets attached to an "endless chain," which are kept in motion by mule or horse power.

(3) "Character of works used for storage and distribution of water. Forward published reports, if obtainable, in regard to any important irrigation and storage works."

Answer. The works used for storage and distribution of water consist of dams constructed so as to elevate the level of the water in streams and rivers where they can not be tapped by the aqueducts and irrigation canals at sufficient elevation to reach the destined fields of cultivation; also large reservoirs are formed, as above stated, through the instrumentality of massive dams, generally of stone masonry, the water being collected during the rainy season and held for use when needed.

(4) "The system of water distribution, whether governed by laws, rules and regulations, or customs. Give duty of water per acre, *i. e.* the amount used per acre and per season, the cost of rental to user, tenure of ownership of water, and whether the same be public or private, national or community.

Answer. As a part answer to the fourth interrogatary, the department of public works handed me a copy of the decree of June 5, 1888, which I herewith have the honor to inclose, accompanied by a translation of the same into English.

Each State of the Republic has its separate laws and regulations regarding the distribution of water. The duty ot water per acre, or the amount used per season per acre, varies according to the quality of the soil, climate, and plants under cultivation. Moreover, the cost of water is generally included in the rental paid for the lands, which varies exceedingly in different places, according to the peculiar circumstance attending each locality.

The ownership of the water is both public and private, but generally the latter, as the water privileges, being considered of quite as much value as the land itself, have in many instances been transferred or transmitted by inheritance along with the title to the land.

(5) "Character of climate in irrigated region and nature of soil; annual rain-fall or other precipitation."

Answer. The climate of the irrigated region in this country corresponds to the climate of the different States of the Republic, as in all of them there exist irrigated lands, with this general statement, however, that on and near the sea-coast the climate is much warmer and the rain-fall much greater than on the table-land and in the mountain districts.

As a further answer to this question, the said department of public works furnished me with a copy of the geographical, statistical, and descriptive study of Mexico by A. Garcia Cubas, special attention being called to the seventh and eighth chapters, relating respectively to hydrography and agriculture.

The nature of the soil embraces every variety known to the country, from the light, sandy soil of the table-lands to the rich, dark alluvial of the valleys and the fertile, black loam of "the tierras calientes"—the hot countries.

In regard to the annual rain-fall, said department handed me the tenth number of the monthly bulletin of the meteorological, magnetic, central observatory of Mexico in which is published a report on the rainfall in different parts of the Republic, running through a number of years; also a table containing a comparative résumé on the subject for the years *et seq.* to 1888, and both of which, in deference to the request in said circular, I have the honor to herewith transmit—

(6) Antiquity, or otherwise, of irrigation systems within the section of, and whether the same are maintained at public or private expense.

Answer. The antiquity of the various systems of irrigation in Mexico varies with the different localities, they having been constructed and put into operation not simultaneously, but at different epochs, as the different sections became more or less cultivated by intelligent labor and the necessity of irrigation became apparent. As a general proposition, however, it may be stated that said systems date all the way from the early part of the sixteenth century when the Spaniards took possession of the country, introducing their splendid system of irrigation as rapidly as they began the cultivation of the various localities.

The department of public works further assures me that none of said irrigation works are maintained by public funds.

[Translation.]

[Department of public works, colonization, industry, and commerce. Third section.]

The President of the Republic has thought fit to direct to me the following decree:

Porfirio Diaz, constitutional President of the United States of Mexico, to its inhabitants makes known:

That the Congress of the Union has decreed the following:

ARTICLE 1. There shall be considered as general, public highways, besides the inland roads, railways, etc., to the effect of section 22, article 72 of the constitution, the following:

The territorial seas, marshes, and lagoons situated on the sea-coast. Canals constructed by the Government or by means of public money. Interior lakes and rivers, if navigable. Whatsoever lakes and rivers situated and serving as boundary lines between this Republic and other foreign nations or between two States.

ARTICLE 2. The Federal Executive has the power and right to look after the aforenamed public roadways and to regulate the private and public use thereof, according to the following basis:

A. The towns situated on the sea-shore or banks of a river shall have the gratuitous use of the water necessary for all domestic purposes of its inhabitants.

B. There shall be respected and confirmed the rights of private individuals relating to the use and profit of rivers, lakes, and canals, providing that said rights consist in lawful titles or civil prescription exceeding ten years.

C. The concession or attestation of rights or titles to private parties on the lakes, rivers, and canals relating to the present law, can only be made by the department of public works, excepting the case where said concession shall change or threaten to change the course of the rivers or canals aforenamed, or should deprive of the use of their waters the inhabitants living down the stream.

D. The rights of fishing and pearl-diving on the territorial seas and the uses and profits of marshes and lagoons situated on the sea-shore or national vacant lands, shall be regulated specially by the executive power.

ARTICLE 3. All transgressions of the law comprised in the common jurisdiction committed on interior lakes, canals, or rivers, as well as the controversies that may arise between private individuals, relative to obeying the statutes issued by the department of public works, shall be submitted to the competent local jurisdiction.

MEXICO, *May* 28, 1888.

Miguel Castellanos Sanches, senator president; Luis C. Cariel, deputy president; Guillermo de Landa y Escandon, senator secretary; A. Riba y Echeverria, deputy secretary.

Therefore, I order it shall be printed, published, and circulated, and that due compliance shall be given it.

Signed in the palace of the executive power of the Union, in the City of Mexico, on this 5th day of June, 1888, Profirio Diaz. For General Carlos Pacheco, secretary of State, and the department of public works, colonization, industry, and commerce. I recommend it to you for your knowledge and corresponding efforts.

Liberty and constitution.

Mexico, June 5, 1888.

PACHECO.

CUBA.

REPORT FROM OTTO E. REIMER, U. S. CONSUL, ON IRRIGATION IN THE CONSULAR DISTRICT OF SANTIAGO DE CUBA.

Before answering the questions propounded in your circular of May 2 it would be well to enumerate in brief the reasons which render irrigation in this consular district almost unnecessary. I say "almost unnecessary" because all the crops, such as sugar, cocoa, coffee, plantains, and other crops of minor importance, are dependent on the changes of rainy and dry seasons in this tropical climate. This consular district is well watered by rivers and small streams which irrigate the rich and deep alluvial soil under cultivation. The largest river, the Canto, which finds its source in the Sierras del Cobre, a mountain range to the westward of this city, and after a tortuous and winding course during which it receives various tributaries, empties into the sea 14 miles north of the town of Manzanillo. This river, choked up at its mouth by drift-wood and sand bars, is about 180 miles long, of which 60 are navigable. Captain General Salamanca has caused studies to be made in view of forming a plan to make the mouth of the river navigable, thus opening a water-course which traverses some of the most fertile districts of this province. The Canto, with its tributaries, constitutes the water system of the south coast of this province. Between the Capes Maisi and Cruz the coast line is very mountainous and only small streams find their way to the sea.

The north coast is full of larger and smaller rivers which find their way into the numerous and large bays. Notably the Mayari, Naranjo, etc. So artificial irrigation has as yet not become a necessity excepting, to my knowledge, only in one instance. Messrs. Brooks & Co., an English firm here, owning a sugar estate on the bay of Guantanamo and called "Los Canos," have been compelled, owing to the curious fact that although sufficient rains fall near and around the estate very little falls on its territory, to introduce an artificial system of irrigation. This system of open ditches irrigates about 10 caballerias (333⅓ acres) of cane fields, and as just commenced I cannot give you the results. The water for this system is procured from the Guantanamo River, which is dammed above the area irrigated and the water distributed by a system of canals. The system was instituted after the necessary permission was obtained from the Spanish Government; is a private enterprise, and pays neither rental nor taxes.

The amount of water used per acre depends on the rain-falls of the rainy season and can not be estimated, as the work has just commenced. The character of the climate is tropical and the annual rain-fall, in the absence of all scientific observation, I would estimate at 45 inches.

CENTRAL AMERICA.

REPORT OF U. S. CONSUL-GENERAL JAMES P. HOSMER, GUATEMALA, ON IRRIGATION THEREIN.

In reply I beg respectfully to state that there is no system of water distribution for arid lands in Guatemala.

The practice of irrigation, in the very limited extent to which it obtains, is that of ordinary ditches fed from the nearest water source.

REPORT OF U. S. CONSUL CHARLES H. WILLS, OF MANAGUA, NICARAGUA, ON IRRIGATION.

There is not, nor has there ever been, as far as I can learn, any system whatever of irrigation.

Wear Nandaime, a small Indian town in the department of Rivas, three cacao (chocolate) estates are partially flooded in a primitive way by their owners from small rivers or streams being dammed to cause the water to flow over the plantations, which are below the streams. No system is practiced.

SOUTH AMERICA.

REPORT OF WINFIELD S. BIRD, U. S. CONSUL, LA GUAYRA, ON IRRIGATION IN VENEZUELA.

The subject of irrigation, to which the attention of consular officers is directed by circular instruction from the Department of State, dated May 2, 1889, is one upon which very meager information can be furnished from Venezuela; for although, in a crude way, irrigation is practiced to some extent, yet there are no available statistics to offer in reference to the areas of land under irrigation, and no means of comparing these with the non-irrigable and cultivable lands. Of the small area of cultivated lands in this consular district, exclusive of those planted in coffee, perhaps the greatest part is devoted to sugar-cane; and, from personal observation, it would appear that the crop generally needs more cultivation and irrigation than is usually given it.

The small streams coming down from the mountains form the only supply of water for the purposes of irrigation, and in a tropical climate like this the volume of water is so often reduced during the long and hot summer season that the supply proves inadequate, and consequently the crops suffer to a greater or less extent. The present season has proved quite disastrous in this respect, so much so that crude sugar, usually sold at 10 cents per pound, is now worth 25 cents per pound. The importation of cane products being prohibited by law, it seems that the use of sugar and its compounds, so general in this climate, must be greatly curtailed, and, to many of the poorer classes, entirely cut off.

The character of the works used for the storage and distribution of water are of the simplest description and consist of ordinary dams and trenches. There are no irrigation and storage works of any importance, every process of this nature being conducted upon the most inexpensive and antiquated plan. It is no doubt true that even the Chinese are, in this respect, far in advance of these people in the various appliances and processes for irrigation; and it is equally true that if a more careful and provident system were adopted, much of the water that now goes to waste might be utilized for the reclamation of arid unproductive lands.

The system of water distribution is governed, according to the best obtainable information, by custom only, although there are some statutes in reference to it that, by common consent, have fallen into disuse. The unwritten law is that each person shall have the right to water on a stated day for a certain length of time, when he must close his flood-gate and again await his turn. Under such an arrangement, therefore, it is evident that the amount of water used per acre and per season and the tenure of ownership, etc., can not be intelligently stated.

Everything connected with the subject of irrigation in Venezuela is of such primitive character that it can be of no special interest in the elucidation of plans and processes for use in the United States. No maps nor publications with any reference to it can be obtained or even heard of, and it appears that the subject has never received the slightest degree of the attention that its importance to the agricultural interests of the country so seriously demands

REPORT OF O. McGARR, U. S. CONSUL-GENERAL, GUAYAQUIL, ON IRRIGATION IN ECUADOR.

(1) A very small quantity of land is under irrigation in Ecuador, not the thousandth part of the cultivable land. No grain crops are grown on irrigated land, which is used only for pasturage and for raising alfalfa in small quantities. An infinitesimal part of the arid region, which is extensive in northern Ecuador, is under irrigation.

(2) Small rivers, mountain streams, and springs are the source of the water supply. There are no basins, reservoirs, or tanks used.

(3) There are no works constructed for the storage of water. Its distribution is by ditches. No reports on the subject have been published in this country.

(4) The system of water distribution is governed by custom, except in the few instances where water is carried over the land of adjoining proprietors. In such cases the law regulates and defines the rights and duties of the owner of the easement and of the servient estate. I have no means of ascertaining the amount of water used per acre or per season. It is not measured and it is not rented. The water used for purposes of irrigation belongs to the individual land owner using it. There is no national, municipal, or community ownership.

(5) The climate is that of the winter-Andean region with an average maximum temperature, with shade, of 62 to 68 degrees, the average minimum being about 54 degrees. In some localities the soil is a sandy loam and in others a dark, heavy clay, and very deep. The rains are ordinarily confined to the months between the middle of December and the first of June, and are quite copious in most seasons. I can not state annual rain-fall.

(6) Under the Spanish rule there was something of an irrigation system, regulated by laws, and at the time of the Conquest there was a better and more extensive system than has existed since. That now in use is maintained entirely at private expense.

REPORT FROM J. GRIERSON, U. S. CONSUL, COQUIMBO, ON IRRIGATION IN THE PROVINCE OF COQUIMBO, CHILI.

This province is in a very backward and primitive state as regards cultivation and irrigation, on account of the country being very barren and mountainous, the only cultivation being along the valleys running down between the mountains which convey the snow-water from the Cordilleras. Hay and barley are the principal productions, the former, when green, being eaten on the ground by cattle.

Water is supplied by canals or large ditches cut at different places rom the rivers of snow-water, as mentioned above. Each canal, rom its leaving the river until it reaches the sea, belongs to the owners f land along the upper part of which the canal flows.

No works are made for stowage of water. When the river is full the luice doors to the canals are open all the time, and water is suplied in abundance; but in years when there is little snow on the ountains, and consequently the river low, the sluices are opened, as rranged by the canal committee.

Each canal has a president and a committee, elected from the cursors, ho superintend repairs, allowance of water, etc. The value of a farm epends on the number of inches belonging to it; each proprietor of nd can buy or sell any or all the number of inches of sluice he has a ght to draw from the canal, each inch being worth about $3,000 (gold) and is the same as tangible property. A sluice-wall 15 to 20 inches makes a good farm worth about $3,000 to $4,000 yearly.

The climate is good and very mild. Up the valleys grapes, oranges, and pears grow well, and by irrigation five crops of hay may be cut yearly. From 1872 to 1880 the rain-fall was only 3½ inches per year; latterly, with intermissions, it has been about 7 inches yearly.

The rivers are, of course, under Government control, but the canals are private property and from time immemorial have been superintended and kept in order by their owners. Every town, however, is entitled to a proper proportion of water.

REPORT FROM W. T. WALTHALL, U. S. CONSUL, DEMERARA, ON IRRIGATION AND DRAINAGE IN BRITISH GUIANA.

No systematic irrigation exists in this colony. The need of it is felt when the dry seasons are protracted beyond their ordinary limits, but in such cases the only methods employed to water the crops are of the simplest and most primitive description—by manual labor, without the aid of machinery of any sort. The system of drainage, however, and of the employment of artificial water-ways for the transportation of produce and plantation supplies is elaborate, costly, and extensive. Although not strictly pertinent to the information sought by the Department, the subject is somewhat akin, and a brief account of it may not be irrelevant.

In order to understand the conditions, it must be borne in mind that the rich agricultural region of the colony consists in general of the lowlands adjacent to the sea-coast and the tidal parts of the larger rivers. These lands are several feet below the level of the highest tides, for which reason it is necessary to protect them from overflow by a continuous line of embankments, or "sea-dams" as they are termed.

This cultivable region extends back from the beach and the banks of the lower rivers to a distance varying (by a rough estimate) from 2 to 5 or 6 miles, when it meets what is termed, in the language of the colony—perhaps not very correctly—"the savanna" or "bush" lands. This is a belt of country between the rich coast lands and the hills and forests of the interior, slightly more elevated than the former but lower than the latter, partly open and partly covered with trees, vines, and shrubs, but everywhere abounding in swamps, ponds, and creeks of fresh water.

The estates of the colony are laid off on the plan adopted by the original Dutch settlers and still existing in its main features. They are divided by parallel lines, approximately perpendicular to the line of coast, and forming long, narrow, and somewhat irregular quadrilaterals, which would be parallelograms but for the sinuosities and irregularities of the coast line. The unit of measurment of distance is the Rhynland rood, still in habitual use, of 12 feet 4 inches. The original width of each grant was 100 roods, or nearly a quarter of a mile, and the length or depth from the sea-dam 750 roods, or about 1¾ miles. Such is at this time actually the extent, inland, of the only lands owned in fee-simple, though many of the estates have been extended toward the "savanna," or including parts of it, by grants of possession and occupancy at the pleasure of the Crown, supposed to be practically equivalent to ownership. Many of the original estates have also been united and some of them divided, though the regular parallelism of their side boundaries is still maintained.

In order to protect these estates from overflow in the rainy seasons by the waters of the swamps, ponds, and streams of the "savanna," "back-dams" are erected in the rear of the cultivated area. On the lines of division between the estates canals or trenches are dug for drainage, the earth thrown out from these constituting material for embankments, known as "side-line dams," which also serve as road beds for walking or riding. Smaller cross-drains connect with these side-line trenches.

Besides the trenches for drainage, another system of trenches or canals is employed for the internal navigation of the estate. For this purpose a canal is generally dug through the estate, the excavated earth forming alongside of it an embankment known as the "middle walk." Cross-canals extend transversely from this toward the boundaries of the estate but stopping short of them, so as not to communicate with the side-line or drainage trenches, the terminus of the navigation cross-canal forming a sort of *cul-de-sac.* These canals are used for the transportation, by flat-bottomed barges or "punts," of the crops, fertilizers, etc., in one direction or the other.

These canals are supplied with fresh water from the swamps, creeks, ponds, and in some cases artificial reservoirs of the "savanna," the water being admitted and the supply regulated by means of water-gates, or "kokers" as they are termed, in the back-dams. Stronger and more elaborate kokers are employed in the sea-dams, which are opened at low tide to permit the discharge of the drainage and other fresh water, and closed at high tide to hinder the influx of the sea water.

The coast lands of the colony consist of a stiff clay, interspersed with veins of sand and covered with a superficial layer of vegetable mold or "pegass." The clay being impervious to the percolation of water is very favorable to rapid drainage from the surface.

The chief staple is sugar, though there are some cocoa-nut plantations, and in certain parts of the colony large estates, or "cattle-farms," are devoted to pasturage.

I have spoken of artificial reservoirs. The advantages of these in regulating the varying supply of fresh water during the wet and the dry seasons are obvious. Besides those already existing, others are projected on a still larger scale.

The cost of the works required for drainage and the supply of water to the towns, villages, and estates is assessed on the proprietors and others interested, though they are controlled and regulated by the Government. The money is frequently advanced by the Government with the understanding that it is to be repaid by taxes on the property for the benefit of which it is expended. This, of course, does not apply to the works undertaken by proprietors for the special benefit of individual estates. In some cases, also, participation in the burdens and benefits of public or corporate enterprises is to some extent optional with the individuals interested.

The climate of the colony is torrid, but remarkably uniform, the extremes of temperature being about 73 and 90 degrees Fahr. The average is about 81 degrees. The average annual rain-fall is estimated at about 100 inches.

REPORT FROM E. L. BAKER, U. S. CONSUL, BUENOS AYRES, ON IRRIGATION IN THE ARGENTINE REPUBLIC.

I am in receipt of the circular of the Department of State of the 2d of May last, stating that the question of reclaiming the arid lands of the United States is now attracting the attention of our Government, and instructing me, in aid of its inquiries, to report on the subject of irrigation in the Argentine Republic, and especially directing my attention to the areas of land under irrigation, the sources of the water supply, the nature of the works, the system of distribution, the character of the climate, the annual rain-fall, the antiquity of the works, etc.

ANTIQUITY OF IRRIGATION IN SOUTH AMERICA.

In regard to antiquity, I have to say that the artificial watering of the earth to increase its fruitfulness is of so remote an origin in South America that its history is quite unknown. It has been generally assumed that the practice had its beginning in the Orient; and we know that in the days of the patriarchs various contrivances for flooding the fields and meadows were in general use. It was not, however, until the end of the seventeenth century that water meadows were constructed in Europe upon anything like a scientific system; and only towards the end of the eighteenth century that any great improvement took place in this branch of agriculture. In South America, on the contrary, it is evident that a scientific system of flooding, which consisted in spreading a sheet of water over cultivated fields in such a manner that it could be readily withdrawn was not only practiced by the aborigines of the country from the most remote periods, but that it was done with an amount of precision and knowledge which even to this day are matter of wonder to those who inspect the remains of their works.

It seems hardly possible that the natives of Peru and Bolivia, and of the eastern slopes of the Andes, which now constitute a part of the Argentine Republic, could have acquired their skill from the nations of antiquity beyond the Atlantic; and hence we are at a loss to understand how such a people, without a long-previous civilization, far in advance of their condition when their Spanish conquerors arrived, could not merely have solved the problem of the artificial watering of the land to increase its productiveness, but constructed aqueducts and reservoirs to that end, on such an immense scale and in such an enduring manner that they have defied the changes and vicissitudes of unnumbered centuries. When they were built we do not know; but their remains abundantly prove that the inhabitants from an unknown date were well versed in many of the ways and means of civilized life; that they pursued husbandry and practiced agriculture on scientific principles, and that, in defiance of the general absence of rain, they succeeded in providing bountiful harvests even on the precipitous sides of the sterile sierras. The historian of the conquest of the country refers to the knowledge of agriculture possessed by the primitive inhabitants and the wonderful works of irrigation constructed by them in such a manner as to prompt me to make a quotation from his pages. He says of the "ancient works":

> Much of the country suffered for want of water, as little or no rain fell, and the few streams in their short and hurried course from the mountains exerted only a very limited influence on the wide extent of territory. The soil, it is true, was for the most part sandy and sterile, but many places were capable of being reclaimed, and indeed needed only to be properly irrigated to be susceptible of extraordinary production. To these spots water was conveyed by means of canals and subterraneous aqueducts executed on a noble scale. They consisted of large slabs of freestone nicely fitted together without cement, and discharged a volume of water sufficient, by means of latent ducts or sluices, to moisten the lands in their lower level through which they passed. Some of these aqueducts were of great length. One that traversed the district of Condesuyu measured between 400 and 500 miles. They were brought from some lake or natural reservoir in the heart of the mountains, and were fed at intervals by other basins, which lay in their route along the slopes of the sierra. In their descent a passage was sometimes opened through rocks, and this without the aid of iron tools; impracticable mountains were to be turned; rivers and marshes to

> be crossed; in short, the same obstacles were to be encountered as in the construction of their mighty roads.
>
> Most of these beneficent works of the incas were suffered to go to decay by their Spanish conquerors. In some spots the waters are still left to flow in their silent, subterraneous channels, whose windings and whose sources have been alike unexplored. Others, though partially dilapidated and closed up with rubbish and the rank vegetation of the soil, still betray their course by occasional patches of fertility. Such are the remains in the valley of Nasca, a fruitful spot that lies between long tracts of desert, where the ancient water-courses of the incas, measuring 4 or 5 feet in depth by 3 in width and formed of large blocks of uncemented masonry, are conducted from an unknown distance.
>
> The greatest care was taken that every occupant of the land through which these streams passed should enjoy the benefit of them. The quantity of water allotted to each was prescribed by law, and the royal overseers superintended the distribution, and saw that it was faithfully applied to the irrigation of the ground. (Prescott's Conquest of Peru, Vol. I, pp. 131-133.)

Patches of these prehistoric works are still to be found in the provinces of Mendoza, San Juan, and the upper Andine provinces of the Argentine Republic, though the ravages of time and the reckless indifference of the first conquerors of the country have in nearly every instance reduced them to ruins.

IRRIGATION AFTER THE CONQUEST.

If, however, the early Spanish colonists were more intent in their search for gold than in that for the riches which agriculture produces, their descendants in those far Andine provinces slowly awakened to the fact that the only return they would ever be able to get for their labor would be from the cultivation of the soil. While throughout the pampas, consisting of the provinces of Buenos Ayres, Santa Fé, and Entre Rios, the people followed the lazy but lucrative employment of breeding cattle to the entire neglect or abandonment of agriculture, which exacted more hard labor and patience than they were inclined to give it, in the far interior provinces, where, owing to the lack of seasonable rains, there was a general absence of pasturage and cattle were unable to feed themselves, the colonists were compelled from necessity to direct themselves to agriculture, but they did it in such a way that compared with the science displayed by the aborigines the cultivation of the soil actually retrograded. Mr. Nap, in his work on the Argentine Republic, says:

> While the country was a Spanish colony, agriculture was neglected to the greatest degree, even in those districts where it had previously been the principal occupation of the primitive inhabitants.
>
> Indeed the conquistadores of the Argentine Republic found there an indigenous population more numerous than themselves, which, if it was not quite so far advanced in agriculture as the ancient inhabitants of Peru, had adopted many of their ways and usages in regard to irrigation, and were especially experienced in the cultivation of the soil. The Spaniards, failing in their search for gold, were compelled to accommodate themselves to the circumstances which surrounded them. Thus they adopted the customs and habits of life of the natives, and partially undertook agriculture; and though it was not vigorously exploited, yet it became of a certain importance.
>
> Thus, when the towns increased and a greater consumption was required, the pampa provinces were provided with cereals from the provinces of the interior. For example, the far distant province of San Juan, as late as the year 1860, still sent flour to the Atlantic coast; and notwithstanding the high cost of the transportation by land it was yet able to compete with that of North America, and even surpass it in quality.
>
> But owing to droughts and the constant want of timely rains, it was absolutely necessary to secure the necessary moisture by the artificial means of irrigation; and yet it is unfortunately the case that in some of those provinces so little attention was paid to the proper systems of irrigation that these means for watering the fields were actually worse under the Spanish dominion than they were before the period of the conquest.

Since the organization of the Argentine Republic as an independent government, while agriculture was scarcely thought of in the pampa provinces until recent years, the cultivation of the soil has continued to be the principal occupation of the inhabitants of the interior provinces. And it is only in those of Mendoza, San Juan, Catamarca, Santiago del Estero, Tucuman, Salta, and Jujing that any attention is at all paid to the subject of irrigation. Indeed, but for such artificial means, owing to the lack of rains, it would be impossible to raise crops at all in any of them.

CLIMATE AND RAIN-FALLS OF THE INTERIOR PROVINCES.

In regard to the character of the climate it will be borne in mind that the Argentine Republic extends from 56 to 20 degrees south latitude, and consequently in such a wide zone is subject to a very great variety of climatic conditions. While the far northern provinces have quite a tropical temperature, and the Cuyo provinces have a temperate climate, those portions of the country which extend towards the Straits of Magellan have about six months of quite severe winter. I may also add that the mountain ranges gradually rising on the west to the regions of perpetual snow have great effects upon the temperature even in regions of the same latitude. On this account, in compliance with the instructions of your circular, I shall have to give the character of the climate and the quantity of rain-fall for the different interior provinces separately, beginning with—

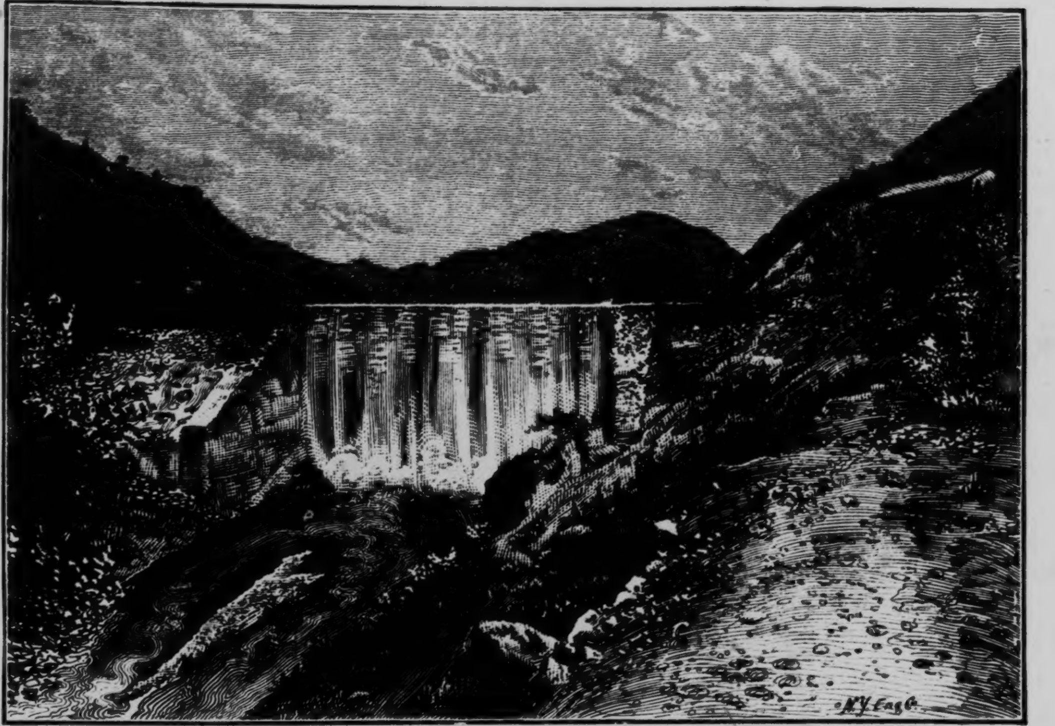
Mendoza.—This province is bounded on the west by the line dividing Chili from the Argentine Republic, and contains about 155,745 square kilometers. A large portion of it is without population. The cultivated portions are mostly in the neighborhood of Mendoza, its only city, which is in latitude 32° 55′ and longitude 68° 49′, and stands at an altitude of 799 meters above the sea. It is situated in the foothills of the Andes. The meteorological office reports for the year 1886 the mean monthly temperature (centigrade thermometer) as follows:

	°		°
January	23.21	July	7.85
February	22.83	August	9.79
March	20.02	September	12.87
April	15.18	October	17.04
May	10.55	November	20.99
June	7.63	December	23.65

The mean temperature was 15.99°. The lowest temperature was 7.5° below zero on the 8th of August, and the highest 41.5° above on the 12th of December, a variation of 49°.

In regard to the rain-fall we have returns of the years 1877, 1878, 1879, and 1880, as follows:

Month.	1877.	1878.	1879.	1880.
January	10.0	0.0	0.3	0.5
February	5.5	11.0	3.3	0.0
March	0.4	7.0	97.0	28.2
April	18.5	2.0	5.0	0.0
May	0.0	8.0	0.0	0.0
June	0.0	0.0	14.0	7.5
July	0.2	[illegible]	0.0	0.0
August	0.0	9.0	10.0	0.0
September	0.1	15.0	2.0	17.0
October	0.0	3.0	65.5	21.0
November	57.5	10.0	8.0	0.4
December	0.0	0.0	7.5	41.0



I.—GRAND DIKE FOR HOLDING THE WATERS OF RIO PRIMERO IN THE VALLEY OF SAN ROQUE, PROVINCE OF CORDOBA.

The director of the meteorological office says:

> From these figures will be understood the extreme aridity of the climate contiguous to the foot-hills of the Andes and that the entire agricultural richness of the Andine provinces depends directly upon the melting of the snows on the elevated peaks of the great Cordilleras. In the city, also, snow is accustomed to fall frequently during the winter, but to no great depth. And yet, owing to the extensive system of irrigation, the greatest part of the lands in the neighborhood of the rivers has been made very productive, being devoted principally to the cultivation of alfalfa, wheat, maize, and the vine.

San Juan.—The province of San Juan lies to the north of that of Mendoza and its western boundary separates it also from Chili. Its mountainous features, however, are more pronounced than those of Mendoza, the Sierras there rising one behind the other in longitudinal chains which form the system of the Andes. The city of San Juan lies in latitude 31° 32′ and longitude 68° 35′, and it is 652 meters above the level of the sea. Twelve years of observations complete gives the mean monthly temperature of the city as follows:

	°		°
January	26.43	July	10.17
February	25.40	August	13.30
March	23.41	September	16.25
April	17.74	October	20.00
May	13.43	November	23.64
June	9.68	December	26.12

The mean temperature is 18.80°. The place is subject to very sudden changes of temperature, the varation in the summer months being sometimes as great as 25 degrees in a few hours.

I have returns complete of the rain-fall for the years 1881, 1882, 1883, and 1888, as follows:

Month.	1881.	1882.	1883.	1888.
January	35.0	3.0	30.0	40.5
February	55.0	12.0	12.0	16.0
March	0.0	0.0	1.0	8.0
April	0.0	0.0	0.0	0.0
May	0.0	6.0	1.0	0.0
June	0.0	4.0	0.0	0.0
July	1.5	0.0	1.0	0.0
August	15.5	0.0	0.0	0.2
September	0.0	0.0	0.0	0.0
October	0.0	7.0	6.0	8.0
November	26.0	0.0	0.0	2.0
December	14.0	0.0	23.0	16.0

It will be seen from these figures that the climate is excessively dry. The clearness of the atmosphere, however, is phenomenal, and although in summer the midday heat is very severely felt, the nights are refreshed by a cool breeze from the south. The "zonda," as the northeast wind is called, is the sirocco of South America, and prevails during the months of July, August, and September, generally beginning about 8 o'clock in the morning and continuing until sundown, during which time the heat is almost suffocating and the air is a cloud of dust. The "zonda," however, is always followed by a south wind, which at once causes a sudden fall of the temperature and re-establishes the atmospheric equilibrium.

In reference to the climate the director of the meteorological office says:

> The quantity of water which falls is entirely inadequate to the requirements of life; and thus it is not astonishing that great tracts of country (travesias) are found almost entirely without vegetation unless the required moisture is supplied by irrigation. With even a limited irrigation, however, these deserts are transformed into fertile fields, which by the contrast seem, as it were, like islands of Paradise, where grow luxuriantly all the products of the temperate zone. The few rain-storms which occur are accompanied by violent winds and great electrical discharges, and hail frequently falls in the months of October and November, causing at times great destruction to the crops.

CATAMARCA.—The province of Catamarca is bounded on the west by Chili and on the north by Bolivia and the Province of Salta. Its superficial extent is placed at 242,309 square kilometers. Its great industry is mining, though considerable attention is also given to agriculture and the dairy. The city of Catamarca is in latitude 28° 25′ and longitude 65° 55′, and its altitude is 545 meters above the sea-level. It is situated in a small valley which on the south opens into a level arid plain. The climate is very similar to that of San Juan, very hot in summer and temperate in winter. The "zonda" here is very frequent and sometimes blows for forty-eight hours, in its progress frequently parching and blasting all vegetation. Indeed the climate is so dry that the drought sometimes continues for eight or nine months of the year. Only on such spots as are moistened by irrigation is any abundant vegetation to be found. The mean temperature for each month is given as follows:

	°		°
January	28.27	July	11.78
February	26.60	August	16.03
March	25.18	September	19.53
April	18.77	October	23.70
May	15.80	November	25.76
June	10.72	December	27.64

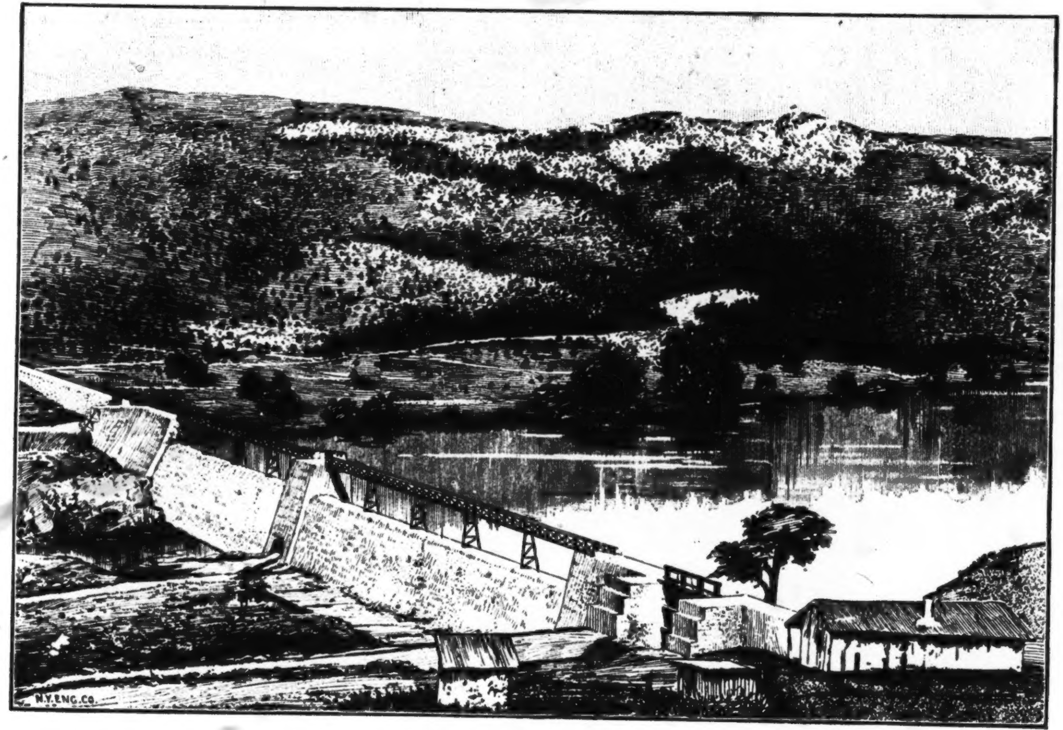
The temperature frequently rises above 40 degrees and scarcely ever known to fall to freezing-point.

I am not able to give the rain-fall, but it is much less than that of San Juan.

TUCUMAN.—The province of Tucuman is to the southeast of Catamarca, but in climate presents a very notable contrast to it, on account of its great humidity and consequently the tropical character of the vegetation. Indeed, owing to its innumerable farms and rich vegetation, it is called the "garden" of the Republic. Its superficial area is about 70,000 square kilometers, a large portion of which is relatively well cultivated the capital city of the same name is in latitude 26° 50′ longitude 65° 12′, and its altitude is 464 meters above the sea. I have the mean monthly temperature of Tucuman for sixteen years, and there is but little variation in the readings. I give that for 1885:

	°		°
January	25.0	July	11.3
February	23.1	August	15.1
March	21.0	September	19.3
April	17.4	October	20.1
May	13.6	November	24.5
June	11.9	December	24.5

The highest temperature recorded was December 25, 1862, when it went to 40 and on three occasions it went down to 0.9.



Report on Irrigation. II.—DIKE OF DISTRIBUTION IN MAL PASO (COMPLETED), IN THE PROVINCE OF CORDOBA.

The rain-fall for the years 1886, 1887 and 1888 was as follows:

Month.	1886.	1887.	1888.
January	307.6	328.0	85.9
February	241.2	95.1	48.7
March	201.1	119.6	211.0
April	26.5	30.3	44.4
May	8.0	5.5	12.0
June	21.1	4.9	29.2
July	0.0	31.8	4.5
August	2.3	2.0	1.5
September	5.6	14.2	65.5
October	40.5	100.4	83.6
November	93.1	97.8	168.3
December	115.2	106.0	221.4

The mean monthly rain-fall by seasons for the fifteen years was as follows: Spring, 205.3; summer, 488.2; autumn, 233.6; winter, 31.1.

Cordoba.—The province of Cordoba is partly pampa and partly mountainous, and, exhibiting great diversity in the quality of the soil, is admirably adapted for agricultural pursuits and grazing, the only drawback being a tendency to droughts during the summer months. The city of Cordoba is situated on the banks of the Rio Primero, just on the edge of the great plain which extends to the Atlantic Ocean, the Sierras rising on the west to a height of 2,500 feet. I have the mean monthly temperature for the last fifteen years, and there is a remarkable uniformity in the figures. I give the following for the year 1887:

	°		°
January	23.4	July	10.5
February	22.4	August	16.0
March	21.0	September	15.5
April	16.3	October	17.7
May	12.7	November	19.7
June	12.7	December	21.6

The rain-fall likewise shows a remarkable uniformity. I have the returns for the last fifteen years, and the largest amount in any one year was 988.7 millimeters, in 1878, and the smallest amount was 528.7, in 1887. For the years 1887 and 1888 it was as follows:

Month.	1887.	1888.
January	91.4	15.3
February	47.8	66.5
March	30.4	130.1
April	68.4	0.0
May	10.5	67.0
June	0.0	2.3
July	7 0	0.0
August	0.0	0.0
September	3.0	9.5
October	49.0	31.6
November	136.3	119 5
December	84.9	161.9

The mean monthly rain-fall by seasons for the last eight years was as follows: Spring, 194.3; summer, 310.6; autumn, 144.3; winter, 16.1.

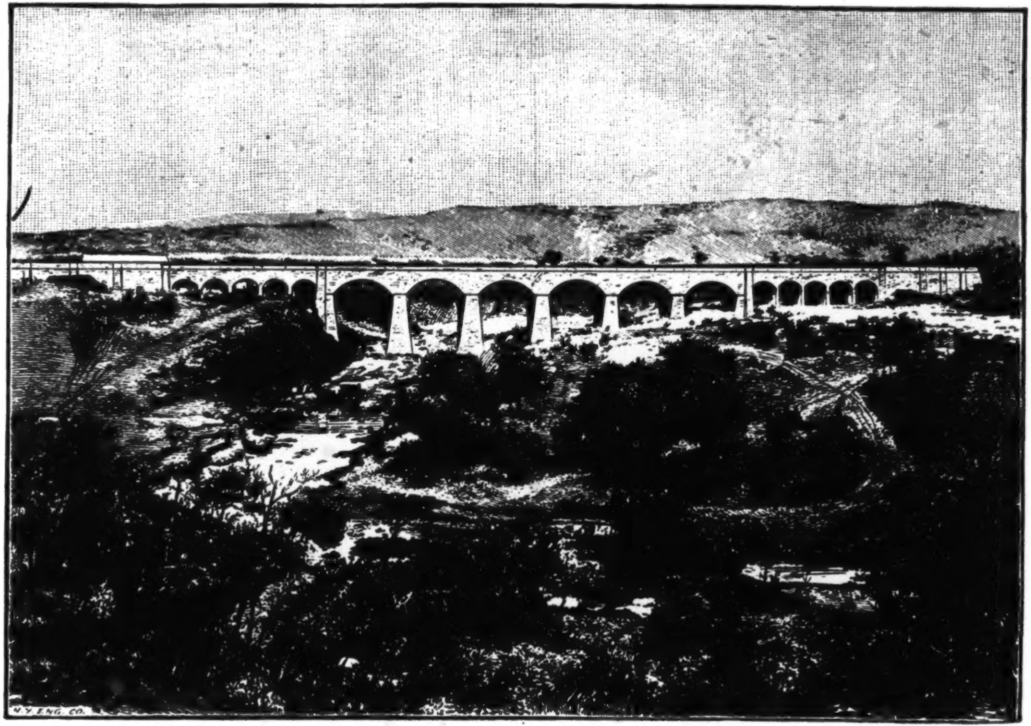
I might extend these meteorological returns, but they are quite sufficient to show the character of the climate in the irrigated regions, and the annual amounts of rain-fall. From an examination of them it will readily be understood that without some artificial means of watering the soil there would not be moisture sufficient for the production of crops with any certainty, unless, perhaps, in Tucuman and Cordoba.

SOURCES OF THE WATER SUPPLY.

The water supply in all these provinces for the purposes of irrigation is almost exclusively from rivers, streams, springs, and small water courses, coming down from the mountains. The great trouble, however, with those rivers which have their sources in the Cordilleras of the Andes is their unequal volume of water. With the melting of the snows, or during the rainy season, they are generally full to overflowing; but they soon run out and at the very times when their waters are most needed. Indeed, with the exception of the system of rivers which flow to the Rio de la Plate and which includes the Uruguay, the Parana, the Paraguay, the Pilcomayo, the Vermijo, and the Salado, there is not a single river in the entire Republic, until we come to the rivers south of the province of Buenos Ayres, which has any outlet. Those of the central system, most of which cross the province of Cordoba, after a dreary course to the eastward, are swallowed up in sands before they reach the Parana. Those which compose the system of the Cordilleras are all lost in quagmires and marshy lagunas before they reach the ocean. With their shallow beds running down very slight inclines, and their great evaporation from the high temperature of summer, many of them quite dry up during four or five months of the year, and these streams are all in those belts of country which have the greatest need of moisture.

CHARACTER OF THE IRRIGATION WORKS.

In regard to the character of the works used for the storage and distribution of the water, as a general thing, it may be said that they are of the most primitive kind. In most cases they consist merely in holding the waters by means of dams built at intervals along the courses of the streams and from the higher levels thus obtained, making canals or aqueducts through which the water is allowed to pass by a gradual descent as it is needed to the lands which are to be irrigated. From these canals the water is distributed by means of sluices and gateways along a system of drains, trenches, or conduits to the fields and meadows which compose the irrigation district. Where the surface is level or flat it is frequently necessary to form artificial slopes for the water to pass over. The whole of the ground is then laid in broad, undulating beds, the upper part of which is quite level from end to end, where the supply channel is cut. All the supply furrows are fed by a main channel at right angles to the beds and somewhat above them. When the flood-gates are opened the water flows into all the upper channels very regularly and evenly till it fills them to overflowing in their entire length. In the case of those streams which come down from the heights of the Andes and course through the valleys or cañons of the Sierras there is no difficulty in holding the water at a higher level than the lands to be irrigated, but where the sluggish rivers meander across an almost level plain, there is occasion sometimes for engineering and the taking of levels. In some instances a channel receiving the water at a higher point than that to which the river flows is dug at a less declivity than that of the bed of the stream and made to carry the water higher than the banks of the river, from which level it is allowed to descend slowly and irrigate the intervening district. In some parts of the Cuyo provinces the works which serve as reservoirs for retaining the waters are of solid masonry, and large sums of money have been spent in their construction. In other provinces the works are merely wooden barriers



III.—AQUEDUCT OF SALDAN OF THE NORTHERN CANAL OF THE IRRIGATION WORKS OF THE RIO PRIMERO, PROVINCE OF CORDOBA.

or earth embankments, which sometimes in sudden freshets are swept away with great damage, thus leaving the people of the district, until they are repaired, without the means of irrigating their lands. I give below the various sources of the water supply.

JUJUY.—This province, which borders on Bolivia, is irrigated at various points by the waters of the river San Francisco, which, making a semi-circle through the southern valleys, finally empties into the Rio Vemejo. While it is the only considerable stream in the province, there are a large number of small mountain riverlets, from which channels also have been dug, and which greatly assist the necessities of agriculture.

SALTA.—On the other hand, this province is supplied with water for irrigating purposes from no less than three large rivers, the Juramento, the San Francisco, and the Vermijo, and by a large number of mountain streams, which are throughout their length utilized for agricultural purposes.

TUCUMAN.—Owing to the chains of mountains which longitudinally pass through the western portions of Tucuman, this province likewise is quite well supplied with water for irrigation purposes; on the south, the streams from the heights of the Aconquija range, from the river San Francisco, and on the east the river Sali, afterwards called the Dulce. These two rivers, together with an innumerable number of mountain riverlets, furnish an abundance of water for irrigation purposes, and nearly all the farms and sugar plantations are thus supplied through the means of ordinary conduits.

SANTIAGO DEL ESTERO.—In this province, the principal source of the waters for irrigating purposes is the river Juramento, afterwards called Salado, which flows along the northern and eastern borders. As far as Sepulturas the river is well banked and both sides are covered with fine farms and sugar plantations, the artificial watering which they receive from the stream producing a marvelous fertility in lands which otherwise would be perfectly barren. Beyond that point, however, it spreads out into marshes or esteros (whence the name of the province) over a country which is unfit for cultivation. Another considerable water course is the river Dulce, which, after leaving Tucuman, flows diagonally through the province, passing by the city of Santiago. In that vicinity it is well banked, and by means of a series of canals furnishes an abundance of water to the estancias and sugar farms on each side. Afterwards, turning to the southeast, it reaches the Salinas or great salt desert, where no vegetation can exist. Beyond this its several channels unite again and forms what is called the Saladillo. Along this stream are to be found spots or "oases in the desert" which have been redeemed by means of irrigating canals, thence coursing over a barren plain the river finally loses itself in an immense salt swamp called Los Porongos.

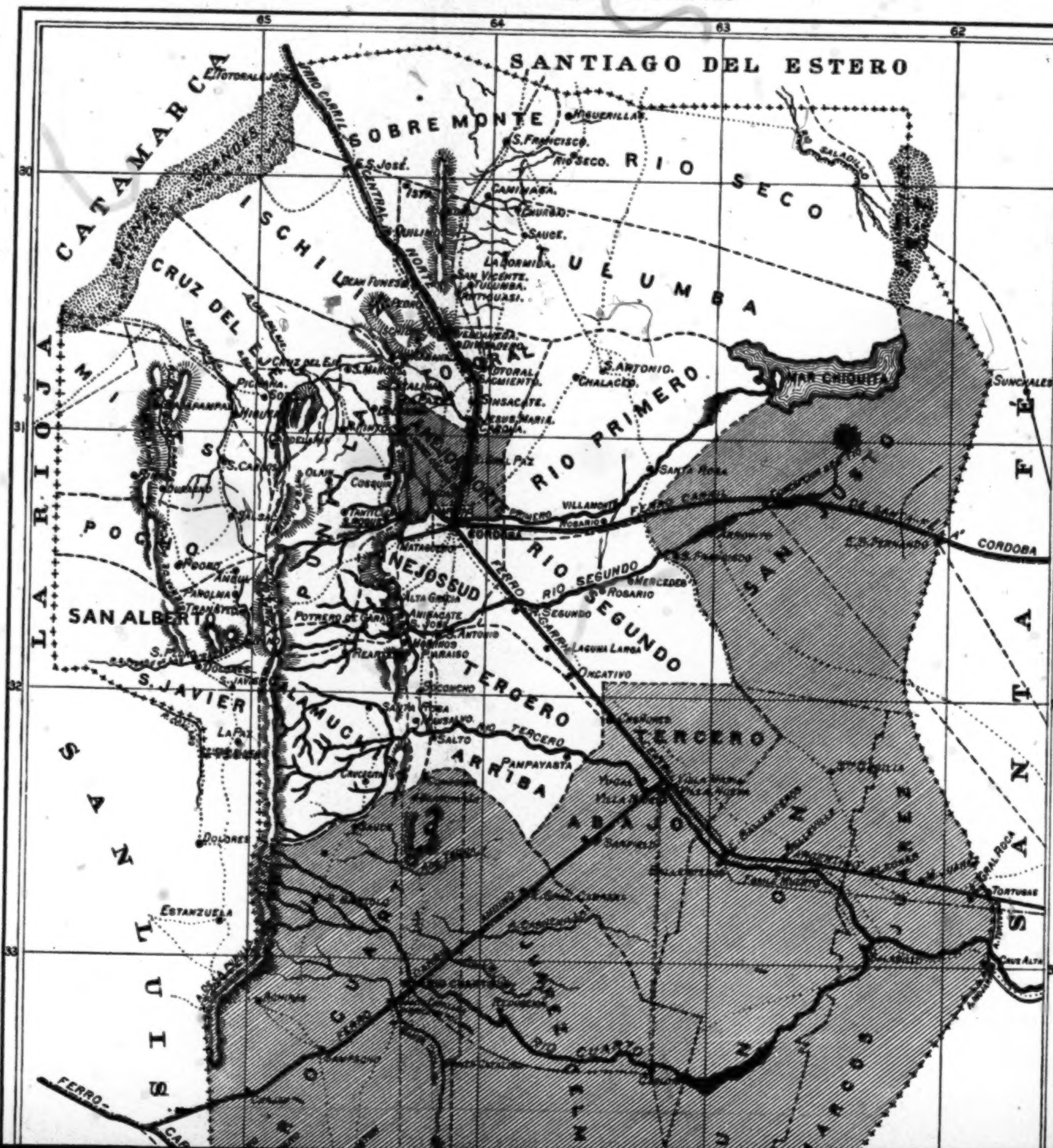
CATAMARCA.—This has no large water courses, though it is crossed by several small rivers, of which the principal are Santa Maria, the Paelen, and the Piedra Blanca, the two last named forming the Rio del Valle, on which the city of Catamarca is located. These streams and their affluents, and indeed every gorge and valley in the province down which courses a mountain torrent, are utilized ere they are swallowed up in the sands, for the purposes of irrigation. But even then the water supply is so inadequate, that there are throughout the province immense districts without water courses and without rain, which must continue to be little less than sterile deserts.

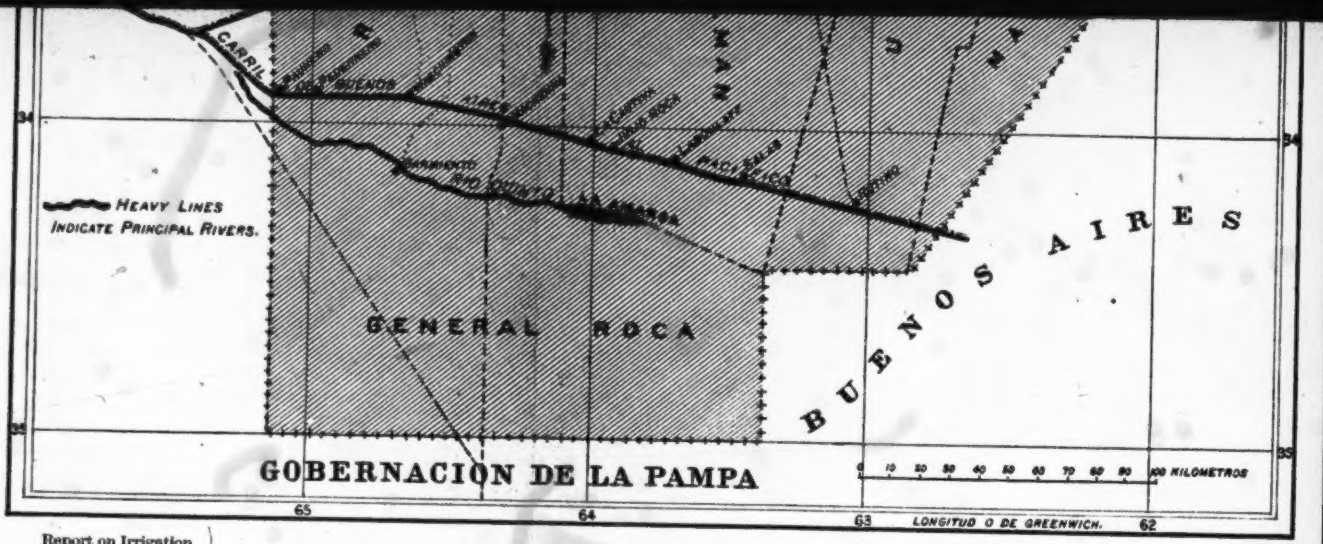
RIOJA.—Its only river of importance is the Vermijo, and this waters only a very small portion of its surface. This river, coming down from the eternal snows of Mount Boneti, traverses the fruitful valley of Jaque, is increased by the torrents which come from the Valle-Hermoso, and turning its course to the south to receive the surplus waters of the valley of Jacal, finally in latitude 32 degrees loses itself in the sand before reaching the lagunas of Guanacache. Throughout its course it affords excellent facilities by means of sluices for irrigation, but the volume of water is wholly insufficient to meet the requirements of the people, and during the summer months, for want of moisture, there are but few places which escape the wide-spread drought. Wherever there is a thread of water, however, coming down from the Sierras, it has been utilized for irrigation, and in the last few years the Government has been boring artesian wells in the hope of obtaining a better supply of water, but thus far with very little success.

SAN LUIZ.—This province is as poorly supplied with water as Rioja. The only river of any importance is the Rio Quinto, which comes down from the mountains in a series of cascades, and after a southeast course is finally lost in the pampa, in latitude 34 degrees, in an immense salt-marsh called Juncal. There are several small streams whose waters are also, by means of dams and canals, utilized for the purposes of irrigation, but the great want in this province is more water; for although in good seasons there is rain-fall enough for the crops, yet this can not be depended on, and an adequate harvest is only certain in those parts where they have streams for irrigation.

SAN JUAN.—This province is in the midst of the rivers which compose the water system of the Cordilleras. The most northward of these is the Colorado, which is fed by several affluents from the far western Sierras. The second is the Vermejo Chico, which also is formed by several affluents in the snow-covered peaks of Copiapo, at whose foot are a series of magnificent farming districts, all watered by canals from these mountain streams. This river afterwards, turning to the south as I have said, makes its way towards the Laguna Guanacache, but is lost before it gets there. The third and most important of the group is the river San Juan, which has its source in the summits of the Cordilleras, in two affluents, and flowing to the east, down the valley of Pismento, cuts through the mountains and, after passing by the city of San Juan, turns to the south and empties into Lake Guanacache. Formerly, on the breaking up of the snows, the floods which came down this river caused most destructive inundations in the vicinity of the city, and sometimes devastated leagues upon leagues of the most cultivated parts of the valley. To guard against this, an immense dyke has been constructed which acts as a reservoir for holding the water during the summer months. From this reservoir have been constructed numberless distributing canals and conduits all along that beautiful valley; and the water is now so abundant that there is sufficient for steady streams along the gutters of the city. The San Juan all along its course, however, offers marvelous facilities for irrigation. At Murallon, its altitude is 800 meters, while at Lake Guanacache its altitude is only 600 meters, thus giving a fall of 200 meters in a distance of not over 40 miles in a straight line. The river, however, is wonderfully crooked, and affords water for an unlimited number of canals and conduits for fertilizing all the adjacent country. Besides this all the small streams and rivulets which find their way down from the mountains are utilized for watering the lands along which they course—indeed they are entirely absorbed for agricultural purposes.

PROVINCE OF CORDOBA AND ITS COLONIES.


65
64
63
62
30
31
32
33
SANTIAGO DEL ESTERO
CATAMARCA
LA RIOJA
SAN LUIS
SANTA FÉ
SOBREMONTE
RIO SECO
ISCHILIN
TULUMBA
CRUZ DEL EJE
MINAS
POCHO
SAN ALBERTO
S. JAVIER
PUNILLA
TOTORAL
ANEJOS NORTE
ANEJOS SUD
RIO PRIMERO
RIO SEGUNDO
TERCERO ARRIBA
TERCERO ABAJO
CALAMUCHITA
SAN JUSTO
UNION
MARCOS JUAREZ
RIO CUARTO
JUAREZ CELMAN
SALINAS GRANDES
MAR CHIQUITA
CORDOBA
FERRO CARRIL CENTRAL NORTE
FERRO CARRIL
A' CORDOBA
RIO SECO
S. FRANCISCO
S. JOSÉ
CANINAGA
CHUÑAGO
SAUCE
LA DORMIDA
SAN VICENTE
TULUMBA
S. ANTONIO
CHALACEA
TOTORAL
SINSACATE
JESUS MARIA
COLONIA
SANTA ROSA
VILLAMONTE
ROSARIO
ARROYITO
S. FRANCISCO
MERCEDES
ROSARIO
SEGUNDO
LAGUNA LARGA
ONCATIVO
COSQUIN
OLAIN
S. CARLOS
POCHO
ANEJOS
PANAHOLMA
TRANSITO
DOLORES
S. JAVIER
LA PAZ
DOLORES
ESTANZUELA
ALTA GRACIA
POTRERO DE GARAY
ANISACATE
S. JOSÉ
REARTE
PARAISO
SOCONCHO
SANTA ROSA
SALTO
RIO TERCERO
PAMPAYASTA
VILLA NUEVA
VILLA MARIA
SANFIELD
TORTUGAS
CRUZ ALTA
SUNCHALES
E. S. FERNANDO
SAN MARCOS
CRUZ DEL EJE
PICHANA
RIO CUARTO
ACHIRAS
SAMPACHO
FERRO-CARRIL


CARRIL
BUENOS
AIRES
PACIFICO
SARMIENTO
RIO QUINTO
LA AMARGA
R
MAN
U
NA
Heavy Lines
Indicate Principal Rivers.
GENERAL ROCA
BUENOS AIRES
GOBERNACION DE LA PAMPA
34
35
0 10 20 30 40 50 60 70 80 90 100 KILOMETROS
65
64
63
62
LONGITUD O DE GREENWICH.

Report on Irrigation.

MENDOZA.—The system of canals and conduits for irrigation purposes is probably more complete in Mendoza than in any other of the Cuyo provinces, and the absolute requirement of water for agricultural purposes gives its rivers and water-courses a peculiar importance. The most considerable of these is the Rio Mendoza, which is formed by two short branches in the eastern slopes of the Andes, the northern confluent descending from Mount Aconcagua, under the name of Rio Las Cuevas, while the southern, under the name of Rio los Horcones, receives its waters from the peaks of Tupungato. After the junction the river runs to the south through the valley between the Cordilleras, and the Sierra Uspillata, and reaching the level plain near Lujan, shortly afterwards doubles towards the north, in this way arriving at the Lake Guanacache, into which, like the Rio San Juan, it finally disappears. Throughout nearly its entire course, it furnishes the waters for an immense amount of irrigation, while the complicated net-work of channels in the immediate vicinity of the city, with their elaborate ramifications, is one of the great attractions of the place. Heretofore the waters, brought down and through the city in open trenches, was used indiscriminately, also, for drinking and culinary purposes, but two years ago, when the cholera visited this country, the epidemic was peculiarly malignant in that city, owing as the analysis proved, to the bad condition of the water in the canals. Since then, all water used in the city has been brought to it in closed pipes and is separate and distinct from that employed for purposes of irrigation; and the well-known healthfulness of Mendoza has once more been assured.

CORDOBA.—This province has probably greater facilities for extended works of irrigation than any other of the interior provinces, as it is crossed by not less than five considerable rivers, the Primero, the Segundo, the Tercero, the Cuarto, and the Quinto, all of which take their rise in different parts of the Sierras, which range on the western boundary of that province and flow to the east or southeast towards the river Parana, but which only the last named finally reaches, allthe rest losing themselves in the sands of the pampa before they get there. These rivers are all utilized for irrigating the different portions of the province, as are also a number of still smaller rivers, which, rising in the Sierras of Cordoba, have their course towards the west until they finally also disappear in the sands.

With a view to increasing the agricultural facilities of the province and thus inducing immigration, five or six years ago, under the instigation of Dr. Juarez Celman, of that province, now president of the Argentine Republic, there was initiated a series of very extended works of artificial irrigation, the several rivers which run through its territory offering peculiar advantages for the purpose. Surveys and scientific inquiries to this end were made by corps of skillful engineers. The first of these works, under the name of the "Irrigation works of the heights of Cordoba" (Obras de riego de los altos de Cordoba) comprehended the distribution of the waters of the Rio Primero, which passes through the city of Cordoba. The work was commenced two years ago and it is just now contemplated and with most satisfactory results. The entire cost was $3,800,000. It is divided into four parts as follows:

(1) The dike of San Roque. This is a reservoir for holding the water of the river. It is located in a narrow cañon, with precipitous mountains on each side, at a short distance from the confluence of the rivers San Roque and Cosquin, which together form the Rio Primero. It is 51 meters in height and 37 meters from the water-line. The thickness of the wall is 51 meters at the base, laid in cement; 29

meters at the water-line and 5 meters at the top. Its length at the base, being from bank to bank, is 30 meters, and at the top 135 meters. It contains 50,000 cubic meters of masonry. It holds 260,000,000 cubic meters of water and converts the valley into a large and beautiful artificial lake. It contains two flood-gates, a pipe of discharge, and contrivances for removing the accumulations of sand. Upon leaving this immense reservoir, the water flows down the channel of the river until it reaches a spot called Mal Paso, a short distance from La Colera, where a second dike has been built.

(2) The dike of Mal Paso, which forms a reservoir for the distribution of the water. This dike is 10 meters in height and 230 meters in length, from bank to bank, and consists of 13,000 cubic meters of masonry. From this reservoir have been constructed two distributing canals, one of which carries the water to the table-lands on the north, and the other to those on the south side of the river.

(3) Main northern canal. This canal is 25 kilometers long and has eleven acqeducts, one of which, that of Saldan, for its extent, its solidity, and its elegance attracts general attention. The point of distribution is at a height of 37.25 meters above the threshold of the door of the National Observatory in Cordoba. The slope or declivity varies between 0.02 and 0.03 per 100 meters. It has twenty secondary canals. The amount of masonry employed in the construction is 44,000 cubic meters; the excavations of stone and earth reached to 615,000 cubic meters.

Main southern canal. This canal is 37½ kilometers in length, and has twenty aqueducts. The point of distribution is in a plain, even higher than that of the Northern Canal. The slope is the same. It has 89 kilometers of secondary canals. The amount of masonry employed in the construction is 45,000 cubic meters. The earth and stone excavations amounted to 842,000 cubic meters.

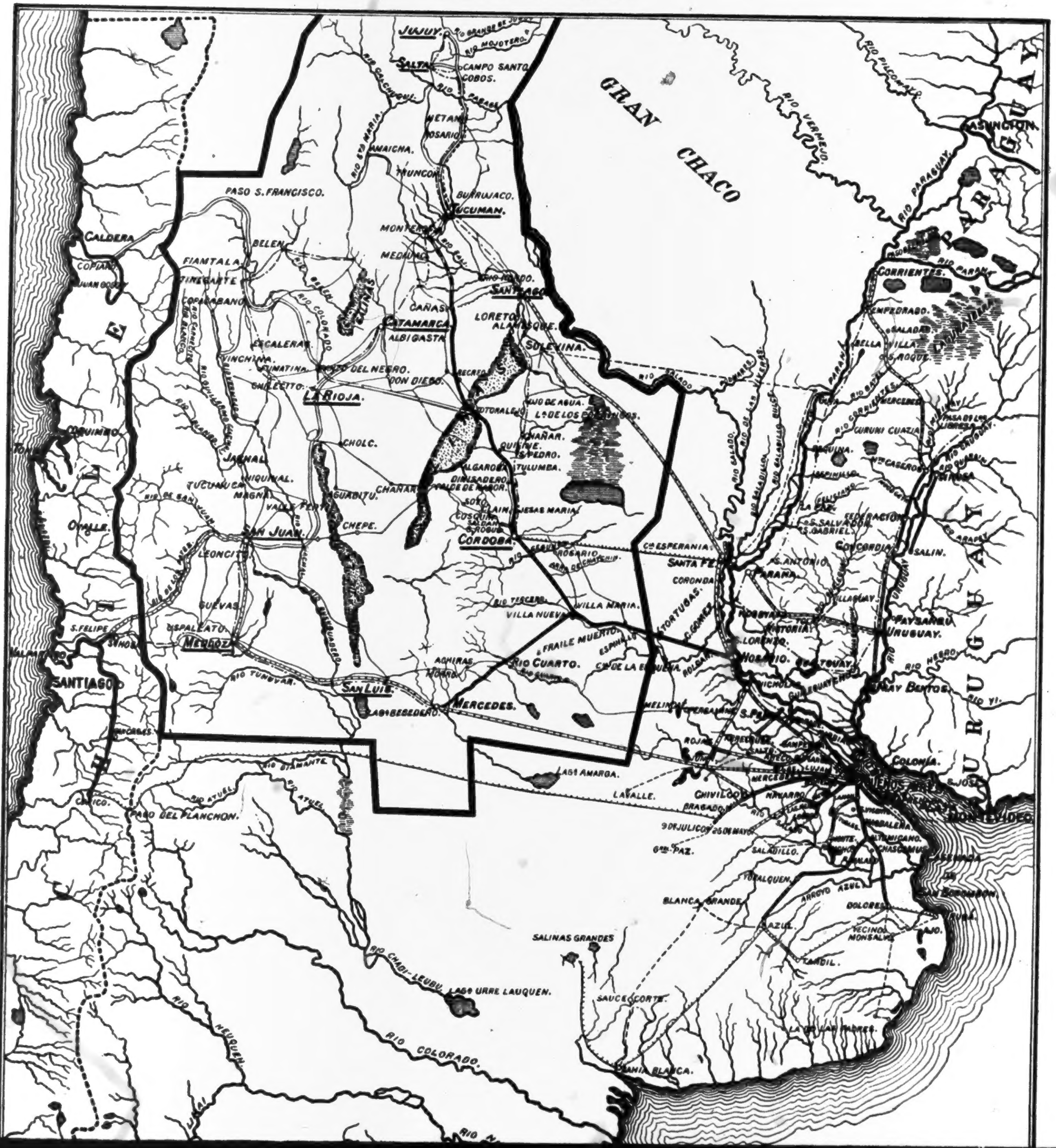
The area, which these colossal works will irrigate, amounts to 48,000 hectares at twelve floodings per year; and double that number at 6 per year.

Besides these, the surveys have been completed and approved for similar works on the Rio Segundo, which will hold 350,000,000 cubic meters of water and irrigate 60,000 hectares of land, at a cost of $4,500,000; also for works on the Rio Tercero, whose principal dyke will be 42 meters high and contain 286,000 cubic meters of water, at a cost of $3,850,000; also for works on the Rio Cuatio for which two dykes are to be constructed each 16 meters in height, which will hold 32,600,000 cubic meters of water and irrigate 17,500 hectares of land; also for the Rio de los Sances, which at a cost of $1,400,000 will irrigate 23,760 hectares of land.

The entire cost of the works completed and the works projected is estimated to be not less than $15,280,000 with a capacity to irrigate 1,209,250 hectares of land, which is equivalent to $73 per hectare. If all these works are ever completed the territory of Cordoba, which now in some parts, owing to the want of rain, is a desert, will take a new departure as an agricultural province.

I regret that I have not been able to be more explicit or go into greater detail in regard to the character of the works of irrigation in all the different provinces; but I have found it almost impossible to obtain any authentic information whatever. Upon the receipt of the circular of the Department, I at once applied to the interior department of the Argentine Government, in the hope that it could furnish me with printed reports, surveys or statistics in regard to the more important irrigation or storage systems employed in the interior provinces, but I

ARGENTINE REPUBLIC.


JUJUY.
SALTA.
CAMPO SANTO
COBOS.
RIO MOJOTERO
RIO CALCHAQUI
RIO PASAGE
METAN
ROSARIO
RIO STA MARIA
AMAICHA.
TRUNCON
BURRUJACO.
TUCUMAN.
MONTEROS
MEDANO
PASO S. FRANCISCO.
BELEN
FIAMTALA
TINOGASTE
COPACABANA
CALDERA
COPIAPO
RIO COLORADO
SANTIAGO
LORETO
CAÑAS
CATAMARCA.
ALBIGASTA
SULEXINA.
ESCALERAS
VINCHINA
GUANDACOL
FUERTE DEL NEGRO.
DON DIEGO.
CHILECITO.
LA RIOJA.
RECREO
TOTORAL
OJO DE AGUA.
CHAÑAR.
QUILINO
S. PEDRO.
TULUMBA.
ALGARROBO
CHOLC.
JACHAL
TUCUMUCA
NIQUIVAL.
MAGNA
VALLE FERTIL
GUADITU.
CHANAR
CHEPE.
SOTO
CORDOBA.
SAN JUAN.
RIO DE SAN JUAN
LEONCITO
CUEVAS
USPALLATA
MENDOZA
S. FELIPE
SANTIAGO
COQUIMBO
OVALLE.
RIO TUNUYAN
SAN LUIS.
ACHIRAS
MORRO
FRAILE MUERTO.
RIO CUARTO.
MERCEDES.
VILLA NUEVA
VILLA MARIA
RIO TERCERO
ROSARIO
C. ESPERANZA
SANTA FE
CORONDA
TORTUGAS
S. LORENZO.
ROSARIO.
CRUZ DE LA EJQUINA
MELINCUE
PERGAMINO
S. PEDRO
ROJAS
LUJAN
MERCEDES
CHIVILCOY
NAVARRO
BRAGADO
LAVALLE.
LAG.A AMARGA.
9 DE JULIO
25 DE MAYO
S.ta PAZ.
SALADILLO.
TOPALQUEN.
BLANCA GRANDE
AZUL.
ARROYO AZUL
DOLORES
TANDIL.
VECINO
MONSALVO
SALINAS GRANDES
SAUCE CORTO
LAG.A LOS PADRES.
BAHIA BLANCA.
LAGO URRE LAUQUEN.
RIO CHADI-LEUBU
RIO COLORADO.
RIO NEUQUEN
RIO ATUEL
RIO DIAMANTE
PASO DEL PLANCHON.
CURICO.
GRAN CHACO
RIO SALADO
RIO BERMEJO
RIO PILCOMAYO
RIO PARAGUAY
ASUNCION
PARAGUAY
RIO PARANA
CORRIENTES.
EMPEDRADO.
SALADAS
BELLA VISTA
S. ROQUE
ESQUINA
CURUZU CUATIA
MERCEDES
LA PAZ
S. SALVADOR
S. GABRIEL
FEDERACION
CONCORDIA
SALTO
SALIN.
S. ANTONIO
PARANA.
VILLAGUAY.
VICTORIA
GUALEGUAY
GUALEGUAYCHU
PAYSANDU
URUGUAY.
RIO URUGUAY
RIO NEGRO
FRAY BENTOS
RIO YI
COLONIA
BUENOS AIRES
MONTEVIDEO
ENSENADA DE SAMBOROMBON
CHASCOMUS
AJO.
TUYU
URUGUAY
CHILE
RIO N

RIO
NEGRO.
RIO BALCHITAS
SALINAS
CARMEN DE PATAGONES.
LAGO NALMEL-HUAPI.
BAHIA SN MATHIAS.
TERRITORY WHICH REQUIRES IRRIGATION.

Report on Irrigation.

was informed that it had nothing of the kind at its command. I then immediately addressed letters to the governors, stating the object I had in view and asking for such data on the subject as I supposed of course they would be able to send me; but although over a month has elapsed I have not yet received a word from any of them, and it is hardly worth while for me to delay my report any longer in the hope of obtaining them. Under these circumstances I have had to depend solely on such outside information as I have been able to procure, and except in the case of the works in the province of Cordoba, to speak only in a general way. In regard to the latter I have had access to a book descriptive of the province by Señor Santiago J. Albarracin, and which devotes a few pages to the subject of irrigation. In regard to the other provinces, however, the modes of irrigation employed are generally so primitive and so simple, being in most cases mere trenches with sloping slides, that I doubt if it would be of any service, even if I could give more detailed statements in regard to them.

DISTRIBUTION OF THE WATER.

In regard to the rules or laws which govern the distribution of the water, of course it all depends upon the tenure of ownership. In many of the provinces, if not indeed in all of them, there are numerous canals cut for irrigating purposes which are the property of the owners of the land, through or over which the canals are made. The province has had nothing to do with their construction and of course collect no rental or tax for the water used. Where the works have been constructed by the provincial governments a tax is paid by those who make use of the water, and this varies in the different provinces according to the expense or cost of the works. I regret that only in a few cases I am able to give the rates charged for the use of public water, not having been able to procure the laws under which the irrigating canals have been constructed.

In the province of Santiago des Estero, it is provided that all agricultural establishments and gardens which use the water of the public irrigating canals shall pay a tax of $1.50 per hour; and manufacturing establishments shall pay $2 each time they request the water, not to exceed four hours each time; for a single hour 50 cents each time. Subscribers for the use of the water for irrigation have the right to six times per month during the year; and in case they do not receive this amount in the course of the year, they are entitled to a proportionate rebate, but the law does not appear to state what amount of water shall be used.

In the province of Mendoza the annual tax is $30 per square (about 5 acres), the water to be used not oftener than one day in the week, the tax to be paid quarterly. For each house situated on the canals, where there is a service of water, a tax of 25 cents per month is charged. Those who make use of the water surreptitiously, or who use it out of their turns, must pay a fine of $20 for each offense.

In the province of Tucuman the water of the "Western Canal" is sold for the purpose of irrigation at the rate of $3 per mark per twenty-four hours; and for brick making at 30 cents per 1,000 bricks.

In Catamarca 6 cents per hour is charged for the use of the water from the Rio Tala, payable monthly.

In Cordoba the charge per square is $30 per year, payable quarterly, the water to be used one day in the week. Those who use the water out of their turn or without permission are liable to a fine of $20 each time

WATER RIGHTS BY PRESCRIPTION.

These water-rates, however, it will be borne in mind, are only collected in cases where the provinces are the proprietors of the works. In many cases, as I have said, the canals are the property of the land owners on each side of the stream. It is a part of the history of the conquest that when the Andine regions came into the possession of the Spaniards they occupied the country in the neighborhood of the rivers in some cases, driving the original inhabitants away from their settlements; and in others not only appropriating their settlements, but even reducing the Indians to the condition of slaves and requiring them to cultivate lands which were their own. These lands were held in vast estates, and with the organization of the governments it was found that all the arable places were in the possession of comparatively a few persons, who either found irrigating canals already constructed upon the lands or who compelled the enslaved Indians to dig them. Thus all these landed estates have had from the beginning a right to the use, if not the control, of the streams along which they are located. And, as with the increase of population, these estates have gradually been divided up into smaller properties and sold; a certain amount of the water for irrigating purposes have been sold with them. Thus the quantity of water which the different properties are entitled to is in most cases fixed by their title deeds.

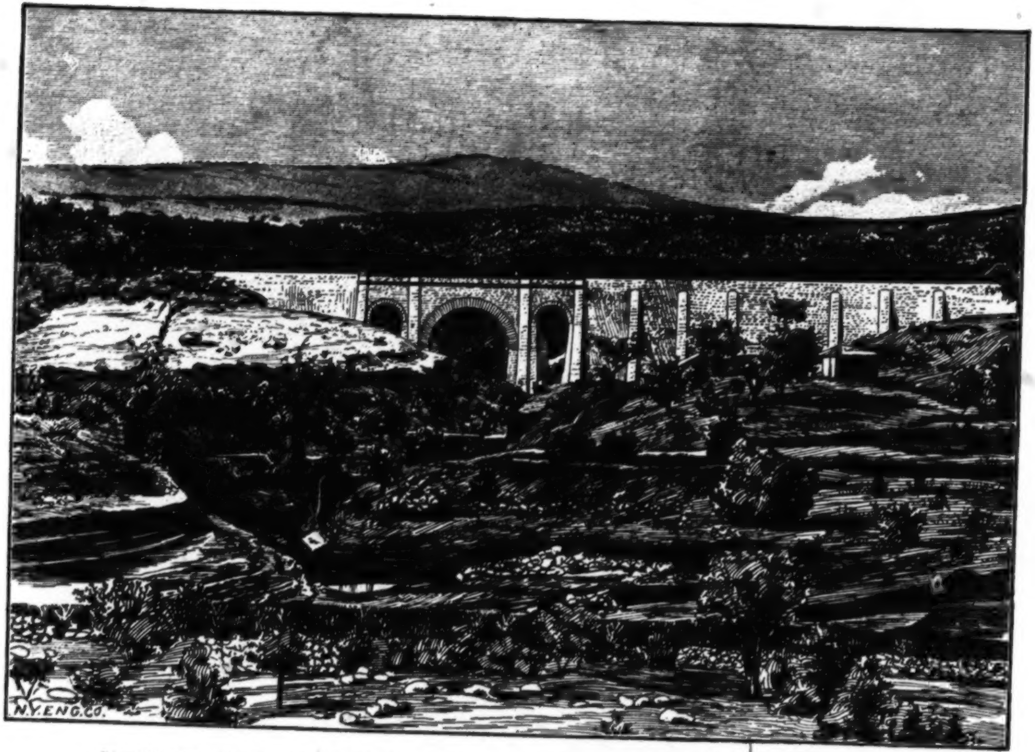
AREAS OF LAND UNDER IRRIGATION.

In regard to the areas of land under irrigation, compared with such as are cultivated without irrigation, together with the quantity and quality of the crops grown, it is not possible to speak with exactness. As no census of the country has been taken for the last twenty years it is usual to base all calculations on estimated figures, and that is all that can be done in this case. Fortunately I find in the message of the President of the Republic to the present Argentine Congress a table of statistics, "being the first ever attempted," giving the amount of land under cultivation in each province for the year 1888, compared with the total areas. I reproduce his figures below:

Provinces which depend on irrigation.

Provinces.	In cultivation.	Total area.
	Hectares.	*Hectares.*
Cordoba	234,395	17,476,700
San Luis	19,809	7,591,700
Mendoza	88,540	16,081,300
San Juan	79,630	9,750,500
Rioja	22,817	8,903,000
Catamarca	44,618	9,064,400
Santiago del Estero	120,400	10,235,500
Tucuman	35,943	2,419,900
Salta	38,525	12,826,600
Jujuy	18,904	4,528,600
Total	703,077	98,878,200

Thus, out of a total area of 98,878,200 hectares of land in these interior provinces, we find that only 703,077 hectares are under cultivation, being scarcely .07 per cent. of the entire area. It will readily be seen from this that it is only along the water courses that there is any irrigation, or indeed any vegetation at all.



IV.—AQUEDUCT No. 13, NORTHERN CANAL OF THE IRRIGATION WORKS OF THE PROVINCE OF CORDOBA.

Report on Irrigation.

The provinces which, owing to the frequency of the rains, do not require irrigation for the production of crops, are the following:

Provinces which have no irrigation.

Provinces.	In cultivation.	Total area.
	Hectares.	*Hectares.*
Buenos Ayres	868,658	31,123,700
Santa Fé	586,537	13,158,200
Entro Rios	136,151	7,545,700
Corrientes	46,631	8,114,800
Total	1,637,977	59,942,400

In these four riverine provinces out of a total area of 59,942,400 hectares of land, there are 1,637,077 hectares under cultivation, being about 2.5 per cent. of the entire area.

The President in his message calls attention to the difference in the percentage of land under crops in the riverine provinces and in the interior provinces, and says: "It shows the relation there is between easy means of communication and the cultivation of the land." There is no doubt that the outlet the formor have to the sea-board does give them some advantage, but the great advantage which they possess consists in their better climate and their more reliable supply of moisture from fertilizing rains. A large percentage of the lands in the interior provinces, owing to the limited supply of water they afford, beyond the immediate banks of their water-courses, must continue to be what it now is, an unproductive area of desert, unless the deficiency can some time be made up by the sinking of artesian wells, a problem which the Argentine National Government has for some time been trying to solve, thus far, however, without any great success. Should artesian water, however, be finally reached in sufficient quantities to meet the requirements of agriculture, all the interior provinces, most of whose areas are now but waste places, would receive a new stimulus and have a more prosperous future in store for them. They would then be able to produce crops not only of as good quality, but perhaps in as great quantities as the more favorable portions of the Republic. Until then, however, the provinces of the littoral must continue to be the chief centers of the Argentine agricultural industry.

PACIFIC OCEAN.

REPORT FROM H. W. SEVERANCE, U. S. CONSUL-GENERAL, HONOLULU, ON IRRIGATION IN THE HAWAIIAN ISLANDS.

This report has been delayed in order to include reference to a published report, now inclosed, on water-supply for irrigation by Messrs. Schuyler and Allard*. Thesee ngineers, being competent men, have examined the sources of supply on the island of Oahu, as well as giving valuable information concerning irrigation on the other larger islands of this group; and although this information is limited, the fact is fully established that irrigation is essential to success in the growth of the leading product, sugar-cane, as well as rice.

The only map bearing upon this subject is attached to the report of Messrs. Schuyler and Allardt. It has been difficult to obtain the information in an extended form but the points to which the circular alludes have as far as possible been answered in this report.

---

* Report not received.

Where irrigation is continuous the product of sugar has increased to an average of 4 tons per acre, while the same lands without irrigation formerly yielded only the average of 2 tons per acre.

The area of good cane land is limited; the most reliable estimates do not exceed 90,000 acres. Of rice land 7,000 acres, and of land suited for bananas at present under cultivation 3,000 acres; total, 100,000 acres. Of the cane land about 45 per cent. is irrigated, the remainder, except for rice land, which is all under irrigation, is subject to the annual rain-fall, which is copious on the high lands on the windward or eastern side, while it is limited on the leeward or western side.

The quantity of sugar produced in the year 1888 was estimated at 120,000 tons. Two-thirds of this of a good light color, polarizing from 86 to 96°, and one-third of the yield polarizing from 76 to 84°, all of which was sold at good figures for refining purposes.

The estimate of rice was 20,000 tons, one-third of which was exported and the remainder consumed here. All of good quality.

Of bananas about 100,000 bunches; 75,000 exported, balance consumed here.

THE SOURCES OF WATER-SUPPLY.

From mountain streams, springs, artesian wells, and storage reservoirs.

THE CHARACTER OF WORKS, DISTRIBUTION, ETC.

These consist of dams and basins, by which water is imponded and then conveyed by wrought-iron and cast-iron pipes, flumes, and open water leads and ditches at various distances from 5 to 40 miles. This system of distribution is regulated largely by leases from land-owners and by custom and common consent with sanction of law.

AMOUNT OF WATER USED PER ACRE AND PER SEASON.

For twelve months' irrigation per acre on the Spreckelsville plantation on Maui 566,280 cubic feet were used, equal to 3 inches per acre, every week, or say 5.8 cubic feet for 1 pound of sugar produced. This may be a large quantity, as the usual estimate would be 1 cubic foot of water per second to properly irrigate 45 to 65 acres of cane or 30 acres of rice.

THE COST OF RENTAL TO USER.

On page 21 of report forwarded the highest cost of pumping is estimated at $3 per acre per month, or $45 per acre per crop. No reliable estimate can be found of cost of water-supply distributed by pipes, ditches, flumes, artesian wells, or springs. This would depend on the distance, the means of conveyance, the character of the country, and the flow.

TENURE OF OWNERSHIP OF WATER.

Both private and by lease from Government.

CHARACTER OF CLIMATE IN IRRIGATED REGION.

Variable, according to elevation; on the leeward or western side, in proximity to the ocean, dry; the eastern side generally moist and cool; good soil in the valleys, yielding fair crops.

ANNUAL RAIN-FALL.

Mean rain-fall on the island of Oahu from 1867 to 1883 was 62.6 inches (see page 24 of report inclosed), while the minimum rain-fall, along the coast exceeds 24 inches, and upon the mountain slopes from 40 to 90 inches, according to elevation; in the Hilo district on Hawaii, 120 inches.

ANTIQUITY OF IRRIGATION SYSTEM.

A system of irrigation has always existed among the Hawaiians throughout the Kingdom, conveying the water from the mountain slopes and springs through the valleys over hill-sides for the production of their chief article of food, the *Arum esculentum* or kalo, from which poi is made. Many of the ancient water leads are still maintained at private expense by the owners of leases of the land running from the mountain to the sea.

ASIA.

REPORT FROM JOHN TYLER CAMPBELL, U. S. CONSUL, FOOCHOW, ON IRRIGATION IN CHINA.

As the rain-fall is equally distributed throughout the year in this province (Fohkien) there is no land dependent alone on irrigation; but in the culture and growth of rice, which is generally understood to be the principal crop grown here, irrigation is at times indispensable, and is a subject which deeply concerns the farmer in this country. The rice crop can not be made without a great deal of water, and in the seasons of drought its absence is sorely felt.

THE CULTIVATION OF RICE.

In the first place a small piece of ground is highly fertilized, plowed, or dug up and put in good order very much as cabbage beds are prepared, then the rice seeds are sown, after which the water is turned on and the bed kept submerged with about a half of a foot of water until the plants are sufficiently large to be transplanted to the fields. And here again irrigation is required. The ground is plowed and put in order for the plants, but before planting the fields are covered with water about one-half of a foot deep and the soil is worked into mud; the plants are then set into the mud and water in rows. Water is kept standing on the land until the plants are well along. Irrigation is therefore essential to rice growing.

HOW LAND IS IRRIGATED.

This country is well situated for the construction of reservoirs on a large scale. Dams could be easily built across the gulches and deep caños in the mountains, and reservoirs could be made wherein immense quantities of water could be stored and when needed for irrigation could be turned on the fields in the valleys below by the force of gravity, but this idea has never been acted upon by the Chinese, if it ever entered their minds. Small ponds are made adjacent to the fields, and the water is pumped from these and the natural water supplies into the rice fields by man power alone.

THE MODE OF IRRIGATION.

The water used for irrigation is drawn up from the ponds and water-courses by an endless chain, or rather an endless rope pump, which is worked by one man or sometimes two men by treading upon a wheel, made with a number of radiating arms, which causes the wheel to turn upon its axis. A horizontal pole about 5 feet above the shaft is made fast, and the men support themselves by leaning upon this pole while treading the wheel. One end of the box through which the chain draws the buckets is placed in the water at an angle of about 45 degrees with the pond, river, or canal from whence the water is drawn into the field. The box is open at both ends and is made strong and light. The whole apparatus is easily carried by one man on his shoulders. The faster the man treads the wheel the more water is pumped, and the machine is kept going night and day when water is needed for irrigation.

The pump is run very much on the principle of the tread-mill so far as the motor-power goes, and the water is carried up with the buckets something like wheat is raised in an elevator. In this province neither horse nor steam power has ever been thought of, and the manner of pumping water it is believed has not changed for three hundred years. Water is conducted into the fields, which are usually marked off into small compartments, according to the number of proprietors, by earth embankments, the water filling one after another until all are covered. Horses are never used in this province by the farmers, and in fact are rarely seen here. Everything is carried by human beings on their backs. The vegetable garden, flowers, and small plants are watered by water carried on the backs of the laboring people—men, women, and children.

None of the modern appliances for conducting water over the land have as yet found their way into China. No greater or stronger power than human hands is ever called into requisition, nor is there any likelihood of any innovation to the long-established custom being permitted in this land where farms are so small and labor so cheap. No farmer will expend money in experiments for irrigation when he can hire a laborer at from $10 to $12 per year to keep the time-honored pump in motion. The working classes themselves would strongly oppose the introduction of labor-saving inventions that would take work from them, and tend to cut off their employment. The farms are small, less than 1 acre in many cases, but they have been tilled for perhaps thousands of years, and by the skillful use of fertilizers and by care and attention to each plant crops are raised that would astonish the owners of rich soil.

THE WATERS OF THE RIVER MIN.

The river Min runs diagonally through this province, and a few miles above this city it divides into several branches, which, after pursuing separate courses for 15 miles, unite a little above the pagoda anchorage, and empty into the Pacific Ocean 2 miles below. Along the river are numerous small valleys which can be easily irrigated from the river, but the mode of irrigation is rude and simple. The pump is used for the larger fields and small plants, and garden vegetables are watered by water carried on the backs of the laboring people. The everlasting pole on the shoulder of the bearer, with buckets suspended from each end, is rarely out of view. The water is carried in this way, in many places a long distance, but no complaint is heard in any quarter. When the rains cease water must be supplied to keep alive the growing vegetation so essential to the existence of the people. During a dry season men, women, and children are engaged in carrying water which is carefully sprinkled over the vegetation, and the greatest patience and care are shown in keeping moisture about the plants. In this part of China the rain-fall is fairly distributed throughout the season, but if the rain does not come at the needed time the water buckets are called into requisition to supply the necessary water for the crops.

LAND UNDER IRRIGATION.

There are no means of ascertaining the area of land grown in rice. This seems to be the only product of the soil that necessitates irrigation. There are no statistics available showing the quantity of land under cultivation. As far as observation goes the whole face of the country, excluding the precipitous mountains and running streams, is used either for farming purposes, for residences, or for cemeteries. The water-supply is abundant for all purposes in ordinary times. There are numerous rivers, streams, and springs in all parts of the province. There are no laws governing the use of water. Custom rules in this as in almost all the affairs of life in China.

REPORT FROM THOMAS F. PETTUS, U. S. CONSUL, NINGPO, CHINA, ON IRRIGATION.

(1) It is impossible to ascertain the areas of lands under irrigation or cultivation, owing to the difficulty in getting at the records kept in the tax office and the absence of published returns of land taxes. The district is well cultivated, and every strip of land available is under cultivation.

(2) The supply of water for bottom land is from canals. The supply canals are run from the river to the hills, dug from 50 to 80 feet wide. At the foot of hills all running water from springs is emptied into the canals, so as to form a never-failing supply of fresh water. The canals are not allowed to connect with the river, as the water in the latter is salt or brackish. At the foot (or end) of the canal an embankment of stone is made to a height above the sides of the river, this is covered with moistened, slippery clay, so that boats entering or leaving the canal are hauled over. A hawser of twisted split bamboo is fastened either to the stern of the boat or a strong beam crossing it at the bows. The hauling is usually done by capstans, sometimes by oxen.

These canals have no locks. The supply canals are from 2 to 4 miles apart; minor canals are dug at right angles, and supplied with water from the main arteries, about 200 to 400 feet apart, from 10 to 30 feet wide. Thus every farm and garden is supplied with free water.

(3) The farmers, when compelled to irrigate their land, use a wooden chain-pump, which is as long as required, placed so as to draw water from the canals, worked by cog-wheels, the ox performing the labor; so a stream of water some 10 inches wide constantly flows. A field of 2 or 3 acres of rice is soon overflowed.

For gardens and small plots of ground a hand-pump of the same kind is used, generally worked by two men.

The hill lands are terraced and are irrigated by springs, water being conveyed by small ditches or by pipes made of bamboo.

(4) There are no laws or rules governing the water system. The canals are free, and there are no expenses to the user beyond those of drawing the water from the canals.

(5) Climate damp and warm from April to 1st of July; July, August, and September, hot and dry; November and December, dry and pleasant; January, February, and March, damp and disagreeable.

The system of irrigation according to Chinese is over a thousand years old.

The soil is alluvial. Rain-fall for 1888 was 68.31 inches.

REPORT FROM CHARLES SEYMOUR, U. S. CONSUL, CANTON, CHINA, ON IRRIGATION.

(1) Irrigation of land is so general in southern China that a comparison between irrigated and non-irrigated lands is impossible. Rice is the chief crop on which cultivators rely for support, but near Canton and other large towns and cities a great diversity of productions may be found, as vegetables of all kinds are cultivated, and the lands being so subdivided as to be devoted to small parcels, and under the management of small owners, to many kinds of crops, with a view to early supplies for immediate city consumption.

The yield of good land,* which has been properly fertilized and irrigated, supports a family of five persons, who will each consume 2 pounds of rice, and other things in moderate variety and supply. Two crops of rice and one of vegetables are produced annually when the land is well tilled. A ton and three-quarters of rice per acre each year is a fine crop. In tilling the small pieces of land about Canton, with a generous use of fertilizers, the utmost vigilance is given to irrigation.

(2 and 3) The sources of water-supply are the small tributaries of the large branches of great streams, and in many places where they are inaccessible pools of water are held in reserve by hardening the bottoms and sides of pits and hollows and depressed or sunken lands. Between rows of growing vegetables, trenches filled with water, obtained from the creeks, brooks, or pools, are kept, and once or twice a day the water is scooped from these trenches upon the raised grounds, in which the roots have great depth of loose and moist soil to promote growth. When these trenches of water are not available, owing to scarcity of water or to porous land, the men and women carry, suspended from a yoke across their shoulders, two large buckets with long spouts, and sprinkle the rows of vegetables copiously. Sometimes the water for this purpose is carried in buckets a considerable distance. For the irrigation of rice lands, which have to be submerged, the lands are divided into small patches at different levels, so that the appearance is that of a beautiful system of terraces, near a bountiful supply of water, which is raised to the upper level by chain-pump and tread mill process with coolie power. From the upper to lower levels the water descends so gradually as to avoid washing away the substance or fertility of upper to lower lands.

(4) The system of water distribution is generally conducted and used on the mutual or co-operative plan, which prevails in China in so many branches of industry and business as to lead one to believe co-operation is reduced to a perfect system on the basis of equity.

(5) The character of the climate in this province is mild and warm. The lowest temperature at Canton in winter is about 37 or 38° Fah. The rainy season of March and April, with copious showers and rains of considerable frequency during May and June, and occasional show-

---

*The consul makes no mention of the area required.

ers up to the end of August, supplying crops with abundant water when most needed for the first and second rice crops. The actual measurement of rain-fall is not known. During the rainy season the water-fall is torrential at times.

The antiquity of the irrigation system in China is established. This portion of China is favored with streams, and water-ways, sloughs, and natural deposits of water for the temporary season of drought; so that being abundance of fertilizing properties available for agricultural and horticultural operations, the excellent supply of water required for irrigation of land favors the production of the largest crops of which any land is capable of yielding.

REPORT FROM A. C. JONES, U. S. CONSUL CHIN KIANG, CHINA, ON IRRIGATION.

SIR: In compliance with the circular letter of instructions of the Department of State, on the subject of irrigation, dated May 2, 1889, and received on the 7th instant, I have the honor to inform you that, so far as I can learn, there never has been any national or other governmental system of water distribution in China. There are no reservoirs worthy of the name in any part of the country. This province of Kiangsie, as its name signifies, is the province of rivers and mulberry trees, and is perhaps the best-watered section in the empire. The almost annual inundations, caused by the overflow of the Yellow River and the Yangtsze Kiang, fertilizes the submerged lowlands of the province and renders unnecessary any artificial means for the cultivation of crops except that of rice, which requires in the early stages of planting and growth a great deal of water.

The methods of providing water for the rice and other crops in general all over the country are very simple, and are governed by no laws or regulations beyond the local customs of the people.

The farms, so-called, are rarely over 2 acres in extent, and are separated by ditches or raised pathways. There are no fences and no ranging stock.

To provide a water-supply for the fields the farmers usually club together and make large pools to receive the rain for common use. It is then when required supplied to the fields by pails. When a natural streamlet exists, it is utilized by conducting it through ditches or bambo pipes to the fields.

Sometimes the water is supplied from the streamlets by the most primitive arrangement of a water-wheel worked by treading with the feet.

These are the methods in vogue since the earliest days in this district, and no improvements on them have ever been attempted. In other districts I have seen the water-wheel worked by buffaloes.

The rain-fall is very uncertain. Usually in May and part of June there are heavy rains; but last year a long-continual drought almost destroyed the whole rice crop of the district.

In reading of the astuteness of the Chinese and of their reputation generally as to shrewdness and sagacity, one naturally would expect other things of them; but my observation of the working class and the farmers leads me to the conclusion that while they are hard-working and patient, they are a shiftless and hand-to-mouth people.

REPORT FROM J. D. KENNEDY, U. S. CONSUL-GENERAL, SHANGHAI, ON IRRIGATION IN CHINA.

Following the Department's inquiries in their order I have to report as follows:

(2) Rice fields are usually flooded from rivers, streams, and canals.

(3) There is no system of storage of water for irrigation.

(4) All irrigation throughout this section of China (if flooding rice fields may be called irrigation) is carried on by individuals. No further information under this heading obtainable.

(5) Warm, moist, and fertile.

(6) The present means of pumping water from streams into fields has been practiced in China from time immemorial.

In general: From Mr. G. James Morrison, an English civil engineer, who has had much experience in China, I learn that from observation made during extensive journeys in the interior of this country he has seen no other means of irrigation than the system of pumping from streams directly into the fields, save the more laborious method he saw in the northern sections of China of lifting water in buckets and throwing it over the bank by hand.

On the island of Formosa he saw a more extensive system of irrigation, the water being conducted down the hills for some distance.

From Mr. John Fryer, a distinguished sinologue, to whom I applied for assistance in making this report, and who obtained his information from Chinese sources, I learn that in northern Shan-Si an arid tract of land has been reclaimed by irrigation. The information is so meager that I merely mention it. In many sections of China there is at the present day extensive tracts of arid land and no attempts are made to reclaim them.

REPORT FROM JACOB I. CHILD, UNITED STATES CONSUL-GENERAL, BANGKOK, ON IRRIGATION IN SIAM.

About one-half of the country is under cultivation, and of this portion fully four-fifths is under irrigation.

Rice is the staple, consisting of two kinds, Va Suan, or garden rice, which is tranplanted, and the second grade, Va Muang, or field rice.

It is estimated that about 10,143,800 piculs are annually grown in Siam.

Water is supplied to the fields by means of canals, which branch out from the rivers in all directions.

The water is conducted into the fields by small canals and ditches (the fields are divided off into ris, containing about one-third of an acre), around the four sides of each ri, in turn, until the whole number of ris is full.

There are no published works upon irrigation. This system is governed by laws and customs. There is no duty upon the water, but if the land is government property there is an annual rental in the form of a tax of 28 cents per ri, which includes the use of the water. The large canals are built at the expense of the general government, but the small canals leading to the fields must be dug by the individual.

The climate is tropical, with a wet and dry season. The average annual rain-fall is 67.04 inches.

The system of irrigation has been in use from time immemorial and is maintained partly by public and partly by private expense.

REPORT OF ERHARD BISSINGER, U. S. CONSUL, BEIRUT, ON IRRIGATION, ETC., IN SYRIA.

(1) AREAS OF LAND UNDER IRRIGATION, ETC.—As there are no statistics kept in Syria it is not possible to state with any degree of positiveness the exact areas of land under irrigation, and the different authorities competent to speak on so important a subject differ somewhat in their various estimates. A high government official in Damascus, who has devoted much study and attention to the matter, gives the approximate area of cultivated land in the vilayet or province of Syria as 30,000 feddans—336,000,000 square feet. (A "feddan" in Syria is understood to comprise that extent of land which can be plowed and prepared for seed by a pair of oxen in one day.)

An equally reliable and competent authority in Beirut, from his own observations and knowledge of the country, estimates that only about 5 per cent. of the cultivated lands are irrigated in the province known as Mount Lebanon, and probably not over 2 per cent. in all Syria, while the proportion of irrigable, as compared with non-irrigable, areas is calculated by the former authority as equal to about three parts out of twenty-four, or 12½ per cent.

Quantity and quality of crops grown.—The total quantity of crops grown is not ascertainable, not even approximately, and any attempt to arrive at exact figures would be useless and a mere waste of time.

The quality of the crops varies according to climate, soil, and locality; they comprise nearly all the cereals grown in the United States, besides "durah" or maize (both yellow and white), sesame, hemp, cotton, etc., also bananas, pomegranates, figs, dates, oranges, lemons, mulberries, olive, and other fruits, and all kinds of vegetables and other garden products.

Orchards well watered, as those for instance at Sidon, Tripoli, and other places in Syria, are reputed to be very remunerative in a pecuniary point of view, yielding, it is said, as high as 10 per cent on the capital invested, clear of all expenses.

(2) *Sources of water supply.*—The sources of water supply are lakes, rivers, streams, and other water-courses, springs, ponds, wells, and cisterns or tanks. The waters of lakes for irrigation purposes are only utilized in a few instances, such as Homs, Tiberias, etc., as will be seen later on, and reservoirs, on a large scale, do not exist at all in Syria.

(3) *Character of works used for storage and distribution of water.*—Published reports of irrigation and storage works do not exist; a wood cut of a huge Persian water-wheel in use at Hamah, with an accompanying description in print published from notes furnished by a competent authority here, is all I have seen.

Generally speaking the character of the irrigation works is of the most primitive kind. From rivers the conveyance of water is usually by means of canals or rough ditches badly leveled and aligned, often without masonry except at the intake, the retaining weirs for obtaining necessary head being remade every season of bowlder, stones, and brush-wood, rarely over 3 feet high.

Irrigation from springs is generally much the same as from the rivers, though necessarily on a smaller scale.

From wells the system universally employed is that of the "Na'hura."

The "Na'hura" is of the simplest construction, cheap, quickly made and repaired, and easily worked, while it raises a comparatively large quantity of water. Its construction consists of a clumsy cog-wheel, fitted to an upright post, and made to revolve horizontally by a donkey, mule, or horse attached to the sweep; this turns a similar one perpendicularly placed at the end of a heavy beam, which has a large wide drum built into it, directly over the mouth of the well.

Over this drum revolve two rough hawsers, or thick ropes, often made of "myrtle" twigs and branches twisted together, and upon them are fastened small earthen jars or wooden buckets. One side descends while the other rises, carrying the small buckets with them; those descending are empty, while the ascending ones are full, and as they pass over the top they discharge into a trough which conveys the water to the cistern. The length of the hawsers and number of buckets depend upon the profundity of the well, for the buckets are fastened to the hawsers about 2 feet apart; the wells are of different depths, but generally average from 10 to 15 feet. It is claimed that with good animal power a bucket containing about 2 gallons of water can be raised every second (see table in "Acca-Haifa" report).

The "Shaduf," so conspicuous on the Nile, is not used in Syria, but on the shores of Lake Tiberias an apparatus much like it has been seen at work, and the well-sweep and bucket is also met with in many places.

Another method (very common in the land of Philistia) may be observed on the plains of central Syria. It is a large buffalo skin so attached to cords that when let down into the well it opens and is instantly filled, and being drawn up, closes up so as to retain the water. The rope by which it is hoisted to the crop works over a wheel and is drawn by donkeys, mules, oxen, or camels that walk directly from the well to the length of the rope and then return, only to repeat the process until a sufficient quantity of water is raised; this is also a very successful mode of drawing water.

The wheel and bucket, of different sorts and sizes, are much used where the water is near the surface, and also along rapid rivers. For shallow wells merely a wheel is used, whose diameter equals the desired elevation of the water. The rim of this wheel is large, hollow, and divided into compartments answering the place of buckets. A hole at the top of each bucket allows it to fill, as that part of the rim, in revolving, dips under the water. This, of course, will be discharged into the trough when the bucket begins to descend, and thus a constant succession of streams falls into the cisterns. The wheel itself may be turned by donkeys, mules, oxen, or camels.

Small water-wheels are sometimes turned by feet, but the process is tedious, toilsome, and not productive of much result.

At Homs, in the Tripoli district, there is a lake or artificial basin of about 4,000 acres in extent, formed by draining the Orontes River. It is very shallow in summer, probably not over 10 or 15 feet at the deepest part, but will reach a depth estimated at from 30 to 40 feet in the winter. The lake was made for the double purpose of regulating the summer flow of the Orontes and for obtaining sufficient head of water to irrigate the extensive gardens of Homs. This lake is the only artificial system of irrigation on a large scale in the country, but it is not kept in very good repair.

The "Pools of Solomon," at Tyre, may also be mentioned; they are natural artesian wells of great volume, irrigating some 1,500 acres of garden land from artificially raised conduits.

(4) *The system of water distribution, etc.*—In regard to this, Ottoman law literally says:

> In contestations relative to water-courses for drinking or irrigating purposes, the customs and usages existing *ab. antiquo* only are to be taken into consideration.

These usages and established rules vary somewhat in different localities; but it is the almost universal custom that the water belongs to the community and to the lands irrigated by it; the allotted quantities of water can not be altered or alienated without the permission of all the proprietors unanimously; nor can the lands be sold without the water, nor the water without the lands.

The amount of water used per acre—is estimated by a reliable authority as varying from 25 tons in the plain for garden products to 4 tons per acre in the high lands for mulberry trees.

The actual or precise quantity of water used per acre or season, can not, however, be accurately stated; it varies greatly according to the soil and its products. Mulberry trees, for instance, need only to be well watered three or four times during the dry season; but the water should penetrate the ground at least 3 feet. This would require the the land to be inundated to a depth of at least 8 to 10 inches. Vegetables, cereals, etc., should be watered more frequently, at least once or twice a week.

Where there is scarcity of water, judicious manuring would do much towards assuring good crops; but this practice, outside of the vicinity of Beirut and other large cities, is either wholly unknown in Syria or only resorted to in very isolated cases.

Tenure of ownership of water, etc.—The Turkish regulations and laws are very comprehensive and precise on this subject, and for a fuller understanding of the same, a translation of the most pertinent paragraphs is appended herewith:

OTTOMAN REGULATIONS CONCERNING PROPRIETARY RIGHTS OF WATER, ETC.

Water, herbs, and fire are things *ex commercium*; all men enjoy them in common.

Water running under ground is the property of no one in particular.

Wells not sunk by any one in particular and which are used by the public in common, are *ex commercium*.

Seas and great lakes are things *ex commercium*.

Streams of the public domains, that is to say, those which do not specially belong to any one, are those whose bed is not the property of a number of persons; such streams are *extra commercium*, as for example, the Nile, the Euphrates, the Danube, etc.

"Private" streams (Arabic, *enharmunlouké*), *i. e.*, those whose beds traverse the lands the property of private persons, are of two kinds.

First. Those whose waters are subdivided among co-proprietors, but which do not empty or exhaust themselves completely into the lands of the latter and which run afterwards into public rivers; such water courses are also designated "public," because part of them is public domain. The right of pre-emption (chufaa) is not applicable to these water courses.

Second. "Private" water courses (nehrihass) which run within the limits of the property of a given number of persons and whose water is exhausted and disappears upon such property without re-appearing to form another confluent. Pre-emption rights are only applicable to such water-courses.

Alluvium deposited by a stream on the land of a private individual becomes that person's property; no one else can lay claim to proprietary rights thereto.

Herbs of natural (wild) growth upon lands the property of no one in particular are *ex commercium;* the same with herbs that grow upon private property unknown to the owner; but if the latter waters his land or incloses it with a view to prepare it for cultivation, then the herbs growing thereon become his property; no one else can appropriate them, and he who gathers them is held responsible therefor.

By herbs are meant such plants as are not artificially watered; mushrooms, for instance, are included therein, but trees are not. Trees of natural growth (*i. e.*, wild growth) upon mountains which have no owners (djibali moubalra) are *ex commercium*.

Trees of natural (wild) growth upon the property of any one belong to the owner of such property; nobody can cut them down without his authorization. He who grafts a tree becomes the proprietor of the shoots and fruits thereof.

If anybody occupies a thing *ex commercium* he becomes the exclusive proprietor thereof.

Examples: The water which a person draws from a stream with a receptacle becomes his undisputed property, and if a third person consumes it without the owner's permission he is held liable therefor.

The occupation of a thing must show intent; consequently he who has placed a receptacle with the intention of collecting rain-water becomes the owner of such water. The same with water accumulated in a basin or cistern; but the rain-water found in a receptacle not expressly placed for such a purpose is not the property of the owner of the receptacle, and other persons may appropriate such water.

It is necessary in the occupation of water that it does not run continually; so for instance, well-water which filters through is *commercium*. He who consumes the water thus obtained by infiltration, even without the proprietor's consent, is not held liable for damages.

Again, water is not considered as having been appropriated where as much enters a basin on one side as escapes on the other.

Every one may enjoy a thing *ex commercium* on condition that such enjoyment causes injury to no one.

None can prevent a person from occupying or appropriating a thing *ex commercium*.

Everybody can utilize the waters of public streams for his lands, and may for this purpose, or for the purpose of constructing a mill, dig canals and ditches or trenches, on condition. however, of doing no injury to any one. Works which cause an inundation, those which completely exhaust a stream or which prevent boats (barges) from floating, are to be interdicted.

Man and beast may drink of the waters not the individual property of any one. The right of "chirb" (*i. e.*, the right to use water for irrigation and for the consumption of animals) of water courses, not public property, belongs to the owners of these streams (courses); any other persons, however, may drink therefrom. Thus no other person than the owner can serve himself of the waters belonging to a community or of a ditch, trench, or well, for irrigating purposes; but he may drink therefrom and even water his animals, provided the number of these be not so large as to damage the water course, the canal, ditch, trench, or conduit; he can likewise draw water therefrom with a pitcher or pail, and carry it to his house or garden.

Those who possess a brook, stream, basin, or well upon their lands, whose waters are renewed by nature, may prevent any one who wants to drink therefrom from entering their property; but if there exists no other water *ex commercium* in the neighborhood, the owners are obliged to either offer the use of their water or allow their lands to be penetrated; and, in case they fail to offer their water, those who wish to drink may enter the property, provided no harm is done thereto by damaging, for example, the edge of the wells or the water conduits.

One of the coproprietors of a common water course can not, without the permission of the others, cut a channel, ditch, trench, or gutter; he can not change his "turn" or share of the enjoyment of the water established *ab antiquo* nor cede such right to a landed proprietor who has no right to the waters of such a river for irrigating his field or watering his cattle. The authorization to perform these acts given by the other coproprietors could be evoked by these latter or by their heirs.

In all contestations touching drinking water or water for irrigating purposes, the rules, regulations, and usages established *ab antiquo* are to be enforced.

The waters of rivers, streams, springs, and other water courses, passing through the lands of a village or a city are the property of the community and must be distributed, as has been the practice *ab antiquo* in such a manner as to secure a supply to each landed proprietor during certain hours, either weekly or fortnightly.

Every owner of land knows the exact time and quantity of water to which he is entitled, and in almost every village there is a civil officer who is charged with the duty of looking after the proper allotment and distribution of the water among all the inhabitants.

As clocks and watches are not commonly in use among the peasantry, the time is measured by various devices, such as hour-glasses, etc.

Besides the Beirut Water Works, noticed under the head of "general remarks," there exist in Syria no irrigation works which supply water against payment, and the Turkish Government has no other interest, nor claims any other right to rivers, streams, springs, and other water courses than to place an increased valuation upon the lands irrigated therefrom, and to levy a comparatively heavier land tax.

(5) *Character of climate in irrigated region and nature of soil.*—The climate of the coast region is warm and damp. Thermometer ranges from about 40 to 90 degrees Fah. (in the Lebanon and other mountains

the range is from 10 to 20 degrees less in the winter and from 5 to 15 degrees in the summer.)

The climate in the interior is generally dry, but with greater thermometric range, say 25 to 30 degrees and 90 to 95 degrees Fah. The following table will show the average readings in Beirut during a period of ten years:

Thermometrical observations taken at the Syrian Protestant College at Beirut, Syria, from 1879 to 1889.

Month.	1879.	1880.	1881.	1882.	1883.	1884.	1885.	1886.	1887.	1888.	1889.
	°	°	°	°		°	°	°	°	°	°
January	60.92	52.20	61.70	58.70	56.20	54.60	56.60	60.20	55.54	55.30	57.10
February	65.24	58.60	58.00	53.20	56.00	55.30	59.30	59.50	57.52	59.60	60.64
March	62.33	57.81	61.70	62.30	64.40	60.10	62.40	59.70	61.10	64.50	63.16
April	69.26	55.70	67.40	66.00	65.60	66.40	65.80	64.60	67.64	66.50	65.84
May	73.38	70.30	71.70	69.60	70.78	71.16	74.60	70.70	72.36	70.80	71.06
June	81.35	79.50	77.40	76.10	78.65	77.90	78.40	78.90	78.64	76.60	78.12
July	85.79	82.88	82.80	81.40	81.90	80.35	82.50	81.70	82.66	83.75	82.87
August	84.20	84.40	85.60	82.60	83.47	82.00	83.30	83.05	83.97	83.60	......
September	82.05	81.20	82.90	81.70	81.55	76.30	80.90	81.30	81.00	81.60	......
October	74.96	77.90	76.50	74.64	76.90	74.20	76.80	75.40	79.77	78.22	......
November	67.55	71.80	67.40	68.16	67.30	66.82	68.90	65.00	70.84	65.22	......
December	60.38	59.50	60.80	61.00	60.60	63.60	62.40	61.60	62.50	58.33	......

No statistics for the interior are known to exist.

The soil throughout almost the entire Vilayet of Syria is of a heavy clayey (argillaceous) nature, which, in drying up, becomes very hard, causing it to crack. In Beirut and other localities the experiment of using sand to improve the soil has been successful, but on a more extensive scale, and upon large tracts, this process would perhaps not prove practicable or feasible.

The character of climate is generally very good in the plains, but better in the mountains; the lands not irrigated are of course the most salubrious; the non-irrigated districts in the "Hauran" (east of Damascus) are considered by far the best, next come the regions to the north, then the Baalbek district, the plains of the "Bekaa" or "Cool Syria," and the districts of "Hasbaya" and "Rashaya." The land around Damascus is all irrigated and the soil is very fertile.

Annual rain-fall or other precipitation.—Along the coast, near Beirut, the annual rain-fall averages about 30 to 38 inches, but in the interior it is much less. One authority estimates it as low as 15 inches, while another makes it from 15 to 50 inches, or an average of 32½ inches. The rain-fall for Beirut for a period of ten years and six months is herewith annexed.

Rain-fall at Beirut, in inches, from 1879 to 1889, observed by the Syrian Protestant College at Beirut.

Month.	1879.	1880.	1881.	1882.	1883.	1884.	1885.	1886.	1887.	1888.	1889.
January	3.100	9.330	1.320	4.910	12.750	10.630	10.370	5.820	8.910	6.065	6.930
February	2.230	4.205	9.440	10.180	9.251	6.063	4.163	9.865	2.560	6.625	2.885
March	5.600	3.585	5.360	1.325	3.305	3.650	1.640	8.200	1.685	2.745	2.500
April	.540	2.125	2.975	6.250	.900	1.654	3.430	.580	.350	5.158	.840
May	.770	.480	....	2.570	.330	.517	.030	.420	.373	.170	.100
June	....	....	.110	.060	....	....	.400	....	....	.903	.280
July	....	.280	....	....	....	.010	....	....	....	....	......
August	....	....	....	....	.290	.035	....	....	....	....	......
September	.120	1.013	.765	....	....	1.010	.700	.525	.140	.045	......
October	3.390	.510	1.385	3.125	2.115	1.936	.080	2.205	....	1.330	......
November	4.500	1.050	5.540	3.100	15.304	4.350	3.910	3.860	3.065	7.220	......
December	13.373	9.665	5.760	6.357	6.448	.240	6.910	5.460	10.170	7.883	......
	32.685	32.343	32.655	37.877	50.713	30.136	31.655	36.995	27.253	38.148	......

Annual average during ten years, 35.146 inches.

No statistics are kept of the amount of the annual rain-fall in the mountains and the interior, but it is variously estimated at from 15 to 50 inches, according to locality.

The precipitations are: Dew during the summer and the fall more or less plentiful. Very plentiful in spring, sometimes sufficient to ripen the grain, when rains cease early.

In February, March, and April hail-storms are not uncommon. If they occur late they are apt to destroy the mulberry leaves and the vine.

Snow falls on the mountains and in the interior, but no statistics are kept of the quantity.

Generally the country is at least five months without any rain at all, and a month after the last rain-fall the land is dried up to the depth of the roots of the trees, causing a total cessation of all vegetable life, unless irrigation is resorted to. May is the last month in which rain falls, but the copious down-pours really cease with the end of March or beginning of April.

(6) *Antiquity of irrigating systems, etc.*—All the existing irrigation works are of considerable antiquity, some date from time immemorial. On the right banks of the Dog River, about 5 miles north of Beirut, there still exists an old aqueduct, built upon arches and partly cut through the solid rock, running along the river side, which is said to date back to the time of the Roman occupation. The present use is to convey water for the irrigation of a vast tract of land, and to furnish the domestic supply for the village of Jumi, etc.

The ruins of another aqueduct, where the water was conducted over river and dale, are still to be seen in the valley of the Beirut River, about 8 miles above its mouth.

The water-works and conduits of Damascus, Tripoli, Homs, and Hamath are also of great antiquity, and the water is conducted by means of canals of masonry; or where this was impracticable, through earthen pipes and sometimes also through stones scooped out for this purpose.

The ancient canals in the plains of Mesopotamia, between the Euphrates and Tigris are still extant; but they are choked up with the accumulated rubbish of centuries, which, with a little energy and hard work, however, could easily be removed. (See also the report of the "Acca-Haifa" district and the annex to the "notes on irrigation" in the Vilayet of Adana.)

No maps or publications bearing upon the subject of irrigation, etc., exist in the province of Syria.

GENERAL REMARKS.

Under irrigation are usually placed lands lying along the foot of a mountain, from which rivers, streams, springs, or other water-courses flow, and which, by reason of their gentle slope, adapt themselves admirably for irrigating purposes.

In Beirut the area under irrigation extends about 5 miles in one direction and 8 or 9 in another, and the necessary supply of water is furnished by the Beirut River, conducted through five canals. Another strip of varying width and about 12 miles in length runs along the Mediterranean Sea, and is irrigated by the waters of the Dog River, the powerful spring of Antelias and other springs of minor capacity.

The irrigated lands in these districts are planted principally with mulberry trees for the silk industry, besides all kind of vegetables and garden stuffs.

At Tripoli the irrigated lands consist mostly of orange groves, about 5 miles square in extent, which, however, there is no lack, for the river that flows down from Mount Sannin (of the Lebanon range) furnishes an abundant supply, sufficient also for the ancient Tripoli city water-works. From Tripoli northward there runs a narrow strip of land between the sea and the mountains of about 1 to 2½ miles in breadth and about 16 miles in length, irrigated from the waters of springs and rivulets which have their sources there. Onions are the principal product of these lands; they are annually exported in large quantities in small sailing vessels. In the interior of the country, wherever there is artificial watering, "durah" or maize is generally grown, and is said to be quite remunerative; but it will not prosper without water.

Between Tripoli and Homs, in the valley of the Nahr "Jabir" (River Eleutherus), large tracts of lands are thus year after year planted with "durah." The crop per acre it has not been possible to ascertain with precision, but it is asserted by an eye witness that the best-looking of these fields would compare very unfavorably with the corn fields in Illinois, for instance, and that they would probably not produce much more than one-half the average yield of American farms. Upon the highlands (plateau) traversed by the river Orontes there is very little irrigation, for the river itself has, in the course of centuries, imbedded itself so deeply that the ancient water conduits can no longer be utilized and new ones have not yet been constructed. The conveyance of water in general is by means of canals or ditches expressly dug for this purpose, where they do not already exist, or where the water does not run of itself; the canals are usually very old, but are not kept in very good repair.

The waters of springs are carried into cisterns or tanks built of masonry, well cemented, which are usually emptied each day; large reservoirs are unknown in Syria, and the maxim among the natives in force is: "That irrigation is only profitable where the water runs unaided by man," that is to say, where condicts and consequently pecuniary outlays are unnecessary. Their ancestors were apparently of a different opinion, judging from the numerous works left by them scattered broadcast over the land.

Of modern irrigation and water works, the Beirut Water Works take first rank; they are the property of an English stock company, which furnishes Beirut with an excellent quality of drinking water at fixed rates, as well as a needful supply for irrigating purposes at reasonable charges.

Sidon a few years since built a pipe line to convey the waters of a spring or springs, situated about 2½ miles distant, into the city; and the municipality of Homs, three years ago, also contemplated the introduction of water works, but the project failed through the opposition of the city of Hamath, which apprehended a decrease and even a scarcity of water for its own supply.

Several efforts have been made by an intelligent and enterprising mechanic, established in business in Beirut, a citizen of the United States, to introduce mechanical and steam power as a profitable means of artificial irrigation. The first attempt made by him was in a region lying between Tripoli and Antioch, a broad plain traversed by a number of rivulets, whose beds, however, had become so deep that canals could no longer be made serviceable as conduits or conveyances of their waters, especially as there was not sufficient fall or headway.

A rich Arab who had seen the irrigation works in Egypt, conceived the idea of applying them practically to his lands situated in the district above mentioned and went so far as to order a machine of five horse-power. The pump was a "pulsometer" with 4-inch pipes, and the water had to be raised to an elevation of about 30 feet. The pump was guarantied to lift 750 litres or 166⅔ gallons per minute; it worked for forty days, fulfilled all its expectations, and would have been capable of irrigating an area of at least 80 acres in extent; but it appears that the fuel proved too expensive, wood being scarce and coal very dear, so that the experiment has been for the present at least abandoned.

A second attempt was made in the spring of this year in "Hazmyeh," in the neighborhood of Beirut, and notwithstanding that the water had to be elevated fully 130 feet, proved entirely successful.

The water is first raised about 10 feet from a well dug close to the Beirut River, by means of a cylindrical pump worked by a steam motor of three horse-power, and then forced through iron pipes along a hill to the height of 120 feet into a basin holding about 90 cubic meters, 3,543 cubic inches of water, for irrigating purposes. The basin can be filled in about six or seven hours, and the capacity per hour therefore is about 14 cubic meters, or 551 cubic inches. The investment seems to have proven an entirely satisfactory one in every respect.

A "Hallonday" wind motor has also been in operation near Beirut for over four years, which raises water to a considerable height and works satisfactorily. In general, irrigation as practiced in Syria does not entail any greater or other expense than the cost of maintaining the canals, conduits, etc., in good repair; but this, it must be repeated, is not always done.

Irrigation, as has already been shown, is regulated entirely by usage and well established rules, and every parcel of land has a right to the use of water for certain well fixed length of time. For instance: A small proprietor near Beirut has five acres of land; every Friday he can take as much water during six hours as he may need to thoroughly saturate his land; if he fails to take advantage of his privilege, he simply forfeits it without being indemnified therefor. Where water is scarce, as in many places in the mountains, it is often divided into hours and even fractions of hours, and good care is taken that no one receives or takes more that his allotted share. The sole owner of a spring—a rare occurrence, however—may of course use the water thereof at his own pleasure.

It is worthy of remark that in Mount Lebanon the waters of every spring, no matter how limited its capacity, is caught up into cisterns of good solid masonry, and is utilized for irrigating and domestic purposes, and no matter how steep the mountain sides or how poor the soil, the smallest available and tillable space is planted with onions, vegetables, marrow, or egg plant, and three and sometimes even four crops are thus produced each year.

The lands in Mount Lebanon are exceptionally well kept, and the population is principally composed of Christians (Maronites and Greeks, etc.), and Druzes, who are quite prosperous, and whose destinies are presided over by a Christian governor-general.

If the foregoing notes do not contain much of practical value or importance for the purposes intended, they may at least serve to impart some interesting if not useful information regarding the people of the oldest country, and of their ancestors the Phœnicians, which may not be generally known in the United States.

ANNEX B.

IRRIGATION, ETC., IN THE DISTRICT OF ACCA-HAIFA (SYRIA).

From materials furnished by Consular Agent J. Schumacher and Civil Engineer G. Schumacher.

The Acco-Haifa district and the region of the Hauran probably offer little in the way of irrigation that will prove of much value or interest, for the purpose of the State Department would appear to be to secure information of a practical character on a larger scale.

Interrogatory No. 1, "areas of land under irrigation," etc., of which the succeeding five interrogatories are merely an elaboration, can be summarily answered by the statement that there practically do not exist in Gallilee, in Nablus, or in the Jordan Valley any irrigation works in the full sense of the word as understood in the United States, and that land under irrigation in those districts is almost wholly unknown, forming but an infinitesimal—probably not more than the two-hundredth—part of the whole arable land.

In the Jordan Valley, on the Hûlé (sea of Merom), north of the Batîhâ and south of the Lake of Tiberias, also in the Wäd el Arab and Wäd el Tanjibe, the Bedouins irrigate small parcels of about 10 to 60 acres, upon which "durah" (maize) is grown, yielding annually two and even three crops. This result is due in part to the exceptional climate of the Jordan Valley with its tropical heat—a perfect hot-house—to the rich alluvial soil washed down from the basalt mountains, and also, perhaps, chiefly to the great abundance of water in the Jordan and Huromax (Arab, Sheri'al el Menädise); whereas the higher regions of Palestine and the littoral of the Mediterranean Sea are comparatively too poor in water supplies to enable their inhabitants to irrigate their lands to any great extent.

The irrigation process in all these districts supplied by water is of the simplest and most primitive character. In the early morning or shortly before sunset, young Bedouins in a semi-nude state may be seen roughly constructing from stones and earth a temporary dam to obstruct the waters of a stream or wadi (valley) while others provided with broad hoes dig little ditches, through which they lead the overflowing waters to be distributed over the parcels it is intended to irrigate, allowing the water free course in the lower lying lands, thus inundating or rather completely setting them under water. These manipulations are of daily repetition; the dams have to be regularly rebuilt, for the pressure of the water causes their daily destruction, and it is interesting to watch with what assiduity and perseverance these Bedouins are continually remaking and renewing the little ditches or canals which need their unremitting attention.

Reservoirs, basins, tanks, etc., do not exist, and the systems in practice here will therefore scarcely commend themselves to the inhabitants of more progressive countries.

Here and there, along the sea of Tiberias, remnants of ancient Roman irrigation works may be met with; but they are in such a deplorable state of dilapidation that of their original construction only a catchment basin remains near the head of the spring and a portion of a conduit (in masonry) is also yet in a fair state of preservation. The original character or the practical application of these ancient works can, however, no longer be established or recognized; for the Arabs not only made no use of them, but allowed everything to fall into decay and ruin, preferring the antediluvian ways of their own ancestors to the innovations of the Roman intruders.

In response to interrogatory No. 4, it may be said that "the system of water distribution," etc., depends wholly upon local custom as regulated among the different communities themselves. If several inhabitants of a village, for the purpose of irrigation, desire to utilize a spring in common they will use and distribute the waters thereof in conformity with local tradition as sanctioned by the municipal authorities; uch at least is the custom or practice in this vicinity. In all cases the proprietary ights of a village spring remain vested with the community, and the spring itself an never be sold.

The climate (question 5) in the irrigated districts of the Jordan Valley and in the rable lands bordering the Lake of Tiberias is, on the whole, rather insalubrious, ngendering malarial fevers caused by the evaporation (exhalations) during the heat f the day and the rapid cooling off at night; in other words, owing to the sudden hange and wide range of temperature.

For habitation, irrigated districts are carefully avoided in these parts, and as a rule ly negroes are capable of withstanding the deadly effects of the miasmata.

According to careful observations and measurements in Haifa during a period of welve years, the Phiviometer registered from 19.60 to 34.04 inches per year; last ar it reached 33.86 inches. The yearly average, however, may be taken to be 26 hes.

A draw-well in almost universal use in these regions, and by far the most practical and cheapest method of irrigating small parcels and gardens, is the "Hanani," a sketch of which in its improved form as in use by the Haifa German-American Colony is annexed herewith.

The "Hanani," as used by the natives, is of a much more imperfect and primitive construction than that of the colonists.

It may be worked by either donkey, mule, or horse (wholly unattended), and can be utilized to a depth of 150 feet. The size of the well buckets decrease in proportion to the profundity of the well to allow the "Hanani" to be worked by a single animal of either of the above species.

The amount of water raised diminishes in consequence with the increasing depth of the well, and the following table will serve to illustrate the practical results observed:

Place of observation.	Depth of well.	Amount of water raised per hour in gallons.
	Feet.	
Haifa	25	5,200 liters* = 1,144⁴⁄₉ gallons.
Haifa	30	4,000 liters = 889 gallons.
Gaza (Palestine)	146	2,500 liters = 555½ gallons.
Sea of Merim	15	6,500 liters = 1,444⁴⁄₉ gallons.

* Four and a half liters equal 1 gallon.

Of course the employment of steam would greatly increase these figures.

These quantities will vary according to the working capacity of the different animals employed, and the above figures were obtained by well-nourished animals, resting one hour after every three hours of consecutive work. The principal basin is generally replenished in from six to eight hours. It is constructed of masonry and well cemented, and ordinarily was 20 feet in length, 18 feet in width, and 7 to 8 feet in depth.

The main basin empties itself into a smaller one, 4 feet square by 2 feet deep, from which the water is conducted directly into the main irrigating canal, made of masonry, and situated in the most elevated part of the land, which feeds the numerous little ditches that distribute the water over the garden or field to be watered. The "Hanani" is of great durability and seldom needs repairs, especially if the water is free from saline particles; it is of the simplest construction and can be handled by the most inexperienced person.

REPORT ON IRRIGATION IN THE CONSULAR DISTRICT OF MERSINA (ASIA MINOR), SYRIA.

In the Vilayet of Adana, Syria, there are about 4,740,000 acres of land cultivable, but no irrigation works.

In the plain between Mersina and Adana there are about 400,000 acres irrigable, and between Adana and Missis about 350,000, through which there are three rivers, the Cydnus, the Sarus, and the Pyramus flow, but up to the present there are no irrigation works. The consequence is that for the last four years part of the crops has been completely destroyed, and what has succeeded could not be produced at prices to compete against the American and Russian markets in Europe.

The Turkish Government, on the pressing demands of the agriculturists, have recently taken the matter of irrigation in hand, and His Excellency the Vuli Sirri Pacha asked me to assist him in making the necessary surveys and plans, and I have just handed him the plans to irrigate a portion of the plain from Tarsus towards Adana for a distance of about 15 miles, which can be done at a very small cost. The other parts of the plain, however, towards Adana and between this latter and Missis will cost about £400,000 to irrigate properly, and although this sum would be comparatively nothing compared with the results, yet the Government, in order to avoid this outlay, want to try to make these irrigation works "a la Turque" if possible, but unless they are carried out by a competent company I am afraid it will be a failure.

The principal crops grown are cotton of very short texture, about 16,000 tons; wheat and barley of second quality, about 25,000 tons; sesame seed of first quality, about 4,000 tons; raisins of very inferior quality, about 4,000 tons.

The soil is partly red and partly sandy. Rain-fall averages 22 inches per annum.

The antique irrigations simply consist of the cultivators in the immediate neighborhood of the rivers and mill streams taking advantage of the water passing their farms.

NOTE BY THE BEIRUT CONSULATE ANNEXED TO THE REPORT OF THE "MERSINA CONSULAR AGENCY."

In olden times the vast plains of the Vilayet of Adania,Syria, were entirely irrigated by the rivers that pass through them. The Romans were in the habit of damming out the required quantity from the waters of the Djihoun, Seihoun, and Cydnus, and, conducting it to the foot of the mountains, form a high level on both sides of the rivers, along the surface of the ground, accumulating earth on both sides of its banks, making in this way a wide, high canal, extending from the mountains on both sides of the rivers in various directions to the sea. The farmers had thus the water within their reach and could easily, and at little expense, by means of subsidiary canals, conduct any portion of it to irrigate their lands.

These long and ancient canals, extending from the foot of the mountains to the sea in all directions, are still extant, and need but to be freed from the rubbish that centuries have accumulated to be again serviceable.

REPORT FROM HENRY GILLMAN, U. S. CONSUL, JERUSALEM, ON IRRIGATION IN PALESTINE.

With the exception of Jaffa and its immediate neighborhood, there is no part of this consular district in which any extensive and systematic attempt at irrigation according to modern methods is made.

THE JORDAN VALLEY.

In the Valley of the Jordan, which contains from 500 to 600 square miles of some of the richest land in the world, and which is never visited by frost, being from 700 to 1,300 feet below the level of the Mediterranean Sea, and where, with its semi-tropical climate and facilities for irrigation, several successive crops, may be produced annually, only the most feeble and primitive methods of conducting the necessary water to the few and ill-cultivated fields are followed. This unique valley, capable, with proper agricultural treatment, of sustaining an immense population, has no settlement worthy of the name. The wild Bedouin Arabs range throughout its length and breadth, and in defiance of the Turkish Government, which have in vain attempted to drive them out, come and go at their own free will.

Small fields, gardens, or patches of ground are here and there cultivated in the neighborhood of some stream having its source in one of the perennial springs of the region. From such a stream the water is conveyed in shallow drains or ditches to wherever required, and is carried through the fields or gardens by still smaller channels, the water being shut off or let on simply by the action of the foot, opening the tray inlet, or blocking it up with a few pebbles or masses of clay, as may be desired. This is a habit as old as the oldest writings, and of which mention is made in the Bible. "Where thou sowest thy seed, and waterest it with thy foot, as a garden of herbs." (Deut. 11, 10.)

Only the common farm crops are cultivated; but they are of specially exuberant growth.

At Nablous, or Ancient Shechem, or Sychar, similar methods in general are followed. The comparatively few fields and gardens are well watered from the abundant streams which have their rise in the Mounts Gerizim and Ebal, making it a spot of beauty in the midst of wild and unreclaimed surroundings. In one or two instances here there have been made some efforts at a more enlightened system of irrigation, the water from the clear and copious springs being conducted by aqueducts of stone masonry, and more satisfactorly supplied. The result in the luxuriant gardens, in which most of the various kinds of fruits and vegetables suitable to the climate are found, testifies as to what might be accomplished were more intelligent, systematic, and thorough measures adopted.

Throughout Palestine a very little water produces a wonderful result. The soil, naturally fertile, immediately responds to the effect of the periodic rains. The bursting of the land into bloom after the first heavy showers of the rainy season is a sight never to be forgotten. The hillsides and valleys that through the dry season had lain burnt up and barren, like a calcined bone, are suddenly, as if by miracle, turned into a garden of the most brilliant blossoms; the scarlet ranunculus and anémone, pomegranate, and many other flowers and shrubs only known to us in cultivation, "making the wilderness and solitary place rejoice and blossom as the rose."

THE KING'S GARDEN, JERUSALEM.

In the valley of the Kedron, on the southerly side of Jerusalem, is the king's garden, which dates back to the time of Hezekiah, if not to that of Solomon. It is mentioned in Nehemiah (3, 15) where it speaks of "Siloah by the king's garden."

The few acres which are at present under cultivation here are irrigated in the usual simple manner. The source of the water supply in the celebrated pool of Siloah, or Siloam, a reservoir 53 feet long, 18 feet wide, and 19 feet deep, which is fed through a subterranean conduit by the overflow of the pool of the Virgin, an intermittent spring about one-quarter of a mile to the northward. The water is conducted from the former pool partly by underground drains, regulated by the most primitive of sluices into smaller channels in the direction required, where still finer ramifications or branches distribute it to the drills or rows in which the crop is planted; much as in the other instances mentioned, and with as little regularity or system.

In these garden plots all the ordinary vegetables and many kinds of fruits are produced in good quantity and of fair quality. And up the terraced slopes, even to the very walls of Jerusalem, some of the largest cauliflowers come to perfection, and are in the market in the months of February and March. This vegetable sells at the rate of three heads for 12 cents.

There is no special regulation as to the use of the water other than that of the most patriarchal kind, the owners of the adjacent land having free access to the pool for all requisite purposes, including household uses, and the watering of their flocks and herds. Much of the water is also brought into Jerusalem for sale in goat skins.

KING SOLOMON'S POOLS AND GARDENS.

About 8 miles to the southwest of Jerusalem are the wonderful pools of Solomon; while, below them, in the narrow valley of Urtas, lie the renowned gardens of the wise king, except the garden of Eden, I suppose the oldest recorded gardens in the world. These works are mentioned in Ecclesiastes (2-46) as follows:

> I made me great works; I builded me houses; I planted me vineyards; I made me gardens and orchards, and I planted, in them, all kinds of fruits; I made me pools of water; to water therewith the wood that bringeth forth trees.

There is little doubt, too, that the scenes depicted in that beautiful oriental love-song—"The Song of Solomon," found here their original.

Josephus also speaks of this place: "Very pleasant it is in fine gardens, and abounding in rivulets of water," and tells us that Solomon was wont to visit it frequently, describing him as driving out there in the morning sitting on high in his chariot, clothed in white, and surrounded by his handsome mounted guards, all of great stature, and in the flower of manhood, arrayed in Tyrian purple, and in armor, their long hair sprinkled with gold-dust. It would be difficult to overestimate the noble character of those remarkable works, especially considering the periods in which they were constructed.

The pools consist of three enormous reservoirs, partly cut in the rocks, partly built of massive marble masonry. Their dimensions are as follows: The upper pool, 380 feet long; breadth at east end, 236 feet; at west end, 229 feet; depth at west end, 25 feet.

The middle pool, which is distant from the upper pool 160 feet, is 248 feet long; it is, at east end, 250 feet broad, and at west end, 160 feet, while the depth at east end is 39 feet. The lower pool, 248 feet eastward of the middle pool, has a length of 582 feet; a breadth at end, of 207 feet, and at west end, of 148 feet; and a depth at east end, of 50 feet, having sufficient capacity, as Dr. Thomson has said, "to float the largest man-of-war that ever ploughed the ocean." Each pool overflows successively by regulated sluices into the next below it, in the order here given, the last pool emptying its superabundant water into the valley.

Those venerable structures are at the present time in an excellent state of preservation. They are said to have been repaired by Pontius Pilate, which would be about 1,855 years ago.

The source of the water supply is the sealed fountain of Solomon, at the foot of a hill a short distance west of the upper pool. This fountain is always kept locked, hence the name. A flight of twenty steps descend from an arched doorway into an underground vaulted chamber, where four streams of pure and cool water converge. This fountain also afforded in former times a constant and abundant supply of water to Jerusalem, a goodly stream being conveyed by the carefully and skillfully constructed stone aqueduct of Solomon, which demonstrates that they understood at that early day the principle of the syphon, having introduced it into the Holy Temple inclosure.

About two years ago, the less ancient Saracenic aqueduct being put in repair, the water was once more brought into the site of the temple area, and into the so-called Fountain of the Cup, which stands between the Mosque of Omar and the Mosque Al Aksa, and doubtless marks the site of the brazen laver made by Solomon for the ablution of the priests in their sacrificial worship.

But the aqueduct soon again lapsing into disrepair, the water is, at present, barely conveyed in small quantity as far as Bethlehem, of which town it is the principal supply.

Of the 75 acres of land below the pools, in the valley of Urtas, 25 are under cultivation, and are irrigated.

Independently of the pools, the garden lands of the valley are also largely watered from a separate copious spring, which has its rise in the side of the mountain and at the foot of the village of Urtas. The soil is a red clay, exceedingly fertile, and to this day the finest fruits and vegetables in the Jerusalem market come from these gardens.

Of the fruits produced may be mentioned apricots, peaches, nectarines, apples, prunes, plums, citrons, lemons, pomegranates, mulberries, figs, and grapes. The vegetables include peas, beans, beets, ockra, egg-plant, onions, leeks, garlick, potatoes, turnips, cabbage, cauliflower, carrots, cucumbers, pumpkins, vegetable marrow, tomatoes, and radishes.

About two-fifths of the land belong to three Europeans, and the remainder is owned by the native Syrian fellahin (peasants).

The distribution of the water is regulated by the old custom or system of "fassels;" a night and a day forming a "fassel." Each family owning land there knows, from time immemorial, its respective rights and share in the "fassel" of water. Some have an entire "fassel," and again the same is divided among the different members of a family to irrigate their respective shares of land. The water is carried from one plat to another by drains in the usual simple manner already described. The Europeans who own land there have made, however, a cemented conduit to convey their share of water into their ground. No statistics are obtainable, none ever having been kept, as to the duty of water per acre.

No special rent or fee is paid for the water used, nor are there any charges on the land in connection therewith, the only payments made being the usual government taxes, the werko (land taxes) and ushur (titles).

Solomon's Park, the Sealed Fountain, and the Aqueduct are public property, and are under the control of the Turkish Government.

JAFFA AND ITS ORANGE GROVES.

The town of Jaffa, looking down from its pleasant elevation, on the one side on the deep blue Mediterranean and on the other on its multitudinous palms and odorous orange groves, may well be considered entitled to its name, which, softened in the Arabic pronunciation to Jaffa, means "beautiful."

The orange groves and gardens and their system of irrigation, though they have been greatly extended within comparatively recent times, have unquestionably an origin of quite respectable antiquity.

(1) The area of land under irrigation at Jaffa would exactly include the space occupied by its orange groves, being nearly one-third of the cultivable ground belonging to the community, that is, of 9,000 acres of cultivable lands about 3,000 acres are under irrigation.

The orange and the lemon are the chief crops; but other fruits, such as citrons, limes, peaches, apricots, grapes, pomegranates, and melons, and all the ordinary garden vegetables are also produced in abundance, and of fine quality. The vine especially is of late receiving much attention, and within the last few years extensive vineyards have been planted. Neither the vine nor the olive, of the latter of which there are many groves, require any water other than the usual rain-fall.

The superiority of the Jaffa orange is world renowned, whether its size, juiciness, or flavor is considered.

In an average season oranges and lemons, together with other fruits and vegetables, to the amount of $335,000 have been exported from Jaffa. Besides this is the immense home consumption, of which there is no record.

(2) The sources of the water supply are wells which are fed by underground springs.

(3) The engine in use for raising the water is in every case without exception the so-called bajara or bayara, a modern machine of the most simple construction, driven by horse or mule.

Its principal parts are a whim-beam or capstan, with horizontal wheel attached moving a vertical wheel connected by shaft with a third wheel, which carries at its circumference a chain of pendant reversible buckets. A pole inserted in the whim-beam is fastened to the horse or mule, with the monotonous circuit of which animal the entire machine is set in motion, the wheel with buckets revolving in the well dipping up the water and emptying it into the conduit or tank. The tanks are usually close to the wells, and are cemented basins, built of stone. They are filled during the day, the water being distributed from them, through the various channels, during the night in order that the loss by evaporation may be reduced to the minimum.

There are about seven hundred of those bajaras at work at Jaffa.

(4) The system of water distribution, being entirely under private control, is governed by neither law nor regulation.

The quantity of water used per acre during the season of twenty-three weeks or one hundred and sixty-one days is 2.300 cubic meters, at a cost of from 20 to 25 cents per diem. Thus, for instance, the average expense for irrigating an orange-garden with an area of 5 acres would be for one hundred and sixty days, at 20 cents, $160. The value of the crops might be estimated at from $500 to $700.

(5) Owing to the peculiarity of the climate, the orange groves are obliged to be watered during the summer months, or rather during the "dry season," when no rain falls; that is, from May till October or November. The rain-fall in the winter months, or say from November till May, varies from 17 to 30 inches. The average temperature is, in the day-time, from 70 to 90 degrees Fah.; during the night from 53 to 56 degrees.

The soil in the orange groves is of mixed clay and sand, with rather more of the latter than of the former. Is exceedingly fertile, and is particularly well suited to the orange.

(6) As to the antiquity of the system of irrigation, the close resemblance of the bajara to the Spanish "moria," has induced many persons to imagine its being introduced here at some early period from Spain. But as the family likeness of these wheels to the ancient Persian wooden water-wheel is equally great, and as the Crusaders, in the eleventh century, are reported to have found the orange-tree (*Citrus aurantium*) already in Palestine, the actual system of irrigation may as well belong originally to this country, or to the East, and may have been introduced from Persia.

GENERAL REMARKS ON THE CLIMATE.

In addition to the facts already given respecting the climate of Palestine, I add the following remarks: It is evident from the statements of history, both sacred and profane, as well as from other testimony, that this country in former ages was not only under a more general and thorough state of cultivation as regards its agricultural districts, but also that it possessed extensive tracts of forests, which have long since disappeared. Consequently its rain-fall was more favorably regulated, being more equable in its distribution. The result would naturally be not only the temporary advantage of the improved growing crops, but the enrichment of the soil and the permanent benefit of the land.

At present, seasons of almost tropical rain are followed by the long dry period in which not a drop of rain falls, and nearly every green herb perishes and burns up for the lack of moisture. Swept by the resistless torrent of the "rainy season," the higher lands are stripped of their soil and entire districts are seen in which the bare and barren ridges of rock crop out like the bones in the skeleton of some gigantic animal.

The phenomenon of the "air cushion" is seen here to perfection. Before a rain sets in it generally takes several days of incubatory preparation before the result comes. Great clouds roll up and cover the entire heavens with their dense masses; but in vain they attempt to discharge their contents, or if they succeed in dissolving, the thirsty atmosphere drinks up the moisture before it ever reaches the earth; and this must continue until the intervening strata composing the "air-cushions" are sufficiently saturated to permit the rain to fall through, which then occurs in a violent and often injurious downpour. Deprived of the gentle mediation of the growing crops, and especially of the forests, which would have established the proper relation and a just equilibrium, through their continual evaporation, the parched ground languishes for the rain that is denied it, or that, when given, comes in almost an unwelcome shape.

During the serious drought of 1887 and 1888 this phenomenon was seen in an extreme degree, weeks, and even months, passing without adequate rain, though the greater part of the time the heavens were dark with clouds.

The intervening unsaturated "air cushion" drank up the contents of the clouds, as already described, so that little or no rain could pass through it.

It is thought that the agricultural colonies established here within recent years have already begun to produce a perceptibly beneficial effect in this direction, but probably it is too soon yet to look for any decided change.

REPORT OF W. C. EMMET, U. S. CONSUL, SMYRNA, ASIA MINOR.

There is no irrigation practiced in this or any other district of Asia Minor, except in kitchen or fruit gardens in the neighborhood of large towns.

In these cases the supply of water is from wells on the premises, and the machinery used is a large wheel-bucket pump, worked by a horse.

These wells are of various depths and the supply of water utterly fails in some during long-continued droughts.

No water-works or artificial lakes are to be found anywhere, although there are numerous rivers, streams, and lakes which could be adapted to overcome the effects of the dry season, which usually lasts from five to six months.

These water sources belong mainly to the Government, in some instances to religious communities (mosques), but the right to use the same can be obtained at moderate cost.

In this section the yield of crops depends on a merciful Providence in withholding rain during the growing and harvesting seasons; the ingenuity or industry of mankind takes but an insignificant part in producing large crops.

Although the largest revenue to the Government is derived from tithes on agricultural products, the over-taxed peasantry labor under great difficulties and receive no encouragement or assistance from the Government.

The area of irrigated land does not amount to 1 per cent. of the arable land in this province.

The annual rain-fall rarely exceeds 26 inches per square foot, in fact, that is considered an ample supply.

The proportion of irrigated surface is so small that no perceptible effect is made on the climate of the district. The soil is mainly a sandy loam.

THE INDIAN OCEAN.

REPORT FROM ALEX. R. WEBB, U. S. CONSUL, MANILA, ON IRRIGATION IN THE PHILIPPINE (SPANISH) ARCHIPELAGO.

Owing to the numerous streams that rise in the mountainous districts and flow through the low lands to the sea, as well as to the copious rains, which will average 100 inches during the year, irrigation is seldom necessary in the Philippine Archipelago. When it is resorted to the most primitive methods are followed. If the rainy season commences later than usual the rice lands are sometimes irrigated by damming the mountain streams and turning the water over the paddy-fields through small channels, and in some cases the very old-fashioned chain-bucket windlass is used. This is a simple contrivance, composed of a number of small, water-tight boxes, formed into an endless chain by means of stout rope or leather bands, which run over a roller anchored in a river or creek, and a windlass on the bank turned by hand or cattle power. This is also used, in some cases, during the dry season on the lands where "zacate" or swamp-grass, which is fed to horses and cattle, instead of hay, is raised. On the low lands near the coast, where the rivers and creeks rise and fall with the ocean tide, sluice-ways and gates are sometimes used to flood the zacate lands during the dry season. These fields are seldom more than an acre or two in extent, and a comparatively small quantity of water is needed to flood them. The sluice-way is usually about 1 foot or 18 inches square, and when the tide rises the gate is left open until the required amount of water has entered, when it is closed and remains so until more water is needed.

On an estate belonging to the Dominican Fathers between Calamba and Bruan, and on another owned by the Augustinian Fathers near San Francisco de Malabon, both situated on this island (Luzon), some irrigation is done during the dry season by turning aside the mountain streams on the zacate land, and near Carite, about 27 miles northwest of Manila, a small stream is conducted through an iron pipe for about one hundred yards for the purpose of irrigating the paddy and zacate fields when water is needed. As a rule, however, the only irrigation received by the rice fields is from the rain-fall. The rice is planted about the commencement of the rainy season and is harvested shortly after the opening of the dry season, which seldom continues more than three months. The atmosphere is always moist at night, and heavy dews keep the earth damp and prevent the vegetables from drying up.

There is no portion of the archipelago where irrigation is conducted on an extensive scale and no means are known here by which the total area can be ascertained. All the irrigation is done on small patches of land and at private expense.

There are no storage works nor any general system of water distribution for irrigation. The Spanish water laws are in force for the government of the water supply used for household and street-sprinkling purposes in Manila, but among the general laws there are none upon the subject of irrigation.

AUSTRALIA.

REPORT FROM G. W. GRIFFIN, U. S. CONSUL, SYDNEY, ON IRRIGATION AND WATER CONSERVATION IN NEW SOUTH WALES.

There is perhaps no question that has attracted so much general attention throughout New South Wales and the other Australian colonies as that of irrigation and the reclamation thereby of arid lands. Royal commissions have been appointed in the colonies for the purpose of conducting inquiries in regard to the best means for distribution and conservation of water. The peculiar physical formation of this great island continent, as shown in the absence of lofty snow-clad ranges of mountains and great rivers, had added an element of difficulty to the inquiries of the commissions.

In my report entitled "Irrigation," transmitted to the Department of State in 1887, I endeavored to summarize the results of the New South Wales water commission inquiry. My report was republished by the Government of this colony in book form, and a copy will be found along with the publications I send herewith under separate cover, a detailed list of which will be found at the end of this report. Since that date the commission has made a final report, and a copy of this is also forwarded in the same manner.

It will be seen from the final report that a considerable portion is taken up with a discussion of the various plans proposed for the utilization of the waters of the rivers Murray and Darling. The following are the conclusions at which the commission arrived as the result of their investigations:

(1) That on water conservation mainly depend the prosperity and the development of the whole extent of the central and western divisions of this colony, and that though less required in the eastern division, it will add in many places there also in an important degree to the productions, and therefore to the value of the land.

(2) That as the land-holders, as a general rule, are quite equal to the task of providing sufficient water for the stock which the land can carry under present conditions, Government works for supplying water to stock are required only on a limited scale, and generally only on traveling stock routes.

(3) That the great object of water conservation in this colony, and particularly in the country west of the dividing range, is irrigation.

(4) That the purposes for which irrigation is chiefly required are (*a*) to provide fodder and grain for horses, cattle, and stud sheep; (*b*) to afford supplies to be kept in reserve for saving stock of all kinds in bad seasons; (*c*) to produce fruit, vegetables, and miscellaneous crops, and (*d*) to increase generally the productive powers of the land.

(5) That any well-considered and properly executed project for irrigation in the country west of the dividing range would afford a good direct return on the capital invested, and would be a distinct benefit to the colony at large.

(6) That legislation on the subject of water rights is a matter of pressing necessity, both to protect the rights of the state and to foster and encourage local and private enterprise.

The severe droughts in Australia, recurring periodically, constitute the most serious difficulty against which the people have to contend.

AREAS OF LAND UNDER IRRIGATION.

Irrigation works in New South Wales have only been carried out on a very small scale by private enterprise by the squatter, a term applied to the occupiers of land in Australia, to provide fodder for working and stud stock, and by the culturist for orchards, vineries, and gardens. I am informed by Mr. A. Pepys Wood, civil engineer, that no attempt has been made to irrigate agricultural holdings as such. The efforts, however, that have been made, limited as is their scope, have been found valuable, not only to the parties directly concerned, but to the public, as showing the wonderful results to be obtained from the soil and climate of the western districts, especially when a certain supply of water is available for watering. When this supply has been constant the results are said to have amply repaid the owners and to prove the large profits to be derived from such works if carried out judiciously on a lawful scale.

The area of irrigated land in New South Wales is at present so small as to be scarcely worth taking into consideration. It is true enough that a few individuals have irrigated portions of their lands at their own expense, but the absence of any well-defined laws on riparian rights goes far to prevent the people from utilizing the surplus waters of the various rivers and creeks. The main dependence of the Australians, thus far, for their water supply has been on dams, tanks, and wells.

In the Lachlan district a number of farmers have practiced irrigation on a small scale. Mr. T. Towser erected a pump about a mile from Forbes where there is a bend in the Lachlan River. The plant cost about £600 ($2,920). The plant consists of a six horse-power engine, a five-inch centrifugal pump, and 75 feet of piping.

The pump lifts the water to a height of 38 feet and has power to bring up 2,500 gallons of water per hour. Mr. Towser, during the drought of 1888, irrigated 12 acres of vines and fruit trees. He flooded the land four times. To water half an acre of land necessitated the use of the pump nine hours and he estimated that the 12 acres absorbed 2,600,000 gallons of water. Mr. Towser, speaking of his experment, said:

> I could hardly get props enough to keep my trees from breaking down under the very heavy load of fruit, while other orchards not irrigated, in the district, yielded a very small quantity of fruit.

The Lachlan soil, with the help of irrigation, will grow the finest fruit in the southern hemisphere. The fruits produced are numerous and include many varieties of oranges, lemons, citrons, pears, peaches, apricots, nectarines, quinces, figs, loguats, grapes, and strawberries. The fruit, which had to be sent a long distance to market, is described as unsurpassed in quality and, notwithstanding the high cost of freight and poor facilities for handling it, realized a good profit. It is proposed to reduce the cost of irrigation on this property by using a 10-inch instead of a 7-inch pump. Irrigation is used in the same district by the Messrs. Eadles & Co., who have a 9-inch pump for irrigating about 800 acres of grass land suitable for high-class stock, also a 7-inch pump is used for a smaller tract. Both pieces of land have carried eight to ten heep to the acre, while other stock farms, not irrigated, were literally uined by the drought.

It may be well to mention that Forbes is a town on the river Lachan, 250 miles west of Sydney. It has a population of about 3,000 inhabitants and it is rapidly becoming a center for the trade of a large section of the country around. The town is supplied with water filtered from the Lachlan, laid on in pipes at a considerable cost. The district contains about 10,000 inhabitants and carries 1,000,000 sheep, 10,000 horses, 5,000 cattle, and 2,000 pigs. In one year 8,315 acres were planted in wheat and produced 100,519 bushels.

Mr. Gatenby, about 25 miles from Forbes, irrigated in 1888 90 acres of land, which was laid down under grass, lucern, maize, and orchard. He used a 6-inch pump and he estimates the cost of irrigation at £2 ($9.73) per acre.

Mr. Gatenby stated that with a larger pump he could reduce the cost to about 10 shillings ($2.43) per acre. He found that lucern only required half the quantity of water necessary for ordinary grass. His grass land, which was watered once a month, carried eight sheep to the acre, and his maize land produced 100 bushels to the acre.

I learn from the third and final report of the royal commission on the conservation of water in New South Wales that at Windbar 7 acres yielded 30 tons of lucern hay per annum, under irrigation, at a cost of £3 ($14.60) per ton, during a drought when chaff delivered cost £23 ($111:93) per ton. It was estimated that the experiment with irrigation on his property resulted in a saving of £1,000 ($4,866) in the year.

Again, it is stated that at Tapio 18 sheep to the acre were maintained in splendid condition on a patch of 22 acres of irrigated land, while on the surrounding country 13 acres barely sufficed to keep one sheep alive; and further, Mr. N. Sadlier, of Albemarle, stated that on an area of 3 miles square, irrigated by the flow of flood-waters over low-lying land, he kept 8,000 sheep in the middle of summer and had a good lambing, while the same land, when not irrigated, did not carry 1,200 sheep. The only difficulties which seemed to present themselves were in regard to maintaining a permanent supply in the river to make irrigation possible during the time most needed—a prolonged drought—and the want of practical knowledge to employ the methods of irrigation.

It will be well enough to mention here that the farmers who have tried irrigation are highly gratified with the results, and in most cases their profits have doubled and trebled more particularly where the irrigation was used in the natural grasses of the country and with lucern, maize, and sorghum.

I could give many instances where irrigation has been adopted with unvarying success, but the areas are mostly small, probably not exceeding a total of 50,000 acres. In the colony of Victoria, however, very large areas are being rapidly placed under irrigation.

SOURCES OF WATER SUPPLY.

The sources of supply of water for irrigation are from rivers, creeks, tanks, and wells. The shortage of water supply extends over such vast areas of country as to be a source of astonishment that no well-directed effort has been made to conserve at least a portion of the supply falling during the tropical rains, especially in the northern territory.

With reference to the works situated on the rivers, the requisite supply of water has been obtained by pumping. For this work the centrifugal pump is generally used, though in some cases, such as for orchard and garden irrigation, direct acting pumps or the "Blake" or "special" type are used. It is said that none of the western rivers, except the Murray, can be relied on for irrigating large areas, unless works be constructed to impound an artificial supply. Certainly with some rivers, such as the Namori the supply in long-continued dry seasons is even inadequate for the small areas being dealt with at the present time.

The discoveries of subterranean fresh water north of the Darling River and the immense supply being obtained from some of the artesian bores point to a near development of irrigation on a more or less extended basis in that region. In the country south of the Darling the water in nearly all the wells that have been sunk is said to be brackish, which, together with the mineral matter contained in it, is unsuitable for irrigation. Were this not the case the depth (averaging 100 feet) would preclude its use for this purpose except when drawn by windmills, as fuel for motive power in most places where these wells are is reported to be scarce and expensive. It remains to be proved by boring whether at a greater depth an artesian supply of fresh water can be obtained; but as the geological formation is entirely distinct from that north of the Darling, it is said to be very doubtful if the same results will follow deep boring.

I have visited a property on Oxly street, Queensland, where water strongly impregnated with salt was used for irrigating the soil for growing lucern. The owner of the land was gratified with the benefits of such irrigation, and he held the opinion that many of the salt lakes in Australia would not be looked upon as a misfortune in the future. It was, however, pointed out to him that a continuation of the use of saline water must sooner or later result in the destruction of his lucern crop.

The apparent benefit from the use of salt water was apparent from the reason that lucern to a very large degree neutralizes salt in the soil. This has often been remarked in the alfalfa (lucern) field of California, and farmers account for the fine crops of alfalfa in southern California to the alkaline soil there. It is possible that on the high dry banks of a river where the soil is deep and good and with abundant natural drainage, that saline water might be pumped on lucern fields for a number of seasons without materially injuring the soil. Of course natural conditions would have to be taken into consideration, as for instance, in the case of the land to which I have lately referred, where the subsoil is thoroughly washed over by the heavy tropical rains.

Mr. H. C. Russel, Government astronomer, who has, since his arrival in the colony in 1870, devoted great attention to water supply, is very decided in the opinion that there is an abundant supply of underground water in the western districts of New South Wales. Many theories are advanced as to its origin. Some attribute it to a flow of water from the lofty mountains of New Guinea. When Mr. Russell pointed out, about ten years ago, the remarkable relations existing between rain-fall and the rivers of the west, he was told that his statements could not be true. No rain that fell would wet the ground 18 inches deep, much less afford water for underground supplies. With equal confidence it was asserted that the water which did penetrate into the ground was all dried out of it by evaporation, and further that the greater part of the Darling River basin was so flat that the water would not flow, and the rain, therefore, did not and could not find its way into the river. Mr. Russsell determined to wait the results of several years of patient investigation before speaking again. With regard to the first objection he has affirmed that in heavy rains water reached the Darling from the flat countries.

Evidence as to this fact was found in the rain-storm during 1885. In regard to the water from the mountains of New Guinea he said that, even admitting the theory, the area was insufficient. He did not think the water which flows into the Darling passed into the ground, although it was in evidence before the royal commission that parts of the Darling River basin were exceeding porous and allowed the water to sink down freely.

It is the opinion that irrigation in most parts of this colony from tanks is practically impossible, as water conserved in excavated reservoirs would cost about 6 shillings ($1.46) per 1,000 gallons, a price practically prohibitive. The future of irrigation seems to be largely dependent on the storage of some portion of the flood-waters now running to waste, and this can not be effected by expensive works confining such storage waters to the river channels, which, under the most favorable conditions, would only provide for watering a narrow belt on either side of the river channels, but must be effected by diverting and storing the water in the basins or lakes that nature has formed and into artificial basins or reservoirs constructed, as in America and other countries, among the hills, from whence it could be distributed by gravitation.

CHARACTER OF WORKS USED.

As already stated, irrigation in New South Wales has hitherto been confined to lands bordering on or adjacent to one or other of the rivers, and no works have been undertaken to increase or regulate the supply. Where the country is suitable the distribution is effected by channels or ditches laid out so as to conform to the features of the ground, and of sizes proportionate to the duty they may be required to perform. Pumping water for irrigation effected by Tangee centrifugal pumps, sometimes by windmills. The water is pumped up into storage tanks of iron or brick and then run off by gravity on to the land to be irrigated in pipes.

This method is, I think, peculiar to Australia. I have never observed it in California, or indeed in any other part of the United States with which I am acquainted. In portions of the country where the rainfall is tropical, and the soil becomes so dry that every drop of water is precious, tanks and pumps appear to work well, as there is no waste from soakage, evaporation, or capillary attraction.

The expense attendant on the above method renders its adoption on a large scale too costly. Orchards and the paddocks around many homesteads are, however, irrigated in this manner.

On the Torrens River, in South Australia, one of the farmers uses a pump with a four horse-power engine and the water is pumped to a height of 35 feet into a square brick tank, 10 feet long, 5 feet wide, and 2½ feet deep. More than half the tank is below the surface of the ground. The water when needed is distributed through 2-inch pipes sunk under ground and laid in different directions. At intervals of from 40 to 50 feet, stand-pipes communicate with the surface, and, being furnished with stop-cocks, the water is turned on or off at pleasure. From the stand-pipes canvas hose can be adjusted and laid on to the particular spots where the water is required. To facilitate the operation shallow trenches are scooped out near the trees requiring to be watered, and the water is led from one depression to another when the lengths of hose are insufficient.

At Emu Plains an extensive orangery is supplied with water in a somewhat similar manner, but here the water is received out of a well about 30 feet deep. The Tangye pump is placed 20 feet above the water and forces it into a number of 400-gallon iron tanks arranged on trestlework; 1,000 gallons of water are drawn from this well per hour. On the

Nepean River a farmer has an irrigation plant which is worked by a six horse-power Tangye engine, and the lift of water is 23 feet; from thence it is forced a distance of 850 feet to the storage tanks. The cost of the engine was £110 ($535), and the piping £50 ($243). The water flows from the tanks by gravity; open furrows are used. In the Riverine district, about Deniliquin, 481 miles southwest of Sydney, where the summer winds are very hot, fruit trees are kept in full bearing by mulching, *i. e.*, spreading litter, whether leaves or other matter, around the butts of the trees. Trenches 4 or 5 inches deep are opened in the soil about 5 or 6 feet from the trees; water is let into the trenches when required. It is said to pay to adopt these means even when the water has to be carted a considerable distance. The average rain-fall in this district is only about 16 inches per annum, but nevertheless fruit is very profitably grown.

The success attending artesian well-boring in various parts of Australia led to an investigation of the subject by Mr. W. Anderson, geological surveyor, of New South Wales, and I learn from his report that the Lower Cretaceous formation in which artesian water is known to occur extends over a vast area in the eastern half of the Australian continent, occupying the greater part of the interior of Queensland, a large portion of central and south Australia, and the northwestern plains of New South Wales. The southern extension of the Cretacis-Tertiary formation occupies a considerable area to the north of the River Darling in the neighborhood of Bourke. Mr. Anderson says it is astonishing that while this formation has been known for many years, pastoralists on the northern plains did not until recently realize the fact that they have beneath them an invaluable supply of water. He does not recommend boring for water where Silurian slates occur, for the reason that all the Silurian rocks of the district have a general strike of E. 20° N., and stand nearly vertically, therefore they can not possibly hold water in any abundance, and where Silurian formations occur there is always a thinning of the Cretaceous beds.

The principles which govern the location of water in the deep-seated beds of the formation, such as the Cretaceous and its subsequent rising to the surface as artesian water when tapped, are gravitation and the fact that a confined and continuous flow of water must rise to the level of its hydraulic grade. Mr. Anderson directs attention to five positions in which water may be found in the flat western country:

(1) In the Cretaceous formation itself;

(2) Between the Cretaceous formation and the Silurian bed-rock on which it rests;

(3) In the silted up Pleistocene river channels;

(4) In the immediate neighborhood of the present water-courses; and

(5) In the superficial portions of granite, as at Byrock.

The water in most of the wells that have recently been sunk is in quantity sufficient to indicate a permanent flow.

Such water is used for irrigation by gravity at very little cost.

SYSTEM OF WATER DISTRIBUTION, WHETHER GOVERNED BY LAWS OR CUSTOMS.

All irrigation works in New South Wales have hitherto been carried out by private enterprise. Each owner appears to be a law unto himself, and so long as he does not interfere with his neighbors' water rights is subject to neither rules, regulations, nor customs. In Victoria there is an irrigation act, and the necessity for passing a similar act in this colony is urged very strongly by both press and people.

It would be very difficult to form anything like a just estimate of the quantity of water used per acre in New South Wales. The consumption of water on the River Murray, which is the boundary between the colonies of New South Wales and Victoria, for farms in Victorian territory, and which cover a larger area, is, however, very considerable.

The peculiar river system of Australia has been explained in my published Report on Irrigation, and I will not now refer to it further than to say that the Murray is the most important river in Australia, and together with its tributaries drains an area of 27,000 square miles.

The Murray is navigable for boats of light draught for a distance of 1,700 miles from its mouth. In making its way towards the ocean it passes through a considerable portion of the colonies of Victoria and South Australia. New South Wales, although by her constitution, received from Great Britain, entitled to the control of the river, has taken no effective steps to utilize its waters for the purposes of irrigation.

Both the other colonies have, practically, taken possession of the watercourse, and I learn from a report just submitted to the New South Wales parliament, by Mr. J. E. F. Coyle, civil engineer, who has investigated the condition of the Murray, its navigation and use of water for irrigation, that out of one hundred and forty-three steamers engaged in the river trade, sixty-seven are owned in Victoria, fifty-five in South Australia, and only twenty-one in New South Wales. Mr. Coyle states that the other two colonies have ignored New South Wales, not only in regard to the trade on the river, but as to the use of the water for various irrigation schemes.

A number of wharves have been erected on the Victorian side by the Government there, together with sheds, plants of machinery, and other works which Mr. Coyle considers inconsistent with the ownership of the Murray by the colony of New South Wales. Since 1886, when the Victorian act authorizing the construction of works on the Murray for irrigation was passed into law, as many as sixty-three different water interests have come into force for irrigation purposes, and the quantity of water being now drawn from the river is exciting alarm among the people of New South Wales. These Victorians consume in summer 102,000 gallons, and in winter 61,800 gallons per twenty-four hours; also 46,579 cubic feet in summer and 161,618 cubic feet per minute in winter.

The Victorian Government has employed steamers in clearing the river from snags and other impediments.

The Government of New South Wales, of course, does not object to that, and it is scarcely probable that she would claim, in spite of her constitutional rights, a supreme control over all the advantages to be derived from the river, but she will undoubtedly object very seriously to any other colony doing so. The Victorians, however, contend that they are simply using the water that otherwise would be wasted, and besides that they have never been granted the right to use it for an indefinite period, for their Government in licensing irrigation works have expressly provided that water can be taken from the Murray only so far as it is in the power of the Government to permit.

Sir Henry Parkes, premier of New South Wales, in a powerful speech delivered in Parliament lately, pointed out what he deemed an aggression on the part of the Victorian Government upon the constitutional rights of New South Wales and very earnestly urged further legislation upon the subject.

The trouble is the question of right to control the waters of the Murray can not be settled by one colony alone, and will probably have to be dealt with at an intercolonial conference at which each of the colonies interested can take part, and an agreement reached by which the benefits of their principal water-way tribute may be shared alike.

CHARACTER OF CLIMATE, RAIN-FALL, ETC.

The colony of New South Wales extends through eleven degrees of latitude, it being entered on the parallels 28° 10′ and 37° 38′ south latitude, and between the meridians 141° and 153° 38′ east longitude. The area embraced within these limits contains 310,938 square miles, or 199,000,000 acres.

The climate extending through so many degrees of latitute, very naturally permits almost any variety, from hot to cold.

The northern part of the colony resembles that of the south of Italy, Spain, and Greece, while the southern portion is not wholly unlike that of northern California.

At Kiandra frost and snow prevail for a considerable part of the year; but on the plains of the interior the thermometer rises to 130° above zero, and sometimes there is no rain for eight months in the year.

The average annual rain-fall, according to a recent return supplied by the Government astronomer, Mr. H. C. Russell, was 23.68 inches for a period of fifteen years, from 1874 to 1888, the lowest average being for 1888, when it was 13.40 inches, and the highest in 1887, when it reached 34.39 inches. Mr. Russell has prepared the following table to show the average rain-fall in New South Wales for each year from 1874 to 1888:

Year.	Inches.	Year.	Inches.
1874	33.46	1883	17.96
1875	29.38	1884	15.86
1876	27.66	1885	19.48
1877	20.48	1886	26.04
1878	25.05	1887	34.99
1879	30.75	1888	13.40
1880	19.93		
1881	20.73	Mean, fifteen years	23.68
1882	20.11		

Mr. Russell states that the drought in 1888 was the most severe ever experienced, but during November and December rain fell and broke up the terribly dry weather.

During December, 3 inches of rain fell at upwards of two hundred recording stations, chiefly along the coast line, while the great western plains, which needed the rain most, remained to the end of the year in a state of drought. Not once during the year did rain enough fall on these plains to make water run on the surface of the ground.

On the Marano River the four months of winter passed with only .03 inch of rain. Even the native trees died for want of water in some places. In Sydney the average rain-fall for a month is about 4 inches; but over large areas in the west the rain-fall for the whole of 1888 was under that amount.

At South, on the Darling, it was 2.47 inches; at Menindie 2.82 inches. Mr. Russell remarks, that living in a moist climate near the sea, it is difficult to realize what such a record means in a dry, windy, hot place. The wonder is that plant or animal can live through it. Then, taking the mean of fifty places, the rain-fall for the whole colony was 43 per cent. below the average, and it is noteworthy that the rain-fall of 1887 exceeded the average by 42.7 per cent.; so the wettest and driest years on record are side by side showing a difference in rain-fall amounting to 85.7 per cent of the average.

When forwarding some valuable publications, Mr. Russell remarks in his letter to me of 28th September that, knowing what important questions could only be answered by statistics about rain, rivers, and evaporation, he began to collect them and to educate the people to keep rain records. In 1870 he found five meteorological stations at work. Now they number nearly one thousand. Records of the heights of the western rivers were begun in 1862 by Government officers, but they were not kept up In the annual rain reports are to be found every known rain-fall record for this colony. Mr. Russell has the control of the rain-fall records, and he states they are fairly complete for a young country, but the work of carefully gauging the output of the rivers has not yet been commenced by the Government. The records which he gives of the water at each place, the water velocities, are not measured, because competent officers for that work have not yet been stationed on the rivers. The velocities he has used were determined years since, and are assumed to hold good for the same height of flood for each year.

Since 1887, however, officers from Victoria have been systematically measuring the discharge of the river Murray, and have so far confirmed the results which Mr. Russell had obtained in the way indicated.

ANTIQUITY OF IRRIGATION SYSTEMS.

The remarks I have made in this report show that the various modes of irrigation practiced in New South Wales are wholly of recent date. The maps and publications which the Department of State direct me to obtain for the select committee of the Senate on the subject of irrigation are enumerated in the following list:

List of printed documents and maps relating to irrigation and reclamation of arid lands; sources of water supply; systems of water distribution; character of climate, and so far as relate to the colony of New South Wales.

1. Royal commission. Conservancy of water. First report of the commissioners. 1885.
2. Maps, diagrams, and plans referred to in the above report. 1855.
3. Royal commission. Conservation of water. Second report of the commissioners. 1885-'86. (Maps and plans are attached.)
4. Royal commission. Conservation of water. Third and final report of the commissioners. 1887.
5. Maps, plans, and diagrams to accompany the above report. 1887.
6. Royal commission. Conservation of water. First report of the commissioners. Abridged edition. 1886.
7. Royal commission. Conservation of water. Third and final report of the commissioners. Abridged edition. 1887.
8. New South Wales, her commerce and resources. By Consul Griffin. Report on irrigation. Pages 13 to 21. 1888.
9. Climate of New South Wales, descriptive, historical, and tabular. By H. C. Russell, B. A., F. R., A. S. 1887.
10. New South Wales. Physical geography and climate. By H. C. Russell. 1884.
11. The river Darling. The water which should pass through it. By H. C. Russell. 1879.
12. Some facts bearing upon irrigation. By H. C. Russell. 1883.
13. Notes upon the history of floods in the river Darling. By H. C. Russell. 1886.
14. Notes upon floods in Lake George. By H. C. Russell. 1886.
15. The source of the underground water in the western districts. By H. C. Russell. 1889.
16. Notes on the experience of other countries in the administration of their water supply. By H. G. McKinney, C. E. 1887.
17. Rivers of New South Wales. By H. G. McKinney, C. E. 1888.

18. Water supply in the interior of New South Wales. By W. E. Abbott. 1884.
19. Forest destruction in New South Wales and its effects on the flow water in watercourses and on the rain-fall. By W. E. Abbott. 1888.
20. On wells in Liverpool plains. By T. K. Abbott, P. M. 1880.
21. Metropolitan water supply. By Mr. James Manning. 1875.
22. Comparison between the Prospect and Kruny Hill schemes, proposing a high-pressure water supply for Sydney. By F. B. Gibbs, C. E. 1880.
23. Importance of a comprehensive scheme of water storage and canalyzation for the future welfare of New South Wales. 1881.
24. Tanks and wells of New South Wales. Water supply and irrigation. By A. P. Wood. 1883.
25. Results of rain, river, and evaporation observations made in New South Wales, 1879 to 1888. By H. C. Russel, F. R. S., Government astronomer of New South Wales. 1879 to 1888. (Ten parts).

The documents above enumerated are forwarded to the Department of State in separate cover.

Additional information, publications, maps, and plans have been promised me in time for transmission by next mail. I have reason to believe that the whole will form the most complete collection of literature on irrigation and water conservancy ever brought together relating to New South Wales.

LETTER FROM MR. JAMES WILSON TO CONSUL GRIFFIN ON IRRIGATION IN NEW SOUTH WALES.

Commercial, Pastoral, and Agricultural
Association of New South Wales,
40 *Hunter Street, Sydney, August* 28, 1889.

Sir: I have received from you questions on the subject of irrigation and the reclamation thereby of arid lands, with information that a special committee has been created by the Senate of the United States to investigate the questions involved.

The collation and systematic organization of reports on this subject from all parts of the world which your consular system affords can not fail to be of the greatest public utility, not only to the United States but to every arid corner of the universe, and it is to be hoped the committee will produce a report on a comprehensive scale which, when published, will prove of immense benefit to generations yet unborn.

For some time the Commercial, Pastoral and Agricultural Association of New South Wales has been engaged in noting the steps taken in this colony to deal with the arid lands in her vast interior and in collecting documents showing the great aid afforded by the Royal Society of New South Wales and kindred scientific associations for dealing with the local question, and in contrast with other countries, from more or less unofficial sources. I shall have much pleasure in placing these records at your disposal.

To my mind the question to Australia of water conservation, distribution, the development of underground reservoirs proved to exist, the economical adaptation of such, and rain fall observations as will minimise waste from the effects of periods of drought, by regulating supply, is as necessary as a mainspring to a watch. Upon the satisfactory solution of water difficulties depends the future development of this vast island continent, whose very existence a century ago was comparatively unknown. Of this continent New South Wales embraces a territory of 195,882,012 acres, and her present record of population is only a little over one million. To the United States our population and occupancy of territory when compared must form an insoluble problem; but the key is to be found in the pastoral stage of development in civilization during the nineteenth century, as practiced in Australia, and when we compare the numbers of the population actually outside our towns and cities the position will appear more explicable why we can not in the present stage point to existing irrigation and water conservation works and irrigable and non-irrigable areas and their results. The works in existence at present are only the outcome of private individual enterprise within freehold limits and bear no proportion whatever to the exigencies or necessities of the country at large, its rain-fall or river systems.

The mode of land tenure, the centralizing departmental form of government, and political inability to deal with so extensive a public estate upon a broad and national basis, are the true causes of neglect of and inertia towards our progress in this direction. It is from no want of consideration or inability on the part of our best men to grasp the importance of the situation, but from the general *laissez-faire* of our political economy which provides that all public works in the colony are conducted and controlled by government departments centered in the city of Sydney, not in touch with what might be termed local or district wants, and resenting interference with their prerogative unless under political pressure—a system which ascribes drought and disaster to Providence and fails to use means nature has provided for amelioration.

A more valuable compendium of information from many sources on irrigation in New South Wales than that presented in your consular report to the Department of State, Washington, republished by the New South Wales Government in 1888, does not exist, nor one more truthfully and fully describing this country; and I would respectfully suggest that that report be laid before the committee of the Senate. You have fairly pointed out the difficulty of riparian rights as they exist at present and the incidence of common law as prohibitive to deal with water conservation on a comprehensive scale, and you have cited the opinions of the water conservancy commission, appointed in 1884; it only now remains to supplement this by reference to their report in 1887, since published.

There have been no water-trusts created and no law changing riparian rights in this colony. The first bill in New South Wales to provide a water-trust, a municipality bill for the irrigation of a town common at Wentworth of 21,000 acres, on the New South Wales side of the river Murray, is now before parliament. Successive governments have for years past promised a scheme of local or district government which will embrace powers for dealing with water and irrigation by local trusts. Hitherto in this colony the public works for water conservation have been confined to constructing watering stations on the traveling stock routes in arid districts, wells, tanks, and dams. The government first recognized the necessity for such in 1869, and in 1888 it would appear from a statement relating to watering places, one hundred and forty-four in number, that an expenditure of over £270,000 ($1,313,955) had been made in construction and appliances, their maintenance costing over £25,000 ($121,663) per annum. These works have no doubt exercised a large and beneficial influence upon our pastoral progress.

I would suggest that you obtain from the government printer, Sydney, such official documents bearing on the subject as have been printed from time to time.

It only now remains to state that the government has conducted preliminary steps to carry out a scheme of irrigation and water-supply by canals, submitted to the water commission by H. G. McKinney, civil engineer; surveys are completed and the engineers are now taking levels for canals near Albury, on the Murray River. The main Albury canal will be 176 miles in length Jerilderie branch canal 33 miles, and the Tuppel branch 31 miles, a total of 240 miles. The estimated cost of this undertaking is £1,500,000 ($7,299,750), and the area to be irrigated 570,000 acres.

To water conservation and irrigation as presented in other countries, and especially in India, all our New South Wales and Victorian schemes must appear insignificant; but we are only a young country and a small community anxious to profit by the experience of others, and will gladly benefit by the results of the inquiry being made by the special committee of the United States Senate, embracing as it will consular reports from all countries.

I shall have pleasure in forwarding your inquiries in any way in my power.

I remain, with much personal esteem, yours faithfully,

JAMES WILSON.

G. W. GRIFFIN,
U. S. Consul, Sydney.

SOUTH AFRICA.

REPORT OF GEORGE F. HOLLIS, U. S. CONSUL, CAPETOWN, ON IRRIGATION IN SOUTH AFRICA.

South Africa has been described by some one as a country in which the rivers have no water. This is only too true during a portion of the year, while during the rainy season the rivers have a torrential character and the traveler must perforce halt at the river banks and wait for the rain to run by.

Until recently irrigation has been a matter of private enterprise and the works have been of the simplest and cheapest character. Wherever springs have been found it has been the custom to strengthen them by the building of a primitive dam above the spring's source, and the water so consumed is then conducted by a system of furrows over the area to be benefited. Where the water of rivers could be utilized the same system of furrows is followed and narrow strips of land on either bank of the stream are thus brought under a higher system of cultivation and large crops are the result of such a system.

Irrigation in this primitive way may be said to be the rule in the South African Republic, the Orange Free State, and in a large portion of the Cape Colony. In 1877 the Government passed an act for the promotion of irrigation, the principal provisions of which are as follows: Any three or more owners of land within any area in which it is deemed expedient to store water by artificial means for the purpose of irrigation may petition the government to proclaim such area an irrigation district, provided such petitioners shall be the owners of not less than one-tenth of the land in such district to be proclaimed. The governor may then dispatch an engineer or other competent person to the locality, where a public meeting of land owners is called, after due notice, and a report is sent to the governor as to the propriety of constituting such irrigation district. Should such report be favorable and receive the assent of two-thirds of the owners of land situated within its area, the governor may proclaim such district an irrigation district. The performance of all acts, etc., relating to irrigation and the storage of water in such proclaimed district shall be vested in a board having corporate powers, to be chosen from the land owners of such district. Every owner of land is entitled to vote at an election for members of uch board, and shall have one vote for each $500 valuation of land.

The charge and conservation of every natural river, stream, creek, nd water-course, and of every dam, pond, and embankment within the imits of an irrigation district which is by its nature common to two or nore of the owners of land within such district, and the absolute con- rol and regulation so far as the same can be effected by artificial means f the supply of water throughout the course of any such river, stream, tc., within such limits, shall be vested in the irrigation board of such istrict. Such board shall have power to cleanse, repair, and maintain n a due state of efficiency any stream, river, etc., as above; to deepen r otherwise improve such water-course, and to erect dams, reservoirs, tc.; in fact, to maintain, improve, and construct any works that shall e necessary for the proper storage and conservation of water for irri- ation purposes.

Provision is made for full compensation for any injury sustained by ny person by reason of the exercise of the powers of the board. The oard may also enter and take possession of any land, covered or un- overed by water, as may be necessary to carry out the purposes of is act. The board may levy rates at so much per acre in all land ithin the area which is irrigated or capable of being irrigated, provided at no land shall be taxed that is otherwise irrigated or improved by eans contemplated by the act.

Power is given the board to borrow money either by public tender or om funds provided by Parliament, in which latter case the governor ay loan to the extent of one-half of the value of the lands; such loan be a first charge on the same, and he may appoint officers to inspect ch lands and works.

IRRIGATION BY PRIVATE OWNERS.

Any owner of land, not within the limits of any irrigation district, oposing to improve the same by the storage or conservation of water l desiring a loan from the Government for such purpose, may make application for such purpose, giving bonds for the payment of the cost of investigation, and the governor may then cause lands, plans, estimates, and specifications of proposed works to be inspected and reported on. Provision is made for the loaning of money by the Government under due restrictions, which becomes a first and preferment charge upon the land at the rate of 8 per cent. for the term of twenty-four years.

Any mortgagee having claim on land must join with the holder of the title thereof in an instrument to be filed with the registrar of deeds. Provision is made for arbitration, the making of by-laws and regulations and penalities for the fraudulent taking or polluting of the water, or for obstructing or impeding the flow of water within the area proclaimed.

Two years later an act was passed by which provision was made for the loan of money by the colonial government to municipalities desirous of such assistance in carrying out works of irrigation, the terms of which are similar to the act of 1877, and provide that the interest in such loan shall be provided from the rates levied by the towns availing themselves of the provision of the act. The act of 1877 was amended in 1880, providing for the advance by the Government of the loan made by advances of one-fifth of the amount, and making provisions for repayment of the loan according to the following schedule:

Schedule A.

If the owner shall desire to repay the sum advanced in one year, the rent charge for one year shall be per centum, £106; if he shall desire to repay it in two years the annual rent charge shall be, per centum, £54 11*s.*; if in three years, £37 8*s.* 6*d.*; if in four years, £28 17*s.* 6*d.*; if in five years, £23 15*s.*; if in six years, £20 7*s.*; if in seven years, £17 19*s.*; if in eight years, £16 2*s.*, 6*d.*; if in nine years, £14 14*s.*, 6*d.*; if in ten years, £13 12*s.*; if in eleven years, £12 14*s.*; if in twelve years, £11 19*s.*; if in thirteen years, £11 6*s.*; if in fourteen years, £10 15*s.* 6*d.*; if in fifteen years, £10 6*s.*; if in sixteen years, £9 18*s.*; if in seventeen years, £9 11*s.*; if in eighteen years, £9 5*s.*; if in nineteen years, £8 19*s.* 6*d.*; if in twenty years, £8 14*s.* 6*d.*; if in twenty-one years, £8 10*s.* 6*d.*; if in twenty-two years, £8 6*s.* 6*d.*; if in twenty-three years, £8 3*s.*

Schedule B.

The present value of every £1 per annum rent charge shall be:

For one year, £0 18*s.* 11*d.*; for two years, £1 16*s.* 9*d.*; for three years, £2 13*s.* 6*d.*; for four years, £3 9*s.* 4*d.*; for five years, £4 4*s.* 3*d.*; for six years, £4 18*s.* 4*d.*; for seven years, £5 11*s.* 8*d.*; for eight years, £6 4*s.* 3*d.*; for nine years, £6 16*s.* 1*d.*; for ten years, £7 7*s.* 3*d.*; for eleven years, £7 17*s.* 9*d.*; for twelve years, £8 7*s.* 9*d.*; for thirteen years, £8 17*s.* 1*d.*; for fourteen years, £9 5*s.* 11*d.*; for fifteen years, £9 14*s.* 3*d.*; for sixteen years, £10 2*s.* 2*d.*; for seventeen years, £10 9*s.* 7*d.*; for eighteen years, £10 16*s.* 7*d.*; for nineteen years, £11 3*s.* 2*d.*; for twenty years, £11 9*s.* 5*d.*; for twenty-one years, £11 15*s.* 4*d.*; for twenty-two years, £12 0*s.* 10*d.*; for twenty-three years, £12 6*s.* 1*d.*

As early as December, 1881, no less than sixty applications had been made by the districts desiring to avail themselves of the terms offered by the Government. Owing to the peculiar character of the topographical features of the country and the fact that most of the rivers of South Africa are dry in the summer and flooded during the rainy season, a vast deal of scientific labor must be expended in order to determine the sites most advantageously situated for the construction of storage basins and other irrigation works. Topographical and geological surveys are being made under the direction of the Government.

It will probably be found necessary to make the formation of water boards compulsory, so that those land-owners situated above areas already proclaimed will be amenable to Government supervision in the conservation of their water courses. Wherever irrigation has been properly tried in the colony it has met with unqualified success, assuring large crops to husbandman and guarantying the stock-raiser against loss by drought.

From the lamentable reports now coming in from the up-country of the great loss of sheep by reason of the almost total lack of rain-fall this winter, I should judge a great impetus will be given to this question. Many farmers have reported a loss of from 10 to 50 per cent. of their stock, which would not have occurred had the districts been secured against drought by storage basins. Some idea of the enhanced value of irrigated land may be seen in the report made by one owner, who stated that his increased rentals would repay the loan for four years.

The most complete storage work completed in this colony, and the most important, is that of Van Wycks Valley, full reports of which with accompanying maps, Nos. 1, 2, 3, and 4, I send by book-post in to-day's mail. The rain-fall in this section is very irregular, the average for eleven years having been 10 inches, and in some years falling to 3 and 4 inches. The reservoir has depended on the catchment area of, say 240 square miles. This has been found to be insufficient for a full supply, and a furrow is now nearly completed through which the water of a neighboring river will be brought in, by which it is estimated that the water-covered area will be increased to 19 square miles with a depth of 27 feet.

The land under irrigation is held by the Government and is leased at a minimum price of 10 shillings per acre. The bailiff in charge has the sole control of the flow of water and uses his discretion in its supply, some land within the area requiring more water than other portions. Owing to many causes, the chief of which was ignorance of the character of the land—fostered by the report of interested persons who declared that the water would prove to be too salt for agricultural purposes, and who desired the work should fail and be abandoned, giving them a chance to acquire it—the poorest tenants, mostly assisted by the Government supplying seeds, were alone secured. Their success has, however, been so marvelous that the lands will soon be eagerly sought after. It is estimated that last year 1,300 acres were irrigated at an expenditure of an inch of water per month from the surface. The rain-fall over the whole colony is so irregular that I have taken the subdivisions of the colony for the purpose of comparison and have summarized the reports from an average of six stations in each district. The rain-fall for these districts for the year 1888 was as follows, in inches:

	Inches.
No. 1. Cape Peninsula	
No. 2. Southwest	53.84
No. 3. West coast	32.95
No. 4. South coast	15.18
No. 5. Southern Karroo	33.60
No. 6. West Central Karroo	17.59
No. 7. East Central Karroo	14.12
No. 8. Northern Karroo	16.15
No. 9. Northern border	11.43
No. 10. Southeast	8.84
No. 11. Northeast	28.17
No. 12. Tianskei	20.39
	25.00

The topographical features of South Africa are so peculiar that the system answering for one district is not applicable to others, while the rain-fall varies greatly as one leaves the coast and ascends to the various table-lands. In general, it may be said that, the land being almost entirely denuded of trees and bush, the rain is not drank up by the soil but runs rapidly over the surface, seeking its natural outlet to the sea, while the evaporation is very great, estimated at 6 feet at Van Wycks Valley, necessitating deep storage basins.

Streams which are alive the whole year are very few.

Boring for water has not been attempted on a large scale, but the experiments made in certain sections have given very encouraging results.

SOUTH ATLANTIC ISLANDS.

REPORT FROM THOMAS C. JONES, UNITED STATES CONSUL, FUNCHAL, ON IRRIGATION IN MADEIRA.

In answer to your circular and inquiries in regard to the system of irrigation now in practice on this island, I beg to submit the following report:

I can not answer your questions in as full a manner as I should like owing to the meagerness of statistics.

The public works here are of the most primitive kind. The same implements that tilled the soil and constructed the water-ways three hundred years ago till the soil and construct the water-ways of to-day. Stone is plentiful and labor is cheap; the island is furrowed with water-ways, but the new is no improvement on the old.

(1.) The area of Madeira is about 240 square miles. About one-half of the island is in cultivation. The whole of the sea-board is more or less cultivated by irrigation.

Where water is plentiful such crops as sweet potatoes, beans, cabbages, etc., are grown as high as 3,000 feet elevation above the sea; but maize is seldom grown above 800 or 1,000 feet, owing to the short summer season on the hills.

The area which is under cultivation by irrigation with sugar-cane, potatoes, onions, maize, etc., and almost at all seasons, and where, therefore, the population is concentrated, varies between 500 and 1,500 feet above sea-level, and may be estimated at a little more than one-third of the whole area of the island.

It is difficult to estimate the quantity of the crops grown, as the exports are pretty well limited to sugar, wine, onions, potatoes, and bananas. Sweet potatoes, which is probably the largest crop grown, beans, cabbages, are consumed in the home.

Almost all the cereals and food plants are grown in Madeira.

The wheat is of the bearded kind, with a hard, semi-transparent grain, and commands a better price than the imported. A large part of the vegetable subsistence is derived from the pumpkin tribe.

The banana is one of the best paying crops. It is confined below the 500-feet line. Oranges grow at an elevation of 1,500 feet.

(2) The water supply is derived from perennial springs and from the many gorges which carry off the water from the hills to the sea during the rainy season. After May these gorge streams are quite dry long before they reach the sea, their water having been drawn by the different levadas.

The north side of the island, being more precipitous and well-wooded, supplies its different levadas as well as several of those on the south side.

There are no reservoirs or catchment basins. They would be expensive to make owing to the precipitous nature of the hills, and it is doubtful whether the broken and rocky hillsides would hold the water unless the whole bottom were concreted.

(3) The character of the works used for distribution of irrigation water is levadas or open culverts. These are constructed of masonry or cut in solid rock at high levels. They pass through tunnels, over bridges, and along the sides of precipitous mountains, carrying the water to the cultivated lands below.

Some of these levadas are a few miles in length while others are 60 and 70 miles long.

(4) The system of water distribution is governed by custom and the flow is rated by the hour.

Some levadas deliver their whole contents during an hour or more as the proprietors of the water may be entitled to it. Others deliver say one-quarter of their contents at a time. The irrigator only requires the quantity of water at a time which will run along a furrow without washing the soil away.

The Sta. Lugia levada, for instance, contains 4,245 horns of water, to which there are proprietary rights acquired by purchase from the original makers or by inheritance. It now takes fifty days for each proprietor, of one hour to have his turn again; but he receives it instead by the quarter, every twelve and one-half days.

Besides the proprietary right there is in all levadas a right of water which belongs to the levada, and the committee of management for the year sells this water in January for the benefit of the levada, for repairs, etc., the water being plentiful at that season.

During the recent sugar-cane disease the price of an hour of water fell 50 per cent. in the Sta. Lugia Parish, viz, from $6 to $3.

Each piece of ground within the district of a given levad is entitled to its hours of use of the stream. For eight or nine months of the year the water is turned on to the proprietors as they may desire, but when the dry season sets in the committee puts it a "giro" or space of time occupied in making the tour of the whole district, which giro varies from 15 to 60 days, according to the extent of the district.

The "Levadeiro" or distributor of water is a salaried official, paid by the committee. He also collects a small fee of about 3 cents per hour per annum of the proprietary rights, and a higher fee on rented water. These fees are fixed annually by the committee.

When extensions or repairs of any magnitude are undertaken the money is borrowed, usually from the proprietors, and paid back in water or by rates levied over preceding years.

The foregoing applies to the old levadas, which were constructed by the proprietors.

No two levadas are alike in their volumes of water, in their velocity, or in their rates. In the neighborhood of Funchal the price of an hours rain in the season is from $5 to $8, while on the north side of the island it will never exceed $1 per hour.

The Government has, during the last fifty years, constructed levadas, which collected the waters in almost inaccessible gorges on the north side of the island, and conduct it to the warm south side. These waters are distributed to the cultivators of the soil at a nominal cost.

But when the Government levada is completed, and leaves the hands of the department of public works for those of the local, it gradually falls into ruin for want of attention.

No repairs can be made without estimates, and these have to be submitted to Lisbon for approval, and when approved, the time is generally so long that the original estimates are insufficient.

As water is the most valuable property in Madeira there is more quarreling about it than about anything else in the island. It is a fruitful source between the well-to-do and the poorer class. More people go to prison for stealing and tampering with water than for anything else.

One of the principal difficulties attending the management of the levadas was the want of a legal standing as corporate bodies of their committees. A quarrel between two levadas, draining their supply from the same valley, occasioned a lawsuit which has lasted now more than forty years. Within the last few years a law has been passed enabling the committees to incorporate themselves, with power to acquire property, and otherwise protect and improve their levadas.

They can purchase the land containing their springs, protect the forest and the trees along their lines. Every farmer of thrift has on his land tanks to store his water, and from these tanks little levadas distribute it when and wherever he wants it.

Water rights are held under title deeds, which specify the intervals at which the supply shall be given and the length of time it shall continue. Water is always of ready sale. If a crop fails from any cause the water for that land is sold to a more fortunate neighbor; though sometimes at a very reduced rate, as was the case in the time of the sugar-cane disease.

Under any system, it is hard for the poor. Their supply is scant, and they must receive it when their time comes, seasonable or unseasonable, day or night, and without tanks they can not care for or properly distribute it.

(5) The irrigated region is the coast belt, which during the summer season will produce crops that will ripen before the early autumn sets in. The nearer the seashore, with its consequent semi-tropical heat, the more valuable becomes irrigation.

The annual rain-fall in Funchal is about 28 inches; but the hills which supply the springs are almost always covered with clouds and wet mist, the water contents of which can not be estimated.

The soil varies in quality. That of the coast belt is calcareous tufa, with an admixture of vegetable matter, and is very rich. Wheat and barley are grown on the same land from generation to generation with hardly any application of manure.

The soil best adopted to the vine is a decomposed red tufa, especially where there is an admixture of stone with it. The hill regions have a stiff, clayey soil.

(6) There are levadas here probably 300 years old, but several of these have had their courses changed during political troubles and from other causes.

The levada, for instance, which now irrigates St. Vincente on the north side of the island, was constructed by the inhabitants of the Brava Valley on the south side, and was lost to them during the interegnum between the Spanish and Portuguese occupation. The Government is now constructing a levada, which will collect its waters in the hitherto quite inaccessible Inferno Gorge for irrigating the St. Vincente Valley, when it will restore to the Brava Valley the levada which originally belonged to it.

The source of this new levada is at the height of 4,700 feet above the sea, and after entering the valley it is intended to throw the water down a series of cascades with a fall of more than 300 feet.

A constant flow of a pint of water is sufficient to irrigate 5 acres of ground; that is, the water must flow into a reservoir and be used from that as required.

I have had translated the "Regulation for the Government of the Government Levadas of the Island" and have had it attached to this report. There are no maps or drawings of these works obtainable.

The engineers, contractors, and others who build our Government levadas come from Lisbon, and the plans, estimates, etc., are kept there in the office of public works. There are no publications that I can find.

Mr. John B. Blandy, of this city, is the largest land and water proprietor on the island. He has had more to do with the construction and working of these water ways, and is probably more of an expert than any person on the island. I am indebted to him for this report. He will take pleasure in giving the Senate Committee any facts that are in his possession.

PROVISIONAL REGULATION FOR THE GOVERNMENT IN THE DISTRICT OF FUNCHAL, THEIR ADMINISTRATION AND THEIR RESPECTIVE REVENUES.

FIRST PART—THE LEVADAS.

ART. 1. The regulation of the government levadas in the district of Funchal and the superintendence of the revenues of same are under surveillance of the treasurer of the same district, according to the decree published on the 10th of November, 1849, and the regulations for the administration of the public revenue, published on the 28th of January, 1850; also a Government grant, published on the 14th of September, 1860.

ART. 2. The levadas that belong to the government in the said district are the following:

Rabacal, in the parish of Calhéta, Fajaã dos Vinhaticos, in the parish of Santa Anna, Iuncal, and Furado, that irrigate Santa Cruz and Machico.

ART. 3. The Levada Rabacal will continue to be divided into two branches, one that irrigates Calhéta and Estreito, the other that waters Prazeres and Fajaã da Ovelha.

ART. 4. The Levada Fajaã dos Vinhaticos will continue to be divided into two parts, each containing an equal quantity of water.

ART. 5. Levada Iuncal and Furado are also divided into two branches, one that irrigates the parish of Santa Cruz, the other, Porto da Cruz.

ART. 6. To superintend the said levadas there will be appointed a staff of men, to be paid by the treasury of the home government.

ART. 7. The number of men, their rank, and respective salaries for each levada will be as follows:

Levada do Rabacal.

One director, with a salary of 17 per cent. on the revenues of the levada, calculated to be	$156.67
Two levadeiros (or water men), at $24 each	48.00
Two caretakers at 24 cents daily, each	175.20
Total	379.89

Levada Fajaã dos Vinhaticos.

One director, with a salary of 8 per cent. on the revenue of the levada	$43.00
Two levadeiros, at $16 each	32.00
One caretaker, at 12 cents per day	43.80
Total	118.80

Levada Iuncal and Furado.

One director, with a salary of 8 per cent. on the revenue of levada	$44.16
Two levadeiros, at $16 each	32.00
One caretaker, at 12 cents per day	43.80
Total	119.96

ART. 8. Besides the above items, which are for salaries, there will be another item of $180 yearly to compensate any deficiency in the salaries.

ART. 9. For directors of the levadas are appointed by government under the proposal of the treasurer, and keep the appointment as long as they are worthy of it.

ART. 10. The levadeiros are appointed yearly by the delegate of the treasurer under the proposal of their respective directors.

ART. 11. The caretakers are appointed by the delegate of the treasurer under the proposal of their respective directors.

ART. 12. The duties of the director of the levada are permanent and are as follows:

I. In the proper season for irrigation he is bound to see that the waters are fairly distributed.

II. To make as far as it lays in his power all the waters enter into the levada, so that the lessee of the water may have his share or more when his turn comes to irrigate his ground.

III. To have repaired any small damage made to the levada when necessary, having it in his power to call for help should he be unable to attend immediately to the said repairs.

IV. To avoid the loss of water should he know it, and give notice, etc., of same to the administrator of any damage done to the levada. If there are damages he may appeal to the department of government works.

V. To watch that the duties of the levadeiro and caretaker are properly carried out.

The director of the levada is answerable for its good keeping and also of the small canals that bring the water from the springs.

ART. 13. The duties of the levadeiro last during the irrigation season only. They are bound to deliver to each lessee the quantity of water that he rents to irrigate his ground according to a list given him by the clerk (or tax collector).

ART. 14. The duties of the caretakers are permanent and are as follows:

I. To live close to the levada.

II. To watch in summer and winter the levadas, that they are kept in proper repair, and that the springs are drained so as to enter the levadas.

III. To keep all the traps of the levadas open when it rains.

IV. To clear all obstacles that are carried by the water that may cause overflow.

V. To see that the levada is in proper repair, and to have repaired any wall that may have fallen over the levada, and to have removed any earth that may obstruct its course.

VI. To walk the course of the levada continually, or the part that he takes care of, to complain to his director of any theft of water, or if any damage that he can not repair.

VII. To watch the good keeping of the trees close to the levada.

VIII. To fulfill all the orders given him by the director as regards the levada.

ART. 15. The caretakers of the levadas are considered as forest-keepers, and are bound to watch the forest and bushes of his district complaining to the administrator of the locality should there be any damage to the forest.

ART. 16. The director of Levada Rabacal is bound to live close to the same levada, in one of the buildings, at a place called Rosadas, and to keep the houses clean when visitors stay there on their way to see the levada, and he is also answerable for the good keeping of the furniture, of which he has an inventory given him by the administrator, which there is a copy sent to government department of the district and one given to the caretaker of this levada. The director can have a house to live in conditional that he keep the tools belonging to the levada, and also those of the public works.

PART SECOND—TO LEASE THE WATERS.

ART. 17. To rent the water each levada must have a giro (that is a rotation of days) so that each lessee during the irrigation season shall receive the quantity of water he bargained for or bought.

The giros are fixed.—For the Levada Rabaçol is established every sixteen days or three hundred and eighty-four hours in each branch.

For the Levada of Fajaã dos Vinhaticos every sixteen days or three hundred and eighty-four hours in each branch.

For the branch of Inncol and Furado, that irrigates Santa Cruz, the giro is twenty-five days or six hundred hours.

For the branch of same levada that irrigates Porto du Cruz the giro is sixteen days or three hundred and eighty-four hours.

ART. 18. The leasing the said waters shall take place yearly in the month of March in the office of the administrator of the locality in the presence of the notary of the crown, and besides these, the director and levadeiros chosen by him are to be present to give any information that may be required.

ART. 19. For the said leasing it is necessary that placards, signed by the administrator, advertising the day appointed for the lease, should be posted in the most public places of the parish and at the church doors, stating the giro of the levada and the price per hour.

A copy of these placards shall be sent to the vicars of the parish where the levada runs, to be read before the mass is celebrated.

ART. 20. The giro of the waters in each levada can only be altered by the Government after the civil governor has given his opinion and the delegate of the treasurer.

ART. 21. The price of water in each levada is annually fixed by Government, according to information given by the different functionaries.

ART. 22. The lease of these waters are made so as to include the greatest number of landed proprietors whose grounds require water, making a just and equitable distribution of it according to the wants of each individual; those that in former years rented water and paid for it have the preference, and that the quantity demanded is indispensable to the soil under culture to be irrigated.

The water can not be rented to those who are in debt for any of the preceding years.

ART. 23. The notary will take the names of all those that buy water, the quantity of hours bought, the price which the lessee has to pay, all signing a document in which they bind themselves to pay the amount as soon as it is demanded.

ART. 24. Of the document above mentioned copies are to be made so that they can be sent, one to the treasurer by post, another to the director of the levada, and two others to the levadeiros. These last need not have the amounts of money written on them.

ART. 25. The original of the above document to be kept in the archives of the Government office after the necessary papers for collecting the amounts have been made out.

ART. 26. The day on which the waters are distributed placards are to be posted in the most public part of the parish, also on the parish church doors.

PART THIRD—TO COLLECT THE RENTS.

ART. 27. The collection of the water rent of the levadas takes place in August and is collected by the tax-collector of the parish.

ART. 28. That the lessee may know when the rents are to be paid the tax-collector must have placards posted up in the most public places, at least eight days before it commences, giving notice of, first, the place where the rents are to be collected; second, the day on which he commences to receive rents.

ART. 29. The lessee who can not pay during the said period has to pay 3 per cent. on the same amount or a fixed sum of 4 cents when the said amount comes to $14. The above is declared also in the placards according to Article 20.

ART. 30. The receipts given must be according to model No. 2 of instructions published February 8, 1843.

The list must be made out according to Article 24, before mentioned, and must be in the hands of the collector before the 15th of July of each year, according to practice already established.

ART. 31. The sums received from the rents of water will be booked as "revenues of the levadas," and the 3 per cent. on fixed rate as revenues of the levadas.

PART FOURTH—DIFFERENT DISPOSITIONS.

ART. 32. The administrator has the same duties to fulfill as regards the levadas as he has toward other national properties, to see especially that the services of the levadas are properly performed by those that are intrusted with it.

ART. 33. If the repairs of the levadas be so expensive as to call for the aid of the public works, the administrator of the parish is obliged to inform the delegate of the treasury that he may ask the civil governor of the district to have the necessary repairs made.

ART. 34. The appointment of the levadeiros must be made yearly, by the administrator, during the month of February.

ART. 35. The salaries are to be paid every quarter. Other trifling expenses attending repairs to be paid at the end of each month in which they are made.

ART. 36. To pay the salaries of the employés, as well as the different items attending the levada repairs, annual pay-sheets are to be made by the administrator and sent to the treasurer to be paid.

The balance-sheets, to be paid, must be accompanied by the directors' vouchers signed by the administrator.

ART. 37. If at any season the irrigation water is not all sold, the giro can not be altered, but the administrator must let the delegate of the treasury know.

ART. 38. If at any time there is not a competent director appointed, the delegate of the treasury in the district may appoint a person *ad interim* until he gets one to fulfill the place definitely. The appointment of the director can be made by the administrator and in that case he receives the salary of a director.

ART. 39. If the place of care-taker becomes vacant the director can appoint a person *ad interim*, until he definitely engages an individual, in the mean time he must acquaint the delegate of the treasury of the person he proposes.

ART-TRANSITORY.

To proceed with the lease of waters for the current year the price of water is as follows, subject to the approval of the Government:

In the Levada da Fajaã dos Vinhaticos and its branches, 70 cents; in Inncol branch, 60 cents; in the Furado branch, 50 cents.

If at any time the Levada da Fajaã dos Vinhaticos has not sufficient quantity of water for irrigation, for example, in the height of summer, the two branches are to be united by the mutual consent of both lessees the price then will be $1.40 each hour of water; that the lessee receives.

The other levadas are subject to the same conditions when there is a dearth of water and in that case the price is double.

HOME DEPARTMENT OF THE DISTRICT OF FUNCHAL,
March 28, 1862.

The delegate of the treasury.

FRANCISCO HAVIN DE SONTA.

Approved.

HOME DEPARTMENT OF THE DISTRICT OF FUNCHAL,
April 7, 1884.

The first official.

FRANCISCO JOAQUINN PESTANA.

REPORT OF HENRY PEASE, U. S. CONSUL, SANTIAGO, ON WATER SUPPLY AND IRRIGATION IN CAPE VERDE ISLANDS.

The subject of irrigating arid and cultivated lands in this colony is not varied or extensive enough to form the basis of a report such as requested.

Nature has been so unbounteous in her supply of fresh water to the Cape Verde Islands, that there are no lakes, rivers, ponds, or large streams, except during the rainy months, which are August, September, and part of October. But there are many springs on the islands of St. Antone, St. Iago, and St. Nickolas, issuing through the rocks at the base of the mountains, in the bottoms of the deep valleys and ravines. It therefore became necessary that the inhabitants should have settled near a spring. Yet about half the towns and villages on these islands are so remote from fresh water that all their supply is brought from 1 to 3 miles on donkeys or the heads of women.

QUANTITY AND MODE OF IRRIGATION.

It would be difficult to obtain any precise information as to the quantity of land under irrigation, as there are no reports or statistics on such a subject. Yet from observation, and information received from some land-holders, I should not underrate the areas, by stating that the only lands receiving irrigation during the dry season, which is from November to August, are a few patches of flat ground in the valleys below the level of the springs, cultivated as "garden plots."

The mode of irrigating is by making with a "hoe" (the principal agricultural implement used in this colony) a number of small trenches leading from the springs through the cultivated grounds,

EUROPE.

REPORT FROM DARIUS H. INGRAHAM, U. S. CONSUL, CADIZ, SPAIN.

I can not learn of any maps or works on the subject, though the latter may exist translated from the French, but are regarded as merely theoretical and of no interest or value to a people who have from the time of the Moors, and perhaps of the Romans, carried on practical systems of irrigation chiefly in the provinces of Murcia, Valencia, and Granada, and to a lesser extent in western Andalusia. In these provinces, especially Seville, which is watered by the Guadalquivir, whose valleys are rich not only in corks, grains, but in olives, oranges, palms, grapes, and other semi-tropical fruits, ditches are dug through the lands and fed from the river; and in other localities the irrigation is done by a sort of water raiser from wells, called norias, consisting of a chain of buckets going over and over as they come up from the well, filling and emptying by the operation, and propelled by a blinded animal, a horse, cow, ox, or mule, going round and round, and kept within the circle of the noria by a pole running from the head of the animal to the pivotal post. Thus secured he goes along all day long around the circle without driver or guide. In some cases a steam engine is in use among large properties, but the noria is of great antiquity. In Damiel, La Mancha, 3,000 norias are used, only in summer, and the same exist generally throughout Spain.

In Lorca, a town near Carthagena, where the land is salty and the river overflowed, an enormous dam has been built in recent years to retain the water.

As no statistics are published, I am unable to reply to some inquiries of the circular, but it is believed that the difference between irrigated and non-irrigated lands is as one to twenty-five in value.

There is no Government system or control custom regulating all, as it did in the time of those masters of irrigation, the Moors. For instance, at Granada a sort of court called the water court has existed by the customs of centuries, to pass on all questions of irrigation and rights between owners, and this court is regarded as high authority, dispensing exact justice and enjoying a reputation like none other in Spain. It is organized from custom; it sits at certain times at the Alhambra to hear causes, as it has done since the mediæval ages, its members coming on mules or horseback, and alighting before the bench provided for the hearings.

In one of the towers of the Alhambra a bell rings at different times of the night to indicate the flow of the waters of the Xenil and Darro, which have their confluence at this point and irrigate the vast Vega of Granada.

In this section I am not able to give the names of any experts on irrigation, as in this consular district the operations are limited as above described, but I would refer to Mr. W. Langdon, of Huelva, engineer of the Rio Tinto mines, who once furnished me an interesting paper on the teredo, a worm attacking submerged wood; and in Cadiz, Señor Don José Maria Conte, a distinguished writer and interested in agricultural subjects.

REPORT FROM CLODOMIRO PEREZ, U. S. CONSUL, CADIZ, SPAIN.

The immense importance and the successful solution of the irrigation problem implies, has justly attracted, and no doubt will always attract, a vivid attention in all agricultural countries, and as regards the European continent perhaps more especially so in Spain, where, owing to the heterogeneous character of the soil and climate, a judicious distribution and utilization of the water supplied by abundant rivers, brooks, and springs, or in certain regions, however not otherwise obtainable than by storage from rain-fall and underground sources, is, together with an obvious need, one of the most beneficial agents for general prosperity.

Water, apart from satisfying the peremptory purposes of quenching thirst, averting fire dangers, and contributing to public health and embellishment, proves a cheap and useful auxiliary of industries, but more principally a capital element, a solid guaranty to enhance and increase the agricultural production and all other interests inseparably associated with the yield of the soil, a branch that represents the most conspicuous and positive wealth.

Since in remote ages this rich and so oftentimes coveted territory entered the noble road of civilization and human progress, cultivators could not fail to become perfectly aware of the favorable influence exerted on the growth of plants, and consequently on the result of crops, through the opportune agency of irrigation, whether natural or artificial. It has been, therefore, the common aim of the Spanish people, as well as of those patriotic and enlightened rulers who have guided the destinies of the nation with a true devotion for the public welfare, to give a constant aid and all possible impulse to everything that tended to the protection and development of the water supply system.

The hydraulic works for irrigation carried out in Spain in ancient and modern times, although not yet completed to all the extent of which this country admits and even requires, show bold conceptions. They are in many cases magnificent, practical monuments erected by intelligent active minds, who thus have endowed large districts with the fruitful and lasting germ of the luxuriant life there enjoyed by past and present generations.

The treatise on "water and irrigation" (Aquas y Riegas, two volumes), which, as instructed by circular of May 2, 1889, I have the honor to send the Department of State with the present report, will, I am confident, afford useful information to the special committee appointed by the United States Senate to investigate into the matter of irrigation as practiced in Spain, and perhaps excuse diverse omissions I may incur.

While I respectfully call the attention of the Department upon said book saying that it is the only work published in this country which in every direction treats the subject in a reliable and exhaustive manner, I beg to mention that its author, Mr. Andrés Plaurado, is the chief forestry engineer for the district of Madrid and a qualified authority, both at home and abroad. He recently, in the name of the Spanish "Ministerio de Fomento" (the department embracing public works, agriculture, industry and commerce), took part in the discussion held at the International Congress of Paris on the utilization of the water of streams.

His views upon the subject "*De l'avenir des canaux d' irrigation,*" a remarkable essay, met the approval of eminent foreign scientific men.

Mr. Llaurado's work, "Water and Irrigation," contains an elaborate historical and technical description of the canals and reservoirs built in Spain; also useful suggestions, resting upon his practical observations, concerning construction, financial and economic results, and the best means to secure the success pursued in enterprises for irrigation.

First of all, I will now point out the prominent conclusions arrived at by Mr. Llaurado, namely:

It is an axiom that in northern countries irrigation increases the product of cultivation, especially in summer.

In southern countries irrigation becomes absolutely necessary, whether to remedy drought or to overcome the consequences of unequal rain-fall.

Reservoirs become absolutely necessary in Spain to store up water during the time there is rain, in order that the decrease produced in streams just when agriculture is most in want of it might be restored.

Irrigation undertakings must divide in two different classes:

(1) Irrigation works which can be achieved by the single individual effort.

(2) Irrigation schemes which necessitate the interposition and subsidies of the Government.

Private activity, from a financial stand-point considered, will be able to accomplish irrigation schemes, provided the rate consumers pay for water covers the expenses of working them, the amount of interest corresponding to capital invested, and a fair profit. Otherwise the business must result in a failure for private concern, while, though it can not be absolutely asserted, it is advantageous for the Government, whose ample unlimited means of action allow them to balance loss with profit.

What now is met with at the "Canal Imperial de Aragon" and at the "Canal de Urgel," under direct management of the public administration, clearly evidence that assertion. The construction of the first-mentioned canal cost the Government about 20,000,000 pesetas ($4,000,000). and since the reign of Carlos III, when it began to be worked, up to our days the immediate direct net produce earned by the administration aggregates the sum of 37,000 pesetas annually ($7,400), a notorious meager yield in proportion to the capital invested.

But the business, however, far from being ruinous for the State, has largely compensated the outlays by creating great sources of wealth, which deliver up to the public treasury a good part of their income.

It must not be overlooked that, in order to render mutually advantageous to companies and farmers the utilization of water schemes the irrigation tariff must be rated cheap.

The modest yet mighty sphere of private spirit is able to achieve with success many works in totality superior to the limited number of enterprises due to the initiative of the Government.

That does not mean the Government should be allowed to monopolize this kind of undertakings. They are not feasible for the Spanish Treasury in its present circumstances, when it is rather too much influenced by the oscillations of politics.

But the administration can promote such irrigation business as may aid the private companies by affording facilities to individual action, by making public the hydrological data, the investigation of which is not consistent with private initiative, and by framing accurate statistics on the rights for use of available public water.

As refers to the great works of canalization the Government ought to undertake the construction for its own account, and when they are finished cede them on fair terms to the irrigation syndicates, reserving itself the right of superintendence and protection, in order that the sacrifices made by the people may not result fruitless.

The Spanish Peninsula extends approximately over eight latitudinal and upwards of twelve and one-half longitudinal degrees; its periphery measures 3,300 kilometers; the surface of its soil comprises about 50,000,000 hectares (123,500,000 acres), with elevations exceeding 3,500 meters above the level of the ocean, vast table-lands, deep valleys, and nearly 2,000 kilometers sea-shores extending along four slopes, washed by different seas, and facing different cardinal points of the globe.

The contrasting conditions of climate enjoyed according to local circumstances can well be imagined; they are so manifold that in this sense, rather than a mere peninsular, Spain comprises by itself a vast continent joined to the rest of Europe through the mountain range of the Pyrenees, and partakes the scale of subtropical up to sub-Alpine temperature, with burning summers, as in the Sahara Desert, or glacial winters, as in Scandinavia. A glance at the hereto appended summary of meteorological observations gives a fair idea on the physical consequences which arise in various regions.

In the qualities of the soil all gradations exist, from the hardest and most compact clayish soil to that of the most loose and movable silicious nature, in all possible shapes, the evenest as well as the steepest and most rugged. It also differs in depth from the shallowest and most naked soil up to the most covered with vegetable layers; and as to the hygrometrical conditions from extreme moisture to the most complete dryness, from the least fitted to irrigation, and to such as is perpetually condemned to receive no other water than from rain-fall.

Of the total area of Spain (50,000,000 hectares) 40,000,000 hectares are cultivated for crops and pastures; about 2,000,000 thereof are benefited by irrigation.

Among other peculiar features common to the north coast of Spain the provinces of Santander, Oviedo, Biscay, and Guipuzcod, in which this consulate and its respective agencies of Gijon, Bilbao, and San Sebastian are located, partake of the most frequent and greatest rainfall in any part of the Spanish peninsula or in Europe.

I quote what Mr. Llaurado says, referring to the above-mentioned provinces:

> On account of the great moisture, the air being almost always in a state close to saturation, ordinarily no other farming grounds but the meadows require a suppletory irrigation. In comparatively dry summers, however, some orchards will be irrigated, principally on alluvial soils of new formation where the underlying stratum, consisting of loose pebble-stones, allows an easy permeability. Permanent meadows constitute the main basis of the agricultural wealth, for they are calculated to supply food for 400,000 heads of horn cattle and a good number of horses and sheep besides, as refers only to the province of Oviedo, and nearly equal proportionate ciphers are applicable for the remnant three provinces, especially for Santander.

In order to examine the cultivation of meadows as it is practiced here, we must suppose them divided in two groups, namely, irrigated and not irrigated meadows.

The first ones are generally lying on the declivities or on the valleys, in the neighborhood of some spring or brook, the water of which may be easily drained; and the last-mentioned meadows occupy the tablelands on the tops of mountains and all such places not much accessible for irrigating them by artificial means, which enjoy no other irrigation but that imparted by eventual rains.

The irrigated meadows, in their turn, form two groups, in the first of which are included those the products of which are consumed by cattle on the meadow itself, the summer harvest excepted, this being mowed and stored for stable food. In the second group are comprised the meadows the produce of which is mowed and cattle fed therewith when yet green, and which furnish, besides, the summer harvest like the meadow lands of the first group. In these irrigations last during all the year, and are only discontinued as long as the cattle are kept within the stable, this being done the months of April, September, and October, on fine days in winter, when tardy frosts are feared, and during twenty to thirty days before harvesting the hay.

Not irrigated meadows, in spite of the moist climate, yield considerably less than the irrigated ones, irrigation being, therefore, indispensable if it is desired to obtain abundant pasture and hay.

The remark has been already made that the water used for this kind of cultivation is either drained from brooks or from little perennial springs, as well because of the continuity and facility of their utilization as on account of the difficulties met with in the drainage from streams, the most part thereof offering deep beds and an excessive slopeness.

The system for irrigation of meadow lands most commonly applied in these provinces is that denominated "irrigation by inclined channels," or also "spike channels" (*riego por regueras inclinadas* or *regueras en espiga*). The distribution channels are devised nearly in the sense of the greatest slopeness of the ground; the irrigating channels connect with them and spread out to right and left hand.

A rapid sectional change takes place on the distribution channels at the point where they separate into branches with the irrigating channels. The last-mentioned channels, by having a gradually narrowing section from their parting point down to the opposite end, pour out the water by getting inundated. Another contrivance is also combined with this briefly described distributive system which consists of collecting channels called *azarbes*, dug on the natural lines of junction on the meadow ground terminating in an outlet channel. Sometimes, when the extent of the meadow is not considerable, or when the quantity of water available is but small, the collecting channels are changed into new feeding channels for the supply of other lots situated farther down.

Within the four provinces above named discrimination of three different climates and regions must be made, depending from situation, whether on the sea-shore, inland valleys, and mountains. The climate on the sea-shore is mild; orange trees can thrive in the open air. In the valleys the climate is fresh; there orange trees, as also grape-vines, only thrive on sheltered places. The climate on the mountains is cold; they generally in winter are covered with snow. Here lies the center of the Cantabrian Mountains, a branch of the Pyrenic Mountain range, with lofty summits, some of them as high as 2,678 meters above the level of the sea.

The highest temperature at the inland valley of Cabuerniga, Santander, during a period of three years (1872–1874), as recorded by the foresty engineer, Mr. Louis Calderon was 48° heat in the sun, 39° in the shadow, and the lowest, which, like the other extreme temperature, very seldom occurs, was 4° below zero. Many years the temperature never exceeds zero degrees. When the thermometer points out 8° or 10°, water generally falls on the mountain pastures lying highest, called *puertos* or "harbors," in the shape of snow.

The forestal and cattle raising industries are the most genuine and prominent riches in these provinces, especially in Oviedo and Santander. The structure of the soil consisting of narrow valleys surrounded by mountains with varied but for the most part too steepy slopes for a safe and commodious cultivation, it is obvious to say that the agriculture, limited to valleys and flat lands of small extent, can never attain a great developement. But, in exchange for the forest and cattle interests, there is proportionately immense room in the best conditions for success, as the frequent rain and continuous mists, covering almost constantly and at all seasons of the year those mountains, maintain a most suitable, fresh, and moist character to vigorous spontaneous vegetation.

The communal pasture grounds being abundant and of such good quality, natural meadows are, most of them, intended to harvest fodder for feeding the cattle during the time the atmospherical inclemencies hinder a direct grazing. As the period when this occurs is no longer than three or four months in the year, the cattle-raising industry is certainly susceptible of a far greater increase as soon as the meadow lands are more carefully cultivated and larger quantities of hay are produced. With the quantity of fodder indispensable for a head of cattle in other provinces, three heads will then be fed here, because the period cattle have to be kept in the cow-house is much shorter. A permanent keeping in the stall is not advisable unless the absurd principle should be established to abandon the enormous wealth the beautiful and vast grazing grounds of the high meadows (*puertos*) represent.

The system now partly prevalent in cattle-breeding is of course such as arises from the local conditions; in the West region horn-cattle are raised until two years old, whereupon farmers in the East region and on the sea shore devote themselves to raise the same up to full growth. In the first-mentioned region natural as well as high meadows (*puertos*) are abundant, while in the other parts that kind of meadows are scarce, and consequently cultivation-meadows become necessary.

One should think that in the Cantabrian coast, one of the rainiest countries of Europe, the system of drainage, rather than that of artificial irrigation, would often be applied. Yet irrigation is here of no little importance, mainly to obtain natural meadows and repair the irregularities of meteoric water used for other cultivators.

Irrigation is most frequently made use of here during the months of March and April, when grass begins to shoot up. The soil is left altogether inundated when strong frosts are feared, in order that the covers of water might protect the soil against the consequences of frost or ice. In normal years artificially irrigated meadow-lands produce greater harvest than those called "*praderas de secano*" or "dry land meadows," but in exceptional years of drought the irrigated meadows are the life-boats wherein farmers save their cattle.

Milk, so its products, butter and cheese, all of an exquisite natural flavor in these provinces, it can be affirmed, have no rival of higher standard in the world. It is obvious to reveal the secret of such excellent qualities, which consists in nothing else besides a good cattle race but the conditions of plenty of pure air and nutritive aromatic pastures. The cow breeds called "of Tudanca" and of "Campoo," in the neighboring districts of Cabuceniga and Régnosa, respectively, Santander, and the "Asturian" race, province of Oviedo, justly enjoy a great renown.

For centuries the mountain woodlands of Santander have been providing with superior timber (oak) the Spanish navy and merchant ship-yards, also (beech) cooperies for preparing barrels or casks for wine and wheat-flour exportations to the Antilles. They scarcely have escaped the total devastation that has been the fate of public forests in Spain.

The planting of trees to replace those consumed or cut from the parish forests was formerly compulsory for all citizens who enjoyed the rights to use the same. That duty is completely neglected; though it has not been repealed, it is not enforced as it ought to be.

I have thought it pertinent to make some digressions on the circumstances attending agriculture and cattle-raising, those two branches which form the great wealth of the mentioned provinces, because of their being so closely connected with irrigation.

On the whole, the geological and climatic conditions in this northern part of Spain keep the greatest resemblance with the counties comprising the "wealden formation," in the southeast of England, such as Kent and Sussex.

An agent which considerably modifies the damp character of this climate is the south wind. It acts like an enormous sponge to absorb the humidity, and as a natural stove where both the air and the soil are speedily dried up. The atmosphere acquires then such transparency that scarcely any gradual lines or shadows of varying distances on the horizon are perceived. It is peculiar to the south wind that immediately it ceases to blow it is generally followed with rain, and that while it is blowing on the coast, rain will most likely be falling on the elevated plateau of Old Castile. The winds which prevail longest in the year come from the west-northwest, succeeding the periods from the south. The east-northeast winds are those blowing in summer until September or October, when they maintain clear, dry weather for longer time.

In the provinces of the North, adjoining those where this consulate and its agencies are situated, irrigation by artificial means is practiced, more extensively at Leon, which borders on its northwest side with Santander and Oviedo. The Ecla Canal irrigates there about 13,000 hectares (32,125 acres). When its construction began (1859), the estimates amounted only to 625,000 pesetas ($126,000), but ten years later (1869) the sum of 3,250,000 pesetas ($650,000) had been expended. It carries a quantity of 6,480 cubic meters water per second. This canal was built by grant to a foreign private company. According to agreement the annual rate farmers have to pay for water varies from 19.45 pesetas to 97.27 pesetas ($3.89 to $19.45) for each hectare of land irrigated. Notwithstanding the yearly aggregate cashed by the company has been about 8½ per cent. on the capital invested, it does not produce sufficiently to pay the interest to capital, the expenses of maintainance, management, and of interest necessary for amortization. The company met with some embarrassment, perhaps, by not having secured through a formal written engagement how far they had to rely upon consumption of water. Until a year when extreme drought prevailed in the country, the attitude on the part of many farmers to subscribe for the use of the water for this new canal was quite reluctant, but then they obtained a practical conviction of the positive advantages derived from artificial irrigation to supply the absence of rain.

On the vast plateau of Old Castile the "Canal de Castilla" crosses a distance of 207.792 kilometers from Alar del Rey, Santander, dividing in two branches at El Serron, Palencia: one of them, the "Canal del Sur," 54.432 kilometers long, down to Valladolid, and the other, the "Canal de Campos," 78.929 kilometers long, to Medina de Rioseco," the center of cereal production in the North, called for this reason, by Spaniards, "*el granero de España*," or "the corn-barn of Spain." The section of the "Canal de Castilla" from Alar del Rey to El Serron takes the denomination of "Canal del North," and is 74.431 kilometers long.

The "Canal de Castilla" is an important water-road for transportation, navigated by barges carrying each about 33 tons; the water of it serves also as a motive force for a good number of large mills and factories. But the same is scarcely used as a means of artificial irrigation. Its most noteworthy works are seven locks on the "Canal de Campos," twenty-four on the "Canal del Nerth," and seventeen on the "Canal del Sur."

On the "Canal del Norte" section, the canal carries 4.47 cubic meters water per second, being distributed between the two branches in the proportion of 2.79 cubic meters to the "Canal del Sur" and 1.68 cubic meters to the "Canal de Campos." The uppermost part of the canal in the last-mentioned section is 15.55 meters wide, at the surface of the water 11.66, and at the bottom of the canal 5.83 meters wide; it has a depth of 1.93 meters. The towage-path along the canal measures 3.33 meters width in places where the earth had to be cut off, and 4.44 meters at the embankments.

The Pisuerga and Carrion affluents of the river Duro, are the feeders of the "Canal de Castilla," the construction of which, begun in the middle of the last century, was interrupted, and reached its completion during the reign of Queen Isabel II.

In normal years the want of moisture necessary to the growth of most cereals, wheat, barley, rye, etc., seems not to be much felt on the boundless-looking corn-fields of the northern provinces of Castile. The arable surface of the soil is deep and fertile, though the monotonous perspective of vast plain land impresses the mind with aridness, seeing that it is almost completely denuded of trees everywhere, for the prejudice is most prevalent there among cultivators "that trees are only good for sparrows to build their nests on and as places of shelter for the voracious winged enemies of plantations."

During the war of Crimea the shipments of wheat-flour from Castile, made at the port of Santander, amounted to enormous quantities. An enthusiastic fever then existed throughout Castile. The boasting phrase, "*Agua y sol y guerra en Sebastopol,*" ("Water and sun besides war at Sebastopol,") whereby Castilian farmers expressed their prosperous situation in those years, was so generally pronounced and repeated that it became a proverbial sentence.

A great number of flour-mills were erected on the canal, and the largest possible extent was given to the production of cereals. Those exceptional incidental causes by which the agriculture was favored have passed long ago; they are now not more subsistent. Farmers in Castile devote their care not only to cereals, but also to extend the grape-vine plantations, and must adopt all improvements in modern agricultural progress if they will keep pace with the cheap production of other countries. Irrigation will be of course a means to the profitable result of a varied cultivation.

The province of Logroño bordering with the back province Alava, is one of the agricultural districts where great benefits are obtained through artificial irrigation that makes it very productive in all kinds of fruits and vegetables. It is the richest orchard and kitchen garden in the northern region of the river. Elbro, the source of which is at Fuentibre (Fons Tiberus), near Reynosa, Santander. This river becomes navigable at Saragossa, supplies water for the "Canal Imperial," and some other of the most important irrigating canals, and no other river in Spain is more used for irrigation; the advantages it affords to agriculture are considerable.

At Logroño and the neighboring districts known all under the denomination of "La Rioja" good wine is obtained and mostly exported to France, and also shipped to other countries by Bilbao and Santander. Fruits and vegetables (capsicum, tomatoes, peas, etc.), are prepared in cans in important quantities for house and export consumption.

The practical and wise laws founded or issued by the Arabs during their domination in the south of Spain, in the provinces of Valencia, Murcia, and Granada, maintained there more specially by careful traditions, are the basis of the new laws framed for all irrigating corporation, who will enjoy certain privileges. These privileges consist substantially in the right that when as prescribed they unite in "Sindicatos" or syndicates, they can appoint their own independent courts, all proceedings being public, verbal, and the decisions of these independent courts (*Turados de Aguas*) or water-juries inappealable.

In Leon such syndicates exist, so in Logroño, but in none of the above-mentioned provinces of the North, where, for the reasons I have explained, artificial irrigation exhibits an individual, isolated aspect.

Engineers in the construction of some of their great hydraulic contrivances do, perhaps, only observe and copy the works of nature. There are no "lakes" formed by rivers in Spain to collect water for further distribution in "natural deposits;" to supply the same on suitable elevated places, sometimes in the mountain gorges, reservoirs, called "albuheras" or by the more modern name "pantanos," are built, where the water is stored up. *Acequia* (as many words of Arabic source) means exclusively irrigation canal.

In Valencia farmers have inherited with the valuable irrigation system of the Saracens also their good practical habits for agricultural. There they know what great value water involves. They always carefully look that the ground be well leveled in order that both the water coming from canals and from rain-fall is equally beneficial to the plants, because otherwise some parts of the soil will become covered with water while other parts remain dry, and in some others water will carry away the humus, salts, and oxides, the richest elements contained in manure to aid vegetation. Nobody knows as they do to retrench the flowers and buds when the plants are too overcharged, as they are aware that a smaller number makes fruits get ripe earlier and improves the quality. Nobody else knows better than those farmers how to select the precocious ears, one by one, with the purpose of ameliorating the species and accelerating the period for ripeness. The Valencia farmers remain constantly near their plantations, and through artificial irrigation they realize in that climate an abundant and incessant crop of rich products.

REPORT FROM J. L. RATHBONE, U. S. CONSUL-GENERAL, PARIS, ON IRRIGATION IN FRANCE.

(1) Areas of land under irrigation; compare with the non-irrigable and cultivatable areas when possible. Also, quantity and quality of crops grown?

The surface of irrigated lands is roughly estimated at 2,350,000 hectares. As cultivated lands are not generally irrigated, it is not easy to compare non-irrigated with irrigated lands. Pastures are the only lands generally irrigated.

The average production per hectare of irrigated and non-irrigated pastures is: Irrigated pastures, 37 quintals; non-irrigated, 31 quintals. This difference of 6 quintals represents a total value, in the first case, of 230 francs; in the second, of 190 francs, per hectare. Among the areas devoted to cultivating the vine, some are submerged, while others are irrigated. But the value of their produce depends upon other causes than irrigation.

(2) Sources of water supply, whether from rivers, streams, springs, lakes, wells, reservoirs, catchment basins, or tanks, etc.

The canals cut for purposes of irrigation all flow from rivers. In some instances attempts have been made, by means of artificial reservoirs, to increase the quantity of water yielded by the river. It was for this purpose, for example, that the reservoir of Oridon was constructed in the department of the Hautes Pyrénées. Its object was to increase the volume of water in the river Neste, from which flows the canal of the same name.

(3) Character of works used for storage and distribution of water. Forward published reports, if obtainable, in regard to any important irrigation and storage works.

The number of reservoirs above mentioned is still somewhat limited. The works carried out in view of distributing the water generally consist, first, of a principal canal, or chief branch through which the volume of water to be distributed flows from the river; second, of a small canal, fed by the principal one; third, of a net-work of streams, drains, and ditches which provide each land-owner with the quantity of water to which he is entitled.

(4) The system of water distribution, whether governed by laws, rules, and regulations, or customs, give duty of water per acre, *i. e.*, the amount used per acre and per season; the cost or rental to user; tenure of ownership of water, and whether the same be public or private, national or community.

The use of water for irrigating is regulated by the French code. The articles of the code bearing particularly on this point are the following:

> 643. The owner of the spring can not change its course when he provides the inhabitants of a commune, village, or hamlet with the water necessary for them; but where the inhabitants have not acquired or prescribed the use of the same, the owner may demand a compensation, the exact amount of which is to be fixed by an expert.
>
> 644. The owner of a property skirted by a running water which is not national property, according to article 538, has a right to the use of the water for irrigating his lands while it flows past them. The owner of ancestral lands traversed by this water may use it within the full limits of his lands, on condition he restores it to its proper bed before it leaves his estate.
>
> 645. If a dispute arises between the land-owners to whom this water may be useful, the tribunal called upon to give its decision in the matter shall conciliate the interests of agriculture with the respect due to the rights of property, and, in every case, with the particular and local customs and regulations which pertain to the passage and use of water.

The works executed for purposes of irrigation may be divided into two classes:

(1) Those undertaken and carried out by companies called syndical associations.

(2) Those undertaken and carried out by a contractor.

When a syndical association carries the work into execution, its statutes usually determine on what lines the distribution of water shall be regulated. But when the works are taken in hand by a contractor, the distribution is fixed, either by a decree published after the council of state has recorded its decision, or by a decree signed by the prefect or chief magistrate of the department in which the works have been, or are to be, executed. The prefect is empowered to sign these decrees since August, 1886.

The syndical associations are composed of land-owners whose interests are affected by the want of irrigation. Their powers, privileges, etc., are more or less determined by common law.

The French Senate is at present discussing a projected rural code, which will contain a certain number of articles relative to irrigation.

In a general way the quantity of water required to irrigate a hectare is equal to an outflow of one liter per second all the year round. The cost per hectare is apt to vary considerably if the works are executed by a syndical association. In that case the average cost may be set down at 40 francs per annum for a supply of water equal to about 1 liter per second. If, on the contrary, the works are carried out by a contract, the cost is always a fixed one, it can never vary, inasmuch as it has been determined by the deed of concession.

The following table shows the figures of the tax raised for some of the leading irrigating canals:

Canals.	Departments.	Cost.	
		A.	B.
		Francs.	*Francs.*
Pierrelatte	Drôme, Vaucluse	50	60
Bronne	Drôme	50	60
Visubie	Alpes Maritimes	80	....
Verdun	Bouches-du-Rhône	70	....
Saint-Martory	Haute Garonne	35	50

When two figures are given for a single canal the figures in column A show the tax due by the land-owners who subscribed before the water of the principal canal (see Answer 3) was turned into its destined channel, while the figures in column B denote the amount paid by those who subscribed afterwards. In the case of the last-mentioned canal, the figures shown in column A, the sum paid by land-owners who subscribed before the deed of concession was promulgated, and in column B the amount paid by those who subscribed after its promulgation.

Springs only may be owned either by private individuals, by the state, or by the small districts called communes.

Running waters are considered *res nullius*, but the use of them is regulated according to law on the non-navigable water-courses.

The water of navigable water-courses is considered national property.

(5) Character of climate in irrigated region, and nature of soil, annual rain-fall, and other precipitation.

Although the practice of irrigating is as widely spread in the north as in the south of France, it is chiefly in the regions bordering on the Mediterranean, where the summer rains often fail, the most important irrigating canals have been cut. In the north, east, or west the works designed to promote irrigation are nearly always carried out by private individuals. This is especially the case in the department of the Vosges. In the south they are, for the most part, the result of the combined efforts of a certain number of individuals. They are mainly undertaken where the soil is of a chalky nature and in lands formed by alluvium.

Among the systems adopted to distribute the water may be mentioned an interesting one practiced in the department of the Bouchesdu Rhône. It is a kind of irrigation by submersion. The lands subjected to this method are constantly increasing in extent.

The land owners whose properties are situated on the banks of the Rhône obtain, when they require it, and by means of elevating machines, the quantity of water necessary for the process of submersion, which lasts sixty days and consumes not fewer than 1,500 cubic meters per hectare. The estates in the center of the island of Camargue, in the same department, are less favored than those seated on the river banks. The water has to be conveyed to them from the river by means of small canals and side channels, which generally belong to syndical associations of a very remote origin.. These side channels work during the rising of the Rhône. As, however, the frame-work of their flood-gates is almost on the same level as the low-water mark of the river, when it is not higher, it often happens that, when the Rhône is low, the side channels become dry. Besides this, the season for submerging the land often coincides with this autumnal fall of the river, and irrigation is practically brought to a standstill.

Numerous plans have been formed to find these side channels by means of large canals cut in the north of the island. But none of them have yet been carried out. Pending the execution of a plan a society of land-owners, headed by the Count of Chevigne, recently set an example well worth following. Their project is not less remarkable for the way in which it was conceived than from the results which may be expected from it. They are thirteen in number, and their combined estates contain some 1,500 hectares. In order to keep their side channels constantly supplied with water they applied to several mechanical engineers for machines, and finally adopted an apparatus presented by one of them, and which has given the most satisfactory results.

Its characteristic feature is that instead of being a fixture it floats and can be conveyed from one place to another. Thus it can be made to work anywhere. It consists of a boat built wholly of iron, and equally adapted to fluvial and maritime navigation. Its length is 24 meters; its breadth 5 meters; and its draught of water nearly 1½ meters. It carries three engines on the compound system in juxtaposition, and of 200 horse-power. Two of them each turns a rotary pump by bearing directly on its beam. The third, which can be made to work either of the two pumps, is used only when one of the other engines is out of order. On the one hand, these machines are condensing engines; on the other, their steam is provided by boilers on the Bigot system. These latter are used in the French Navy, and possess a collective warming surface of 80 square meters. Their consumption of fuel is therefore comparatively small. The pumps fixed up on board are on the Decœur system. They raise the water from a depth varying between 1½ and 2½ meters, according to the level of the Rhône, and distribute the water at the rate of from 750 to 1,500 liters per second.

The following table gives more ample particulars. To understand its figures rightly it is necessary to know beforehand that they are given when both engines are working together and distributing 500 liters per second:

Height above river.	Horse-power.			Number of turns.	Consumption.	
	In quantity of water brought up.	On the beam of the pump.	On the sucker.		Total per hour.	Per horse-power of water brought up.
Meters.						
1.00	15.0	24	32	140	35.20	2.340
1.50	22.5	36	48	160	46.86	2.348
2.00	30.0	48	64	160	70.40	2.340
2.50	37.5	60	80	170	88.00	2.340

When the pumps distribute 1,500 liters instead of 500, these figures remain proportionately the same. The suction is performed in a special division provided with vases, and the water is thrust back into a collecting pipe which serves for both engines at the same time the boat is working; it is moored on the spot from which the water is drawn up. The collecting pipe has a weir provided with a slat spout. It runs into a sheet-iron reservoir placed at the head of the side channel and outside the river dam. The connecting of the weir with the collecting-pipe is accomplished by means of a link with a hinge to it which enables the spout to remain constantly in position on the edge of the reservoir, whatever the motion of the boat may be. By this arrangement the work done by the pumps is limited to a height corresponding with the difference in the level of the water, and with that fixed for submerging the land. This second level is slightly below the height of the reservoir itself.

The annual rain-fall for all France is estimated at about 77 centimeters.

(6) Antiquity or otherwise of irrigation systems within the section treated of, and whether the same are maintained at public or private expense?

The cutting of a certain number of canals for irrigation in the southern districts dates from several centuries. The more important works, however, are of comparatively recent origin. During the last ten years, especially, a great impulse has been given to the construction of works devoted to irrigation. Subjoined is a list of the most notable enterprises of this kind. It is taken from the "Journal d'Agriculture pratique."

Departments.	Description of works.	Cost. *Francs.*
Drôme	Canal de la Bronne	13,000,000
Alpes-Maritimes	Canal de la Vésubie	7,000,000
Aude and Hérault	Canal to be used for submerging both departments	2,400,000
Duôme and Vaucluse	Canal de Pierrelatte	8,000,000
Basses-Alpes	Canal de Tranasque	4,500,000
Hautes-Alpes	Canal de Ventaron	2,000,000
Aude	Canal de Canef	1,000,000
Bouches-du-Rhône	Drying up the Fos Marshes and purifying the waters of the Cran.	18,000,000
Hérault	Canal de Gignac	4,200,000
Loire	Canal de Farey	7,000,000
Alpas-Maritimes	Canal de Toulon	1,200,000
Aude	Canal de Cuxac	2,000,000
Do	Canal de Suc	} 1,160,000
Do	Canal de Fabrezarn	

The public treasury generally contributes one-third of the costs of the works; the land-owners interested in them defray the remaining two-thirds. In the case of the most important works, the state, besides contributing its third, has guarantied for the space of fifty years, to the parties who covered the loans raised for the purpose of carrying out the works, the interest due on the sums lent to the contractors.

TRANSLATION BY UNITED STATES CONSUL DUFAIS, OF HAVRE, OF A LETTER ON IRRIGATION FROM MR. LUCIAN, CHIEF ENGINEER OF ROADS AND BRIDGES, DEPARTMENT OF CALVADOS, FRANCE.

CAEN, *August* 30, 1889.

SIR: I beg to answer in the following order the several questions asked in your letter of the 8th instant:

(1) Calvados being a cattle-raising country since a long time, the utmost has been done to utilize the water. The new demands for irrigation are therefore very rare, and it is to be supposed that the surface of the irrigable lands is already under irrigation. This surface, according to a statement made in 1870, was only 1,372 hectares (3,390 acres). This small proportion of the surface of the department which contains 552,000 hectares (1,364,544 acres) is explained by the dampness of the climate, which rather needs being made salubrious by drainage of marshes, etc., than by irrigation.

It is important to note that nearly 20,000 hectares (49,440 acres) are irregularly watered by flood or wild waters.

Artificial irrigation is exclusively applied to permanent meadows.

(2) The water used for irrigation comes exclusively from the streams.

(3) The works constructed on streams for the distribution of the waters used for irrigation generally consist of bars fitted with water-gates able to be lifted above the highest water. These bars are authorized by a prefectoral commission prescribing the dimensions and dispositions. Moreover, everybody may after an administrative inquiry obtain the authorization of using a stream of which he is a borderer, said water, after he has used it, to be returned to its natural course, under all reserves, however, of the rights of third parties.

(4) Nearly all irrigations in Calvados are of a private character; there are none of a collective use to report but two.

Irrigation of the small valley of Aute (arrondissement of Falaise). A decree dated February 11, 1881, rendered after inquiry, has authorized and located the establishment of 16 bars constructed in the River Aute. A prefectoral decree settled the dates and hours of irrigation for each bar. The surface of the land to be watered is 152 hectares (376 acres).

Irrigation of the valley of Orber within the limits of the department at Lisecua. It is not a question in fact of irrigation exclusively. The land proprietors joined in a syndical association to secure on one hand the irrigation of 286 hectares (707 acres) of meadows, and on the other the working of the numerous factories situated in an industrious valley, where there are at least 85 streams and brooks. This syndicate is regulated by a decree dated June 18, 1864, which stipulates the use of the waters and settled the dates and hours of using the water, always considering the wants of the factories.

A syndical commission, whose members are appointed by the prefect (according to the statutes), manage gratuitously the interests of the association, the expenses, etc., by means of a roll rendered executory by the prefect and which is collected by the "receiver of finance" of the district, commissioned to that effect. By means of this roll the expenses are apportioned between the interested land-owners in proportion to the value of their property. There are no fees for the use of the waters, which are common property of the adjoining landlords.

The syndical associations established previous to 1865 are under the rules of the law dated June 21, 1885, modified by the recent law dated December 22, 1888.

(5) Climate damp; the yearly average rain-fall is 700 millimeters (27½ inches).

Calvados soil, heaths and waste lands, 12,000 hectares (29,664 acres); rich soil, 150,000 hectares (370,800 acres); calcareous soil, 150,000 hectares (370,800 acres); gravel soil, 8,500 hectares (21,212 acres); stony soil, 5,000 hectares (12,360 acres); sandy soil, 2,500 hectares (6,180 acres); marshy soil, 70,500 hectares (174,276 acres); diverse soils, 173,300 hectares (429,092 acres).

The most part of these soils is divided as regards agricultural purposes in 317,000 hectares (783,624 acres) arable lands, and 141,000 hectares (348,550 acres) of natural and artificial meadows.

REPORT OF CHARLES B. TRAIL, U. S. CONSUL, MARSEILLES, ON IRRIGATION IN THE DEPARTMENT DES BOUCHES DU RHONE.

Metric denominations and their equivalents:

Meter equals 39.37 inches.
Hectare equals 2.471 acres.
Liter equals .908 quart, dry measure.
Liter equals 1.056 quart, liquid measure.
Hectoliter equals 2 bushels, 3.35 pecks, dry measure.
Hectoliter equals 26.44 gallons, liquid measure.

Much attention has been given to irrigation in France during the past century, and the Government has from time to time sought to increase the public interest in this most important subject by publishing scientific reports on the same, and, more recently, by instituting "concours" and offering prizes to those adopting the best methods and securing the best results from irrigation. In the north of France irrigation is accomplished by simply inundating the land, and is confined principally to submerging meadow lands in the autumn by turning off large quantities of water from the rivers and streams; in the central portion, by the use of water from springs and wells distributed over the land by hand and machinery; and in the south province, the Department des Bouches du Rhone and its neighbors, by irrigating canals.

Irrigating canals of any importance are confined to the valley of the Rhône, the foot of the Pyrénées, and to only a few other localities in France. The canals of northern and central France are only used for transportation.

Given sufficient water there is no reason why a canal should not serve for both transportation and irrigation. This is done in Italy with the addition of obtaining motive power from the current as well; but in France the canals only fulfill one function at a time with but a few exceptions.

The use of canals for irrigation is of very ancient date in France. The first canal in Provence that we know of was constructed by Marius, the consul, in 103 B. C., for the purpose of transporting supplies to the Roman army, then encamped near Arles, and it is probable that it afterwards, when abandoned as a water-way, served to irrigate the land contiguous with it. Arthur Young, traveling through Provence towards the close of the last century, was particularly interested in the irrigating canals he there saw, and expressed his surprise that other parts of France did not imitate the Midi in this most important of rural economies.

Irrigation of some sort is indispensable in the Midi. Without its aid agriculture would have to be abandoned. Three months and occasionally nine pass by without rain-fall. The summers are long and the heat great and continuous, while the sun shines through an intensely pure air, unobscured by a single cloud, subjecting the land day after day to a constant drying and scorching process and causing every particle of humidity to evaporate.

The department des Bouches-du-Rhône, to which the report is limited, forms the southeast of France bordering on the Mediterranean and, as its name implies, comprises the territory surrounding the mouth of the Rhône. Its northern boundary is the river Durance, which, rising in the Alps, flows westwardly and empties into the Rhône not far below Avignon.

From the Durance the irrigating canals are principally drawn. The area of the department is 510,487 hectares. The entire surface artificially watered embraces 35,091 hectares, and of this the Durance contributes water for 26,880 hectares, or—

	Hectares.
Irrigation from the Durance	26,880
Irrigation from Huveaune, Arc, La Touboulu, etc	2,911
Irrigation from the Rhône	5,300
	35,091

A glance at the map on page 12 of the "Rapport sur la Concours ouvert en 1875," accompanying this report, explains why it is that the Durance has been so heavily tapped to supply irrigation for this department.

Provence is composed of mountains, hills, and plains. The greater part of the soil is naturally very poor, it being detritus brought down from the Alps by the Durance, and in flood-time spread over the plains. Strong winds sweep over it at times. The soil naturally produces only stunted trees and coarse grasses; but by irrigation and the liberal use of manure a maximum of fertility is obtained where from the want of water absolute sterility reigned.

Geographically speaking, the department des Bouches-du-Rhône presents three distinct features. First. A mountainous section to the north and east, composed almost entirely of limestone of a dull gray color and in part quite naked of vegetation, and in part covered with wood. Streams from the mountains descend to the Durance, to the Rhône, and to the Mediterranean. Second. Two plains, la Crau in the center of the department, very stony, and la Camarque to the west, composed of mud and sand. Third. Marshes and ponds, shallow reservoirs, whose waters flow slowly to the sea.

There was an old French proverb that said Provence had three curses to contend with: Parliament, the river Durance, and the mistral. Parliament was swept away by the revolution. The Durance, whose waters at times overflowed its lands and carried destruction in their wake, has been tamed by man's ingenuity and from a curse its waters have become a blessing; whilst the mistral, the northwest wind, the great drawback to life in Marseilles, and in all Provence, that at times sweeps with terrible force over the country up-rooting trees and destroying buildings, has, owing to the greatly increased humidity of the atmosphere, caused by the irrigations from the Durance, lost much of its former force, is less frequent, and of shorter duration. It is supposed that the mountains here were once covered with timber, the rain-fall regular, and the land fertile; but their denudation of timber deprived the country of a storage for humidity; the rain-fall becoming irregular caused the volume of water in the streams to vary greatly, mountain detritus was spread over the formerly fertile plains; the heat and duration of summer became greatly augmented, and the hot air arising from the parched arid earth originated the mistral.

There are five groups of mountains and they take up three-quarters of the department. The topography in this section is the most varied, the mass being twisted into peaks and chains, between which lie valleys, lakes, and ponds. The plains la Crau and la Camarque take up the remaining superficies of the department. They incline slightly towards the sea and the large rivers. La Crau, comprising 35,000 hectares, of which 15,000 are cultivated and irrigated (1875), is formed mainly of pebbles brought down from the Alps in the glacial period. Before the construction of the canal de Craponne la Crau was one vast uncultivated tract, affording but a scant and coarse pasturage enjoyed in common by the inhabitants. Since the coming of the canal this region has been metamorphosed; rich farms spread over what was once but a desert. La Camarque is that vast delta comprised between the two great branches that the Rhône divides itself into before entering the sea.

It keeps growing constantly from the additions made to it by the deposit of matter carried down by the river in suspension. In area it is 88,300 hectares; 50,000 are wild, uncultivated pasturage, and 23,000 marshes and ponds, and 15,300 under cultivation. There are several canals in this section, but the figures above show how much remains to be done. The history of the formation of this plain by the river dates back to 400 B. C. From statistics of 1855 it appears that of the whole area of the department about 7 per cent. is water.

	Hectares.
Ponds and irrigating canals	
Transportation canals	456.75
Lagoons	44.38
Rivers, lakes, streams	11,565.34
	23,270.64
Total water area	35,337.11

Considerable tracts of land formerly under water have been reclaimed. In some cases a canal for drawing off the water from swamps and marshes has also been used for irrigation. These reclaimed lands when properly drained and watered have proved fertile enough to pay handsomely those who had the foresight to plan and execute the necessary work.

When we come to examine into the quantity and quality of crops grown and the increase in and of the same due to irrigation, we are met with the difficulty of statistics that are conflicting and at times irreconcilable.

Even in the extent of the department we find—

Area of department statistics of—	Hectares.
1864	
1867	512,232
1870	496,464
	510,487

a difference for which no explanation is given.

A table of agricultural statistics was prepared by M. Villeneuve in 1820 and one by the Government in 1870, which are taken as reliable. It will be seen that both these tables make the departmental area about the same. In 1820 the cultivated land was 169,000 hectares to 341,000 hectares uncultivated, or as 1 is to 2; while in 1870, if we add the woods to the uncultivated, we have: Cultivated, 201,000 hectares; uncultivated, 309,000, or as 2 is to 3, instead of as 1 is to 2, in 1820; a gain of 32,000 hectares of cultivated land in fifty years, or about 19 per cent. Here are the tables:

1820.

	Hectares.	
Cultivated:		
Arable land		
Meadows	105,000	
Vineyards	16,000	
Olives	20,000	
Gardens and pleasure ground	24,000	
	4,000	
Uncultivated:		169,000
Waste land		
Lagoons and swamps	233,000	
Woods, bush, and scrub	47,000	
	61,000	
		341,000
Total area		510,000

1870.

	Hectares.	
Wheat		
Rye	70,200	
Barley	390	
Oats	1,000	
Corn	8,400	
Seeds and dry vegetables	50	
Potatoes	6,650	
Cabbages, carots, beets, etc	5,900	
Madder	6,000	
Tobacco	1,490	
Hemp and teasels	80	
Fallow land	980	
	20,000	
Arable land		121,140

	Hectares.	
Olives	12,000	
Vineyards	29,300	
Mulberries	3,000	
Almonds and other fruit	13,000	
Orchards	1,300	
Gardens and pleasure	4,000	
Tree cultivation		62,600
Meadows, dry	3,400	
Meadows, irrigated	5,900	
Clover and other fields	8,200	
Grazing and fodder		17,500
Woods and forests	87,800	
Willows and wickers	3,200	
		91,000
Heath and wild pasture	104,860	
Taxable built property	1,800	
Lagoons	35,000	
Marshes	17,000	
Roads, water courses, and uncultivated lands	59,587	
		218,247
Total area		510,487

According to the Government report of 1875 it appears that this increase of 32,000 hectares of cultivated land in fifty years was due solely to irrigation, there being about that much more land irrigated in 1870 than there was in 1820.

Statistics in France are not obtainable for periods of more than fifteen or twenty years at a time, then a break of a year or two occurs caused by a revolution and a change in the form of government, so that we have no statistics covering very long periods, we have them only in sections.

Taking up the agricultural products somewhat in detail and making a comparison of certain years as obtained from statistics, we have for cereals in 1840, 70,312 hectares devoted to their culture, and after a period of thirty-two years, 1872, 82,223 hectares employed in the same culture.

Wheat shows an increase of over 30 per cent.; oats remain about the same; rye, which in 1840 was 2,711, in 1872 falls to 380; barley, in 1840, 4,211, to 2,507 in 1872; corn, in 1840, 56, to 30 in 1872, the tables showing an increase in area sown in cereals of 16½ per cent. in thirty-two years.

1840.

	Hectares.		Hectares.
Wheat	53,232	Madder	4,143
Maslin (wheat and rye)	1,135	Teasels	1,112
Rye	2,711	Hemp	31
Barley	4,211	Mulberries	1,456
Oats	8,967	Natural meadows	5,475
Corn and millet	56	Clover and other fields	5,470
		Fallow land	64,432
Total cereals	70,312	Woods (commons and private)	103,421
Vineyards	24,901	Orchards and plantations	6,126
Potatoes	2,415		
Dry vegetables (beans, etc.)	2,207	Total agricultural area	463,697
Gardens	2,042	Roads, water-courses, etc	49,294
Beet-root	307		
Olives	24,475	Total area	512,991

	1871.	1872.
	Hectares.	*Hectares.*
Wheat	70,858	71,119
Rye	290	380
Barley	350	2,507
(Maize) corn	40	30
Oats	7,346	8,187
Total cereals	....	82,223
Dried vegetables (beans, peas, etc.)	5,509	3,650
Potatoes	6,569	5,7[illegible]9
Tobacco	100	217
Beet	120	400
Madder	1,400	1,400
Hemp	3	3
Olive orchards	12,000	12,000
Vineyards	29,397	28,897
Fallow land	*23,000	....
Natural meadows	*9,000	....
Clover and other fields (sown)	*10,000	....
Woods and forests †	*58,000	....
Wild pasturage	*140,000	....
Other lands	*138,206	....
Total area	510,487	....

* Approximated.

† Woods and forests belong to the department, to public establishments, to commerce, and to individual owners.

The increased area devoted to wheat was obtained from cultivating waste land. From 1820 to 1839, 65,000 hectares were anually sown in cereals; from 1840 to 1859, a mean annual of 76,000; from 1860 to 1874, a mean annual acreage of over 78,000.

As to the yield of wheat per hectare, it varies not only on different farms, but on the same farm in different years. A good year returns about 15 hectoliters to the hectare, or about 16⅔ bushels to the acre. In 1868 the yield per hectare was only 8.05 hectoliters, or about 9 bushels to the acre. The wheat, winter wheat almost exclusively, is sown two consecutive years on the same land, which is then given a year's rest.

Of fallow land—arable land permitted to lie idle—there was in the department in 1840 60,000 hectares; in 1852 this had fallen to 29,000, and since 1862 to less than 23,000.

The jury who examined the irrigated farms in 1875 and awarded the prizes* state in the "rapport" that the disappearance of idle land is due to irrigation.

---

* The prizes referred to were offered by the French Government in 1875 to encourage the advancement of agriculture by irrigation. First prize, farms of over 4 hectares showing best results from irrigation, a gold medal and 1,000 francs; second, 700 francs; third, 600 francs.

For farms of less than 4 hectares: First prize, gold medal and 600 francs; second, 500 francs; third, 300 francs. A silver medal accompanied the second prizes and a bronze one the third. It was intended that the "concours" should last for five years, but it seems that it was given up after two years. The first year thirty-nine farmers contended for the prizes, and the jury who visited their farms made a brief report on each one; their report is to be found in the "rapport" for 1875 that accompanies this brief investigation.

The statistics for the cereals, 1860 to 1874, fifteen years referred to above, are:

Year.	Areas sown with— Wheat.	Rye.	Barley.	Maize.	Oats.	Total of cereals.
	Hectares.	*Hectares.*	*Hectares.*	*Hectares.*	*Hectares.*	*Hectares.*
1860	78,900	1,294	1,937	....	9,000	91,131
1861	63,054	515	1,044	....	8,066	72,679
1862	61,652	649	1,039	....	7,557	70,897
1863	62,539	646	2,072	....	7,891	73,148
1864	67,040	665	1,075	....	6,717	75,497
1865	63,875	462	1,200	....	8,086	74,423
1866	67,418	648	2,133	....	8,042	78,241
1867	70,100	350	500	....	8,500	79,450
1868	68,200	300	500	....	8,100	77,100
1869	70,000	300	492	....	8,100	78,892
1870*	....	....	....	....	....	....
1871	70,838	290	550	40	7,946	79,664
1872	71,119	380	2,507	30	8,187	82,523
1873	69,975	450	595	65	11,431	82,516
1874	68,775	430	598	70	6,562	76,365
Average of fifteen years	68,107	527	1,160	51	8,170	78,015

* No statistics by reason of the war.

[Quantities in hectoliters.]

Year.	Wheat. Aggregrte.	Wheat. Per hectare.	Rye. Aggregate.	Rye. Per hectare.	Barley. Aggregate.	Barley. Per hectare.	Oats. Aggregate.	Oats. Per hectare.
1860	1,218,358	15.43	11,888	9.20	41,916	21.65	180,000	20.00
1861	731,426	11.60	5,834	11.33	5,971	5.72	141,558	17.55
1862	600,490	9.74	7,353	11.33	16,886	16.25	115,547	15.28
1863	750,458	11.45	5,943	8.93	38,539	18.60	133,674	16.94
1864	905,046	13.50	8,795	13.22	19,511	18.15	134,497	20.04
1865	818,878	12.82	6,929	15.00	21,648	18.03	170,920	19.91
1866	968,122	14.36	9,849	15.20	30,812	14.44	141,459	17.59
1867	829,984	11.84	5,320	15.20	7,310	14.62	159,800	18.80
1868	551,056	8.05	3,990	13.30	5,950	11.90	110,573	13.65
1869	933,100	13.33	4,500	15.00	10,627	21.60	110,573	13.65
1870*	....	....	....	....	....	....	....	....
1871	1,159,945	15.54	3,520	12.14	11,880	21.60	189,522	25.80
1872	1,101,795	15.50	4,856	12.78	44,488	17.74	195,424	23.87
1873	984,548	14.07	5,301	11.78	6,878	11.55	317,095	27.74
1874	1,152,732	16.75	6,536	15.20	8,999	15.05	196,909	30.00
Average crop per hectare	....	13.14	....	12.61	....	16.20	....	20.06

* No statistics by reason of the war.

The other more important products of the department are: Potatoes; vegetables, dried and fresh; the olive, vine, fruits, and tobacco. In their cultivation arrosage from the canals is being used more and more every year, as will appear later on.

For potatoes we have:

	Hectares.
1840	2,415
1852	3,446
1871	6,569
1872	5,729

No statistics as to yield per hectare.

For dried vegetables, beans, peas, lentils:

	Hectares.
1840	2,207
1852	2,608
1862	3,407
1871	3,509
1872	3,650

Fresh vegetables, market gardening, in 1862, 4,117 hectares. Since that time the raising of "primeurs" for the London, Paris, and Marseilles markets has greatly increased, so that the acreage now given to fresh vegetables exceeds 6,000 hectares.

The olive fell off from 24,000 hectares in 1840 to half that figure in 1872. This was caused by the large importation of Italian olive-oil and also to serious losses sustained by the French olive farmers, due to a succession of heavy frosts.

The vine has experienced many vicissitudes and shows great fluctuation.

	Hectares.
1840	24,991
1855	44,069
1869	61,303
1872	28,897

The old method of sowing wheat, etc., in the spaces, 1 to 2 meters between the rows of vines, is now regarded as very bad farming, neither harvest being up to the full yield, and the land is rapidly impoverished by the double work exacted of it. In 1866 a new enemy of the vine made its appearance in Vaucluse, and from thence gradually spread over the greater part of France, threatening the total destruction of viniculture. This was the phylloxera, a microscopically small bug, prodigiously fecund, multiplying itself by myriads on the roots of the affected vines, and exhausting the sap until the plant died. This insect after destroying one vineyard migrates to the next to continue its work. Various expedients were tried to kill the enemy, the object being to find some substance that, mixed with the earth, would destroy the insect without injury to the vine; but these efforts were not crowned with complete success.

A viticulteur, M. Francon, of the Bouches du Rhône, conceived the idea of drowning the pest, and it now appears that if the afflicted vines are submerged under water for a sufficiently long time they are completely freed from it. M. Francon submerged his vines for thirty consecutive days immediately after the vintage and killed the phylloxera without injuring the vine. The quantity of water necessary to submerge a vineyard depends on the permeability of the soil. About 864 cubic meters of water every twenty-four hours for each hectare was sufficient in M. Francon's case. The earth must be completely saturated to the depth of the roots. The submersion being accomplished the vines should be pruned and manured. This, of course, in the autumn after the vintage.

Among fruits the almond has been increasing in favor steadily since 1860. From 1,500 hectares in 1860 the number went up to 7,000 in 1870.

Other plantations of less extent and importance are: Figs, capers, jujube, pistache, peach, apple, pears, cherries, apricots, pomegranates, medlars, quinces, walnut, prunes, and agerole.

Much greater care and study is required for irrigating with good results the larger fruit trees than is necessary with the cereals and vegetables.

In 1863 there were seven hundred and fifty-two farmers, who raised 183,500 kilos of tobacco on 124 hectares, which the Government report of 1875 says paid them 945 francs per hectare, or about $90 per acre. In 1875 there were only two hundred and sixty-five farmers raising tobacco on 43 hectares. These are the last statistics. Now as to cost of production. Heavy manuring and frequent arrosage are required. The decline in tobacco production is partly explained by Government interference. A special permit must be obtained to raise it, and the Government specifies the kind of tobacco to be grown. It can be sold only to certain firms and at a fixed price. Its production in this department is unimportant.

One is led to compare southern California with Provence. The first has a milder average climate and a richer soil, enabling it to produce even a greater variety of fruit, in addition to the cereals, than southern France. It is stated that the counties of Los Angeles, Santa Barbara, Ventura, San Bernardino, and San Diego are alone capable of producing all the figs, grapes, olives, oranges, lemons, nuts, and prunes imported from France, Spain, and Italy. When land there is improved with bearing vines and fruit trees it brings from $100 to $500 per acre, while unimproved land can be had for one-fifth that price. Unimproved land in southern France means non-irrigable land, and can be had for $15 per acre, while lands of identically the same soil that are irrigated (*qui sont arrosés*), bring $500 per acre, devoted to the olive, small fruits, etc. These are the land values given by M. Menestrel in 1822, and it seems they are about the same to-day.

Southern California presents a similar climate, better soil, doing away with or greatly lessening the use of manure, one of the heaviest items in French farming, and needing but one thing—irrigation—to make the whole country as productive as the very choicest sections now are and capable of supporting an immense population. The most important question for southern California is irrigation, a rural economy that has been studied and successfuly practiced here for centuries.

While the cereals seem to be suited to large farming (*la grande culture*,) the vine, olive, small fruits, etc., pay better when produced on a small scale (*la petite culture*).

Southern California should be divided up into thousands of small fruit farms. French properties of this sort are frequently not more than 20 acres, sometimes much less, that being all the land one average family can cultivate without the employment of hired labor. The products of such a farm are raised on small patches.

One frequently sees but one acre given to wheat, another to the vine or olive, several for gardening, and the remainder in pasture on a 10 or 15 acre farm. The diversity of production prevents the farm work from being over-exacting at any one period, enabling the family to work on the different crops at different times, and keeping it busy all the year round. Besides it is found, even on these small farms, marked differences in the soil occur, so that experience has taught that it is more profitable to divide up 10 acres in several cultures than to confine them to but one. These small farms require little or no machinery in the American sense of the word.

Southern California should be covered with a net-work of irrigating canals as is the Bouches du Rhône. It appears that the Santa Anna is tapped to such an extent that in summer the river bed is perfectly dry and the irrigating value of its waters quite limited. By the construction of reservoirs for the storage of the waters that are allowed to escape to the sea in winter the irrigable area can be increased to any desired extent.

It is interesting to note that just as the water supply for arrosage in the Midi was and is managed by companies, so we read in the San Bernardino Times that "the Ontario Land Company has driven a tunnel in under San Antonio Creek a distance of nearly 1,800 feet at a cost of about $52,000, and they have about 250 inches of water, worth $250,000.

Part II. Irrigating canals, their origin and management, will be forwarded as soon as certain statistics can be obtained.

REPORT FROM F. F. DUFAIR, U. S. CONSUL, HAVRE.

[WITH INCLOSURES ON IRRIGATION IN THE DEPARTMENTS OF MANCHE, ILLE-ET-VILAINE, AND MAYENNE.]

This service (irrigation) is under the immediate management of the chief engineer of ponts et e chaussés (roads and bridges) in each department of France and under the head control of the chief engineer, director of agricultural hydraulics, Mr. Philippe, of the ministry of agriculture, at Paris.

The fact that Mr. Quinette de Rochemont, the head engineer of the port of Havre, has been absent for some weeks, the only government officer who could give me the desired information, must plead my excuse for not reporting before this.

From him I learned that there is no system of irrigation in the arrondissements of Havre and Yvetot, in the department of the Seine-Inférieure; the remainder of this department is under the management of Mr. Vivenot, chief engineer at Rouen. The chief engineers of the departments in my consular district, besides the above named, are Mr. Lucau, at Caen, Calvados; Mr. Perrin, at Alençon, Orne; A. Gouton, Cherbourg, Manche; L. Rousseau, Rennes, Ille-et-Vilaine; Floueand de Fourzcroy, Laval, Mayenne, to whom I addressed myself for the required information, and, with the exception of the two first named, they very obligingly answered my questions by the letters herewith inclosed, accompanied with my translation.

[Translation.]

LETTER OF A. GOUTON, CHIEF ENGINEER OF ROADS AND BRIDGES OF THE DEPARTMENT LA MANCHE.

CHERBOURG, *August* 17, 1889.

In answer to the request for information which you were pleased to address to me on the 8th of this month, I have the honor to say that there is very little irrigation, properly called, practiced in this department for summer watering. On the contrary, the climate, which is a most temperate one, makes submersions of low meadows during the winter months by means of brackish water very useful.

With these general remarks permit me to sum up the answers to questions 1 to 6 as follows:

(1) I have no data as to the extent of irrigable compared with non-irrigable or cultivated land in the department. It consists of pasture land for grazing cattle, or of meadows furnishing mowed hay.

The quality of this pasturage is most excellent, such as that of Isigny, Bessin (neighborhood of Bayen), Carentan (or, properly called, Cotentin), Valognes, etc., producing the famous butter of Isigny and Cotentin, the best in France.

(2) The water producing this rich grass in the department of Manche is almost exclusively rain-water. Rains are very frequent but rarely stormy or chilling, and

the average annual rain-fall at Cherbourg or Isigny reaches from 1 to 1.10 meter (39⅜ to 42 inches).

There are numerous springs, brooks, and streams, but it is only in the winter time, with rare exceptions, that lands are being overflowed.

(3) Therefore there are no reservoirs, only simple trenches, for the distribution of the water on irrigated meadows.

(4) The usage of water for irrigation is regulated by common law (articles 643, 644, 645, code civil) and the laws of April 29, 1845, and July 11, 1847.

Besides that, work of irrigation occasions syndical associations, subject to the law of June 21, 1865.

(5) The climate of the soil is most variable in the department of Manche, presenting the greatest variety of geological formations next to tillable soil.

(6) The local habit of submerging lands in the winter months in sweet water is very ancient; it is principally practiced on meadows and pastures near the sea, where the soil is below the level of high tides.

Winter irrigation in other regions of the department is in the hands of individuals without either rules or co-operation.

The general service of the water-courses, useful as well as detrimental to agriculture, devolves upon the department of ponts et chaussées (roads and bridges), having charge of agricultural hydraulics and belonging to the minister of agriculture.

[Translation.]

LETTER OF LÉON ROUSSEAU, CHIEF ENGINEER OF THE DEPARTMENT OF ILLE-ET-VILAINE.

RENNES, *August* 14, 1889.

SIR: Irrigation in the Department of Ille-et-Vilaine is of very small importance. Here is in a few words my report to the minister of agriculture:

Regular irrigation, that is to say, such as permits the possibility to admit and to draw off again the waters according to the requirements of cultivation at the proper time, is extremely rare.

One single instance of this kind has been submitted to the engineers in 1888 concerning the brook Français, on the confines of the departments of Ille-et-Vilaine and Manche.

Elsewhere irrigation consists only in submersion, in consequence of the rise of brooks, of natural meadows situated in the bottom of their valleys. The receding of the waters into their beds after freshets is facilitated by a great number of trenches dug at the confines of the several parcels of fields or traced according to the depressions of the soil.

Submersions are also practiced in some dried up ponds which have been transformed into meadows. These ponds having been drained by breaching a dike or highway to allow the water to run off, the system of irrigation consists in temporarily stopping up such breach to allow the water to rise and to overflow the neighboring fields.

LÉON ROUSSEAU,
Chief Engineer of Road and Bridges, Ille-et-Vilaine.

[Translation.]

LETTER OF MR. FLOUAND DE FOUZEROY, CHIEF ENGINEER OF ROAD AND BRIDGES, DEPARTMENT OF MAYENNE.

LAVAL, *August* 10, 1889.

SIR: You are pleased to send me an interrogatory regarding irrigation.

I should have been happy to answer it, as far as this department is concerned, but it would be difficult to do so in a precise manner.

Irrigation is frequent in this department, where the soil is very much broken and divided into a great many basins; there are thus many small and rapid water-courses, where it is easy to construct small dams and to turn the water into trenches to irrigate numerous natural meadows; but there are no statistics existing to state the extent of land susceptible of irrigation compared with such as is non-susceptible.

There are no reservoirs; there is only one syndical association of small importance occupying itself, principally, with the draining of meadows with the view of making them salubrious.

The climate is rather rainy, the subsoil impervious; there are no extended or deep valleys, neither are there table-lands or heaths.

On the whole I don't believe that the interrogatory which you did me the honor of addressing to me can be answered in an interesting or precise manner.

Please accept, etc.

FLOUAND DE FOUZEROY.

REPORT FROM ALBERT N. HATHAWAY, U. S. CONSUL, NICE, ON IRRIGATION IN SOUTHERN FRANCE.

Irrigation here is applied for the most part to ornamental, horticultural, and vegetable gardens, instead of to fields of general agriculture, and to no grain lands whatever, and in but small extent to the vineyards and orchards of oranges, lemon, and olive. The expense for flowage water, procured from the hydrants works of the city of Nice, renders such use largely unprofitable, and the scarcity of the natural supply precludes its systematic application to any wide degree, except in the valleys of the Var and lesser rivers. When irrigation here is practiced production is doubled without injury to the quality of the crop; sterile soils, long useless, recover and yield abundantly, and in many localities, to insure valuable returns to the husbandman, it is of absolute necessity.

The ordinary sources of water, for the purpose, are ancient wells from which, during hours in each day, it is drawn by mule-power and quite primitive machinery into distributing tanks and inherited slow methods of labor.

The said company having obtained a concession, with an appropriation therewith of two and one-half millions from the state, was organized in 1878 and its works established at a cost of 12,000,000 francs.

Its supply is obtained from the river Vesubie, in the valley of that name, distant about 30 miles from Nice, from which river it is led, flowing at the rate of 4,000 liters each second, in an open, cemented canal to a distributing reservoir on the heights in the suburbs of said city. In its treaty with Nice the company is bound to supply the city, for the annual payment of 80,000 francs, with 60,000 cubic meters of water daily for its abattoirs, sewers, fountains, and public works. The water for domestic uses, also provided by said company, is derived from a separate source, viz, the mountain springs of Sainte Thecle. Under the aforesaid concession from the state the company covenants, during the term thereof, viz, until 1972, to maintain the construction of their works for the public utility of the region and to furnish flowage at fixed prices therein stipulated. Otherwise than this, said corporation is unsubjected generally to the Government control. The established tariff for its continued use for irrigation on ordinary levels is as follows, viz: For 1 cubic liter per day, annually, 30 francs; for 2 cubic liters per day, annually, 55 francs; for 3 cubic liters per day, annually, 60 francs, and for each additional daily cubic liter, 20 francs annually. The tariff for its periodical use is proportionate to the above table, conditioned, however, to an agreement as to quantity to be consumed. The service pipes are in all cases at the charge of the proprietor.

The region, having thus facilities of irrigation, is by nature restricted to the foot-hills and narrow valleys of this district, beyond and above which are the mountains barren of or discouraging to cultivation. The limits, owing to the configuration of the coast, the counter scarps of Alps, and the proximity of the sea, which serves as a vast reflector of the sunbeams, is semi-tropical in character. The soil, producing two or more variable crops a year, is alluvial, with a humus surface and a gravelly substratum, and quickly absorbs all moisture. In May the temperature averages 64°, in June 70°, and in July and August 78° Fah. In winter it averages 52°. From May to November more than one hundred days are usually without clouds. The average rain-fall is from 80 to 100 centimeters per annum.

REPORT FROM EDWARD CAMPHAUSEN, U. S. CONSUL, NAPLES, ON IRRIGATION IN SOUTHERN ITALY.

I have the honor to report that on receipt of your circular instructing me to furnish information on the subject of irrigation as practiced in this country, I immediately applied for statistics to the prefect of the ten provinces composing this consular district.

In course of time, after the delay usual to these officials, they replied that, owing to the scarcity of water-courses, there were no lands under irrigation in their respective provinces. It is claimed that the geological and lithological condition of the country are such that it would be impossible to carry any system of irrigation into effect.

This country depends absolutely on the rain falling mainly during the months from November to April. The average annual rain-fall is said to be about 20 inches. There are some lands under private irrigation. The water supply belonging to the respective land-owners is taken from wells, at a depth varying from 25 to 100 feet, water being found in abundance at that depth in most parts of the country. Near the coast of the Adriatic and Mediterranean wells are formed by the infiltration of salt water. Some of these belong to communities, but no definite law or regulations appear to exist for the use or distribution of the water, and there is no irrigated land, in the true sense of the word, in this district.

I inclose a copy of the law concerning the derivation of public waters and also a publication discussing a project for supplying the province of Ban with water for domestic purposes.

REPORT FROM EDWARD P. EARLE, U. S. CONSUL, COGNAC, ON IRRIGATION IN THE DEPARTMENT OF LA CHARENTE.

I deferred answering the Department's circular of May 2, 1889, concerning the methods of irrigation in use in my consular district, until I could fully possess myself of the facts of the case. To this end I sent the circular, through Hon. Oscar Planat, the mayor of Cognac, to the chief engineer of La Charente, at Angoulême. I received from him a few days ago, through the mayor, a long, rambling reply to my interrogatories, which may be summed up as follows:

(1) That the engineer has no knowledge of any system of irrigation now in practical use in this department.

(2) That all his information is derived from the library and archives of his office, and finally that he refers me to the departments forming the old government of Provence. There, he says, extensive systems of irrigation are practiced. He also suggests that inquiries should be addressed to the minister of agriculture, at Paris.

For my own part here are my observations:

This part of France is quite abundantly watered; the Charente, the Nee, and many other smaller streams traverse it, and so far as my observation extends the question with farmers here is what to do with surplus water rather than any question of irrigation. All the canals, dikes, and ditches are exclusively for the purpose of restraining overflows or for draining wet or submerged lands. The river and creek bottoms are generally broad and level and very subject to overflow, to the great detriment of the grass planted thereon. The receding waters leave a fine deposit of mud on the stems and blades of the grass, which, drying with the hay, becomes a dust very damaging to the stock eating it. At this moment, when the new hay crop is come into market, almost all the horses of the arrondissement are affected with a severe cough like that of hay fever.

The highlands of this arrondissement are quite out of the reach, in my judgment, of any practicable system of irrigation, nor does it require it. Some seasons are said to be very dry, but a protracted drought I take it, is a rather rare occurrence. The principal characteristics of the climate appears to be its humidity. The night moistures or dews seem to me quite sufficient by themselves, the soil meanwhile being a little stirred to furnish all the plant requires.

I send no maps, published reports, or books on the subject of irrigation in France, as the consul at Marseilles, where that system of agriculture prevails, can make a more discriminating selection than I could here. I content myself with saying, in fine, that no system of irrigation prevails in my consular district. I do not know, nor have I been able to find, any competent expert on that subject.

REPORT FROM WALLACE S. JONES, U. S. CONSUL, MESSINA, ON IRRIGATION IN THE PROVINCE OF MESSINA, SICILY.

Irrigation in Sicily dates from the occupation of the island by the Mussulmen. They took possession of Palermo in 831, and gradually extended their sway. Ruins of the Emir's castles, agricultural terms still in use relating particularly to irrigation, and numerous African plants all testify to their former presence here. In the year 872 they first began the use of the "*noria*" (*senie*), raising well water into water towers (*giarraton*) or cisterns (*giabiat*), whence it was distributed by means of small ditches (*sajat*), and this is the system in general use to-day.

Irrigation did not attain the same development in this province as in that of Palermo for the reason that water veins are not as numerous here. Since 1850 the search for water has been steadily on the increase, due to new methods of reaching it (by drilling) and of raising it (by endless chains of iron buckets instead of the old-fashioned *noria* with paddles) and to improved gearing. Water is pumped up, and many of the wells are 100 feet deep and over, by horse-power; oxen are also much used for this work, and occasionally by steam-power. There is no coal in Sicily, and the lack of roads makes its transportation from the seashore too expensive.

According to the Italian civil code all waste under the beds of rivers or torrents belongs to the State; but while this is the law it happens, nevertheless, that owners of land along the water-courses use the water with more or less immensity, so that but a small quantity may be said actually to belong to the public domain.

The supply of water for irrigating purposes in this province is small. The extremely mountainous district of Val Demone is not adapted to the percolation of rain-water, particularly as a short-sighted policy has destroyed the natural reservoirs, the forests, thus permitting the rain to run off and waste. As a result not a single river is to be found in the province, but we meet at every hand destructive torrents (their beds are dry in summer), whose havoc is ever on the increase. There are no less than thirty torrents in a stretch of country 45 miles wide in this province. Natural springs are but few, so that the greater portion of the water used for irrigation as well as for drinking purposes is obtained by means of costly hydraulic works, tunnels, wells, cisterns.

The topography of the Messina district does not allow of the formation of lakes, and, with the exception of two small brackish sheets of water near the Faro and of a fresh-water pond in the commune of Rouella Valdemone, we find no lakes here.

Owing to the deficiency in the water supply and to the greater portion of this district being mountainous but one-sixteenth of the total cultivable area (*i. e.*, 14,000 hectares) is irrigated. Of the irrigated area:

	Hectares.
Oranges and lemons occupy	7,600
Market gardens*	800
Flax and hemp	200
Indian corn	1,000
Legumes (beans)	1,400
Fruit trees, peaches, pears, etc	500
Reed cane	2,000
Marshes	500
	14,000

Irrigated land produces crops not only superior as to quality but threefold as to quantity compared with non-irrigated land. Irrigated open land sells for three times as much as the non-irrigated; near the city of Messina it fetches from $780 to $1,230 per acre.

The water is pumped into well-cemented reservoirs or vats, generally prismatic in form (because cheaper), rarely circular. We also meet with covered cisterns. From the collecting reservoir the water is made to pass into the distributing reservoir through gutters called "condotti," or "tubi," conduits or pipes. The water is carried from the distributing reservoir to different parts of the grove, either by trenches called "sajat," or by brick conduits either closed or open on top. The latter are known as "brinzi."

The open conduits are to be preferred, because they do not choke and because they are not liable to burst.

Should the grove be extensive, small distributing reservoirs called "bisternoli" are established here and there.

This distributing of water for irrigation purposes, when the water is private property (for by law the owner is allowed to make what use of it he pleases, provided he does no damage to his neighbors), is not governed by law, but by special customs that vary with the locality and which it would be impossible to enumerate.

The cost of water for irrigation purposes is so complicated a matter that it can not be fixed precisely, but this much can be said: In this province a penna (a goose-quill) of water, *i. e.*, 36 gallons of water per hour, costs from $200 to $260 per annum.

Here, as a rule, water is private property. Some communes own water either by purchase from private parties or because its source is on community land.

The title to water is acquired by bargain and sale, exchange, gift, and can also be acquired by prescription. Not less than thirty years of undisturbed enjoyment are necessary to create title by prescription.

---

*It should be added that garden truck is very generally cultivated in the vacant spaces in orange and lemon groves.

As to the climate of this province, the maximum of heat is 87° Fah. Some winters the thermometer falls to 20° below freezing, but this temperature prevails for a very short period. Snow covers the tops of the mountains for several months during the winter, and nearly every year reaches the sea-shore, covering the ground for a few hours. At Messina the temperature changes with the currents (which are tidal) that pass through the straits. From October to December it rains frequently; in January and February it rains and snows; in March and April it rains constantly. Open weather begins in May and lasts to September with an occasional heavy down-pour. Annual rain-fall 22 inches. During the spring and autumn months fogs prevail on the mountains; it rarely hails; dew and white frost occur frequently; frost in April inflicts considerable damage.

No hydrographic maps or publications bearing upon irrigation in this province exist. Less attention has been paid to irrigation in Sicily than in any other portion of Italy; but little progress has been made since the days of the Arabs.

A few years ago a technical school for instruction in hydraulics was opened in Palermo. If the water of the numerous torrents in Sicily were to be controlled and utilized in irrigation, many localities now infested by pernicious and malarial fever would become healthy and habitable. Statistics show that one-fifth of this island is subject to the influence of stagnant water and of the dry beds of torrents during the summer and the organic matter accumulated for centuries in these low spots breeds foul emanations that poison the air.

No works for the storage and distribution of water have as yet been undertaken by the Government in Sicily. In 1858 a company with a capital of $150,000 undertook, under a charter from the Bourbon Government, to utilize the water of the River Simeto in irrigating a portion of the plain of Catania, the total area of which is 65,506 acres. A rough stone dam was thrown across the river at Paterno and two principal canals, one to the right (20,000 yards long) and the other to the left (30,000 yards long) of the river-bed were opened down to the ocean. Four secondary canals (leading from the principal canals) were also opened, and these were intersected by numerous irrigation ditches, the latter of a total length of 10,000 yards. The banks of the canals are faced with stone or with logs whenever the land has a tendency to slide. At the dam the canals are 6 feet wide at bottom, 29 feet wide at top, and 6 feet deep; the banks have an incline of 45 degrees.

The dimensions of the canals decrease as you go from the dam. The depth of water in main canals should never exceed 4½ feet. The average mean amount of water that passes through the canals is 722 gallons per second. The company charges $67 per 7 gallons a second from April to October 1, and $33.50 from October 1 to April 1.

In the plain of Catania, on a calcareo, argillaceous soil, wheat legumes and flax require 4¾ inches of water from October to April. Summer pasture lands require 12 inches of water. The very stiff clay lands in this plain appear to be adapted to rice culture only. Quite an area is so flat that the water ponds on the land and the slime left by the water impoverishes the land and makes it more difficult to cultivate. This undertaking has been a failure financially; not only has the original capital been sunk but a debt of $120,000 hangs over the company.

The only other work of importance in Sicily connected with irrigation is the dam 2½ miles above Ferranova, province of Caltanisetta.

This massive stone dam is 360 feet long, 24 feet wide at the base, 15 feet wide at the top, and 30 feet high, and was thrown across the River Gela at a cost of $85,000 by the wealthy Duke of Montelevore, descendant and heir of the great Cortes, as far back as the year 1788. An irrigation canal leads out from either wing of the dam; area irrigated 11,860 acres. Below the dam the water falls on a stone platform 138 feet wide by 123 long, and then follows its old bed to the sea. At the point where this dam is erected the river runs through a gorge, the sides of which constitute natural stone walls. An elliptical gap, 80 feet wide by 10 feet deep, has been left towards the middle of the dam. At this point fascines are thrown against the dam on the water side, and earth is thrown on the facines, constituting as it were a floating island, the surface of which is brought almost to a level with the dam on either side of it. Pistachio trees, tamarack shrubs, and grass are set to grow on this island, which serves as a tumbling dam.

As the water rises it gradually rus off, overflowing the island, which, in times of a strong freshet, is carried away bodily. It costs $500 per annum to keep up this island; it would cost $800 to replace it. The land irrigated by means of this dam produced from 1862 to 1865, 5,000 bales of cotton (of 450 pounds) per annum. Cotton is still grown for home wants on a small scale.

Since 1865, the Italian Government has expended large sums in draining marshes, lakes, and ponds, and in controlling the course of rivers and torrents in Northern and Central Italy. Valuable documents, not for sale, however, treating of these works have been published by the minister of public works. As yet no government report has been published treating of works of irrigation, and to get at figures it would be necessary to apply to the several prefectures of the several provinces.

By the law of December 25, 1883, the Government is empowered to loan funds (principal payable in thirty years) at 30 per cent. to irrigation associations (consozzi) and to provinces and communes for the purpose of carrying on works of irrigation, provided the supply of water to be obtained shall be not less than 25 gallons per second and provided the province or commune advances an amount at least equal to one-tenth of the sum loaned by the state.

REPORT FROM CONSUL JONES ON IRRIGATION OF ORANGE AND LEMON GROVES IN SICILY.

In Sicily, generally speaking, no attempt is made to grow oranges or lemons unless it be possible to water the trees during the summer months. There are, however, favored spots (for instance near Aci Reale, 40 miles south of Messina) where, owing to water veins in the subsoil, the trees retain their vigor during the summer. The proportion of non-irrigated to irrigated groves is as 1 to 15 (in extent).

One hundred ten-year old lemon-trees that are watered produce on an average 15,000 lemons, whereas one hundred trees that receive no water (other conditions being equal) produce but 10,000 or one-third less.

The groves are watered from twelve to twenty-five times during the summer, *i. e.*, either once every two weeks or once a week, and at each watering at least 350 cubic meters should be allowed to the hectare (1 hectare=2.47 acres).

At the last spring working of the trees the land is trenched in order to obtain an equal distribution of the water.

Parallel trenches are opened (generally about 6 inches deep and 8 inches wide at the bottom) between the rows of trees, the intermediate space being divided into symmetrical squares or divisions.

If the grove be very level the water is carried from the distributing reservoir by lines of brick pipes (brinze) open on top, resting on narrow stone walls built with the necessary incline to reach the most distant point from the reservoir.

The system is applied to the irrigation of groves where the water supply is abundant and is derived from a stream or spring. Oftentimes when the water must be pumped up by horse-power the tenant, unless it be otherwise stipulated in the contract, will so arrange his trenches as to collect the water in a basin at the foot of the trees. This method is not to be commended, for it retards the developement of the fruit, of the lemons more especially, and predisposes to gum or foot-rot.

One-year-old orange and lemon trees should be watered once a week; three-year-old require water once every twelve days; from the fourth to eighth year, once every two weeks. With the bergamot, however, weekly irrigation is required during the life of the tree. It is always preferable to irrigate during night-time. Isolated trees are sometimes watered by sinking an earthen pipe (3 feet long by 4 inches in diameter) not far from the trees, and filling the same with water. This method has the advantage of causing the tree to send its roots down. The beds of the torrents suck down the water from the springs on the hill-sides. To bring this water to the surface, oblique ditches are cut across the torrent-beds down to the water veins, and a drain (provided with numerous loopholes) in masonry is put in to collect the water. These drains, following more or less the trend of the land, carry the water into the groves to the right and left.

Bastard fruit, *i. e.*, fruit maturing out of season, always commands good prices; hence it frequently happens that tenants allow the trees to go without water during June and July (the trees sicken badly; the leaves turn yellow, and there is great loss of vitality), and begin watering heavily and frequently in August, to form the trees to put on blooms in September, and in that way produce late fruit.

REPORT FROM PHILLIP CARROLL, U. S. CONSUL, PALERMO, SICILY.

(1) There are 508,601 hectares of land embraced in the Province of Palermo, of which one-fortieth is cultivable and irrigable. Nearly 176,000 hectares are under irrigation, yielding on the average an eighth per cent. crop.

(2) Water is derived principally from deep wells, pumps, and reservoirs, the latter being supplied by means of earthen and iron tubes or pipes communicating with the adjacent mountains, as well as by rivers, streams, springs, and falls in a very limited degree, during certain months of the year. The supply of spring water is, however, said to be decreasing.

(3) A pamphlet upon the system of irrigation in the Province of Palermo, by Prof. Ferdinando Alfonso, kindly furnished by the prefect of this province, is inclosed herewith, as to the character of the works used in irrigation.

(4) The distribution of water is governed by its owners, viz, the municipality, the Government, and private individuals, and is based

upon the measures adopted by the municipality of Palermo centuries ago.

The amount of water used on the average is from 300 to 350 cubic meters per hectare of land.

By the system in vogue nearly 17 liters of water can be conveyed to a designated point per second, and an area containing nearly 13 acres can be irrigated weekly, the charge therefor being 5 lire per hour.

Irrigation is commenced on April 15 annually. For obvious reasons it is not resorted to during winter, excepting in prairie lands for promoting the development of grass.

(5) The average annual temperature of the Province of Palermo is 17° centigrade.

In the mountainous regions the climate is temperate, and on the seacoast very warm.

A characteristic of the province is the almost absolute absence of rain from May to September.

The average annual rain-fall of the province is 59 centimeters. Rain later than May is rare and generally meager, and should the usual copious spring rains fail to make their appearance crops suffer severely.

(6) As stated, the present system, consisting of pumps, wells, falls, reservoirs, etc., has obtained for centuries, under the auspices of the municipality of Palermo monasteries and private persons, but since 1866 the Government has controlled the water belonging to religious bodies, it having in that year confiscated all property belonging thereto. The Government either sells or rents this water. The expense is defrayed by the respective owners.

SESSIONS OF THE COMMITTEE.

Page.
Washington, D. C., January 17, 1890 5
January 21, 1890 37
January 24, 1890 68
January 31, 1890 95
March 13, 1890 132
March 14, 1890 151
March 18, 1890 162
March 21, 1890 170
March 22, 1890 183
March 28, 1890 205

INDEX.

A.

Page.

Altitudes:
  Angles of elevation and depression by ... 179
  Arid region, north and south ... 10
  Central City, at ... 57
  Fort Robinson, Nebraska ... 57
  Gila River, of the ... 33
  Groton, at ... 54
  Indian Creek, Nebraska ... 57
  Hamilton County, in ... 59
  High, observation of climate ... 104
  Instruments to ascertain ... 179
  Kearney, Nebraska ... 57
  Keya Paha, Nebraska ... 57
  Low, observations of climate ... 104
  List of, Nebraska, in ... 57
  Mouth of Snake River, at ... 57
  Nevada ... 102
  Niobrara River, Nebraska ... 57
  Ogallala, Nebraska ... 57
  Pine Bluffs, Nebraska ... 57
  Scotts Bluffs, Nebraska ... 56
  Sidney, Nebraska ... 57
  Topographic survey, by ... 178
  Yellowstone Park, Wyoming ... 245
Appropriations, allotment, and expenditures ... 139
Artesian wells ... 34, 35, 44, 45, 46, 55, 59, 66, 86, 87, 88, 90, 91, 92, 93, 94, 95, 96, 98, 99, 169, 220, 221, 238
  Battle mountain at ... 240
  Boring of ... 45, 92, 94, 97
  Brownville at, in Nemaha County ... 57
  Cambrian Rocks, through ... 47
  Cass County, in ... 47
  Chemical composition of water in ... 51-57
  Cost of ... 92
  Cretaceous ... 47
  Classification, Dakotas, in ... 47, 50, 51, 52, 53
  Dakotas, the, data of ... 53
    sandstone, in ... 94
  Devil's Lake, analysis of water in ... 51
  Exploration of ... 89
  Flowing ... 45
    Toombstone, at ... 99
    Nebraska ... 57
  Geological formation, Kansas ... 57, 58
  Grafton, at ... 53
  Great Bend, at ... 59
  Huron, at ... 89, 92
  Jamestown, at ... 51, 92
  Kansas, of ... 59
  Larned, at ... 59
  Lincoln, at ... 57
  List of, west of the Dakotas ... 50

Page.

Artesian well—Continued.
- Locating, 87
- Location, in the Dakotas, 47
- Manitoba shallow wells, 48
- Meade County, in, 97
- Minnesota, region, 47, 48, 49
- Nebraska, in, 57
  - in northern and central, 97
- Nevada, in, 102
- Omaha, at, 57
- Pan Handle region, in the, 97
- Pierre, at, 47, 50, 51, 52, 53
- Pleistocene, 52
- Pressure of, at Grafton, 54
- Redfield, at, 89, 92
- Red River Valley, in, 47, 52
- Region of, 97
- Richfield, at, 59
- Rosenfield, at, 48
- Russell, at, 59
- Source of water in, 54
- Staked Plain and Panhandle region, upon, 98
- St. Helena, at, 57
- Subhumid region of the Great Plains, geological data relating to, 47–61
- Strata, water-bearing, Carboniferous, 59
  - Cretaceous, 59
  - Miocene, [illegible]
  - Pleistocene, 52
  - Trias, 59
- Tables of, in Dakota, 47
  - Kansas, 60
  - Manitoba, 48
  - Minnesota, 49
  - Nebraska, 57
  - Texas, 62
- Table of temperature (Dakota sandstones), 52
- Texas, of, 45, 61, 97
- Tombstone, Ariz., at, 99
- Tower City, at, 53
- Unsuccessful in Minnesota, list of, 48
- Winfield, 59

B.

Basins:
- Artesian, 88, 91, 93
- Arkansas drainage, the, 14, 147, 148, 151, 163, 181, 183, 185, 187, 188, 195, 197, 206, 207
- Carson, the, 79, 149
- Chama, the, 25
- Colorado, the, 38, 45
- Dakota, the, 96
- Denver, the, 45
- Drainage references, 23, 37, 101, 155, 160, 163, 166, 170, 171, 174, 179, 199, 208, 209, 210, 211
  - Colorado, of the, 38
  - Pecos, of the, 16
  - Taos, of the, 29
- Geologic, the, 44, 45, 86
- Gila drainage, of, 34
- Great storage, 101
- Great, in the, 36, 40
- Humboldt, the, 239
- Hydrographic, references to, 23, 25, 26, 32, 47, 66, 140, 152, 153, 155, 157, 162, 163, 175, 196, 197, 210
- Interior, the, 118, 119
- Irrigation, 221
- Natural, 66, 207
- Republican, the, 97

Basins—Continued. Page
  Rim Rock of the Artesian ....
  Rock Creek, the 93
  Sand, White Rock Cañon 239
  Snake River, the 30
  Taos, the 147, 148, 151
  Truckee, the 29
  Upper Arkansas, of the 79, 149, 151
  Yellowstone Lake, natural storage 163
Bird and animal life in arid regions 43
131

C.

Canals, mention of:
  High-line ....
  Low-line 26, 99, 107, 140, 228
  New Mexico, construction of, in 33
  Sites for 17
Cañons: 23, 32, 64, 65, 76, 77, 80, 152, 162, 163, 166, 193, 199
  Embuda ....
  Eureka 18, 20, 24, 25, 29
  Grand 160
  Panamint 38
  Santa Anita 144, 160
  San Antonia 123
  San Dimas 123
  San Gabriel 123
  Sawpit 123
  Soledad 123
  Tejunga 123
  White Rock 123
Cities and towns: 25, 26, 29, 30
  Albuquerque ....
  Bernalillo 25, 26, 29, 70
  Bismarck 25, 26, 30
  Blanchford 44
  Buena Vista 52
  Calabasas 148
  Cambrian 99
  Chicago 48
  Cia 46
  Crookston 30
  Deming 52
  Denver 99
  Dodge City 36, 46, 161, 220, 230
  El Paso 97
  Emerson 17, 18, 20, 26, 27, 31, 70, 78, 105, 147, 148, 181, 196
  Eureka 48
  Florence 161, 239
  Fresno 100
  Garden City 20
  Grafton 148
  Granada 47
  Greeley 148
  Helena 230
  Jemez Pueblo 44, 80
  Johnstown 26
  Las Vegas 217
  Leadville 181
  Lincoln 148
  Livingston 55
  Los Angeles 81
  Los Lunas 123
  Maricopa 25
  Marienfelt 99
  Midland 97
  Mojave 97
  Niobrara 100
  Odessa 55
  Pasadena 97
123

Page.

- Cities and towns—Continued.
  - Phœnix 35, 147
  - Platteville 230
  - Pocatello 150
  - Point of Rocks 31
  - Pueblo 186, 187
  - Riverside 123
  - San Francisco 79, 180
  - San Jacinto 123
  - San Marcial 29
  - Santa Barbara 123
  - Santa Fé 26, 30, 70, 149, 181
  - Socorro 25, 26, 27, 29, 31
  - St. Vincent 48
  - Tacoma 110
  - Tubac 99
  - Tucson 36, 99
  - Tuuvacacori 99
  - Vermillion 47, 50
  - Wadsworth 79, 149
  - Washington, D. C 161, 220
  - Yankton 47, 50, 59
  - Yuma 147
- Climate, reference to 104, 130, 171, 242
  - Agricultural, the 32
  - Arid, the 46, 63
  - Cold, a 16
  - Southern California, in 122
  - Subhumid 46, 63
  - Subtropical 35
- Coal:
  - Anthracite fields 12
  - Arid region in 12
  - Component beds of 56
  - Rock Springs, Wyoming 13
  - Sulphur Creek, at 13
  - Supply of 12, 13, 14
- Counties, Names:
  - Butte 79
  - Clark 58
  - Clay 58
  - Comanche 58
  - Croley 59
  - Dickinson 58
  - Elko 238, 239, 240, 241
  - Esmeralda 102
  - Eureka 239, 241
  - Humboldt 239
  - Jewell 58
  - Kern 79
  - Lander 239
  - Lassen 79, 149
  - Los Angeles 122, 340
  - Marion 58
  - McPherson 58
  - Modoc 149
  - Morris 58
  - Norton 59
  - Nye 102
  - Phillips 58
  - Pratt 58
  - Reno 58
  - Rice 58
  - Russell 59
  - San Bernardino 122, 340
  - San Diego 122, 180, 340
  - Santa Barbara 340
  - Sheridan 59
  - Ventura 340

Counties, names—Continued. Page.
  Washington
  Weld 58
  White Pine 230
Countries, names and mention of: 102
  Africa
  Algeria 46
  Asia 199
  Austria 46, 129
  British America 110
  Canada 63
  China 47, 54, 111
  Egypt 102, 103
  England 102, 103, 199, 287
  Europe 252
  France 46, 65, 260
  Germany 34, 110, 199, 252
  Great Britain 110, 252
  Greece 304
  India 305
  Italy 139, 180, 199, 204
  Manitoba 34, 110, 199, 305
  Mexico 47
  Norway 17, 18, 21, 27, 28, 31, 32, 63, 99, 105
  Prussia 9
  Russia 110
  Spain 199
  34, 199, 305
  United States 5, 12, 18, 27, 43, 44, 63, 64, 65, 66, 71, 73, 79, 88, 99, 100, 105, 110, 122, 129, 132, 145, 156, 157, 190, 200, 242, 250, 252, 256, 259, 287, 288, 302
Creeks:
  Bishop
  Cherry 239
  Goose 230
  Hanks 238
  Maggie 239
  Monument 239
  Rock 148
  San Antonio 239, 240
  Santa Fé 341
  Sulphur 26, 30
  Susie 13
  Thousand Spring 239
  Walnut 240
Crops 100
  Barley 16, 90, 101, 196, 238
  Bunch-grass 130
  Cereals 127
  Corn 21, 239
  Grain 19, 21, 38, 42
  Grasses 9
  Hay 15, 19, 24, 30, 31, 32, 99
  Indian corn 16, 26, 38, 39
  Oats 130
  Potatoes 21, 38, 39, 130
  Rice 9, 21, 38, 39
  Roots 38
  Rye 99
  Sugar 9, 38, 130
  Vegetables 35, 38
  Wheat 38, 239
  16, 19, 21, 38, 39, 42, 130

D.

Dams, mention of.
  Arizona, in
    at Walnut Grove 194
  Ditches, for, near Rio Grande 138
  Eagle Rock, site at 26
  El Paso, international at 150
  Hassayampa 105
  159, 211

Page.

- Dams, mention of—Continued
  - Johnstown, at ... 194
  - Loose rocks ... 139
  - Sites ... 23, 32, 65, 76, 77, 162, 193
  - Teller Ditch Company ... 187
- Drainage areas ... 28, 32, 34, 23, 137, 43, 64, 66, 69, 73, 81, 98, 99, 100, 102, 103, 107, 194, 202, 206, 217, 222
  - Albuquerque, at ... 26, 29
  - Arkansas, the ... 212
  - Colorado ... 39
  - El Passo, at ... 32
  - Jordan, the ... 39
    - Headwaters of ... 23, 24, 32
  - Hydrographic ... 26
  - Lake Tahoe, of ... 106
  - Lost stream ... 23, 24
  - Rio Grande, on the ... 22, 23, 25, 28, 32
  - Sagnache, the ... 24, 28
  - San Ildefonso ... 28
  - San Luis ... 24, 29
  - Sevier, the ... 39
  - Truckee, the ... 103

E.

- Engineers:
  - Bodfish, Sumner H ... 183, 184, 205, 206, 207, 208, 209, 210, 211, 212, 213, 214, 215
  - Calderon Louis ... 323
  - Coyle, J. E. T ... 304
  - Dutton, Clarence E ... 132, 133, 134, 135, 136, 137, 138, 139, 140, 141, 142, 143, 144, 145, 146, 147, 148, 149, 150, 151
  - Follett, W. W ... 148
  - Hall, W. H ... 149
  - Hinton, R. J ... 95, 96, 97, 98, 99, 100, 101, 102, 103, 104, 105, 106, 247
  - Langdon, W ... 319
  - McKinney, H. G ... 308
  - Morrison, James G ... 280
  - Nettleton, E. S ... 34, 105, 106, 215, 216, 217, 218, 219, 220, 221, 222, 229, 230, 231
  - Schuyler & Allard, Messrs ... 273
  - Thompson, A. H ... 179, 180, 181, 182
  - Wood, A, Pepys ... 299
- Entomological Commission, extracts from ... 127, 128, 129, 130, 131
- Entomology, Division of, report from ... 125, 126
- Evaporation ... 14, 15, 23, 26, 28, 32, 33, 34, 73, 74, 76, 77, 110, 134, 137, 143, 160, 171, 173, 208
  - Denver, at ... 110
  - Growing plants, of ... 19
  - High altitudes, at ... 14
  - Important study an ... 134
  - Low altitudes, at ... 14
  - Stations, for measuring ... 147

F.

- Falls, river:
  - American ... 150
  - Great ... 44
- Financial policy, for irrigation needs ... 231, 232, 233, 234, 235, 236
- Forts, United States:
  - Benton ... 51, 54, 55
  - Hamilton ... 129
  - Pierre ... 51, 54, 55
  - Selden ... 31, 149
  - Shaw ... 129
- Forests:
  - Area in arid land ... 9, 10
  - Canada, in ... 1, 11
  - Deforestation, southern California, in ... 122
  - Fires ... 11, 12
  - Map of, destroyed by fire ... 11
  - New Mexico, in ... 25

Forests—Continued. Page.
  Pine and cedar, of.................. 10
  Protect the, to.................. 110
Fruits, small, references to.................. 38, 99
  Cherries.................. 130, 239
  Currants.................. 130
  Gooseberries.................. 130
  Grapes.................. 249
  Raspberries.................. 130
Fruit trees, reference to.................. 18, 123
  Apple.................. 130, 241
  Date.................. 35, 38
  Orchards.................. 94, 122
  Orange.................. 35
  Peach.................. 241
  Plum.................. 130

G.

Geological formations in Kansas.................. 58, 59
  Nebraska.................. 55, 56, 57
  Texas.................. 60, 61
  distribution, their area.................. 56
  Kansas, of.................. 58
  Texas.................. 61
Gulf of California.................. 34
Government aid to irrigation.................. 27, 66, 76, 95, 101, 125
  Canada, in.................. 111

H.

Hills, mention of:
  Black.................. 13, 54, 55, 116, 124, 129
  Cypress.................. 128

I

Irrigation, reference to:
  Acres in Rio Grande Valley.................. 20
  Ancient.................. 17
    at El Paso and Mesilla.................. 28
    and modern on the Pecos.................. 17
  Animal and bird life, effect on.................. 109
  Area of.................. 26
  Areas, totals, States and Territories.................. 6
  Arizona, area of.................. 7
  California, area in.................. 18
  Canals and works for.................. 17
  Channels of distribution, for.................. 100
  Colorado, in.................. 7, 20, 27, 28
  Elements that enter into work.................. 171
  Entomological stand-point.................. 124, 127, 129
  Forest conditions, relations to.................. 112, 113, 114, 115, 116
  Gila region, of the.................. 34
  Hinton, R. J., report on, reference to.................. 109
  Idaho, areas of.................. 7
  Jordan Valley, in.................. 39
  Maximum of.................. 21
  Mesilla Valley, in.................. 31
  Montana, areas of.................. 8
  New Mexico, in.................. 18
    areas of.................. 8
  Nevada, in.................. 102
  Oregon, areas of.................. 8
  Pecos on the, New Mexico.................. 16
  Problem, of.................. 205, 206
  Problems of forestry.................. 112, 113, 114, 115
  Pumps, by.................. 35
  Salt River Valley, in.................. 35
  Seasons, of.................. 14, 18, 20, 24, 25, 26, 27, 39, 152, 196, 242

Page.

Irrigation, references to—Continued.
  - State Department, letter to, on 249
    - circular from, on 249, 250
  - Systems of 124
    - large, desirable 100
    - high altitude storage, of 100
  - Utah, areas of 9
  - Vegetation, effect on 109
  - Works, in general 43

L.

Lakes, names:
  - Agassiz 52
  - Clear 147
  - Devil's 47, 50
  - Donner 40, 103
  - Great Salt Lake 40
  - Heart 244
  - Independence 40
  - Jackson 150
  - Lewis 244
  - Salt 39, 130, 150, 240
  - Shoshone 244
  - Tahoe 40, 79, 102, 181
  - Twin 77, 148, 193
  - Utah 39, 101, 150
  - Winnepeg 47
  - Yellowstone 43, 181, 243, 244, 245

Land, references to:
  - Agricultural 24, 25, 28, 73, 99, 122, 218, 238, 239, 240
  - Arid 10
  - Area of timber land within arid sections 10, 116, 117, 118, 119
  - Arid areas, of 5, 23, 32, 33, 44, 65, 66, 71, 97, 102, 124, 125, 131, 134, 135, 155, 169, 186, 200, 211, 242
  - Brush 122
  - Catchment areas 21, 23, 25, 26, 27, 28, 29, 30, 31, 32, 71, 72, 73, 152, 155, 156, 158, 159, 160, 161, 162, 172, 174, 175, 193, 201, 202, 203, 221, 243
    - Bernadillo is a volcanic district 30
    - Mesilla Valley 31
    - Puerco, of the 31
    - Tewan Mountains 30
  - Cienegas, or wet places of Arizona 99
  - Continental divide 243, 244
  - Coteaux 93
  - Desert, Amagosa 173, 181
    - Colorado 100, 122, 123
    - Lands 123, 181
    - Mojave 122
    - Owyhee ....
  - Development of, inhabited localities 108
  - Flat 73
  - Forest 30
  - Foot-hills 13, 77, 95, 99, 122, 145
  - Grass 30, 40
  - Great Plains 54, 98
    - reclamation of 96
  - High 38, 79, 92
  - Irrigable 14, 15, 26, 28, 29, 30, 32, 66, 73, 77, 78, 84, 140, 145, 148, 149, 150, 152, 161, 162, 163, 164, 174, 200, 201, 219, 220
    - Bear River Valley, in 149
    - Idaho, in 84
    - Montana, in 84
    - Puerco, of the 31
    - Utah, in 84
  - Lava fields, San Ildefonso Valley 25
  - Lost stream region 34
  - Low lands 33, 34, 38, 41, 79
    - Arizona, of 33

Land, references to—Continued. Page.
Los Coyotes Ranch ....
Madison plateau 123
Mesa 243, 245
Moistened 26, 30, 44, 81, 99, 167
Montana—table of mountain, and plain and forest area by counties 42
National Park 116
New Mexico, mountain meadows of 43
table of mountain, and plains and forest area by counties.. 30
Non-irrigable 117
Pasturage 29
Plains of Arabia 25, 26, 30, 66, 106
Plains region, timber 129
Plains of Saskatchewan 116
Plateau of Arizona 131
Potato region 33
Public 39, 40
Rio Grande Mountains, area of 81, 236
Sand plains, Chama River 28
of the the Gila 25, 33
Sand hills 33
Sand dunes of the Rio Grande 33
Jemez 17
San Luis Park 30
Slides 24
Specific 160, 218
Staked Plain 21
Subhumid 97
Swamp 169
Table 43
Tewan plateau 99, 100, 185, 186, 187, 240, 242, 243
Timber 30
Total area of arid region 25, 26, 30, 66
Valley 10
area Rio Grande, of 36
Wheat 20
Wyoming, areas by counties 81
actually irrigated 117
Yellowstone Park 9
Laws: 79, 81
Desert land act ....
Entries under timber culture act 199, 235
Homestead act, under 120, 121
Pre-emption act, under 76, 199, 236
Provisions of Powell bill 199, 236
Timber culture, foreign 67, 68
Timber land act 236
.... 199

M.

Maps, mention of:
Culture ....
Irrigated areas, showings 71
Rio Grande, of 5
Topographic 22
Wooded area of arid region 175
Mines: 9
Arid region, in ....
Hydraulic 12
Moisture from Pacific Ocean 41
Mountains, names of: 34
Absaroka ....
Appalachian 243, 245
Battle 177
Big Horn 240
Chiricahua 54, 128
Clover 99
Colorado, of 241
Dragoon 36
Gallatin 99
.... 243

Page.

- Mountains, names of—Continued.
  - Nacimiento, 30
  - Rocky, the, 34, 35, 38, 54, 55, 56, 94, 95, 105, 109, 124, 127, 172, 243, 245
  - Ruby, 239, 240, 241
  - Sheridan, 245
  - Sierra Madre, 122, 123
  - Sierra Nevada, 40, 102, 141
  - Snowy Range, 243
  - Spruce, 240
  - Teton, 243
  - Tewan, 26, 30
  - Tritle, 159
  - Uintah, 38
  - Wasatch, 38
  - Wind River, 38, 243

N.

- Nettleton, E. S., reports on Colorado, filed by, 230, 231

R.

- Railroads, reference to:
  - Atchison, Topeka and Santa Fé, 148
  - Burlington and Missouri River, 13
  - Canadian Pacific, 202
  - Central Pacific, 241
  - Northern Pacific, 136
  - Pacific, 176
  - Southern Pacific, 123, 148
  - Texas Pacific, 97
- Rainfall, 6, 16, 17, 33, 34, 36, 46, 53, 73, 90 97, 98, 100, 107, 109, 110, 122, 123, 141, 137, 139, 144, 152, 158, 159, 160, 161, 173, 174, 203, 206, 208, 217, 225, 141, 240, 242, 245
  - Colorado desert, 100
  - Colorado Mountains, inches of, 36
  - Eastern Dakota, in, 52
  - Evaporation, by, 34
  - Ganges Valley, in, 74
  - Gila River, at, 33
  - Measurements of, 75, 173
  - Mojare, at, 100
  - Rocky Mountain plateau, 127
  - Subhumid regions, of the, 46
  - Texas, 98
  - Yuma, at, 100
- Reservoir sites, 22, 23, 26, 30, 31, 32, 42, 64, 65, 71, 76, 77, 80, 81, 84, 100, 101, 107, 135, 140, 148, 149, 152, 153, 154, 156, 157, 161, 162, 163, 164, 165, 166, 171, 173, 174, 181, 194, 195, 199, 201, 206, 207, 208, 209, 211, 216, 219, 239, 241, 242
  - Arkansas on the, 77, 98, 193
  - Artesian, 45
  - Bear Lake, 148
  - Bull Run Basin, 238
  - Butte and Lassen Counties, Cal., in, 79
  - California, in, 79
  - California, list of, 82
  - Clear Lake, near San Francisco, 79
  - Colorado, list of, 82
  - El Paso, at, 21, 27, 220
  - Fall River Reservoir, 79
  - Hope Valley, 156
  - Idaho and Western Wyoming, list of, 79, 83
  - Jackson Lake, 79
  - Monaco Meadows, Kern County, on the, 79
  - Montana, list of, 80, 83
  - Nevada, 79
  - Owyhee, on the, 238
  - Providence Lake, 156
  - Sand, in the, 47

Page.

Reservoir sites—Continued.
- Storage 28, 40, 41
  - on the Gila 100, 167
- Survey to estimates 151
- Squaw Valley, in 240
- Susie Creek, on 237
- Sivan Valley 79, 150
- Twin Lake 193
- Utah Lake 39, 148, 156
- Utah, list of 83
- Yellowstone Lake 81
  - Park 79

Rivers, names and mention of:
- American 41, 42
- Arkansas 14, 15, 16, 18, 37, 58, 63, 69, 77, 97, 98, 101, 136, 150, 156, 184, 186, 198, 206, 207, 212, 213
- Bear 40, 42, 63, 300
- Big Horn 43, 129
- Boise 181
- Bruneau 238
- Cache La Poudre 230
- Canadian 63
- Carson 40, 69, 147, 149, 150, 181
- Chama 25, 29
- Cheyenne 43
- Cimarron 44
- Clark's Fork 241
- Colorado 33 38, 63, 161, 268
- Columbia 42, 43, 63, 238
- Falls 150, 240
- Firehole 244
- Gallatin 80, 148, 150, 244
- Gallinas 184
- Gibbon 244
- Gila 17, 33, 34, 35, 99, 100, 147, 150
- Green 38
- Humboldt 40, 240
- Jefferson 80, 130, 148, 150, 244
- Jemez 26, 30
- Jim 89, 93
- Jordon 39, 40
- Kootenay 43
- Lamar 244
- Laramie 55
- Little Humboldt 239
- Little Owyhee 239
- Lost 150
- Lower Colorado 18
- Lower Rio Grande 21
- Madison 80, 148, 150, 244
- Marys 239
- Merced 149
- Milk 43
- Mississippi 214
- Missouri 10, 15, 43, 44, 63, 80, 89, 90, 91, 93, 96, 98, 124, 140, 147, 148, 150, 221, 244
- Mora 181
- Niobrara 44
- North Platte 63
- Owyhee 150, 236, 239
- Payette 150
- Pecos 16, 17, 21, 63
- Platte 15, 18, 98, 101
- Powder 43
- Provo Fork 39
- Puerco 30
- Red 44, 89, 93
- Reese 239, 240
- Rio Grande 16, 17, 18, 19, 20, 22, 23, 24, 25, 28, 30, 32, 63, 69, 70, 78, 84, 105, 147, 150, 181

Page.

Rivers, names and mention of—Continued.
  Rio Puerco ... 26
  Sacramento ... 41
  Saguache ... 23, 28
  Salt ... 34, 35, 99, 100, 147, 150
  Salmon ... 238
  San Pedro ... 99
  Santa Cruz ... 99
  San Francisco ... 267
  Saskatchewan ... 63
  Sevier ... 39, 40, 150
  Snake, or Shoshone ... 42, 43, 44, 63, 69, 79, 80, 130, 149, 150, 181, 238, 244, 245
  South Platte ... 63
  Spanish Fork ... 39
  Stanislaus ... 149, 181
  Sun ... 80, 129, 140, 148, 150, 151, 181
  Taos ... 24, 29
  Three Forks, Upper Missouri of ... 140
  Truckee ... 40, 69, 147, 149, 150, 181
  Tuolumne ... 149
  Uba ... 181
  Underground ... 35
  Upper Arkansas ... 163
  Weiser ... 150
  Wood ... 150
  Yellowstone ... 10, 43, 44, 80, 81, 110, 129, 147, 150, 181, 220, 243, 244, 245
Rocks, mention of—
  Coal measures ... 51, 55
  Cretaceous formation ... 55, 56, 57
  Cambrian ... 47, 54
  Dakota sandstone ... 54, 55, 57, 94
  Limestone ... 87
  Porous ... 45
  Quartzite stratum ... 90
  Rim ... 90
    Sioux quartzite ... 93
  Sandstone strata ... 53, 86
  Silurian ... 54
  Solid ... 36
  Strata of hard-rock ... 86
  Tertiary ... 57
  Triassic beds ... 55
  White River Tertiary ... 55, 56
Seasons, reference to
    Drought ... 11, 15, 18, 19, 20, 22, 24, 27, 33, 34, 35, 40, 47, 78, 101, 123, 152, 196, 242
    Duration of irrigation ... 18
    Flood ... 22
    Humidity of ... 19
    Non-irrigating ... 26, 27
    Rainy ... 122
    Spring ... 230
    Wet ... 16, 17, 22
Senators, references to:
    Casey, Lyman R., North Dakota ... 5, 12, 14, 15, 16, 18, 21, 22, 32, 33, 35, 37, 39, 42, 44, 68, 78, 86, 87, 90, 91, 93, 95, 96, 97, 105, 106, 132, 151, 162, 170, 172, 174, 180
    Gorman, Arthur P., Maryland ... 183, 192, 193, 194, 195, 196, 197
    Jones, James K., Arkansas ... 5, 11, 17, 34, 35, 37, 41, 68, 72, 79, 84, 85, 86, 132, 137, 138, 142, 143, 146, 151, 155, 156, 170, 187, 188, 190, 192, 193, 197, 205, 209, 210, 211, 212, 213, 214, 220
    Moody, Gideon C., South Dakota ... 5, 13, 37, 65, 68, 89, 90, 91, 92, 93, 95, 132, 139, 140, 141, 142, 143, 151, 157, 162, 164, 165, 166, 167, 170, 175, 176, 177, 178, 181, 182, 183, 189, 190, 192, 196, 198, 205, 207, 213, 218, 119, 220, 221
    Plumb, Preston B., Kansas ... 5, 17, 18, 20, 21, 33, 34, 35, 36, 37, 68, 70, 71, 95, 108, 162, 168, 169, 205
    Reagan, John H., Texas ... 5, 13, 14, 18, 22, 33, 35, 36, 68, 70, 78, 84, 86, 95, 104, 132, 133, 135, 136, 139, 145, 146, 151, 157, 162, 165, 170, 173, 174, 175, 178, 180, 181, 182, 183, 193, 205, 207, 208, 209, 210, 211, 212, 216, 219, 221, 222

Senators, references to—Continued.
Page.
Stewart, William M., Nevada........5, 37, 68, 95, 132, 151, 162, 183, 205, 249
Snow-fall..............................
Precipitation, Sierras on 16, 147, 242, 244
Valleys, in the Sierras.............. 100
Soil.............................. 36
Clay..............19, 32, 157, 171, 173, 174, 219, 234
Gravel.............................. 152
Sand.............................. 97, 152
Subsoil 26, 41, 73, 97, 152, 160, 219, 230
States, names and mention of 19, 171
Arkansas ....
California..........6, 10, 19, 35, 38, 40, 42, 45, 63, 69, 70, 84, ... 14
144, 147, 149, 167, 172, 180, 181, 190, 195, 235, 241. 301, 302, 305, 340
Colorado..........11, 12, 14, 15, 16, 17, 18, 19, 20, 22, 24, 28, 29, 37, 38, 44, 45, 63, 69, 90,
101, 106, 130, 139, 147, 149, 163, 181, 184, 187, 190, 213, 220, 230
Dakota, North and South..............12, 43, 44, 46, 47, 52, 54, 56, 63, 87, 89, 90, 91,
Illinois 92, 93, 96, 97, 103, 106, 116, 128, 221, 244
Kansas.............................. 46
35, 37, 44, 56, 58, 63, 69, 91, 97, 99, 103, 128, 137, 163, 183, 197, 212, 213, 221 .... 14, 16,
Massachusetts ....
Minnesota 148, 212, 213
Missouri 47, 54, 128
Montana 11, 12, 14, 43, 44, 63, 70, 80, 84, 110, 139, 140, 147, 181, 190. 220, 244, 245 141
Nebraska..............35, 43, 44, 59, 54, 63, 91, 97, 128, 221
Nevada. .. 6, 12, 40, 63, 69, 79, 97, 102, 103, 139, 141, 144, 156, 173, 190, 196, 238, 239, 241
New York ....
Oregon 88, 220
Pennsylvania 6, 11, 42, 136, 238
Texas..............11, 13, 16, 17, 18, 21, 22, 27, 28, 31, 32, 60, 63, 90, 91, 97, 98, 131, 221 220
Washington 5, 11, 13, 42, 63, 136, 238
Wyoming 6, 9, 13, 38, 40, 42, 43, 44, 63, 79, 116, 136, 243, 245
Stock-raising:
Cattle ....
Horses.............................. 52, 241
Ranches of.............................. 52, 241
Surveys: 46
Area mapped in Nevada..............................
Arid country, for 70
Arkansas division, in.............................. 108
California, area mapped in 148
Canal lines, rough 70
Canal lines, full.............................. 151
Character of hydrographic needed.............................. 151
Clear Lake, California, of 137
Colorado, area in 149
Coast, the.............................. 69
~~Donner, Lake of~~..............................144, 145, 198
Donner, Weber, and Independence, of 79
Elements in a hydrographic.............................. 149
El Paso Reservoir.............................. 159
Engineer branch of irrigation.............................. 148, 149
151, 153, 156, 170, 178, 183, 193, 195, 196, 199, 205, 215 .... 76, 77, 106, 134,
Estimate for expenditures of ....
Function of irrigation.............................. 133, 227
General instructions for hydrographers 170
Geological, the..5, 9, 45, 86, 87, 91, 94, 95 103, 154, 155, 168, 169, 176, 183, 185, 190, 191, ... 2367
192, 193, 197, 198, 201, 202, 205, 210, 211, 212, 215, 220, 222, 243, 244, 249
Arizona, at ....
Texas central, in 136
Utah, at 137
Hayden, by 136
Hope Valley 70, 184
Hydrographic, branch of 79
106, 134, 139, 152, 153, 159, 161, 162, 165, 174, 199, 202 ....32, 72, 74, 76,
maps ....
Idaho, in 71
Independence Lake, on. 149
Indian, an 79
.... 160

Page.

Surveys—Continued.
- Irrigation, the 23, 68, 69, 70, 86, 101, 104, 142, 152, 153, 154, 162, 168, 169, 170, 177, 185, 190, 191, 197, 198, 199, 201, 203, 208, 210
  - field organization and work 147
- King, Clarence 70
- Land 185
- Land Office 141, 181, 218, 219
- Long Valley 79
- Montana, transcontinental in 136, 148
- New Mexico, reconnaissance of 136
- Object of irrigation by United States 100
- Railroad land 98, 145, 177, 185
- Reconnaissance, New Mexico, of 136
  - Yellowstone, of the 140
- Reservoirs, full 150
- Rio Grande division, in the 148
- Summary, hydrographic 74, 75
- Sun River Valley, in 140
- Topographic, not necessary 99
- Topographic, branch of 22, 27, 29, 32, 68, 69, 70, 73, 76, 77, 80, 85, 87, 88, 89, 94, 96, 98, 100, 103, 104, 105, 133, 135, 136, 137, 139, 142, 144, 145, 146, 151, 152, 153, 155, 156, 157, 158, 159, 160, 161, 162, 163, 165, 168, 170, 174, 175, 177, 178, 179, 180, 181, 182, 183, 187, 190, 193, 194, 195, 196, 199, 201, 202, 203, 205, 208, 210, 211, 212, 215, 216, 220, 221, 222
  - Arkansas Valley, in 197
  - Arkansas Basin, cost of the 189
  - Arkansas Basin, upper 154
  - Colorado, of west of Denver 136
  - El Paso, region above 78
  - India, in 198
  - Yellowstone Park, of 245
- United States irrigation 100, 106, 132, 213, 215
- Utah, Lake of 149
- Webber Lake, on 79
- Wheeler, the 70, 136
- Work, cost of 151, 177

T.

Territories, mention of:
- Alaska 7, 9, 63
- Arizona 12, 33, 38, 45, 63, 72, 97, 98, 99, 100, 131, 138, 144, 217, 220
- Idaho 6, 11, 40, 42, 63, 69, 70, 79, 128, 136, 139, 141, 144, 147, 150, 181, 190, 200, 238, 245
- Indian Territory 13, 59, 63
- New Mexico 12, 16, 17, 18, 20, 24, 25, 27, 28, 30, 31, 32, 33, 63, 69, 70, 84, 97, 99, 103, 116, 139, 141, 144, 148, 149, 181, 190, 213, 220
- Utah 11, 38, 39, 40, 45, 63, 101, 103, 128, 144, 147, 149, 176, 200

Trees, arid regions 19
- Box-elder 116
- Cedar 10
- Cottonwood 10, 116
- Effect of planting, in dry areas 119, 120
  - southern California 123
- Elm 116
- Fir 9, 10
- Green Ash 116
- Hackberry 116
- Hemlock 9
- Palm 35
- Pine 9, 10
- Pinons, or nut-pine 10
- Sequoia, the 9, 10
- Small oaks 10
- Spruce 9
- Timber, of 9, 10, 11, 24, 29, 102, 110, 111, 218, 244
  - culture, Land Office figures 121
  - areas, southern California 122
    - of Interior Basin 118
    - west of one-hundredth meridian 117

V.

Page.

- Valleys, names and referencß to:
  - Albuquerque
  - Antelope 25, 27, 28, 29
  - Arkansas ... 15, 20, 23, 35, 36, 47, 77, 69, 97, 101, 140, 141, 145, 181, 186, 196, 197, 206, 207
  - Bear 123
  - Butte 40
  - California, of 238
  - Carson 40
  - Clover 149
  - Colorado 240
  - Death 98
  - El Paso 173
  - Gallatin 26, 27, 28, 31, 32
  - Goshute 80
  - Grand River 238
  - Hope 38
  - Humboldt 149
  - Independence 240
  - James River 238
  - Jefferson 91, 96
  - Jordon 80
  - Long 39
  - Madison 149, 240
  - Mesilla 80, 242
  - Mississippi 26, 27, 28, 31, 32, 100
  - Nile 137, 145
  - Owens 43
  - Pecos 149
  - Platte 98
  - Puerco 35, 97
  - Red River 31
  - Rio Grande 47, 52, 53, 54, 55
  - Ruby 18, 20, 21, 23, 28, 30, 32, 36, 84, 100, 101, 141, 148, 196
  - Sacramento 238
  - Salt River 6, 40, 41
  - San Gabriel 100
  - San Ildefonso 122
  - San Luis 25, 29
  - San Simon 24
  - Santa Cruz 99
  - Santa Fé 99
  - Santa Maria 26
  - Sevier 123
  - Snake River 39
  - South Platte 42, 130, 141
  - Squaw 230
  - Steptoe 237, 238
  - Sulphur 238
  - Sun River 99
  - Taos 140
  - Truckee 29
  - Uintah 103
  - Upper Snake, of 38
  - Yellowstone 241
- Vineyards in and region 81, 141, 148
- Witnesses and others, names of: 18, 19. 94
  - Curtis, George E., meteorologist
  - Fernow, B. E., forestry 213, 214, 215
  - Gilbert, G. K., geologist 109, 124
  - 170, 171, 172, 173, 174, 175, 176, 177, 178, 179
  - Greene, Charles W 231, 232, 233, 234, 235, 236
  - Hague, Arnold, geologist 241, 242, 243
  - Johnson, Willard D., topographer 183, 204
  - Merriam, C. Hart 131, 132
  - Powell, J. W., Director U. S. Geological Survey 5, 17, 18, 19, 20, 21, 22, 33, 34, 35, 36, 37, 41, 42, 68, 95, 132, 151, 170, 177, 190, 192, 193, 194, 195, 196, 197, 198, 199
  - Riley, C.V., entomologist 124, 127
  - Willits, Edwin, Assistant Secretary of Agriculture 108, 109

Page.

Water:
Bed of 42
Bear River, division of 40
Brackish, or alkaline 51, 52
Cloudbursts or spouts 81, 144, 160, 161, 218
Companies as carriers 65
Conservation of storm or surplus 95
Current meters for measurement 158
Dakota sandstones, derived from 50-52
Disappears in sand 36
Distribution of 140
Division of the, through the States 27, 38, 39, 63, 64, 65
Division of, by drainage districts 64
Donner Lake, from 103
Duty of 19, 20, 134, 152, 157, 171
Equivalents of units used in measuring 229
Flood 20, 22, 24, 25, 28, 31, 40, 77, 81, 138, 144, 160, 172, 206, 216, 217, 218
extreme 30
Pacific coast, on 214
time 26, 41, 72, 137
Flow of 18, 36, 123
mountains of New Mexico, from 20
Rio Grande, in the 105
of, at a particular point, how ascertained 214
Gauging, of 72, 172, 173, 199
stations, for 74, 147
river, height, of 158
Gila, in the 33, 35
Head, American River, of 181
Carson, of 149
Colorado, of 17, 161
Missouri, of 43
of, in mountains 15
Rio Grande, of 27
International problem, at El Paso 32, 43, 63, 105
Interstate problem, of 63, 65
Irrigation by storage of storm 46
lateral streams 33
Jemez River, of, discharges into sand 30
Lost in sand, Saguache River, of 23, 28
Arkansas, of 20
Maximum duty of 20
fall of, basins 138
Measurement of 171, 172, 202, 203
Minimum fall of, basins 138
Mountain of, flowing into Rio Grande 27
National Yellowstone Park, of 243-245
Nile, Egypt, of 43
Overflow dams, of 218
Percolation of, through sand 36
great valleys 98
Point of Rocks, non-irrigating season 27
Puerco, of the 30, 31
Pumping, an American invention 34, 35
Quantity of sediment in 74
Return, conditions affecting 19
Republican Basin surface 97
Rights of 24, 29, 30, 66, 196, 201
Sacramento, of the 40, 41
Sand reservoir, in 169
Seepage of 18, 97, 98, 171, 228
or from Missouri 96
table of measurement of 230, 231
Sheds 80, 137, 209, 238, 239
in certain cañon 123
Silt 21, 22
carried by the Rio Grande 76
Sink at Tucson 36
Sources of supply 45, 46, 47, 53, 54, 55, 232

Water—Continued. Page.
Springs, New Mexico ....
Storm 20, 21, 27, 40, 46, 47, 86, 91, 95, 101, 169, 178 97
Storage 14, 28, 30, 31, 39, 40, 41, 42, 43, 93, 123, 154, 167, 184, 187, 204, 241
Arkansas in, cost of 77
El Paso and Mesilla Valleys, in 28
mountains, in 77
mountain lakes, in 103
reservoirs, in 73
rights to 28
Rio Grande, of the 22, 25, 78, 79, 100, 101
small, for the Great Plains 98
storm water 91, 93
surplus of, at high altitudes 95
Rocky Mountains, in 96
Utah, in 101
Strata-bearing 54, 55
Streams lateral 20
cause of 38
gauging 195
mountain 35
nilometer or river gauge 72
Rocky Mountains, in 34
Subterranean channels of 18, 47
Supply of. 25, 29, 32, 93, 98, 100, 104, 107, 109, 110, 122, 134, 148, 149, 159, 194, 196, 203, 242
artificial 47, 225
New Mexico, mountains of 20
permanent 37
Surface 36, 90
Surplus 27, 159, 196
Taos, of the 29
Tide season, in 125
Underflow or drainage 33
Underflow of 96
Under-ground 37, 94, 95, 102
great basin 36
sound of flowing, Arizona 99
staked plains, Texas 97, 99
Utah Lake Basin 101
supply, development of 103
river 36
Utilization of 15, 33, 34
Snake River, of the 42
Velocity of 72, 214
Volume of 17, 63, 96, 143, 228
average of 76
Colorado, in the 38
flood 72, 73
flowing 162, 164
Rio Grande, of the 22
Waste 100, 171
Missouri River, from 124
Waste-weir 80, 138, 139, 150, 194
way 160, 195, 216, 217, 218
Well-irrigation committee's report, Vol. 1 .... 51, 52
Work of experimenting at Dodge City 97
Wind 143
Hot desert 123
Trade 123
Windmills at Riverside 123

IRRIGATION REPORTS OF UNITED STATES CONSULS.

NAMES AND POSTS.

Page.
Baker, E. L., Buenos Ayres, Argentine Republic 259
Bird, Winfield S., La Guayra, Venezuela 256
Bissinger, Erhard, Beirut, Syria 281, 282, 283, 284, 285, 286, 287, 288, 289, 290, 291
Campbell, John Tyler, Foochow, China 275, 276, 277
Camphausen, Edward, Naples, Italy 344
Carroll, Phillip, Palermo, Italy 349, 350
Child, Jacob I., Bangkok, Siam 280
Dufair, F. F., Havre, France 332
Earle, Edward V., Cognac, France 344, 345
Emmet, W. C., Smyrna, Asia Minor 296
Gillman, Henry, Jerusalem, Palestine 291, 292, 293, 294, 295, 296
Grierson, J., Coquimbo, Chili 257, 258
Griffin, G. W., Syndey, New South Wales 298, 299, 300, 301, 302, 303, 304, 305, 306, 307, 308
Hathaway, Alberto N., Nice, France 343, 344
Hollis, George F., Capetown, South Africa 308, 309, 310, 311, 312
Hosmer, James V., Guatamala 255
Ingraham, Darius H, Cadiz, Spain 319
Jones, A. C., Chin Kiang, China 279
Jones, Thomas C., Island of Madeira 312, 313, 314, 315, 316, 317, 318
Jones, Wallace S., Messina, Italy 345, 346, 347, 348, 349
Kennedy, J. D., Shanghai, China 280
McGarr, O., Guayaquil, Ecuador 257
More, C. C., City of Mexico 251, 252, 253, 254
Pease, Henry, Santiago, Cape Verdi Islands 318
Perez, Clodomire, Santandar, Spain 320, 222, 322, 323, 324, 325, 326, 327
Pettus, Thomas T., Ningpo, China 277, 278
Rathbone, J. L., Paris, France 327, 328, 329, 330, 331
Reimer, Otto E., Santiago De Cuba, Cuba 254, 245
Schumacher, J., Acca-Haifa, Syria 289, 290
Severance, H. W., Honolulu, Hawaiian Islands 273, 274, 275
Seymour, Charles, Canton, China 278, 279
Trail, Charles B., Marseilles, France 332, 333, 334, 335, 336, 337, 338, 339, 340, 341, 342, 343
Walthall, W. T., Demerara, British Guiana 258
Webb, Alex. R., Manilla, Phillippine Islands 297
Willard, A., Guaymas, Mexico 251
Wills, Charles H., Managua, Nicaragua 255
Woessner, John, Saltillo, Mexico 250, 251

INDEX TO REPORTS OF UNITED STATES CONSULS.

Page.

- Africa, South, irrigation in 308, 309, 310, 311, 312
  - basins for storage 311
  - Cape Town 308
  - Irrigation in:
    - Act for promotion of 309
    - By private owners 309, 310, 311
    - Cape Colony, in 309
    - Land under 311
    - Orange Free State, in 309
    - Van Wycks Valley, storage in 311
  - Rain-fall in:
    - Lack of 311
    - Table of, for districts, 1888 311
    - Rainy seasons 308, 310
  - Rivers of 310
  - Surveys:
    - Geological, of 310
    - Topographic, of 310, 311, 312
  - Table-land in 311
  - Water:
    - Boring for 312
    - Evaporation of 312
- America, Central, Irrigation of:
  - Guatemala, in 255
  - Nicaragua, in 255
- America, North:
  - Mexico:
    - Cariel, Luis C., deputy president senate 254
    - Cities in:
      - Cantla 252
      - Guaymas 251
      - Mexico City 251
      - Saltillo 250
    - Climate in, character of, in irrigated regions 253
    - Crops, quantity and quality in 252
    - Cubas, A. Garcias, historian 253
    - Dams of masonry in 252
    - Department of public works in 254
    - Diaz, Porfirio, president of 252
    - Fruit trees in 252
    - Irrigation in 250, 251, 252, 253, 254
      - Antiquity of system of 251
      - Coahuila, in 250, 251
    - Landa y Escandon, Guillermode, secretary 254
    - Pacheco, Carlos, secretary of state 254
    - Plantations in 252
    - Rain-fall in, annual 253
      - scant 251
    - Riba y. Echeverria, A., deputy president 254
    - Sanches, Castellanos, senator president 254
    - Seasons, rainy, in 251, 252
    - Soils of:
      - Alluvial valley 253
      - Black loam of 253
      - Rich land 250
      - Sandy 251
        - table lands, on 253

Page

- America North—Continued.
  - Mexico—Continued.
    - States, of:
      - Coahuila ... 250
      - Mexico, federal district of ... 251
      - Morelos ... 252
      - Sonora ... 251
    - Water:
      - Cost of ... 253
      - Distribution systems, of ... 251, 252
      - Duty of ... 253
      - Lack of ... 250
      - Natural supply of ... 251
      - Power of ... 250
      - Public ... 251
      - Rights and privileges in ... 250, 251
      - Sources of supply of ... 250, 252
      - Storage and distribution works for ... 252
    - Wells, artesian ... 250, 251
- America, South, reports from:
  - Altitudes in—
    - Cartamarca City, Argentine Republic ... 264
    - Murallon, Argentine Republic ... 268
    - San Juan, Argentine Republic ... 263
    - Tucuman, Argentine Republic ... 264
  - Canals in—
    - Main Southern ... 270
    - Western ... 271
  - Celman, De Jaurez ... 269
  - Cities in—
    - Buenos Ayres ... 259, 261
    - Catamarca ... 267
    - Cordova ... 265, 269
    - Demerara ... 258
    - Guayaquil ... 257
    - La Guayra ... 256
    - Santa Fé ... 261
    - San Juan ... 263, 268
    - Santiago ... 267
  - Climate of—
    - Argentine Republic, its interior provinces in ... 262, 263, 264, 265
      - Catamarca, Province of ... 264
      - Cordota, of ... 265
      - Mendoza, of ... 262
      - Tucuman, of ... 264
      - San Juan, of ... 263
    - Chili, in ... 258
    - Ecuador, in ... 257
    - Torrid, the ... 256, 259
  - Countries of, mentioned:
    - Argentine Republic ... 260, 262, 269
    - Bolivia ... 260, 254, 267
    - Chili ... 264
    - Peru ... 260
  - Crops in ... 256, 262, 272, 273
    - Alfalfa ... 257
    - Barley ... 257
    - Cocoa-nut ... 259
    - Coffee ... 256
    - Grain ... 257
    - Hay ... 257, 258
    - Sugar ... 251, 259, 267
  - Dams, their side-lines ... 259
  - Flood-gates, of ... 266, 270
  - Fruit in ... 258
  - History of South America (Nap and Prescott) ... 260, 261
  - Irrigation in countries of ... 256, 257, 258. 259, 260, 261, 262, 263, 264, 265, 266, 267, 268, 269. 270, 271, 272, 273
    - After the conquest ... 261

Page.

- America, South—Continued.
  - Irrigation in countries of—Continued.
    - Antiquity of 260, 261
    - Areas of land under 272
    - Argentine Republic, in 259, 260, 261, 262, 263, 264, 265, 266, 267, 268, 269, 270, 271, 272
    - Argentine Republic, in non-irrigable provinces 273
    - British Guiana, in 258, 259
    - Character of works of provinces, Argentine Republic 266, 271
    - Coquimbo province, Chili in 257, 258
    - Ecuador 257
    - Provinces depending on, Argentine Republic 272
    - Venezuela, in 256
    - Works of Cordova 269
  - Lake of Guancache 268, 269
  - Lands of:
    - Bush 258
    - Cultivated 256, 257
    - Low 258
    - Table 270
  - Mountains of:
    - Aconcagua 269
    - Aconquya 267
    - Andes 260, 266, 269
    - Boneto 268
    - Cordilleras 269
    - Sierra Uspillata 269
    - Tupungato, peaks of 269
  - Provinces of—
    - Buenos Ayres 266
    - Catamarca 262, 267, 271
    - Coquimbo, Chili 257
    - Cordova 266, 260, 271
    - Jujuy 262
    - Jujuy 267
    - Mendoza 262, 269, 271
    - Rioja 268
    - Salta 262, 264, 267
    - San Juan 262, 264, 268
    - San Luiz 268
    - Santiago del Estero 262, 267, 271
    - Tucuman 262, 267, 271
  - Rain-fall in—
    - British Guiana, average annual 259
    - Coquimbo, Chili in 256
    - Cordova, at 265
    - Ecuador, in 257
    - Interior provinces, Argentine in 262, 263, 264, 265
    - Mendoza, at 262
    - San Juan, at 263
    - San Luiz, at 268
    - Tucuman, in 265
    - Want of 270
  - Reservoirs in—
    - Artificial 259
    - Dike of Mal Paso 270
    - Dike of San Roque 269, 270
  - Rhyland rood, unit of measurement 258
  - Rivers of—
    - Cosquin 269
    - Cuarto 269
    - Cuatio 270
    - Juramento 267
    - Las Cuevas 269
    - Mendoza 269
    - Paelen 267
    - Paraguay 266
    - Parana 266, 269
    - Piedra Blanca 267

Page.

- America, South, reports from—Continued.
  - Rivers of—Continued.
    - Pilcomayo 266
    - Primero 265, 269
    - Quinto 268, 269
    - Rio los Horcones 269
    - Rio de la Plata 263
    - Rio de los Sauces 270
    - Salado 266, 267
    - Sali or Dulce 267
    - San Juan 268, 269
    - Santa Maria 267
    - San Roque 269
    - Segundo 269, 270
    - Tala 271
    - Tercero 269, 270
    - Uruguay 266
    - Vermejo 266, 267, 268
  - Seasons of:
    - Dry 258, 259
    - Rainy 258
    - Summer 256
  - Soils of:
    - Clay 259
    - Sandy loam 257
  - Strait of Magellan 262
  - Valleys of:
    - Hermoso 268
    - Jaque 268
    - Pismento 268
    - Rio del, the 267
    - Character of works, Venezuela, in 256
    - Distribution of, Argentine Republic, in 271
    - Drainage system, British Guiana 258, 259
    - Evaporation in 266
    - Floods of 268
    - "Kokers" or water gates 259
    - Overflow of 258
    - Public, cost of 271
    - Quantity of 264
    - Rights by prescription 272
    - Snow 257
    - Sources of supply, Argentine Republic 266, 267-271, 273
      - Ecuador, in 257
      - Venezuela 256
    - Storage in Chili 257
    - Surplus, Valles of Jacal 268
    - Volume of 268
  - Wells, artesian 268, 273
  - "Zonda," northeast wind 263, 264
- Atlantic Islands, South—reports from:
  - Cape Verde Islands, irrigation and water system in 318
  - Madeira, in:
    - Area of irrigation 312
    - Crops of, irrigation 312, 313, 314
    - Fruit of 312
    - Funchal 312, 314
    - Havin de Senate, Francisco 331
    - Laws and local regulations:
      - code of 315, 316, 317, 318
      - collecting rents 317
      - Levadas, the 315, 316
      - leasing waters 316, 317
      - prices of 318
      - public officers, duties 317, 318
  - Pesland, Francisco Joaquinm 331
  - Seasons, rainy 312
  - Soil of 314
  - Valleys of Brava and St. Vincente 314

Page.

- Atlantic Islands, South—reports from—Continued.
  - Madeira, in—Continued.
    - Water:
      - Character of works, the Levadas 313, 314
      - Levadeiro or distributor of 313
      - Rights in 314
      - Supply of 313
      - System of distribution 313
- Asia, irrigation in and reports from:
  - Acca-Haifa, Syria 282, 290
  - Asia Minor 296
  - Beirut, antiquity of 286, 291
    - area under 286
  - China, in 279
    - Formosa, in 280
    - land under 277
    - methods of 275, 276, 277, 278, 279, 280
  - Fryer, John, Sinalogue 280
  - Hallandey, wind pump 288
  - Jaffa, at 294, 295
  - Jerusalem, at 292, 293
  - Messina, at 290
  - Mesopotamia, ancient canals in 286
  - Morrison, G. James, civil engineer 280
  - Palestine, in 291, 292, 293, 294, 295, 296
  - Remarks on 275, 286, 287, 288
  - Shaduf, The, on Nile 280
  - Siam, in 280
  - Syria, in 281, 282, 283, 284, 285, 286, 287, 288, 289, 290, 291
  - Tripoli, land under 287
  - Wooden chain pumps 277
- Cities in—
  - Antioch 287
  - Baugkok 280
  - Beirut 281, 283, 286
  - Bethlehem 293
  - Canton 278
  - Chin Kiang 279
  - Damascus 281
  - Foochow 275
  - Hamath 287
  - Hazmyoli 288
  - Homs 287
  - Jaffa 291, 294
  - Jerusalem 291
  - Nablous 291
  - Ning-Po 277
  - Shanghai 280
  - Sidon 287
  - Smyrna 296
- Climate in 278
  - Character of, in Canton 278
    - irrigated regions 284
    - Palestine 295, 296
    - Syria 285
  - Semi tropical 291
  - Thermometrical observations at Beirut, Syria 285
  - Tropical, in Siam 280
- Crops in 291, 296
  - Bean 293
  - Beet 293
  - Cabbage 293
  - Carrot 294
  - Cauliflower 292, 293
  - Cereal 283
  - Citron 293, 294
  - Cotton 281
  - Cucumber 294
  - Durah or maize 281, 287

Page

- Asia, irrigation in and reports from—Continued.
  - Crops in—Continued.
    - Egg-plant 288, 293
    - Garlic 293
    - Hemp 281
    - Leek 293
    - Ockra 293
    - Onion 287, 293
    - Peas 293
    - Potatoes 293
    - Pumpkins 294
    - Radishes 294
    - Rice 278, 279, 280
      - the cultivation of 275
    - Syria, in, quality of 281
    - Tomatoes 294
    - Turnips 293
    - Vegetables 278, 281, 283, 286, 293, 294
  - Fruit trees in:
    - Apple 293
    - Apricot 293, 294
    - Banana 281
    - Date 281
    - Fig 281, 293
    - Lemon 281, 293, 294
    - Lime 294
    - Mulberry 281, 283, 286, 293
    - Nectarine 293
    - Olive 281, 294
    - Orange 281, 287, 294
    - Orchards at Sidon 281
      - at Tripoli 281
    - Peach 293, 294
    - Plum 293
    - Pomegranate 281, 292, 293, 294
    - Prune 293
  - Lakes in:
    - Artificial, at Homs, Tripoli 282
    - Tiberias 282
  - Land:
    - Arable 296
    - Arid 280
    - Irrigated 286, 296
  - Mediterranean, the 286, 291, 294
  - Mountains:
    - Ebal 291
    - Gerizim 291
    - Lebanon 281, 288
    - Sannin (Lebanon Range of) 287
    - Pools of Solomon 282
  - Rain-fall in 278, 279, 294
    - annual 285, 286
    - Asia Minor, annual 296
    - Beirut in inches from 1870 to 1889 285
    - Jaffa, at 295
    - Siam at 280
  - Rivers:
    - Beirut 286, 288
    - Dog 286
    - Eleutherus 287
    - Euphrates 286
    - Min 276, 277
    - Orentes 282, 287
    - Tigris 286
    - Yangtsze Kiang 279
    - Yellow 279
  - Schumacker, G., civil engineer 290, 291
  - Seasons in
    - Drought 265, 279, 296
    - Dry 280, 283, 295, 296

Page.

- Asia, irrigation in and reports from—Continued.
  - Seosons in—Continued.
    - Harvesting 296
    - Rainy 278, 279, 292, 295
    - Wet 280
  - Snow-fall in 286
  - Soil in:
    - Alluvial 278
    - Clay and sand in orange groves, Jaffa 295
    - Fertile 280
      - Palestine, in 292
    - Red clay 293
    - Sandy loam 296
    - Syria, at 285
  - Springs at Antelias 286
  - Valleys in:
    - Jordan 291
    - Kedron, of the 292
    - Nahr 287
    - Urtas 293
  - Vineyards in 294
    - Grape 293, 294
    - Melon 294
  - Water in:
    - Abundant supply of 287
    - Amount used per acre, in Syria 283
    - Beirut works 287
    - Character of works, Syrian 281, 282
    - Distribution of 294
    - Engine in use at Bajaras 294, 295
    - Evaporation of 296
    - "Fountain of the Cup" 293
    - Ottoman water regulations 283, 284
    - Persian water-wheel at Hamale 281
    - Siloam, Pool of 292
    - Source of supply, China, in 278
      - Jaffa, in 294
      - Fountain of Solomon 293
      - Syria, in 281
    - Supply for Asia Minor 296
      - China 279
      - Siam 280
    - System of distribution, China 278
      - Jaffa 295
      - Syria 282, 283
    - Works, etc., at Damascus, Tripoli, Homs, and Hamatte 286
- Australia, reports from:
  - Artesian well-boring in 298, 299, 300, 301, 302, 303, 304, 305, 306, 307, 308
  - Cities of:
    - Albemarle 300
    - Deniliquin 303
    - Forbes 299, 300
    - Sydney 298, 299, 303
    - Tapio 300
    - Windbar 300
  - Climate, New South Wales, of 305, 306
  - Colonies of:
    - New South Wales [illegible], 303, 304, 305, 307
    - Queensland 301, 303
    - South Australia 304
    - Victoria 300, 303, 306
  - Crops of:
    - Grass 300
    - Lucern (alfalfa) 300, 301
    - Maize 300
    - Sorghum 300
    - Wheat 300
  - Darling River Basin, the 301, 302
  - Fruits grown in 209

Page

- Australia, reports from—Continued.
  - Irrigation in:
    - Anderson, W., geological surveyor, on 303
    - Area under, New South Wales, in 299
    - Authorities on 306, 307
    - Coyle, J. E. F., civil engineer, on 304
    - Eddler & Co., farmers, on 299
    - Lachee district, land in 299
    - New South Wales, in 298, 299, 300, 301, 302, 303, 304, 305, 306, 307
    - Russell, H. C., astronomer, on 301
    - Tangye pump for 302
    - T. Towser, farmer, on 299
    - Works for 299
  - Land, grass and maize, in 300
  - Orchards in 300, 302
  - Plains of Emu 302
  - Rain-fall in colonies:
    - Annual average 305, 306
    - Darling, on the 305
    - Menindie, at 305
    - Riverine district, average of 303
    - Sydney, in 305
    - Tropical fall 301, 302
  - Rivers in:
    - Darling 298, 301, 303
    - Lachlan 299, 300
    - Marano 305
    - Murray 289, 300, 304, 306
    - Namori 301
    - Nepean 303
    - Torrens 302
  - Rocks, Silurian 303
  - Seasons of:
    - Drought 298
      - of 1888 .... 299, 305
    - Dry 301
  - Soil of:
    - Lachlan, in 299
    - Subsoil 201
  - Stock-raising in 300
  - Water in:
    - Artesian, in 303
    - Evaporation of 301, 302
    - Laws and customs, governing 303, 304
    - Riparian rights, in 299
    - Sources of supply 300, 301, 302
    - Storage of flood 302
    - Supply of 299, 303
    - Surplus 299
    - Underflow, abundant in 301
  - Wilson, James, letter to consul 307, 308
- Cuba, irrigation of 254, 255
  - Bay of Guantanamo 255
  - Capes of:
    - Cruz 255
    - Maisi 255
  - Climate of 255
  - Crops of 254
  - Irrigation, Santiago de Cuba, in 254, 255
  - Mountains of Sierras del Cobre 254
  - Rain-fall of, annual 255
  - Rivers of:
    - Canto 254, 255
    - Guantanamo 255
    - Mayari 255
    - Naranjo 253
  - Soil of, alluvial 254
  - Seasons of 254, 255
  - Town of Manzanillo 255
  - Water system 255

Page.

- Europe, countries in, reports from—
  - Albarracin, Señor Santiago, J 271
  - Canals, for irrigation—
    - Ecla, the 325
    - De Campos, the 325, 326
    - De Castilla, the 325
    - Del Norte, the 326
    - Del Sur, the 325, 326
    - De Urgel, the 321
    - Imperial, the 321, 326
    - Provence, in 333
    - Rhone and Pyrenees, in 333
    - Taxes to maintain 329
  - Cattle-raising 323, 324, 325
  - Cities, in—
    - Cadiz 319
    - Carthagena 319
    - Cognac 344
    - Havre 341
    - Lorca 319
    - Marseilles 332, 334, 345
    - Naples 344
    - Nice 343
    - Palermo 347
    - Paris 327, 341, 344
    - Saragosa 326
    - Seville 319
  - Climate:
    - Annual temperature, Palermo 350
    - Character of, in France 329
    - Messina, in 347
    - Northern Spain, condition in 325
    - Spain, of 322, 323
    - Temperature, Cabuerniga, in 323
  - Countries, mention of:
    - England 325
    - France 327, 333, 334, 340, 341, 244, 345
    - Italy 333, 340, 347
    - Scandinavia 322
    - Spain 319, 322, 324, 325, 327, 340
  - Crops, in:
    - Agricultural statistics 329, 335, 336, 337, 338
    - Barley 326, 336
    - Beans 339
    - Cereals 336, 340
    - Corn 348
    - Cotton 336
    - Grass 324, 345, 348
    - Hay 323, 324, 345
    - Oats 336
    - Pease 327, 339
    - Rye 326, 336
    - Tobacco 340
    - Tomatoes 327
    - Vegetables 327
      - acreage of 339
    - Wheat 326, 336, 339
  - Dams, Ferranova, above 347, 348
    - Paterno, at 347
  - Engineers, mention of:
    - Chevigne, Count, France 330
    - Fouzeroy, Flourand de, France 341, 342, 343
    - Gouton, A., France 341
    - Llaurado, Andres, Spain 321, 322
    - Lucian, Mons., France 332, 341
    - Perrin, Mons., France 341
    - Rochemont, Mons., France 341
    - Rousseau, Léon, France 341, 342
    - Villeneuve, Mons., France 335
    - Vivenot, Mons., France 341

Page.

Europe, countries in, reports from—Continued.
- Flood-gates 330
- Francon, M., viticulteur 339
- Fruit trees in:
  - Agerole 339
  - Almond 339
  - Apple 339
  - Apricots 339
  - Capers 339
  - Cherries 339
  - Fig 339, 340
  - Grenadine 339
  - Jujute 339
  - Lemon 333, 340
  - Medlars 339
  - Olive 319, 339, 340, 343
  - Orange 319, 323, 340, 343
  - Peach 339
  - Pear 339
  - Pistache 339
  - Prunes 339, 340
  - Quinces 339
  - Walnut 339
- Irrigation in:
  - Antiquity, France in 325, 326, 331
  - Area under, in France 322, 327, 343, 344, 347
  - Bigot, system of 330
  - Classes of 321
  - Dacaeur system 330
  - Department La Manche 341, 342
    - of Mayenne 342, 343
      - Ille et Vilaine 342
  - Des Bouches-du-Rhone, in 332, 341
  - La Chavente, in 344, 345
  - List of works 331
  - Meadows, of 322, 323
  - Messina, Sicily, in 345, 348
  - Orange and lemon culture, Sicily, in 348, 349
  - Southern Italy, in 344, 349
  - Spain, in 320, 322, 327
  - System of Palermo 350
- Island of:
  - Camargue 330
  - Sicily 347, 349
- Land in:
  - Crops on irrigated 346
  - Foot-hills 343
  - Meadow 324
  - Plateau of Old Castile 325
  - Southern France, in .... 340.
- Metric denominations 332
- Mountains of:
  - Alps 334, 343
  - Cantabrian 323, 324
  - Pyrenees 322, 323
- Plains in:
  - Catania 347
  - La Camargue 334
  - La Cran 334
- Provinces, Spanish, named:
  - Alava 326
  - Andalusia 319
  - Ban.. 344
  - Biscay 322
  - Granada 319, 327
  - Guipuzcoa 322
  - Logrono 326
  - Messina 345
  - Murcia 327

Page.

- Europe, countries in, reports from—Continued.
  - Provinces, Spanish, named—Continued.
    - Oviedo 322, 323, 325
    - Palormo 349
    - Santander 320, 322, 323, 325
    - Valencia 319, 327
  - Rain-fall 322, 327, 333, 334
    - Annual, in France 331
      - Messina 347
      - Palermo 350
    - Southern France, in 344
  - Reservoir at Oridon 328
  - Rivers in:
    - Darro 319
    - Duro 326
    - Durance 333, 334
    - Elbro 326
    - Gela 348
    - Guadalquivir 319
    - Neste 328
    - Rhone 329, 330, 334
    - Santa Ana 340
    - Simeto 347
    - Vesubie 343
    - Xenil 319
  - Seasons of drought 324, 325
  - Seas of:
    - Adriatic 344
    - Mediterranean 329, 333, 334, 344
  - Soils in 323, 334
    - Alluvial 344
    - Deep and fertile 326
    - Nature of 329
    - Sterile 343
    - Province, of 334, 340
    - Qualities of, Spain 322
  - Springs of Sainte Thecle 343
  - Streams in:
    - Chavente 344
    - Nee 344
  - Topography of Des-Bouches-du Rhône 334
    - Messina district 346
  - Trees in:
    - Beech 324
    - Oak 324
    - Palm 319
    - Pistachio 348
    - Timber 334
  - Vineyards in 339, 343, 319, 323, 326, 340
  - Water in:
    - Character of storage works in France 328
    - Court at Granada 319
    - Distribution at Messina 346
      - Palermo 349
    - Flood 334
    - Storage of 340
    - Supply of, in France 328, 343
      - Italy, in 344
      - Messina, in 345, 346
      - Palermo, in 349
    - Surplus 345
    - System in the Bouches-du-Rhône 329, 330
      - France 328, 329
    - Total area of 324, 325
    - Wind, south 325
- Indian and Pacific Ocean Islands, reports from:
  - Archipelago, Phillipine, irrigation in 297
  - Cities in: Bruan, Calanda, Carite, Manila, San Francisco de Malabou .. 297
  - Dominican Fathers 297

Page.

Indian and Pacific Ocean Islands, reports from—Continued.
  Lands in rice and "zacate" or swamp grass 297
  Rain-fall in 297
  Seasons of 297
  Sluice-ways in 297
  Hawaiian Islands, irrigation in 273, 274, 275
    Allardt & Schuyler, engineer's report 273
    Antiquity of irrigation system 273–275
    Climate of 274
    Crops:
      Bananas 274
      Rice 273, 274
      Sugar-cane 273, 274
    Honolulu, at 273
    Rain-fall:
      Annual 274
      Island of Oahu, on 275
      Hilo district, in 275
    Sprecklesville, plantation, at 274
    Water, in:
      Cost of rental to users 274
      Duty, of 274
      Source of supply 273, 274
      Tenure of ownership 274

IRRIGATION

IN

THE UNITED STATES.

BY

RICHARD J. HINTON.
[*Special Agent in charge of Artesian Wells Investigation*, 1890,
Department of Agriculture.]

BEING A SECOND EDITION OF MISCELLANEOUS DOCUMENT NO. 15,
FORTY-NINTH CONGRESS.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1890.

IRRIGATION IN THE UNITED STATES.

EXTENT AND METHODS. AREA OF RECLAMATION. THE STATISTICS THEREOF. ARTESIAN WELLS. LAWS OF STATES AND TERRITORIES. WATER SUPPLY. RATES AND DISTRIBUTION; WITH BRIEF SKETCH OF FOREIGN SYSTEMS, ETC., ETC.

PREPARED BY

RICHARD J. HINTON.

BEING A

SECOND EDITION OF SENATE MISCELLANEOUS DOCUMENT No. 15, 49th CONGRESS.

IRRIGATION IN THE UNITED STATES.

[Prepared by order of the United States Senate Special Committee on Irrigation and Reclamation of Arid Lands.]

PART I.

THE ARID REGION.

An inquiry into the progress and present condition of irrigation in this country necessarily involves a consideration of the extent and character of the area within which the annual rain-fall is not sufficient for the industrial uses of the people. Such an inquiry, broadly defined, involves the extent of the fall of rains or snow within the area indicated; also the evidence obtained as to increase or decrease of precipitation resulting from agricultural settlement or of pastoral occupation, the increase of humidity of earth or air, the destruction of the timber mainly by its use for settlement purposes, the effect of the destruction of the native grasses and the substitution of cultivated varieties; also the sources of water supply, their character, uses, conservation, the means, natural and artificial, employed for their distribution, and what has been and is being accomplished in the way of artificial methods of water distribution and economy, and the laws and customs pertaining thereto. More than any of these, however, it relates itself fundamentally to the largest questions of physical geography. The topographical configuration involves, indeed it controls, the whole matter of aridity, because it determines all climatic considerations. The probability of reclamation by means of irrigation is primarily by the configuration of a given hydrographic area.

Incidentally, the questions arising from deforesting, on the one hand, and of arboriculture, on the other, are related to the inquiry, and have been brought out to some extent. The aim has been to give the actual facts upon these subjects, so far as they could be supplied from observation, experience, experiments, and realized results. This effort has been measurably successful. It has brought together a mass of facts and observations that shed much light on the questions involved, giving a broader idea of the importance of irrigation, and adding greater value to a very large area of the United States, of whose agricultural capabilities but small account has heretofore been taken. It will be developed by the facts herein presented that the area of the irreclaimable arid lands within the boundaries of the Union is, comparatively speaking, quite moderate in its extent. There is, however, a very large area, embracing at least one third of our total land service, wherein the water supply, whether subterranean and surface-flow or in the form of precipitation, is both inadequate and irregular in character.

The eastern boundary of this great area may at present be assumed to be the one hundredth meridian of west longitude. The western boundary may be in part placed at the Pacific Ocean, though more accurately the Coast Range of California would be the line. The northern boundary is the British territorial line west from the one hundredth degree to the summit of the Sierras, or the one hundred and twentieth meridian. Following the summits of the main range, the northwest line would deflect to the central portion of Oregon, following the southwesterly bend of the mountains down to the northern boundary of California. The southern limit of this dry area would be the northern line of Mexico, and thence south by east, along the Valley of the Rio Grande, down to the Gulf of Mexico. The area then, east and west, through its central and larger portion, runs from the one hundredth meridian to the one hundred and twenty-fourth degree of west longitude, and in its greatest prolongation north and south from the forty-third to the twenty-seventh degree of latitude. In its more northern portion it runs east and west from the ninety-eighth to the one hundred and twentieth degree of west longitude. The larger portion from north to south is embraced between the thirty-second and forty-third degrees of latitude, with the sub-arid or semi-humid area, the eastern line of which, though irregular, may safely be stated as the ninety-seventh meridian, the total area extends east and west for nearly twenty-eight degrees of longitude.

These lines cover nearly one-half of the States of Kansas and Nebraska, both States of Dakota, the whole of the States of Colorado, Montana, and Nevada, with nine-tenths of California, one-third of Texas, and about one-third of Oregon; also the Territories of Wyoming, New Mexico, Utah, Idaho, and Arizona, with at least one-third (east of the mountains) of Washington. This embraces about one-third of our whole territorial surface, inclusive of Alaska. How much of the latter-named Territory may be wholly or partially arid or desert in character can not yet be estimated. The east and west lines of this dry region, then, are, in the widest section, over 1,300 miles apart, and in its greatest length, the northern and southern limits are about 1,000 miles apart. If the whole region were compactly arranged it would make a block about 1,000 miles square. The area thus indicated may be subdivided again into three broad divisions, as follows:

(1) The plains region, running north and south from the British American line to the lower portion of the Rio Grande Valley in Texas, and east and west from the one hundredth to the one hundred and fifth degrees of west longitude. This division may be broadly declared to have a general rise and altitude of from 1,500 to 5,000 feet, though it will fall below that at either end of the area. It is but sparcely supplied with streams, which are mainly fed from mountain sources; the annual precipitation is nearly everywhere below a reliable amount for economic uses. In the central portion this precipitation will not, under favorable conditions, exceed 18 inches per annum in the eastern part, and as we go westward it diminishes to 12 and 15 inches per annum.

In the southern (Texas) portion of this area the rain-fall will somewhat exceed 20 inches on the east, decreasing until, on the northwest, it will reach only 8 to 10 inches in the most favorable seasons. In the northern or Dakota portion the average is more evenly maintained. This division will include the western half of Kansas and Nebraska, one-third (or the eastern foot-hills and plains region) of Colorado, the major portion of Dakota, the eastern half of Wyoming Territory, and one third or more of the Indian Territory and Texas, with about one-fourth (or the eastern part) of New Mexico. It is drained by a number of streams, some of them of importance, and is bounded on the east and north by the Missouri River and its afluents, and by the Pecos and

Cimarron Rivers on the west and southwest. Its soil is almost uniformly fertile. Natural grasses of most nutritious quality are found throughout its area. It is the most important grazing section of the West.

Large farming settlements are moving steadily and compactly westward from the eastern line. At various points in its western portion there are important farming communities, created mainly by the use of water as applied through irrigation ditches and by other means of storage and distribution. The valley of the Upper Rio Grande, from the San Juan Range in southern Colorado, to where the river debouches from New Mexico into Texas and becomes the boundary-line between the United States and Mexico, has for many generations been the seat of local and unsystematized irrigation works. The Pueblo or town-dwelling Indians have for centuries practiced it. Since the Spanish conquest, in the sixteenth century, the mixed Mexican people who have inhabited this district have always been obliged to irrigate in order to cultivate. In these latter days our own more enterprising people are inaugurating and carrying on larger enterprises and projects, whose advantages are already perceivable.

(2) The second great division can be more distinctly characterized as the arid section of the United States. It lies between the one hundred and fifth and the one hundred and twentieth meridians, taking in the whole of our intra-mountain region, from the foot-hills of the Rockies to the lower slopes and foot hills of the Sierras Nevada in California, and extending north and south from British America to Mexico. Within this area, except on the higher and arid heights of the ranges, principal or secondary, there is generally good pasturage for cattle. The natural grasses are sun-cured, and afford ample food and range for many million head of cattle.

The problem of water supply is, however, one for serious consideration. There are desert tracts and areas within this great region which are undoubtedly arid and desolate to the extent of irreclaimability. Their extent is a matter yet unsettled, especially in view of the great enterprises projected and in progress in both Colorado and California. Even the mountain plateaus, which, from altitude as well as aridity would seem to be undoubtedly sterile, may yet be found useful, not only in providing for cattle, but, possibly under systematic plans of forest-culture, they may be made the means of protecting the water sources and otherwise favorably modifying climatic and terrene conditions.

The defined outlines of this second division embrace the great basin section, of which Utah and its water reservoir—the great Salt Lake—are the dominating physical and geological features; the Colorado plateau region, which occupies the larger portion of Southern Nevada and Northern Arizona; the beautiful parks of the Rocky Mountains or the eastern flank and ranges of the North American Cordillera system; the table-lands of southern Arizona, and the great valleys and basin formed on the north by the Columbia River and its important affluents in eastern Oregon, Idaho, and Montana.

Arid and desert as this stupendous mountain system may seem to be, it will be found on examination to have large sections capable of agricultural uses, and also to hold within its borders such sources and supplies of water as, properly conserved, protected, and distributed, under the wise and conservative direction of the national and State Governments, will be found of ample utility for the purposes (1) of larger pastoral uses; (2) of more limited and localized, but still extensive, agricultural purposes; and (3) as storage and reservoir sources, from which at no distant day the life-giving waters may be conveyed to and distributed over vast areas, which even our present limited experiences prove to be convertible into fertile farms.

A glance at a good topographical map will indicate to the observant eye the areas under reference. For example, the central section of the Rockies (in Colorado, Wyoming, and a portion of New Mexico) contain the sources of important rivers. This hydrological area is extensive, as there are numerous lakes, some of considerable size, while the snow precipitation is also quite heavy.

Inquiry and examination will satisfy the inquirer that in the extreme west the higher Sierras yield from the snow precipitation alone an amount of water which, under proper engineering conservation and wise plans of distribution, carried out for the common weal rather than for corporate profit, would supply the whole great valley and foot-hills region of central and southern California, now being so largely developed as a wheat and fruit growing region. The eastern slopes of the Sierras belong as drainage area to the huge hydrographic basin of which Nevada is the chief portion. The snows and storage of that region should readily reclaim 3,000,000 acres in western Nevada.

In the northern portion of our intra-mountain area the hydrological system, comprising the Columbia and Snake Rivers and their affluents, will certainly give a sufficient water supply both for pasturage and agriculture.

East of the Cascade Mountains the climate and natural features of the country are very different from those of the great basin lying west of them, so that the popular divisions, eastern and western Oregon and Washington, are fully warranted. In the eastern section the thermometer is much higher in summer and lower in winter than in the western section. The rain-fall is not half as heavy. From June to September there is no rain. The winters are short, but occasionally severe. Snow seldom falls before Christmas, and, though it sometimes lies from four to six weeks, it usually disappears in a few days. The so-called "Chinook," a warm wind, blows periodically, and melts deep snows in the course of a few hours.

In Eastern Oregon and Washington spring begins in February, and lasts until the middle of May. At this season rain falls in sufficient quantity to give life to vegetation and insure good crops. The average temperature is 52°. The rain-fall of the year does not average more than 20 inches. South of the Snake River it is not more than 15 inches, increasing gradually to the northward.

In the southern portion of this area, where the Colorado plateau descends to the valleys of the Gila, Colorado, and Rio Grande, forming the table-lands of Southern Arizona and New Mexico, there has already been utilized a water supply sufficient for cattle, and in several extended portions, as in the valleys of the Gila, Rio Verde, Salt, Colorado, Chiquita, San Pedro, and Santa Cruz Rivers, almost enough to meet the present agricultural and horticultural demands has been turned to account.

It may be estimated, then, that, of our whole intra-mountain region below the timber line as herein outlined, at least 60 per cent. affords fair pasturage, with sufficient watering-places, though often at long intervals apart, and subject to various limitations, which are rapidly being in a degree overcome, and will hereafter largely disappear as more attention and skill are directed to the subject. The facts gathered from Utah and Nevada will show how large are the possibilities of improvement in this direction. No really accurate estimate can be made as to the proportion of this intra-mountain area that may be reclaimed for arable and horticultural purposes; but it is not extravagant to claim that when the accessible water sources shall be brought into use, one-fifth of its acreage (as already defined) may be so utilized. In a very large portion the per cent. will be quite small; in other portions it will greatly exceed the general estimate here made. It must be borne in mind that in both estimates the higher mountain sections, embracing at least one-fifth of the whole region, are excluded. Yet, on the summit of the highest plateau region in northern Arizona, for instance, cattle are successfully wintered at an altitude of from 7,000 to 10,000 feet above the sea.

(3) The third division, which might fairly be ranked first in point of interest, embraces the Pacific coast region from the western slopes of the Sierra Nevada (in California) to the ocean, and takes in the great transverse valley troughs or plains cradled between the Sierra foot-hills and the Coast Range, the great wheat granary of the Golden State, and also the fruit-growing section, yearly rising in importance.

In treating of these three divisions of the arid region more in detail they will be taken up in inverse order, beginning with the one named last in the above statement.

THE PACIFIC COAST DIVISION.

This division embraces the State of California, lying between the one hundred and twentieth degree of west longitude and the Pacific Ocean, east and west, and between the fortieth and thirty-first degrees of north latitude.

In the San Joaquin Valley, at Fresno, and at different points in southern California, as Los Angeles, San Gabriel, Riverside, Anaheim, San Diego, water is found to be attainable at moderate depths, and apparently in all directions. This subterranean supply, wherever it has been reached and utilized, is greatly reducing the need of surface irrigation.

Fruit growers and wheat farmers in southern California unite in the testimony that after irrigation has been practiced for some years a given supply of water suffices for a largely-increased area, the explanation being that when water is first applied to arid land a large part of it sinks deep into the dry earth, or is carried away latterally by seepage; whereas, when the lower strata and, to some extent, the lands adjoining those under irrigation, are moistened, the amount of water absorbed in excess of the actual needs of vegetation becomes comparatively small. How much effect this increased humidity of the soil may have on the atmospheric humidity is not yet known, but the increase of evaporation due to this circumstance and to the cultivation of trees and plants must ultimately produce a beneficial change in this regard.

The full industrial use of water in California must necessarily be governed by the larger topographical and other physical conditions. The precipitation seldom exceeds 22 inches annually, and over a greater portion of the State falls below that figure. The wide range of variation in rain-fall is illustrated by the following facts: At Fort Redding the range of three years was from 15.9 inches to 37.4 inches; at Sacramento the range of seventeen years was from 11.2 inches to 27.5 inches; at Millerton, six years, from 9.7 inches to 49.3 inches; at Stockton, three years, from 11.6 inches to 20.3 inches; at Fort Tejon, five years, 9.8 inches to 34.2 inches; at Monterey, five years, from 8.2 inches to 21.6

inches; at San Diego, twelve years, 6.9 inches to 13.4 inches; at Benicia, twelve years, 11.8 inches to 20 inches. The above figures show the rainfall for calendar years; the following show the amount of precipitation during the rainy season: Clear Lake, 1,300 feet elevation, six years, 16.2 inches to 66.7 inches; Visalia, three years, 6.7 inches to 10.3 inches; San Francisco, twenty-two years, 7 inches to 49.3 inches; Pillarcitos, nine years, 39 inches to 82 inches; Sacramento, twenty-four years, 4.7 inches to 36.4 inches; San Diego, twenty-two years, 4.5 inches to 14.8 inches.

The importance of California warrants a fuller description of the State, its topography, and other conditions bearing on the question of irrigation within its limits. There are two great mountain ranges running northwest and southeast, namely, the Sierra Nevada and the Coast Range. The former is from 4,000 to 8,000 feet high and the latter from 1,000 to 6,000 feet. The two ranges are connected in the southern part of the State at Tehachipi, and in the northern at Mount Shasta. The Sierra Nevada Range extends along the eastern border of the State and is about 450 miles long. The Coast Range extends along the coast to the northern and southern boundaries of the State. The base of the Sierra Nevada Range north of Fresno has an average width of about 80 miles. The Coast Range averages about 65 miles in width. Between the two ranges are the great Sacramento and San Joaquin Valleys, which together are about 450 miles long by 55 miles wide, and may be termed the heart of the State.

In the northern part of the State, and north of the junction of the two great mountain ranges, is the Klamath Basin, through which the Klamath River runs for a distance of 225 miles, between steep hills and mountains and rocky cañons, in a southwesterly course to the ocean. The whole basin of the Klamath is very rugged for a distance of 40 miles from the coast, and along the main river there is very little valley or bottom-land. However, there are several small rich valleys and near the lakes there are large fertile tracts. Pine, cedar, and fir forests cover the mountains, and there are other valuable trees, both on the mountains and in the valleys. In the extreme southeastern portion of the State is the Colorado Desert, about 140 miles long by 70 miles wide, which is the dry bed of a former inland sea. Another great basin, called the Mojave Basin, lying north of the Colorado Desert, extends into the southern part of the State, the surface of which is cut up by many irregular ridges of mountains.

The Coast Range is composed of a multitude of ridges and is intersected by numerous long and narrow valleys of fertile soil, comprising those of the Los Angeles, Salinas, Santa Clara, Sonoma, Napa, and Russian Rivers. The State has numerous small rivers. In the central portion are the Sacramento and San Joaquin, each in its meanderings about 350 miles long. These are the only navigable streams in the State. From the Sierra Range westward into the Sacramento flow the Pitt, Feather, Yuba, American, Consumnes, and Mokelumne Rivers. Into the San Joaquin flow the Calaveras, Stanislaus, Tuolumne, Merced, Chonechilla, and Fresno. Into Tulare Lake flow the Kings, Kameah, Tule, and White Rivers, and into Kern Lake the Kern River. All of these are considerable streams, with an average length of about 120 miles. The upper half of each is in the steep and rugged mountains, where they are torrential in character. After reaching the plain their currents are gentle, and the banks low, fringed with oak, sycamore, cottonwood, and willow.

The rivers of the Coast Range flowing westward into the ocean south of San Francisco are the San Lorenzo, Pajaro, Salinas, Carmel, El Sur, and Cuyama, Santa Inez, Santa Maria, San Buenaventura, Santa Clara, Los Angeles, San Gabriel, Santa Ana, Santa Margarita, San Luis Rey, and San Diego. Many of these are constant streams to within 10 or 15 miles of their mouths, and all of them pass through rich valleys. North of San Francisco the streams of the Coast Range which empty into the ocean are the Russian, Eel, Elk, Mad, Klamath, and Smith Rivers, besides many others of less importance, all of which are permanent streams, bordered with narrow valleys at the foot of the mountains. To all of the rivers of the State flow many small tributaries. There are several important lakes, the Tulare, Owens, Kern, Clear, Klamath, Goose, Fall, Eagle, Honey, Elizabeth, Tahoe, Mono, and Dry Lakes. There are also a number of smaller ones.

The southern portion of the great interior basin of California is commonly known as the San Joaquin Valley, although it comprises the San Joaquin, Tulare, and Kern Valleys. The Tulare Valley is separated from the first named by a low ridge of land, scarcely noticeable, and in times of high water the southern lakes and rivers find an outlet through Fish and Fresno Sloughs into the San Joaquin River, thence to San Francisco Bay. Properly, there is no division lying between the San Joaquin and Sacramento Valleys. The greatest length of San Joaquin Valley is 260 miles, the width varying from 30 to 70 miles. The area is 11,290 square miles, or 7,225,600 acres. The eastern and western sides of the valley slope from the base of either range of mountains towards the lakes or streams in the lowest part, at the rate of 5 to 8 feet per mile; also northward to tide-water in San Francisco Bay, with a general fall of 1 foot to the mile.

The Mount Diable or main Coast Range on the west side of the valley has an average height of about 1,700 feet. The Sierra Nevada Mountains on the eastern side of the valley rise to a much greater height. Mount Whitney, in Tulare County, has an altitude of 15,056 feet, and is the highest peak within the United States. From this mountain the summit-line of the range gradually lessens in height towards the north and more rapidly to the south. These mountains are rugged and broken, sharp, rocky ridges and granite spires rising abruptly to great altitudes. In the small valleys between these ridges is perpetual snow, and about the base of Mount Whitney are a number of small glaciers. This region has some of the wildest, grandest, and most beautiful scenery in the world. The San Emidio, or Tejon Mountains, a spur running at right angles to the Sierra and Coast Ranges, and joining the two, form the southern boundary of the San Joaquin Valley. The foot-hills commence in the northern part of Fresno County at an altitdue of 300 feet above sea level, and in the extreme southern end of the valley at a height of 400 feet. In the hills are many valleys, some of them large and level, others more uneven.

In the Coast Range there are few valleys. About the base of the range are gently-sloping table-lands at an altitude of 100 to 250 feet above the valley, from which the mountains ascend to sharp and narrow ridges cut transversely at intervals of a few miles by natural passes extending through the range. The flanks of the Sierra broaden towards the south. The Sierra foot-hills in the portion of Tulare County, midway between the northern and southern boundaries, rise suddenly from the plain, but to the northward and southward, in Fresno and Kern Counties, the slope is more gradual, the hills lower, and the belt wider.

THE RAISIN VINEYARD REGION.

To the eye of the traveler the plain generally presents a very level surface. In Fresno County, on the eastern slope of the valley, are scattered hillocks 20 to 30 feet in height, with a wide base, rendering them inconspicuous even at a short distance. These are not observable elsewhere in the Southern San Joaquin Valley. Extending along the entire length of the eastern side of the valley, near the foot-hills, is a belt of uneven country known as "hog-wallow" land. These "hog wallows" are little mounds ranging from a few inches to 3 or 4 feet in height, averaging 1 to 2 feet, with a diameter of 16 to 50 feet. There are no deep river-beds traversing the upper part of the valley, although further north these are common. The beds of the southern streams, in fact, are in almost every case higher than the general level of the plain, having been built up into low, wide ridges, by the alluvium deposited during the rainy season through a long series of years.

Fresno, Tulare, and Kern Counties form the southern part of the San Joaquin Valley. The three counties have an aggregate area of 21,770 square miles, or about 13,932,800 acres. Of this large extent of country 13,885 square miles, or 8,886,400 acres, are mountain and hill land; and 7,885 square miles, or 5,046,400 acres, are in the valley, making a body of arable land in these three counties (deducting the surface covered with water) equal to some of the larger Eastern States. The land is divided among the counties as follows: Fresno, 4,480 square miles, or 2,867,200 acres, of mountain and hill land, and 3,520 square miles, or 2,252,800 acres, of valley land; Tulare, 3,835 square miles, or 2,454.400 acres, of mountain and hill land, and 1,775 square miles, or 1,136,000 acres, of valley land; Kern, 5,570 square miles, or 3,564,800 acres, of mountain and hill land, and 2,590 square miles, or 1,657,600 acres, of valley land, including the gently sloping plain skirting the base of the hills. There is a more gradual ascent from the valley proper in Kern than in either of the other two counties. The numerous valleys, large and small, in the mountains and foot-hills are not estimated as valley land.

THE SAN JOAQUIN ARTESIAN WELLS.

There is a large portion of the southern San Joaquin Valley that is not wholly dependent upon the streams for irrigation, considerable water being obtainable from artesian wells. The artesian belt extends from one end of the valley to the other. A good flow is usually obtained in boring to a depth of 300 to 600 feet. The first successful boring for artesian well water in Tulare County was made by the Southern Pacific Railroad in 1879 near Tipton, and a flow rising half an inch above the rim of the casing was secured at a depth of 310 feet. The well is on the eastern margin of the belt. This water was used for irrigating a 40-acre tract of forest trees, which it did successfully.

No rock is encountered in boring, strata of sand, clay, and gravel succeeding one another. It is therefore necessary to use iron casing the whole distance, which is forced down after the auger. The depth at which the first water-bearing stratum of sand or gravel is penetrated is from 310 to 640 feet, although some of the wells have been put down to a depth of 800 feet, passing through several of these strata. The deepest in Tulare County are in the northwestern part, near Lemoore. The section in which the greatest number of good, flowing wells have been obtained is west of the Tulare and near Tipton, the water from some of them rising to a height of 5 or 6 inches above the casing. Wells are also shallower here than about Lemoore. The average depth in Tulare County is about 450 feet. There are in Tulare County about three hundred wells. It is impossible to give the exact number, as so many new ones are being bored. In Kern and San Bernardino Counties the number is not less than five hundred.

In Fresno County fewer wells have been bored. In the southern part of the county water is obtained in one well at a depth of 152 feet. Others have been bored in the region bordering on the San Joaquin River, the depth of these averaging from 150 to 200 feet. In Kern County, at the southern extremity of this great basin, artesian wells were bored several years ago and water was obtained at a depth of 200 to 250 feet, the average depth being less than in Tulare County. Some fifteen or twenty wells have been bored in the county. One, 470 feet deep, furnished about 30 gallons per minute. Others have been bored north of Poso Creek, in the region about Delano and Alila, and elsewhere in the county. The average flow from the wells of Tulare County may be placed at 2½ inches above the casing.

The quantity of water furnished by a well of this capacity is about 247 gallons per minute, or a little more than half of a second-foot. In parts of the San Joaquin Valley shallow wells have been known to fail after two or three successive years of light rain-fall and to flow again after a wet season. This has not happened in the southern portion of the valley. The deeper wells continue to flow regularly. It is claimed that some of the wells in Tulare County will each irrigate 160 acres of land thoroughly, and after the ground has been irrigated and cultivated a number of years and the methods of applying the water perfected a greater acreage can be successfully watered. More recent observations show that these wells are periodical as to flow, being larger and with more power when the mountain snows are melting than at any other time.

The Mussel Slough region in Tulare County was the first to be irrigated on a large scale, and soon became famous for the productiveness of its land. In the foot-hills there is generally sufficient rain, except in very dry years, to mature crops. Where the soil is loose and sandy and where irrigation has been in use for a term of years little water is required other than that supplied by the rain-fall, the ground being sufficiently moist from seepage. In places moisture will permeate the ground for miles from the ditches. In some portions of Kern County the farms comprise from 640 to 1,800 acres, and the checks made for irrigating are surrounded by strong, low embankments, made with a view to permanency. The ditches are made on the highest land, and the levees inclosing these irregularly-shaped checks are built so as to take advantage of the natural inequalities in the surface.

VALUE OF THE FOOT-HILLS.

The foot-hill region contiguous to the great valley which has been frequently referred to deserves more extended notice. This belt is of varying width, extending along the Sierra Nevada Mountains. In the mild climate of the Southern Joaquin plain it is most valuable for the growth of citrus and other semi-tropical fruits. It is particularly adapted to early fruits of all kinds. It has already been stated that fruit ripens much sooner in the orchards of the Fresno and Tulare County foot-hills than on the plains. The same is true of Kern County. Experience demonstrates that in the valley at the mouth of Kern River Cañon, twelve miles from the Southern Pacific Railroad at Sumner, frosts begin one month earlier than in the valley, and cease a month earlier in the spring, and during the coldest period are less severe than on the plain.

Peaches in the foot-hills have ripened a month earlier than on Kern Island; all kinds of stone fruits mature early, while other kinds that do not bear well or regularly in the valley grow to perfection here. An isothermal line drawn through the axis of this belt would traverse the lower and more easily cultivated portion of the foot-hills, and at the southern end of the valley would extend upward and inland to the abrupt mountain wall where Kern River Cañon bisects the range, where it would approach nearer to the valley than farther north, owing to the topography of the mountains and not to other conditions influencing climate. Above the thermal belt, extending through the region of black oak to and into the pine and redwood forests, is an extensive area adapted to the production of a great variety of crops, and particularly to those fruits that require a cooler climate than that of the lower foot-hills and plain. The soil is rich, but the greater part of the hill land is covered with a dense growth of chamiso, manzanita, chaparral, and other brush, which must be cleared before the land can be cultivated.

Small clearings have already been made, and the result has been to encourage others to enter or purchase and do likewise. At no distant day this will be an important section of the agricultural and fruit-growing portion of the three counties named. It is a healthy region. The rain-fall is greater than in the valley, and by conducting water from the mountain streams by the system of piping employed in other parts of the State a sufficient supply can be obtained to irrigate all the best cultivable land, and by the conservation of water in reservoirs during the wet season the small streams could be depended upon to furnish a sufficient supply for a large aggregate area not readily reached by the main streams. Above an altitude of 1,200 feet in Fresno, 1,500 feet in Tulare, and 2,000 in Kern County there is sufficient rain-fall to make irrigation useful but not an absolute necessity.

In the region midway between the plain and the mountains proper the hills are generally precipitous, and although small valleys are numerous, there are few of any considerable area. Land in the southern San Joaquin Valley remote from water supplies has in only a very few instances advanced materially above Government price; whereas that lying contiguous to or supplied with water has advanced several hundred per cent. in value, having been converted from grazing to productive agricultural and fruit land. In Fresno County only has the colony plan of settlement been carried to any great extent. At present there are two colonies in Tulare County, and one or two large tracts of land for sale in lots of 10 to 40 acres. Twenty acres are sufficient for fruit growing, and 40 acres is the largest tract that one man or family should attempt to cultivate, for it pays better to give careful attention to 20 or 40 acres than to imperfectly work more. The first colony started in Fresno County was the Central, near the town of Fresno, on the west side of the railroad. The land on which it was located was a treeless, uninviting plain, and, except in the wet season, verdureless. Now the elm, fig, cherry, and other trees give names to the avenues along which they are planted, and the tract presents a succession of flourishing orchards and vineyards, with scores of beautiful and comfortable homes, surrounded by shrubbery, green lawns, and flowers. Other colonies have since been started, and are in a more or less advanced state. The principal ones are the Washington, Nevada, Fresno, Scandinavian, Easterby, and American, which follow in the order named.

THE DRAINAGE BASINS.

The area of California in its relations to irrigation falls into the following divisions:

(*a*) The natural area of sources, supply, and reservoirs; that is, the higher portions of the Sierra Nevada, upon the western flanks and summits of which the snow precipitation is heavy, whose physical formation creates the great catchment basins, and whose altitude is sufficient to break, deflect, and desiccate the great moisture-bearing currents from the Pacific Ocean.

(*b*) The foot-hills region, extending from Mount Shasta to the San Bernardino Range. This is the seat also of the important mining operations of the State. It is, consequently, the area in which the water-supply section has been largely drawn upon and made extensively available by means of catchment areas, dams, ditches, and flumes. It is also especially in what is designated as the lower foot-hills where the altitude is below 2,500 feet, an area in which these supplies and distributing agencies, natural and artificial, have been extensively utilized for agricultural and horticultural purposes.

Experience has proved that in this subdivision of the State, which for all practical purposes embraces nearly all of Northern California, irrigation must, for such industrial purposes, be heavier and more continuous than elsewhere. Irrigation enterprises therein have up to date been largely of a personal and individual character, except where the hydraulic mining companies have utilized their larger water-works and channels, with the surplus waters they controlled, by selling the latter to the farmers and horticulturists of the region.

(*c*) This subdivision embraces the great valley region of the State, its most important wheat and grain growing section, and includes the extensive drainage basins of the Sacramento, San Joaquin, Feather, Bear, Yuba, American, Cosumnes, Mokelumne, Tuolumne, Merced, Kings, Fresno, Kern, and other streams, large and small. It covers an area of over 34,000 square miles, divided into sixteen counties, within which every problem connected with the industrial use of water and its conservation, legal and practical, is in process of both application and discussion. The most extensive canal system, and the combination of farming interests in the control of supply, or the application of capitalistic enterprise to induce land settlement primarily and water purchase subsequently, are to be found therein.

There are also, as already noted, well-developed artesian belts in the upper portions of this region. The lower portions are subject to tidal overflow and river inundations, while the existence of water at a moderate depth is being demonstrated in almost every portion of the great valley areas. This region embraces not only the major portion of the wheat-producing area, but is also the seat of large viticultural and horticultural activity.

PLANTING AND SUB-SURFACE WATER SUPPLY.

Perhaps the most gratifying as well as significant fact developed by the irrigation experience of California, especially in the valley region, is that connected with quality of the soils, which are generally of great thickness and tenacity. Underlying the surface soils there are found almost everywhere at moderate depths, impervious strata, by which the water drawn too rapidly from the overdrained surface has been happily preserved. Owing to this almost generally established condition of things, water throughout the northern as well as the central portions of the State is being obtained from ordinary wells. It is pumped to the surface and distributed by the agency of the peculiar wind-mills in use, which are now known in all parts of the world.

The altitude of the California valleys is nowhere very great, and the lower portions are at but moderate heights above sea-level. That of the foot-hills region is from 2,500 to 4,000 feet. California experience brings into prominence the question whether the cultivation of the soil in surface-dry and wind-desiccated areas, such as the valleys and lower table-lands of that State were assumed to be but a few years since, does not of itself tend directly to an increase of surface humidity by capillary attraction, or the drawing upon the water supplies that are unquestionably found in the underlying strata. Another question suggested is, whether such supplies are not to be found flowing below or underlying considerable areas of the valley plains and table-land regions of Central and Southern California and elsewhere within our dry areas. The precipitation of rain and snow, with the annual melting [illegible] the latter, would be in itself sufficient to feed such subterranean bodies.

It is evident that these aqueous supplies do not directly flow to the ocean within the hydrological channels and basins that have been worn through the surface and other strata. The streams and rivers of California do not carry volume enough to account for the amount of deposition that must occur within the sub-division designated as the source and supply area of the Sierras. If subterranean bodies of water exist they will be utilized by borings. The high altitude at which waters disappear into the earth must give them, when arrested under the table-lands and plains below by impervious strata, a force ample to propel the same up and above the surface, and to give them the value of living perennial streams or springs. In fine, there are two sources of subterranean waters to be utilized in California for fuller industrial purposes. The first is the water arrested in its flow from the surface at moderate depths, and which can be reached and drawn upward by the loosening of the soil consequent upon cultivation, and by the hardy and penetrative qualities of the plant roots. The other source is to be found in the deeper bodies that are presumably the lost and sunken floods of the Sierras. That such bodies exist there is more than mere conjectural data to indicate.

RECLAIMABILITY OF MESA AND DESERT LANDS.

Passing from these points, the other division of southern California embraces some of the features of both the valley and foot-hills regions. It is also affected in its western portion by the trade winds and other coast influences, and its extreme southern and eastern section is modified and molded by the great Colorado plateau formation of which the boundary mountains and mesas, or table-lands, are in fact a part. There are great stretches of arid mesa, or secondary table-land, which must be counted as desert, though the major portion has native grasses sufficient to feed a large number of animals. There is also sufficient development, especially in Los Angeles and San Bernardino Counties, to indicate the possibility of profitable reclamation in the case of considerable portions of these so-called deserts, provided the waters now available, explored, and in part utilized, can be distributed over their surface.

The southern California division approaches, in many of its products, a semi-tropical fertility and luxuriance. It is the chief seat of the orange culture. The lemon, olive, date, fig, almond, pomegranate, nectarine, and other fruit trees requiring warm and fecund soils, grow in abundance there. The upper or northerly part of this subdivision forms a part of the great wheat-producing area of the State.

The table-land or mesa portions are also extensively utilized for the pasturage of cattle and sheep. In the southern section of California the absence of any considerable hydrological basins with flowing waters in them makes the method of conservation of great significance. The economic use of water therein has almost approached perfection. The conservation of the Los Angeles River and of other similar but smaller streams, within the three great counties into which Southern California is legally divided, is in proof of this.

WATER LAWS AND REGULATIONS.

The practical legal issues involved in the conservation and distribution of water for economic uses within the State of California are of a most serious character.

There are district community methods of control, as seen in the laws and policy found operative within the State. The first comes from the admixture of the Indian community, or pueblo life, with that of the Spanish conqueror, both being affected and shaped by the needs and customs of people to whom irrigation has always been a prime necessity. The Indian, with his tribal, clan, or village organization, has regarded land and water as common or communal property, in the use of which all had a right. The Spaniard regarded the land as his by conquest, but held that the water, being necessary for its full utilization and profit, must be controlled by the king, *i. e.*, the state, and therefore should be for the public use. The English common-law doctrine of riparian rights has no place in the economy of either people. The public charge of the water supply at Los Angeles and elsewhere in southern California illustrates the perfection to which the community may bring control and distribution. The discovery of gold brought with it in California the rapid adoption of a miners' code, both as to the occupation of mineral "claims" and the control of water rights.

This code has become the foundation of nearly all our legislation, State and national, as to the disposition and use of the mineral lands, and, in a minor degree, it has also dominated and shaped the water usages so far as mining is concerned. The public use of water is fairly established in that connection; but as to the other and larger utilization of water in agriculture, the drift of events within the dry area seems to have been for a long time in the opposite direction. This tendency began early in the construction of large works in the upper foot-hills and Sierra regions, for the purpose of obtaining a water supply large enough to carry on the great hydraulic enterprises which, for a quarter of century past, have been so marked a feature of California gold-mining.

The United States Senate Committee on Irrigation sum up the legal relations of water and land as follows:

> The legal questions involved in the beneficial uses of water have been strangely complicated in California. The Indian community system prevailed before and during the Spanish occupation, having been made useful by the missionaries, who obtained such great control of that population. The Spanish conquerors were themselves original dwellers in an arid region When the State passed under the control of this Republic, such small portions of it as were cultivated owed their fertility

entirely to irrigation. The modes of distribution were recognized as being properly controllable by the community. Water was public property. The American miner, with his new enterprises and enormous energy, created a whole code of laws in regard to the use of water. Its basis was the pioneer principle of first come first served, and that has been reproduced in our jurisprudence as "prior appropriation."

In forming a constitution, the people of California incorporated the body of common law. Judges and courts have construed the common law to mean that the doctrine of riparian rights necessary in England and in our Eastern States should be applied to the use and distribution of water to agriculture. It is easy to see that this conflict of prior appropriation and riparian rights must create considerable trouble. A large majority of the earlier irrigation enterprises, generally found in the foot-hills region, were served with water secured under the miners' prior appropriation laws. When the land-owner on a stream demanded his riparian use of the flowing water, litigation or worse at once ensued. At no time, however, were the communities in the southern part of the State organized upon the old Indian and Mexican control involved in this dispute. The prior appropriations had often, it is charged, attempted to monopolize the water supplies, not for their own or immediate use, but for speculative purposes, and as a lien upon the future. This gave some color of equity to the absurd demands for riparian rights, as at times these were sought to be exercised by small land-owners against the large appropriators of water and owners of great tracts of land. A few years since the supreme court of California brought the subject of riparian rights to a crisis by deciding in favor thereof.

As a result of this conflict, California has adopted a plan of co-operative or district control which bids fair to wisely settle all questions of water and its use, of irrigation, construction, and ownership, and of the methods and forces by which these shall be managed and paid for. This is embodied in several legislative acts known as the "Wright Irrigation District Laws." Under these acts the people of any drainage and arable area to be supplied by water from a common source, can, by obeying certain legal requirements, form themselves into an irrigation district, having a common seal, the right to sue and be sued, to make, own, and control irrigation constructions, to issue bonds therefor and pay interest on them, to levy taxes, to meet indebtedness and maintain works, to regulate the use of waters and decide the cost thereof to the farmer and consumer, to condemn lands and water rights, and in short to do all things necessary for a civil organization. These acts have all been passed during the last four years.

The constitutionality of the bonds to be issued have been assailed, but were affirmed and sustained by the Supreme Court. Since then, action under the district laws has been progressing quite rapidly. Some twenty districts had been organized at the time your committee was in California. The bonds of several had been successfully negotiated. Since then, at least ten more have been set up in operation, the larger portion being in southern California. The amount of bonds involved ranged from $6,500 in a San Bernardino district to $3,000,000 in the district now forming in Fresno County. The area so far included will be over 3,500,000 acres. Probably one-sixth of this area is already irrigated.

Under the present system every water user first pays a royalty for the right to use of about $2,500, and thereafter an annual rental of $2.50 per acre. In condemning a ditch system, the district may under the law regard the royalties paid as compensation, to their full extent, of the original outlay. They will pay, therefore, for the ditches on the basis of their annual rental values. The proposed new works will have no charges to meet other than those legally established for the payment of interest, the repayment of the bonds, and maintenance of the district irrigation works.

As the area of reclamation grows larger each year, the annual taxation must necessarily grow much smaller to each individual. The cost under private or corporative ditch systems will certainly exceed at the end of twenty-one years that of the district system, by the entire amount of royalty the private enterprises would have exacted. And when the district debt should be paid off, the small annual cost for maintenance and repairs would be all that irrigators would have to bear.

EFFECTS OF IRRIGATION ON HEALTH.

There is another and very important question to be considered, and that is as to the effect of irrigation on the general health. In California considerable attention has been paid to this subject, and in 1884 a report on the subject was made by the State board of health. There are conflicting opinions in the report made by the board. In certain counties, as Ventura, Santa Barbara, San Bernardino, San Diego, irrigation has been employed for over a century, and the absence of malarial disease is noted, as well where irrigation is practised as where it is not.

Other portions of California show a marked increase of malarial fever where irrigation is practiced. It is not difficult to discover the reasons for this. In Los Angeles and other valleys in extreme southern California, where the soil is, as a rule, sandy or gravelly loam of unknown depth, the water used in irrigating sinks into the ground or (on sloping surface) drains off immediately. It does not remain to saturate the soil unless there be a stratum of clay (hardpan) near the surface. In such sections of the country there is almost entire freedom from malarial diseases. Along the bottom lands of rivers, and where the slope is insufficient to insure good drainage, or where the soil is saturated constantly, the case is different, and there are intermittent and remittent fevers during the warmer seasons of the year. The fact that the people living in these low, wet sections of country are dependent upon impure or surface water for drinking and domestic purposes aggravates the difficulty, for it has been demonstrated that people living in a fever-and-ague country are tolerably exempt from the disease if they drink only pure water.

From all portions of California letters from medical practitioners and other residents are in singular accord in saying that irrigation, when properly managed, does not produce any increase of malarial diseases.

IRRIGATION AND FRUIT RAISING.

The State Board of Trade reported in a careful paper that:

> The peculiar productions of California is another reason why irrigation will soon be a great feature in our agriculture. California is situated quite differently from any other Pacific coast State or Territory. Indeed, many of the productions of its soil are peculiar to it. For instance, there are planted in California, according to authentic data, 50,000 acres in orange and lemon trees; all these must be irrigated. Last year there were shipped East for sale 1,850 car-loads of oranges and lemons, and about 600 car-loads were consumed at home. There are over 20,000 acres of olive trees planted in California. Most of these are not bearing; some of them are; but enough are in bearing to show that this remarkable fruit grows here with wonderful luxuriance and bears abundantly. The olive thrives nowhere else in the United States. Last year there were produced in this State 3,400 cases of olive oil, and of the very best quality. There are 140,000 acres of land now planted in grape-vines in the State of California; and for the year 1888 there were produced 18,000,000 gallons of wine, 20,500,000 pounds of raisins, and 1,000,000 pounds of dried grapes. These vines are the European varieties, which will not grow where the ground freezes; and they are not successfully cultivated in any other part of the United States. Both our wines and raisins are successfully competing with European productions. There are about 1,000,000 prune trees growing in California, outside of the acreage planted during the winter of 1888-'89. This most-needed fruit is not produced in the United States except on the Pacific coast.
>
> In 1888 California produced 7,000,000 pounds of prunes, and it will be observed that there were imported into the United States for the same year, for consumption in America, over 70,000,000 pounds. In a very short time California will be able to supply the American market. There are 300,000 fig trees planted in California, and the figs produced here are of the very best quality. The trees grow luxuriantly and thrive well. It must be admitted that it is of infinite importance to our country to encourage the production at home of all these articles which otherwise we would be compelled to import.
>
> In this connection it may be added that California is a great nut-producing country; the almond grows well and produces well. There are now over 25,000 acres of land planted in almond trees, and this acreage is yearly increasing. In 1888 California produced 180,000 pounds of almonds. The so-called English walnut is also a most valuable California nut, and grows well in nearly all sections of the State where the soil is deep or irrigation possible. No mention is made of the peach, the cherry, the pear, the apricot, the nectarine, the plum, or the apple. All these fruits are grown in California in such abundance that the mention of them seems unnecessary. Add to these fruits the whole berry family, conspicuous among them the strawberry, the blackberry, and the raspberry, and we may well observe the unlimited capabilities of this State for fruit culture.

Its report presents the following facts, among others:

IS IRRIGATION ADVANTAGEOUS?

The advantage of irrigation is twofold: first, the water is applied at a time when it will do the most good, and when the ground is in such a condition that the grain or the fruit trees will get the full benefit of all the water that is run upon the land; and second, where irrigation is practiced there are no droughts. In countries where there is ordinarily an ample rain-fall, the crops often fail by reason of droughts. This arises from the fact that the rain falls in vast quantities, but at unpropitious times, when it does little or no good to the crops.

In California, from about the middle of May until the last of October, we have no rains. During this period grain is harvested.

The use of water is often more valuable for fruit growing than for small grains. We doubt whether the wheat fields of California will ever be irrigated, because fruit is more valuable and the irrigation of orchards is more readily accomplished than the irrigation of the small grains; and because, as a rule, in the great wheat-producing portions of California irrigation for the purpose of producing one crop of cereals is not necessary. But California is especially a fruit-growing country. Its adaptability to almost all kinds of fruit is peculiar. Perhaps no country in the world is its equal; and in some of the great interior valleys of the State, and also in the foot-hill counties, successful fruit growing can be made certain only by irrigation. With the orange and lemon irrigation is a necessity. Where orchards require irrigation it has been proved that to sustain the trees in their growth and fructification, water need not be put upon the land more than from three to five times during the summer and fall months. The practice is to run water in small ditches between the rows of trees through the orchard about once a month, commencing in June and ending in September. Then immediately after irrigating the ground, by allowing the water to flow through these small ditches, the practice is to put in the cultivator, stir up the ground anew, so that the evaporation will not be rapid, and the ground will not settle down and become hard. The land thus remains friable, and the trees grow with great rapidity.

The orchards and vineyards in the coast counties and in central and northern California have hitherto never been irrigated. Where the size of the grape is an especial and important factor, like in the making of raisins, the irrigation of the vines is advantageous, and especially where the vineyard is planted in very hot and dry situations, like at Fresno and Merced. Up to this time no grape vines nor orchards have been irrigated in any of the counties of Santa Clara, Alameda, Contra Costa, Solano, Sonoma, Marin, or Napa, and the fruit trees and the vines grow there with great luxuriance and produce abundantly; and yet in each of these counties vegetables and the smaller fruits, like strawberries, are now irrigated during some of the summer months.

THE AMOUNT OF WATER NECESSARY.

There will not be required the same amount of water for successful irrigation in California as is used in India. In India it requires about 1 cubic foot of water running every second to irrigate 200 acres of land to produce cereals. In Granada, Spain, where cereals are produced, 1 cubic foot of water running per second irrigates about 250 acres.

One inch of water running continually irrigates in southern California about 10 acres. Even less than this amount would be required in portions of central and northern California.

THE RESULTS OF IRRIGATION.

Los Angeles and San Bernardino Counties are conspicuous illustrations of what irrigation can accomplish. Nothing can picture the change which has there been made by means of irrigation. A great plain which once looked like a desert is now covered with beautiful homes, surrounded with orange orchards and vineyards, dotted with towns and cities, which have grown up everywhere as if by magic. The population has more than quadrupled in a single decade. Lands which sold ten years ago at from $5 to $25 per acre now sell at from $100 to $1,000 per acre, and these prices seem to be fixed from what the lands actually produce. Nor is this condition of things peculiar only to southern California. In Placer County water has for some years been used for the irrigation of orchards and vineyards there planted. It is impossible to describe the change thus created. Orchards of every variety of fruits, from the orange and lemon to the apple, and vineyards of every rare variety of grape, and nuts of all known varieties grown in semi-tropical climates, and the fig and the olive, all seem to flourish in the foot-hills of Placer County; nor does the result in Placer County seem to be peculiar to that locality, for everywhere in the foot-hills of the

Sierra Nevadas, where irrigation has been introduced, the result has been equally surprising.

The foot-hill country about Oroville, in the county of Butte, where water has been introduced, is no less conspicuous for its luxuriant tree-growth. Within the last four years 1,500 acres of orange orchards have been planted, and these trees seem to be thriving well. The oranges are rich in color, luscious in taste, and attractive as to size. This is mentioned only to show the effect of irrigation upon both the foot-hill and valley lands of the State of California.

More marvelous still is that section of country lying about half-way between the extreme northern and southern part of the State. Within the past few years a town has been built there, which has a population of over 10,000; the surrounding country is cultivated in everything the farm can produce. Indeed, Fresno County is to-day the great raisin-growing center of the State, and nearly every variety of fruit grows abundantly. There a beautiful orchard stands side by side with an alfalfa or grain field. Homes are literally hid away by the remarkable ornamental tree-growth which irrigation has caused. Ten years ago the lands of Fresno sold at from $3 to $20 per acre; now the same land with water on it sells at from $75 to $750 per acre. This is all due to irrigation. Kern County is another conspicuous land mark on the road to successful irrigation; more than 80,000 acres of land is being irrigated in that county. The production is generally alfalfa.

Everywhere in California during the summer months garden vegetables are raised by irrigation. In the fall, winter, and spring months in most parts of the State they require no irrigation, except such as they get from the natural rain-fall. So with strawberries; this fruit is universally irrigated. In Santa Clara County alone it is claimed there are 1,500 acres of land cultivated in berries, all of which are irrigated; and that there are over 500 acres cultivated in garden vegetables, which are also irrigated. Even in northern counties like Napa, where the annual rain-fall is almost three times as great as in some parts of southern California, strawberries, other small berries, and garden vegetables during the summer months are universally irrigated.

IRRIGABLE AND STORAGE AREAS.

Large areas of plain or bench lands, lying above the bottom lands of the river, are to be found in Shatsa, Tehama, Butte, Colusa, and other Counties. They are all within reach of the water flowing down the Sacramento River and its lateral tributaries. Most of the streams emptying into the Sacramento from the Coast Range sink and disappear during the summer not far below where they debouch from the mountains into the open country; but at their sources there are large quantities of water that can be stored or impounded in the reservoir-sites that are available.

The irrigable lands of Lassen County, lying about 1,000 feet below these sources of water, are not far from 500,000 acres; and east of these lands, in the State of Nevada, is an area of like extent. The lands are rich, sandy loam, productive with water, but comparatively useless without. The climate of Honey Lake Valley is most delightful, being free from excessive heat and not subject to very low temperatures. Here is a region of nearly or quite 1,000,000 acres of public lands that can not now be settled upon, but are nevertheless capable of sustaining a arge population. A rough calculation shows that in Eagle Lake there is stored enough water to irrigate 500,000 acres of land; and at the head of Susan River comparatively cheap reservoir sites are available to store water sufficient for a half million acres more. North of this region lies Madelin Plains, a large area of good lands if irrigated. In Modoc County like areas are lying idle and useless, yet are capable of high cultivation and of sustaining a large population.

Inyo County, Cal., is especially adapted to irrigation, particularly that part of it known as Owens Valley. From Olancha to the head of Round Valley is 100 miles; the whole of this distance, a strip of country from 4 to 6 miles in width, is susceptible of irrigation. There are from 300,000 to 400,000 acres of land of unsurpassed fertility which are utterly worthless without the use of water. It is claimed by experienced engineers that the Owens River carries on an average, and during the summer months, water enough to place at least a surface depth of 15 inches upon an area of 300,000 acres of land, and this without preparing catchment reservoirs. A large portion of this country is still a part of the public domain. Less than 12,000 acres of land are now cultivated in Owens Valley.

In the extreme southern portions of California there is ample opportunity for storage on a large scale. There is a difference of opinion among engineers. Some think there are many basins and cañons in the mountains which are adapted to the purpose, and others think these, on most streams, are wanting. Most, however, agree that the bench lands furnish abundant opportunities for the construction of reservoirs. There are a number of reservoirs of both kinds finished and in process of construction, of capacity varying from a few thousand to a billion gallons. One on Mormon Creek, in the rim of the San Fernando Basin, is of more than the latter capacity.

The number of acres of good land which require irrigation are, south of the mountains, according to the State engineer's estimate, 460,900. North of the Sierra Madre range, Los Angeles County shares with Kern and San Bernardino in the great Mojave desert, so called. This desolate region contains many thousand square miles. In these three counties one-half of this is probably arid beyond redemption; one-half of the remainder is too rough and mountainous to be valuable for cultivation, but the remainder is mostly highly fertile soil, lying favorably for the application of water. Of this vast territory, Los Angeles County possesses 250,000 acres, which can be made to comfortably sustain a population of 100,000 people.

It is stated that the lowest summer flow of the Mojave River is about 5,000 inches. The average flow for six months in the year, the winter and spring months, is from 20,000 to 30,000 inches; during May, June, and July more than 10,000, and for the rest of the season more than 5,000 inches. Of this the Hesperia Land and Water Company has filed a claim of 5,000 inches.

The land is mostly Government land, and the profits thereon would pay for enormous and elaborate works. Big and Little Rock Creeks, which debouch upon the desert plain at higher elevation, west of the Mojave River, are wholly within Los Angeles County. Their flow in winter is thousands of inches, and in summer is sufficient, as at present handled, to irrigate several hundred acres. Facilities for storage on these creeks are as abundant as on the Mojave. The land below is still owned, for the most part, by the Government. The universal testimony is that it is as fertile as the best. It is covered with grass and flowers during several months of the year, and is capable, under irrigation, of producing the most luxuriant and profitable crops. Artesian-well boring has proved successful in places on the desert, but the expense is of course greater than elsewhere. The region is one of the most healthful on the globe. Its hot, dry atmosphere is found congenial to many people. It is especially adapted to the production of certain crops, as the fig and raisin grape. It produces in some places as fine wheat as is raised anywhere, but to become habitable for any more than a few scattered families or small communities, it must have water to save its crops in summer. Value of irrigable land, $50 per acre; non-irrigable land, $1.15 per acre; the number of artesian wells in the region, seven, with an average depth of 340 feet and average flow of 12 inches. The counties of Los Angeles and Orange have an area of 4,812 square miles, or 3,079,680 acres. Their population is fully 150,000 souls. Without irrigation not one-quarter of this number would be living there; and "this in spite of the fact that those two counties produce more than one-half of the corn of the State almost altogether without irrigation; that there are nearly 90,000 acres of good land that require no irrigation."

The land now irrigated is about 150,000 acres, and this is the basis of maintenance of 113,000 people. Theoretically, no increase of this population is wanted without a corresponding increase of irrigated lands. Factories and mineral developments, travel and transportation by sea and land, and the healthfulness and delightfulness of the climate, would add to the population; but the cost of living would be increased in proportion to growth, the homes of the poor would no longer be those of people who control their own destinies; and this would become a rich man's paradise—a thing not to be desired.

Ten years ago the population of the counties was little over 30,000. Fifteen years ago the land on which Pasadena now stands was held at $7 per acre; in seven years it was valued and sold in large quantities at from $500 to $1,000 per acre. This was for orchards—not city lots—orchards made possible only by a supply of moisture for the roots of the trees during the long arid season of the year. So with the whole of the great foot-hill region along the base of the Sierra Madre range from Tejunga and Crescenda Cañada on the west through Altadena, Sierra Madre, Lamanda Park, Santa Anita, Monrovia, Duarte, Ayusa, Glendora, Alosta, San Dimas, Lordsburg, Cucamonga, Rialto, Redlands, and over the San Gorgonio Pass into the desert at Indio, and again at Riverside and Arlington, and places too numerous to mention. The growth has been proportionate to the extent to which irrigation has been carried. The region mentioned was almost worthless even for grazing purposes, and was as incapable of sustaining a population as the Mojave Desert itself. Now visit it and you will find it the most charming region and the most valuable land in all California, or in the United States for that matter.

GROWTH OF ENTERPRISE AND VALUES.

In Fresno County there are 100,000 acres of land now irrigated. This estimate is made by Mr. George Manuel, a well-known civil engineer, but he adds:

"It is somewhat difficult to draw the line between irrigated and unirrigated lands, for the reason that the effects of irrigation by filling up the country affect and render fertile to a great extent lands lying contiguous to irrigated lands, but not themselves subjected to irrigation by the usual methods of application. Of this latter class of lands," says he, "there are about 200,000 acres."

Thus it will be seen that the 200,000 acres are an area double in extent of that which is actually irrigated, and is reaping the benefits without being subjected to any of the burdens of irrigation. Irrigation in Fresno County has heretofore been carried on wholly by the private canal system. It is a voluntary matter by this plan with each landowner whether or not he will contribute anything towards the expense incident to the irrigation of lands. His lands may be surrounded by irrigated lands, and thus in a short time they become sufficiently irrigated by percolation; but he may and does decline to buy water where he can get it by absorption without. By the district plan this iniquity is overcome; and every man who owns land that will be benefited is compelled to contribute his portion of the expense incident to the system, and gets in return all the water he may require.

The following is the estimate made by Mr. Manuel of the amount of land in Fresno County which is now not irrigated, but which is irrigable:

	Acres.
(1) In Madera irrigation district, about	300,000
(2) Under Chowchilla Canal, excluding about 5,000 acres already irrigated.	60,000
(3) Land lying above or east of Madera district, but which can be irrigated by a branch of the main canal of said district (in Fresno County)	87,600
(4) Land lying above water in main canal of Madera district, but which is susceptible of irrigation by a system of storage reservoirs	38,400
(5) Land lying between San Joaquin and Kings Rivers, excluding about 60,000 acres already irrigated, and which can be irrigated by existing works or their extensions	684,960
(6) Land lying above or east of Enterprise Canal, but which can be covered by storage reservoirs or branch canal taken out high up in the mountains	40,000
(7) On west side of Fresno Slough, below Hall survey in Fresno County, which can be covered with extensive irrigation works	113,000
(8) In Sunset irrigation district above Hall survey, proposed to be irrigated by a canal having levees 35 feet high at highest point, and about 15 miles long, and which lie above Hall survey	190,000
(9) Between the 240 and 300 feet contour line on State engineer's map, which can be irrigated by canal taken from Kern River, or by water pumped by water power as proposed by Sunset district in Fresno County	190,000
(10) Land lying above the 300 feet grade line in Fresno County on west side, which can only be irrigated by storage reservoirs on the streams flowing from the Coast Range	293,000
Total	1,996,960

Mr. Manual states further that—

In 1870, in township 14 south, range 20 east, sections 1 to 5, assessed to W. S. Chapman, at $1.01 per acre; section 36, at $1.13 per acre; that made an assessed valuation of that township, in 1870, of a little over $25,500 in round figures. In 1880 the Bank of California tract, a portion of these twelve sections, at $4 an acre, and Bank of California tract, 240 acres, at $5 per acre. C. A. Towne, section 2, adjoining Fresno City, at $5 per acre. C. H. Hoffman, section 12, near Fresno, at $5 per acre. E. Jansen, six sections near Fresno City, at $4 per acre. In 1888, A. T. Covell, in Washington Colony, 5 miles from Fresno, 60 acres, at $150 per acre. Sections 1 and 2 and 11 and 12 at $250 to $300 per acre, $250 per acre being about the average for unimproved land. And this increase in the value of land is due to irrigation. It is the same land exactly, only in different years, as irrigation has progressed.

Sections 6 and 7, at $100 per acre; section 19, at $75 per acre; sections 5 to 8, unimproved, and from one-half to 1 mile from the city of Fresno, at $125 and $200 per acre; sections 17, 18, and 19, averaging $85 an acre, and sections 23, 24, 25, and 26, at $75 per acre. That is the valuation of that township. The first assessment was $25,500 in round numbers, and the last assessment of the city, $6,800,000. And the total valuation of that township is probably in the neighborhood of $9,000,000. Concerning the value of irrigation, I know of one canal that was said to cost in the neighborhood of $50,000. The first year after its inception the increased value of the real estate along the line of the canal was $640,000—land that could before have been bought at $2.50 per acre had increased in value sufficient to make that valuation. So I could give other instances, but I suppose that would be sufficient.

Mr. Thomas Hughes, well known as a real estate operator, also testified that—

In 1881 I purchased 7,000 acres of land adjoining the town of Fresno, agreeing to pay $40,000, and having 6 months to make the first payment of $5,000. I immediately had circulars printed, offering to sell land, with water for irrigation, to parties who would move on the land and improve in trees and vines, without any cash payment. In this way I soon sold the most of this tract, and would borrow on my note with these mortgage notes as collateral security, getting about 50 cents advance on the dollar. I sold the land at prices ranging from $40 to $75 per acre. This gave me a surplus of money to pay what I was owing on the land, and money to make a small payment on the purchase of other lands, which I continued to do from year to year, until I was myself $350,000 in debt, and had mortgage notes due me to the amount of nearly $500,000 for lands in most cases sold on a credit of one, two, and three years, with interest at 10 per cent., payable half yearly. The settlers have all made their places worth to-day from $200 to $1,000 per acre, and all have paid me in full. I have sold thousands of acres of land on these terms, and I have never been compelled to foreclose a mortgage in Fresno County. Men who will work can settle on irrigated land, pay their 10 per cent. interest, improve the land, and pay for their land at prices ranging from $50 to $125 per acre inside of four years. And that, too, on land that before the irrigation system was started could not be sold for more than from $1 to $5 per acre, according to location.

In Tulare County much progress has been made in the work of irrigation. The one criticism to be made on the work in that section is that it is fragmentary and lacks uniformity and systematic methods. Irrigation is consequently patchwork, but enough has been done to demonstrate the miraculous power of irrigation in the San Joaquin Valley.

Mr. P. Y. Baker, civil engineer, for many years devoted to the work, says: "There are about 15,000 acres irrigated in this county, and 950,000 acres not irrigated. There are about 250,000 practically useless without irrigation. Of the above 950,000 there are perhaps 700,000 that produce some crops without irrigation, but very little of it produces fair crops. That is to say, one year with another, the average would be so low that it would be a serious question of making a bare living on most of it. Experience has shown that the proximity of irrigation has added much to the productiveness of non-irrigated lands."

In Merced County provision has been made whereby a considerable area of lands may be irrigated; but the acreage actually subjected to irrigation is small. The Crocker Canal, which is said to have cost $1,500,000, is situated in this county, and will eventually be applied to a large area. The area of the plain lands which may be profitably irrigated is large. So far as irrigation has become an accomplished fact in the San Joaquin Valley, it has been done through private enterprise. Under the district irrigation law of 1887 a number of irrigation districts have been organized, and by this means the irrigated area will soon be rapidly extended. Twelve irrigation districts are reported as organized or in process of organization within the valley of the San Joaquin. The total acreage involved is estimated at 2,000,000; the total amount of the bonds to be issued will not be less than $10,000,000. The area of the following irrigation districts can be given with accuracy:

Modesto	acres..	108,000
Turlock	do...	176,000
West Side	do...	300,000
Madera	do...	330,000
Alta	do...	160,000
White River	do...	60,000
Poso	do...	48,000
Sunset (proposed)	do...	285,000
Fresno (proposed)	do...	300,000
Total area San Joaquin Valley		1,767,000

The total area irrigated in the same section was given by State Engineer in 1885, at 251,140 acres. This area has certainly increased one-fourth, and would therefore be not less than 313,670 acres. It is probably nearer 350,000.

LOS ANGELES COUNTY.

The irrigable portions of Los Angeles County are embraced in the San Gabriel and San Fernando Valleys and the coast plain region. The San Gabriel Valley is 23 miles in length, east and west, 11 miles in width, north and south, with a broad outlet somewhat west of the middle point on its southern side. It is but little less well-defined as a basin than that of San Bernardino. At the lowest point on the higher side of the valley, next the mountain base, 11 miles north and 2 miles east, the elevations range from 625 to 675 feet. At the extreme northwest corner they are between 1,500 and 1,700 feet, and at the other extremity of the valley, next the mountain's base, the plain is 1,000 to 1,100 feet above the sea.

Together with its mountain and hill-side catchment areas the San Gabriel Valley embraces a territory about 560 square miles in extent. The mesa, benches, plains, washes, and bottoms composing the valley itself cover nearly 200 square miles, or about 123,000 acres. Of this amount about 92,500 acres are highly cultivable and productive lands, but requiring irrigation.

The San Fernando Valley occupies the western portion of the Southern California basin. It contains about 570 square miles. Of this area there about 100,000 acres of really good irrigable lands. The coast plain embraces an area of 1,472 square miles. Of the total, leaving out hills, marshes, wet land, and 68,000 acres requiring irrigation, there are about 270,000 acres fit for cultivation by irrigation. It is all below 500 feet in elevation.

The rule as to distribution of rain-fall, as affected by the mountain ranges, is emphasized in Los Angeles; the heavy down-pour is on the slopes of, and on the plains and bench-lands at the base of, the ridges, on the side next the direction from which the storm clouds are brought.

On the coast plain and elsewhere on the lower elevation the down-pour reaches about 15 inches per annum. In the San Fernando Valley, from other causes, it falls to about 11 inches. At the base of these mountains it rises to 15 again, and at Ravenna it falls to less than 11 inches, though the elevation is 2,300 feet above the sea. But as the base of Sierra Madre is reached, the precipitation reaches 22 inches, though the elevation is but 700 feet. On the mountain bench-lands the rain-fall is from 50 to 100 per cent. greater in the valley, but 10 miles distant and but 600 feet lower.

Of the irrigable portions of this county, the San Fernando Valley and the coast plain are materially the driest sections, and the bench-lands and mesas, at the bases of the Cahuenga and the Sierra Madre, receive much the greatest rain-fall. San Gabriel Valley, as a whole, probably receives 50 per cent. greater rain-fall than does the San Fernando, and 80 to 90 per cent. more than does the valley of San Bernardino. The reasons for these differences are found in the following facts: San Gabriel Valley has no high mountain range in front of it, and has a high range immediately back of it. San Bernardino Valley, notwithstanding the fact of the higher range behind it, has also quite a high range in front. San Fernando Valley has a moderately high range in front of it, and only a moderately high range behind it for more than half its length.

The streams all lose their waters in the underlying gravels, within a few miles of their cañon mouths, during fully eight to ten months (including the irrigation months) of almost every year. All but two or three of the larger cañon streams do not, naturally, even bring their waters outside the cañon mouths, for six months of almost every year. The waters are lost in bowlders and gravels, but they reappear below in the springs and *cienagas* of the Los Angeles Valley, or in those of the San Gabriel basin. There are two classes of streams, then, serving irrigation in this region—those which have their independent mountain drainage areas, and come to the interior valley through deep gorges or cañons, and then sink; and those which rise at the outlets of the three main divisions of the interior valley, namely, the Los Angeles, Lower San Gabriel, and Lower Santa Ana Rivers.

There are eleven principal groups or systems of irrigation, the San Gabriel and San Fernando basins being again subdivided into as many more. The description of San Bernardino works will serve largely for those of Los Angeles County. The artesian-well groups are numerous, and their economic use is an entire and extended success. Sub-irrigation by iron and cement conduits is a great feature, four systems alone using 240,013 feet, of which 3,005 feet are of iron piping. There are also 3,607 feet of cement canals. The cost was $275,000, $90,000 of which was for well-boring and water development. These systems belong to the Pomona group of fruit colonies. In practice, a fixed and uniform rate of 10 cents per hour for a run of water is charged, as a *zanjero's* fee, each time a head of water is turned on to an irrigator. The "heads" used in irrigation are 30, 45, and 60 inches in volume, but the rate charged is the same for all, so that the double volume afforded by the 60-inch head costs no more than that afforded by the head of 30 inches, for the twenty-four hours. The actual cost of water to the irrigators per acre ranges between 72 cents and $1.92, and averages about $1.30 per year.

There are in Los Angeles County a large number of settlements made on the colony plan, and a more considerable area occupied by large and small ranches, vineyards, and orange groves. The water system, serving the city and for domestic as well as neighborhood and irrigation use, is as typical as anything in the land, being based on the old Spanish-Indian community plan, as modified by modern use and growth. The *zanjas* have a total service and length as follows:

	High and low service.	
	Feet.	Miles.
Open earth ditches	140, 135	26. 5
Cement pipes or conduit	91, 490	17. 3
Iron pipe	28, 836	5. 5
Wooden flume and tunnel	15, 900	3. 0
Total	276, 361	52. 66

This summary shows that the total length of conduits maintained by the city is 52.3 miles, of which 25.8 miles, or nearly 50 per cent., consists of tight conduits—wooden flumes, cement and iron pipe, cement or masonry-lined canals, brick culvert, etc.—and the balance consists of open canal and ditches of various kinds and sizes.

There are 40 miles of ditches outside this system, but receiving their water supply from the city zanjas, making in all over 93 miles of conduit, connecting with as many more miles of private distributory ditches and pipes. The cost has been during the past fourteen years about $300,000.

The irrigation system of Los Angeles is under the direct control of the city council, from the heads of the zanjas on the river to the southern limits of the city, and from there on the distribution is managed by several associations of outside irrigators.

The council appoints a general zanjero, or ditch overseer, and assistants, fixes the rates for sale of water, orders all zanja improvements that are made within the city, and maintains entire control over diversion from the river. In times past the council has apportioned the water to the land within city limits at the rate of an irrigating head for twenty-four hours to one acre for every thirty days. This was when the acreage irrigated inside the city limits was greater than it now is. This city allotment is now, however, a dead letter, as the inside irrigators have more than they require, and the council has no concern for distribution of the water after it leaves the corporation limits. Every individual irrigator whose lands are inside the city bounds is allowed all the water he wishes to buy and pay for without restriction, and the surplus waters are sold to the outside associations.

Outside the city limits the irrigators are organized in regularly defined districts on the extension of each zanja. These districts abut on the city, and when organized were considered to embrace all lands which could be reached by the spare water of the river. Some of them have been much extended, however, and in one or two instances secondary districts subject to and buying water from the primary districts are found adjoining the latter. With the improvement of the zanjas and the diminution of cultivation within the city the irrigable area has extended year by year, and is now carried even beyond the secondary outside districts. The outside organizations are incorporated associations of irrigators, which elect officers, are governed by sets of by-laws, and appoint zanjeros, whose duty it is to purchase surplus water of the city and sell it to the irrigators, each of his own district, at a premium fixed by the association, which constitutes its compensation.

Water is sold by the irrigating head in measure of time. The rates, always subject to change, are at present in the city $3 per head per day (sunrise to sunset); $2 per head for half day (sunrise to noon, or noon to sunset), and 50 cents per hour. Current rates charged the outside districts by the city are $5 per head per day, $3 per night. Single hour permits are not sold outside. These rates are 50 per cent. higher than they were two years ago. In 1880 the city rates were per day $2; half day, $1.25; night, $1.50. In 1873 they were $1.75 per day, $1.25 per half day; $1 per night, inside city limits. Outside they were $3 per day; $2 per night. In 1870 in the city they were $1.50 per day and $1 per night from March 1 to October 1. After the latter date 75 cents per day and free at night.

The area irrigated under this system is about 12,000 acres, of which nearly 3,000 is within the city limits.

Engineer Hall mentions in his last report 250 different systems of irrigation works within the three southern counties of California; also 18 different artesian water and well basins, the total acreage of which is large.

SAN BERNARDINO COUNTY.

Mounts San Bernardino and Grayback are the culminating points in the topography of southern California. From them, trending southeast, start the San Diego ranges, which enter Mexican territory. Extending west, the Sierra Madre ranges reach away over a hundred miles through Los Angeles and into Ventura County. Standing at the meeting of these masses the San Bernardino peaks are the highest and most commanding objects in the landscape, and play a very important part in modifying local climatic phenomena and regulating irrigation water supply.

From the northwestern end of the San Diego range, or plateau, begins what is known collectively as the Coast Range, extending northward into and beyond Los Angeles County. Its face to the sea is a sloping plain or mesa. East of this range and between it and the Sierra Madre lies the smaller counterpart of the great San Joaquin Valley to the north of it. From the coast to the San Bernardino Peak westward is a distance of 110 miles. Broken by two small, low groupings, it comprises the most valuable fruit region of the State. Within this area will be found at least 100 colony towns and villages; the growing and prosperous city of Los Angeles, and a population of over 250,000 persons, all of whose prosperity depend upon irrigation. In Los Angeles County the coastwise mesa becomes a broad alluvial plain. Engineer Hall, in his volume on irrigation in southern California, says:

> North from the Sierra Madre chain stretches away to the Sierra Nevada mountains, a distance of over 50 miles, and from the Colorado River on the east to the Santa Barbara Mountains on the west the desert plain of the Mojave, comprising an area of 15,000 to 16,000 square miles. On this broad plateau there are extensive tracts of rich soil; but from the want of rain they are barren, and from the absence of water supply they are, except in very limited localities, non-irrigable. The Mojave, then, is not, save in a very much restricted sense, a part of the irrigation field present or prospective, although locally irrigation flourishes there and many small utilizations of water remain yet to be carried out.

It is the Sierra Madre range of southern California which, passing through Los Angeles and San Bernardino counties, constitutes a mountain wall, that, intercepting ocean breezes and storm clouds, precipitates their moisture upon high and rugged peaks, thereby regulating climate and making possible that high degree of cultivation which is necessary for successful horticulture.

The effect of an intercepting mountain range upon rain-fall is most distinctly marked in this region. The San Bernardino section offers no gradations as in San Diego. The clouds drifting inland from the sea are broken on the summits of the Sierra Madre and precipitate their contents upon its bald slope. They cover the crest with snow, and send great rains down the western slopes in heavy torrents. The valley below will have a rain-fall of barely 8 inches per annum. The mountain peaks and spurs above will receive from 70 to 100 inches in the same period. The slopes are exceedingly steep.

The accumulation of vegetable molds and soils, which are recognized as water-holding, are limited in extent. In an earlier geological era the rain-fall was immensely greater. Vast mountain torrents in those days poured through the cañon, carrying great masses of bowlders before them. The operation of the forces thus created have made deep bed-rock cuttings that are now filled with masses of broken matter. Into these flow and disappear the waters that pour from the mountains above. In this wise the artesian waters of the San Bernardino basin are collected.

The Santa Ana River, with an independent mountain area drainage of 220 square miles, is the main surface drain of this irrigable region and also its chief irrigation feeder. There are some twenty smaller and tributary creeks, cañons, or washes. In addition to these drainage areas the northern face of the San Bernardino range is drained by the Mohave River. The basin slope from east to west is about 26 miles in length, and comprises 120 square miles in all. Its future importance in irrigation is considered large. At present it is lost in the sandy waste 40 miles from its source. Engineer Hall classifies the San Bernardino lands as follows:

> (1) The wet and marshy lands of the San Bernardino and Rincorn artesian basins, and the Chino; (2) the moist and semi-moist lands bordering the wet lands of the Rincon on the north, and bordering those of the San Bernardino on the north and east; (3) the moist bottom-lands bordering the Santa Ana River in its course through the Jurupa from the upper to the lower basin; (4) then, going to the other extreme,

the bone-dry red mesa lands, which fringe the entire valley more or less completely; (5) the bowlder and cobble-filled alluvions, which form the ancient dumps of the cañon creeks, and which, along the base of the main mountain range, to a great extent take the place of the red mesa lands; (6) the intermediate plains—dry, sandy, frequently gravelly, and with broad "washes" in parts, but in others with fine, light, rich, and deep soils.

The topographical features of the basin, with its great slopes in the ground surface ranging from 30 to 120 feet per mile, renders impossible any system of irrigation by "checks," such as is practiced in the San Joaquin Valley. It also compels the grouping of irrigation works and areas, deriving their supplies from limited and distinct sources. Three of these groups, embracing a large number of small works, obtain their supplies by diversions from the Santa Ana River or its main tributaries. Four other groups are fed from mountain cañons, the waters in which are derived mainly from subsoil supplies in the strata already described. Other groups obtain water by means of artesian wells, by tunnels driven into the mountain and securing thereby the drainage waters by lifting the sub-water of the cienagos or wet plains, or by other sub-dam works, raising to the surface supplies that would otherwise be lost. It is estimated that the great storage project of San Bernardino County, the Bear Valley reservoir, will very materially change the irrigation possibilities, or greatly enlarge the area of land under cultivation.

The value of water has enormously increased. The North Fork Water Company, which is under guaranty by the Bear Valley Reservoir Company, sold in 1865 at the rate of $30 per share, the water being valued at $18 per inch. In 1880 the value per share was $50, and that of water $26.40 per inch. In 1885 the value per inch of water was $360, and in 1888 $720. In another enterprise $40,000 is reported to have been paid for perpetual right to one cubic inch of water. The South Fork Canal valuation is given at $6 per miner's inch in 1872, and at $615 in 1887.

The different sources of supply, and the character and extent of areas served, compel as great a variety in the systems of distribution. One of the most notable of these systems is that made by tunneling into the mountain cañon walls and securing the drainage waters that pass through them. At Redlands, one tunnel delivers about 30 miner's inches, another about 130. The Ontario Colony enterprise, whose engineers, the Chaffee Bros., have since become known all over the world by their connection with great Australian projects, is the most famous of these tunnel works.

The water company at Ontario, after conserving all the surface supply by means of cemented canals and underground pipe-line, have driven a tunnel into the gravel and bowlders of the cañon bed a distance of 2,850 feet. Nowhere in the world is the duty of water so high as at Ontario. The supply is less than 800 miner's inches per annum, of which the tunnel will furnish from 50 to 60. The whole distribution is conducted through cement pipes. The work of distribution is in charge of a *zanjero*, or watermaster, who delivers water to each irrigator in heads of thirty inches for twenty-four hours each thirty days, for each ten acres owned, which is equivalent to a continuous flow of one inch to ten acres. The secretary of the company and the *zanjero* are the only regularly paid employés, but laborers are at times employed to work under the *zanjero's* direction in caring for and repairing the works. The cost of assessment for maintenence has not exceeded, so far, more than 70 cents per acre. The duty of water is claimed to range as high as one inch to ten acres; it is probably about one inch for seven acres.

The Riverside Colony enterprise and its associates are the most prominent and best known of the fruit colonies in southern California. The works of the Riverside Water Company consist of three main canals and diversions, an extended irrigation distribution system, and a main pipe-line, and branches for the delivery of water, chiefly for domestic purposes.

The supplies are derived from the Santa Ana River and Warm Creek, and from an extensive system of artesian wells. The canal works are thoroughly constructed, provided with 2,400 feet of main flume, dams, head-gates, waste-gates, regulators, measuring-boxes, etc., having a total length of 33 miles of main canals and 50 of laterals. The area of Riverside proper is about 7,000 acres. With other and adjoining enterprises, the total area in the Riverside group will be 26,000 acres. It is the largest single orange-growing section in the State, and is second only to Fresno for raisin vineyards. In 1870 the land was assessed at 75 cents per acre; every acre of it will now average from $800 to $1,000. Originally begun as a land colony or co-operative enterprise, the projectors designed to keep the water supply separate as a continued source of income. Great dissatisfaction followed that plan. The land and water supply now go together. The entire cost of works within the old colony bounds, including legal expenses, is about $500,000. This does not embrace the domestic pipe-line supply. The cost of maintenance is about $30,000 per annum. There is a deficit between receipts and expenditures, however. The number of irrigators is about four hundred; acres owned by them, 6,500. The average holding is 16.12 acres; the highest acreage in one holding is 196. The cultivators of citrus trees is 360; number of vine-growers is 260. The average irrigated holding is 15 acres.

SAN DIEGO COUNTY.

The extreme southern division of California is one of the most remarkable of the arid areas within the Union. Along its eastern borders for a hundred miles or more flows the Colorado River, whose turbid waters drain from the heart of the continent. In comparison with all other water-courses it is a mighty flood, the greatest river of the Pacific coast, the Columbia alone excepted, flowing on undisturbed to the sea, past a vast desert which now challenges the power of man to utilize it. Nearly all of California that slopes toward the Colorado, and drains into it, if there be any drainage from a region so seldom and so sparingly visited by rain, is an absolute desert, within whose limits is included nearly three-fourths of the entire area of San Diego County.

The remainder contains the arable portion. A series of mountains separate it from the desert; their axes are generally parallel to the trend of the coast and distant from it 60 to 80 miles. These mountain masses, looked at from sea, do not form a continuous high chain or range, but a succession of peaks and ridges along the upper margin of a sloping plateau. This reaches an altitude of 4,000 to 5,000 feet, and the peaks and spurs maintain an elevation of 6,000 to 6,500 feet, and in one instance, that of San Jacinto Mountain, nearly 12,000 feet.

San Jacinto descends without a break to the edge of the desert basin, whose center is over 300 feet below sea level. Towards the ocean, the slope is gradual and open valleys are met with whenever the contours permit. The coast line is marked by a broad mesh or plain rising from 50 to 200 feet in the first mile, and continuing from 5 to 15 miles until it reaches an altitude of 5,000 feet, where it blends into the ranges. Immediately beyond and generally lower in elevation will be found a series of land locked-valleys drained by separate waterways that cut their courses deeply to the sea. These valleys are becoming the seat of important irrigation enterprises. The mountain landscapes to the east are more attractive and gentle in outlines than those of the Sierra Madre in Los Angeles County or the more ragged aspects of the San Bernardino range. San Jacinto rises to an altitude of 12,000 feet, and by that fact compensates for an extreme aridity produced by the intervention of other mountain ranges to the south and west, which break the course of the rain clouds. The precipitation on San Jacinto, owing to its heavy snows and the lateness of their melting, maintains the flow of streams and springs by which the plains are in a large part supplied.

The streams which drain the western slope of the county seldom flow continuously to the sea during the dry months of summer and fall. The volume of their flow depends, in each case, not so much on the area as on the altitude of their water-sheds. Precipitation over the country is in a marked degree proportional to altitude; least upon the coast, greatest upon the mountain tops. This rule of proportion is very potent in its effect upon irrigation water supply.

The country is naturally divisible into three rain-fall belts, the first of which comprises all the mesas and valleys adjacent to the coast below an elevation of 1,000 feet, and covers an area of about 1,113 square miles. Within this belt are by far the greater portion of lands irrigable that require irrigation, and the greatest area which is generally free from frosts. The rain-fall in this belt is unreliable in character, subject to great fluctuations, the records showing that thirteen years out of twenty-three the rain-fall was less than 10 inches, and during five years was less than 6 inches per annum, while, with one exception, it never exceeded 16 inches. The effect of altitude is made quite plain by the fact that at Poway, 550 feet elevation, the precipitation in 6 years shows an annual average of 17 per cent. greater than on the coast, while at a further elevation of 200 feet more this rain-fall was 42 per cent. greater than at San Diego.

The second belt, an area about 1,400 square miles, has an elevation of from 1,000 to 3,000 feet. The rain-fall is estimated at from 18 to 24 inches. Ex-State Engineer Hall, who is the authority for these statements, puts the rain-fall at from 14 to 20 inches per annum.

The third belt, lying above an altitude of 3,000 feet, has a climate similar to that in some of the Southwestern States, except that summer rains are very rare and light, and the snows of winter not so deep nor long-continued. Its area is about 1,654 square miles, of which, perhaps, three-fourths is less than 4,500 feet in elevation. There are many fertile valleys, heavily-wooded slopes, and a small area of commercial timber within its borders. The rain-fall of this section is often in excess of its tillage duty. It is in this region that the great storage reservoirs must be constructed. The larger streams of the coast all head in it. There are eight of these in the county of San Diego having a total water-shed area of 3,567 square miles. In the first belt the water-shed is 630, in the second 1,282, in the third 1,655 square miles. The higher part of the mountain plateau and northern slopes of its ridges and peaks are wooded with varieties of pine, oak, and madroña. The upper cañons and valleys have sparse growths of oak, laurel, aspen, and madroña. The main ridges and frequently the northern slopes and lesser spurs are covered with dense low growth, commonly known in California as chaparral or chemisal. Along the streams—in the medium range of valleys—there are growths of cottonwood and willow, principally; and along the main streams and on the sandy bottom-lands adjacent to them, similar vegetation abounds, in some places quite densely.

But the entire coast mesa, the broadest parts of the river valleys, the large valleys just within the line of the mesa formation, the greater portion of the plateau region, and a considerable portion of the mountain ridges are treeless and devoid of vegetation, such as is generally thought to conduce to the conservation of waters for the supply of streams. The light rains are all absorbed; and up to a point where the ground becomes well saturated there is but a small flow of surface drainage water finding its way to the rivers; but when this point of saturation is reached, then a large proportion of the waters of precipitation are shed off, and torrents form, which rush to the main drainage lines, and contribute to sudden and excessive freshets in those streams, carrying great loads of sand and finer sediments. The rains ceasing, and there being but a small amount of snow to melt, on a limited mountain area, the streams soon run down.

For reasons given heretofore, there are no large springs or areas of summer drainage of living waters. This, then, is a country where, in the aggregate, an amply sufficient rain-fall may be had to supply an abundance of water, but where, for the most part, it runs uselessly away to the sea. It is pre-eminently a country where the storing of water on a large scale is necessary to maintain any great irrigated area.

The irrigation systems practiced in San Diego County comprise the simplest known, being such as the Indians and Mexicans are accustomed to, as well also the most scientific and thoroughly well organized plans known to irrigation engineering. Several of the largest reservoirs that have been constructed are now in operation. Flume projects have been completed or are under way involving daring irrigation engineering. The reclamation of the irrigable territory of San Diego County, comprising an area of at least 450,000 acres, depends upon the degree of success with which the waters of six streams and the storm supplies above may be conserved by extensive reservoir systems. These rivers are the Tia, Juana, with five small valleys; the Sweetwater, with the same number; the San Diego, the San Diequito, and the San Luis Rey, with three valleys each, and the San Jacinto, with the Hemit Valley. In the first drainage system eight reservoir sites have been selected, with two great conduit flues connected with them. The Otay River projects comprise two large dams and reservoirs, having a capacity of 1,100,000,000 gallons.

The Sweetwater River system is the most extensive of all. Mr. Hall says:

> The engineering works would be notable in any country, and the lesson which the enterprise is working out on the subject of large storage reservoirs for the conservation of winter water for summer irrigation in this dry country is already highly instructive. It is now looked to with satsfaction by San Diegans as a type of what may be accomplished, under even unfavorable circumstances, upon nearly all the streams of this region.

The Sweetwater dam, a short distance above National City, is one of the boldest pieces of engineering in the country. The dam is constructed as a crown arch, and it is the largest of its character in the world.

The San Diego Flume Company proposes a system which, when completed, will consist of a storage reservoir, a diverting masonry dam, and a line of flume 36 miles in length. The method of distribution will probably be by pipes under pressure or by pipe cement channels. The Cuyamaca reservoir, 43 miles northeast of San Diego, covering 1,000 acres and having a full capacity of 499,880,930 cubic feet, is the chief dependence of this system. The diverting dam has a maximum height of 34.5 feet and a length of 447.5; the width of base is 18 feet and the top is 5 feet. The flume has a full length of 36.6 miles. The main pipe line will have a length of 9 miles. A branch pipe will be 1 mile in length and enter the main city reservoir, which has a capacity of 761,000,000 gallons and covers 100 acres. The cost of these works will be a little less than $1,700,000.

The Mission Valley Storage and Delivery Works will embrace eight reservoirs having a total storage capacity of 9,002,000 gallons. The San Diequito system will consist of a reservoir with masonry dam 80 feet high, 400 feet long on the crest, 170 on the bottom, with a capacity of about 3,000,000,000. There will be a second reservoir, with a capacity of 2,000,000,000 gallons, connected by an iron pipe of 30 inches with the upper one. The San Luis Rey flume provides for the construction of a mammoth reservoir dam, a canal from the cañon of the river some miles below, extending about twenty miles along the mountain and rolling hill-sides south and west of the river, and a secondary storage reservoir at the terminus of the canal in Bear Valley at an elevation of 1,300 feet. From this commanding elevation, but 20 miles from the sea at the nearest point, and 35 miles from the city of San Diego, the territory that may be served is only limited by the supply of water available. Pipe lines are projected in various directions. The main conduit drops into this secondary reservoir with a direct fall of seven hundred feet, and the utilization of this water-power and transmission by electricity to points of use are contemplated.

The Temecula Cañon storage reservoir will have control of 800 inches of running water besides its storage capacity. The same will be distributed by means of 10 miles of flume and 2 miles of iron pipe over a considerable irrigable area. The Hemit Valley system is quite extensive; its principal reservoir will be at an elevation of 4,300 feet, 20 miles above the town of San Jacinto, and in a most favorable location. Its largest reservoir surface will be nearly 600 acres and its capacity will then be about 6,000,000,000 gallons. These comprise the modern projects and systems west of the Colorado Desert, in San Diego County. There is a considerable area served by the old style, neighborhood ditches, and by means of wells from which the water is lifted by windmills. In the desert itself, at the eastern base of Mount San Jacinto, a town has been laid out and 6 miles of railroad constructed to connect with the Southern Pacific at the Seven Palms station. The flow of the White Water River is appropriated, and some 200 acres are laid out in orange trees. This is in the desert region proper, and it is probably the forerunner of many similar projects. That any extensive scheme for the reclamation of the desert as a whole will be attempted for many years is hardly probable.

THE STATE ENGINEER'S OFFICIAL DATA.

The following summary was made by Engineer Hall in 1888, and presented to the United States Senate Special Committee on Irrigation in the summer of 1889:

Area irrigated in San Diego County, 1888.

	Acres.
San Diego and San Diequito Rivers	360
San Luis Rey River	480
San Margurita River	312
San Jacinto River	965
Total	2,117

Area irrigated in San Bernardino County, 1888.

	Acres.
Santa Ana River irrigations:	
Santa Cañon:	
Group	4,435
Basin diversion:	
Group Riverside Mesa subgroup	7,686
South side Santa Ana subgroup	799
Warm Creek subgroup	1,353
Lytle Creek and City Creek subgroup	384
North side Santa Ana subgroup	881
Jurupa Valley group	1,202
Rincon group	933
San Bernardino Valley irrigations:	
South Cañons group	1,466
North Cañons group	1,590
Cucamonga Plains irrigations:	
Cucamonga Plains group	5,361
Total for all groups	26,070

Area irrigated in Los Angeles County, 1888.

	Acres.
Cucamonga Plains irrigations:	
Pomona group	5,375
San Gabriel Valley irrigations:	
Sierra Madre Cañons group	
San José subgroup	225
San Gabriel River subgroup	5,150
Santa Anita River subgroup	350
San Pasquel subgroup	765
Basin group	7,590
San Gabriel and San Fernando group	1,550
San Fernando Valley irrigations:	
San Fernando group	4,875
Los Angeles Valley and Coast. Plains irrigations:	
Los Angeles group	13,987
Coast Plains irrigations:	
Cahuenga-Ballona group	1,535
Lower San Gabriel group	15,600
Lower Santa Anita River group	21,000
Santiago Creek group	2,100
San Juan Capistrano group	800
Total for all groups	80,902

Area irrigated in the three lower counties, 1888.	Acres.
San Diego County	2,117
San Bernardino County	26,070
Los Angeles County	80,902
Grand total	109,089

This area has increased by at least one-third since 1888.

*Sources of and areas irrigated in the San Joaquin Valley.**

[*Summary for* 1885.]

Supply from—	Name of canals.	Irrigated area.
		Acres.
Kern River	Kern River canals	63,365
Poso Creek	Poso Creek canals	400
Deer Creek	Deer Creek canals	1,635
Tule River	Tule River canals	8,075
Kaweah River	Kaweah River canals	33,371
Kings River	Kings River canals	99,571
San Joaquin River	San Joaquin River canals	31,795
Fresno River	Fresno River canals	5,766
Chowchilla River	Chowchilla River canals	[illegible]00
Merced River	Merced River canals	5,916
Tuolumne River	Tuolumne River canals	50
Stanislaus River	Stanislaus River canals	184
Mokelumne River	Mokelumne River canals	112
Total		251,140

* The area has been increased by at least one-third.

PRODUCTS AND THEIR VALUES.

California is estimated to now have a population of over 1,200,000, of which one-third is found within the semi-tropical and southern portions of the State. Another third or more is found in San Francisco. Ten counties will contain over one-half the population.

The immigration increase in 1889 was 30,557.

In 1889 the California wheat product was 42,000,000 bushels.

Value of wheat	$32,000,000
That of fruit	16,000,000
Barley	9,000,000
Cereals unspecified	7,500,000
Wine and brandy	8,000,000
	72,500,000
Out of a total of raw products that include gold, silver, coal, etc	144,704,000
This leaves a balance of	72,204,000

The entire agricultural products of California since 1848 have been as follows:

Wheat	$732,000,000
Dairy	200,500,000
Barley	184,000,000
Wood	161,000,000
Fruit	106,000,000
	1,383,500,000

California—1888-'89.

	Acres.
Area of oranges	50,195
Area of lemons	3,015
Area of raisin grapes	20,000

It is in the great diversity of altitude and precipitation that the irrigation needs of California and the means of supplying them are found. Storage in the mountains and good engineering in the way of distribution will add enormously to the irrigable area of this wonderful State. Every system of water usage and distribution can be found therein; its practices illustrate the primitive wastefulness common to early irrigation, and the remarkable economy in the use of water which intensive farming and horticulture have already produced in the extreme southern portions of the State. Nowhere else in the world, except Madeira, portions of China, and Central Asia, has the "duty of water" been so thoroughly extended. As a consequence the price of land, the cost of water, and the security of crops have all grown in a steadily increasing ratio. Within twenty years land which the owner protested against being taxed at 75 cents per acre has been sold and is now selling at from $500 to $1,500 per acre. On the tract referred to more people are supported per acre and in greater comfort than elsewhere in the world.

The areas of fruit-producing lands on which this occurs are small in extent at present, though they are quite numerous. These areas may be greatly increased by proper systems of water storage. They may be largely added to by the restoration and conservation of the underground supplies so steadily fed by the neighboring mountain drainage.

It is difficult to make anything like a close approximation of the reclaimable area of California. With the water "in sight" certainly 12,000,000 acres will be a low estimate. Water storage on a grand scale, such as the conditions warrant, will insure the reclamation of at least 20,000,000 acres. A large proportion of whatever area may be reclaimed will necessarily be devoted to the raising of products possessing a high market value. Its fruits are among the best in the world. It bids fair to become the successful rival of the oldest wine-growing and wine-making lands; its nectarine, prune, grape, and orange are already found in the markets of the world. The olive, fig, lemon, date, and other semi-tropical fruits are fast becoming of great commercial importance. Nearly all these products are the direct results of irrigation, and they are all benefited by its judicious use. There were 1,537,000 fruit-trees reported in the State at the beginning of 1890.

The enormous addition to the wealth of the State and to the commercial prosperity of the whole country, which is the direct result of the high culture produced by irrigation, warrants a close attention to the united appeal of the people of California for such a survey of the public lands remaining therein and of the State's capacity for water storage as will insure to them that accurate knowledge which enterprise and investment require in the conduct of great affairs.

TAXABLE VALUES OF CALIFORNIA, 1879-1889.

A careful tabulation of the assessment valuations in some of the counties of the State illustrates very forcibly the great increase of wealth produced by the practice of irrigation. It must be borne in mind that the figures given are not over 50 per cent. of the real values.

GROUP NO. I.—*Counties enriched by irrigation.*

[Total taxable values.]

Counties.	1879.	1889.	Increase 1889.
Fresno	$6,354,596	$35,387,173	$29,032,787
Kern	6,005,460	11,831,780	5,826,320
Los Angeles	16,368,649	84,376,319	68,007,670
Merced	5,208,245	14,146,845	8,838,600
Orange	2,317,700	9,270,767	6,953,067
San Bernardino	2,576,072	23,267,955	20,690,982
San Diego	3,525,253	31,560,918	28,034,265
San Joaquin	17,377,129	38,802,606	21,425,477
Stanislaus	6,232,367	15,594,003	9,361,636
Sacramento	18,416,338	34,464,174	16,047,836
Solano	2,651,367	6,966,007	4,314,640
Tulare	5,204,777	24,343,013	19,138,236
Yolo	10,177,427	20,911,325	10,733,898
Total	102,516,281	350,922,885	248,405,414

Orange County was not formed in 1879. It was then part of Los Angeles County. The ratio estimated for increase is on one part in 1879 to four parts in 1889.

GROUP NO. II.—*Counties increasing in irrigation activity.*

[Total taxable values.]

Counties.	1879.	1889.	Increase 1889.
Butte	$10,743,426	$20,730,252	$9,986,826
Colusa	12,420,508	24,365,995	11,945,487
Lassen	1,230,764	2,527,449	1,306,685
Inyo	1,353,300	1,548,695	185,395
San Benito	3,947,728	6,332,911	2,385,183
Shasta	1,961,436	6,594,003	4,632,567
Siskiyou	2,651,367	6,966,007	4,344,640
Sutter	4,120,451	19,079,868	5,959,417
Tehama	4,199,998	11,901,255	7,701,257
Trinity	868,496	1,153,344	284,848
Yuba	4,293,630	7,046,316	2,752,686
Total	47,791,104	99,246,095	51,544,991

GROUP NO. III.—*Foot-hill counties partially irrigated.*

[Total taxable values.]

Counties.	1879.	1889.	Increase 1889.
Amador	$2,468,642	$4,281,969	$1,813,327
Calaveras	1,871,850	4,315,461	2,443,611
El Dorado	2,312,590	3,879,887	1,567,297
Mariposa	1,295,048	1,849,641	554,593
Nevada	6,305,090	6,926,218	621,128
Placer	5,774,860	10,118,060	4,343,200
Plumas	2,115,173	2,309,441	194,268
Tuolumne	1,596,015	2,716,465	1,120,450
Total	23,739,268	36,397,142	12,657,874

The bay counties of San Francisco, Alameda, Contra Costa, Marin, San Mateo, Sonoma, and Napa present the following comparisons:

Valuation in 1879, a total of	$333,146,966
Valuation in 1889, a total of	449,992,603
Making an increase of	116,841,637

These counties are partly affected by irrigation, to the direct extent at least of one-tenth part of the valuation given.

The remaining fourteen counties, of which nine are coast counties, show the following results:

Valuation in 1879	$70,755,631
Valuation in 1889	156,039,572
Increase in ten years	85,283,941

Thus it will be seen that from 1879 to 1889 the taxable valuation increased from $577,949,250 to $1,092,598,297, an addition of $514,649,047. Of this increase nearly one-half, or $248,405,414, was made in thirteen counties, or one-fourth of the State, and is almost wholly due to irrigation. It may be fairly estimated that to the increase of irrigation in California and the rise in land values, etc., as a consequence, is due at least $350,000,000 of the total taxable increase in valuation. That will be a marketable increase of $700,000,000.

THE IRRIGATED AREAS OF CALIFORNIA.

California, though foremost in the extent and variety of its irrigation interests, enterprises, and methods, is behind several other communities within the arid region as to its statistics and data.

A full, clear, succinct statement of the irrigated areas, number of ditch systems, and the mileage, with the cost thereof, is not accessible. The best average estimate obtainable, consulting therefor the State engineer's reports, the State board of trade, evidence offered by local witnesses, and county assessors' returns to the State board of equalization, is the following:

	Ditches.	Cost per mile.	Total cost.
	Miles.		
In the San Joaquin Valley, counties of Fresno, Merced, Kern, and Tulare	800	$5,400	$4,320,000
In the counties of Los Angeles, Orange, and San Bernardino	500	6,000	3,000,000
In San Diego County	36	19,613	700,068
In the remaining part of the State, twenty-four counties, where irrigation is practiced	1,700	640	1,128,000
Counting one-third of the mining ditches in the State as available, and used for small irrigation, we have	289	3,188	921,221
Total	3,825	....	10,375,289

The total valuation or cost given is below the true figures. Much of the data on which the estimates are based is taken from the assessors' returns made for the purpose of taxation. They can therefore be doubled. That will give a total cost of at least $20,000,000.

The acreage is also difficult to arrive at with certainty, but it is fairly covered as follows:

	Acres.
In the San Joaquin counties:	
In farm crops	1,000,000
In vines	13,000
In fruit trees	16,000
	1,029,000
In the southern counties:	
In farm crops	580,000
In vines	45,000
In fruit trees	85,000
	710,000
In the balance of State (irrigated):	
In farm crops	1,500,000
In vines	25,000
In fruit trees	30,000
	1,555,000

The total acreage wholly under ditch and now irrigated is fairly within the annexed totals:

	Acres.
In farm crops	3,080,000
In vines	83,000
In fruit trees	131,000
Total	3,294,000

If all the areas directly cultivated by the aid of natural sub-irrigation, etc., be added, the total area in California will certainly be not less than 3,500,000 acres. The point of interest, however, in these figures is the profitable character of such cultivation, especially in the matter of fruit-raising. Land formerly worth $1 now sells at from $500 to $2,500 per acre. The area of California is reported by the statistician of the Department of Agriculture to be divisible as follows: Tillable, 39.8 per cent.; grassland, 11.5; woodland, 35.5; unproductive (valuable, though, because largely mineral in character), 11.4. These areas compare favorably with the whole country, the per cents for the same divisions of which are as follows: 41.6; 11.5; 35.4; 11.4. In productive character California shows on grain the following:

[Bushels per acre.]

	For State.	For United States.
Corn	26.5	24.2
Wheat	13.0	12.3
Oats	28.2	27.0

THE INTRA-MOUNTAIN DIVISION.

Within the limits of the second great division of the arid region extending east and west from the one hundred and fifth to the one hundred and twentieth degree of west longitude, and north and south from the British to the Mexican boundary, irrigation works and experiments of value will be found in progress, small in extent, perhaps, in most cases, but extensive when aggregated.

The larger portion of Colorado, New Mexico, and Wyoming are within the limits assigned. The whole of Nevada, Utah, Montana, Idaho, and Arizona, and the eastern half of Oregon and Washington Territory are also included. The region comprises 15 degrees of longitude and about 17 of latitude, and makes a total area of 1,100 by 900 miles square.

IRRIGATION AND STORAGE IN IDAHO.

The condition of Idaho, as to the hydrographic facts, the available area for reclamation, the facilities for artificial storage, and the awakened interest of the people, was found to be among the most satisfactory of the communities visited by your committee. A considerable area to the north and to the west of the Sawtooth and Bitter Root ranges is considered in the Territory as outside of the arid range. This area embraces the counties of Idaho, Latah, Nez Perces, Kootenai, and Shoshone. A portion of Lemhi is also included. Unquestionably, however, this section will also be benefited and farming pursuits rendered more secure by water storage and distribution. The remainder of the Territory embraces 32,183,040 acres, of which about 7,000,000 acres are estimated to be irrigable and arable, fertile in soil, and having accessible storage capacity and an available water supply.

The counties wherein are found the largest irrigated areas, as well as the great number of ditches with the smallest service to each, are those in which so large a number of Mormon citizens have settled. The smallness of the ditches constructed indicate the limited area cultivated by each individual or family. It is, however, always sufficient to support them in that primitive plenty which constitutes their standard of life. The primary nature of this work can be seen when an estimate is made of the cost per acre.

In Bear Lake County the total cost for the 21,500 acres irrigated is given at $73,500, or a fraction over $3.60 per acre. The ditches of the northern portion of Bingham County cost $435,000, or a cost per acre of $1.775. Small as this price appears to be, it is necessarily costly, because wasteful. As the water in sight is absorbed, storage becomes a necessity, and the result is the abandonment finally of the small ditches, and the reconstruction of service works on a larger, and of necessity, costlier (at the outset) scale. Taking the medium between the two rates given, and the cost per acre of irrigation in Idaho may be set at $2.66 per acre, or a total for 715,500 acres of $1,187,000.

The extensive river system of Idaho renders the reclamation of its arid lands a very interesting problem. The need of storage is insisted upon. The importance of the river system of Idaho can hardly be exaggerated from the stand-point of reclamation; the number and volume of minor mountain streams must also be considered. Some slight idea of the water supply may be obtained by the presentation of a few of the estimates made in the testimony:

	Cubic feet per second.
Flow of Snake River (at Eagle Rock)	5,000
Flow of Salmon River (in Cassia County)	1,820
Flow of Boisé River	6,000
Flow of Payette River	1,000
Flow of Weiser River	180
Flow of Big Wood River	154
Flow of Raft River	745

These estimates are necessarily partial. They embrace with tolerable accuracy the surface drainage flow above the point of measurement, but they take no account, of course, of the addition to the river volume accruing from the remainder of its other local areas of precipitation and drainage. The average annual rain-fall is about 13 inches. The snowfall is given at an average of 6 cubic feet of packed snow on the ranges. This will give at least, in melting, about 2 cubic feet of water. The capacity, then, of Idaho for storage by main reservoirs at high altitude and at or near the sources of its great streams becomes one of the problems that may be approximately measured and calculated upon.

The Hon. E. A. Stevenson, of Boisé City, Idaho, presented to the Senate Committee on Irrigation, at their Idaho session, valuable testimony as to the value, character, and results of irrigation. A brief summary of its chief points is given. Mr. Stevenson said:

> This town was settled in 1863, but very little agriculture was attempted until 1864 or 1865. When I first saw this town this portion around here was as poor a sage-brush place as you would find in Idaho—a miserable sandy place that nobody imagined would grow anything. It was that way all along this valley. There was a little strip along the river where some grass grew and where there were some willows and trees. The first men who came here settled on that low bench-land, and they have the poorest farms in the country. Those who went back on the sage-brush plains have land that is worth five times as much as the other. And so it is in Washington Territory, at Walla Walla. All those men who went on the Touchet, and all those streams, have poor farms; those who went on the high lands have good farms. But this land without irrigation would produce nothing. It might, if it should rain in the fall, produce a crop of rye, but there is no dependence to be placed on it. But rye will grow almost any place. I have had some experience with irrigation. My partner and I dug a ditch 22 miles long down on the Payette River. We took some water on to some desert land that we have there, and in five years we have raised orchards with lots of fruit. I have cut the grass there twice this year already, and there is a regular forest where there was not a tree in sight in the country. In a short time, five years, these trees were 5 inches through.
>
> The trees are apple, pear, plumb, peach, apricot, prune, and poplar trees; box-elder, walnut, locust, and all the different varieties. I took small trees in a two-horse wagon down there. I told some persons that five years ago I took in a two-horse wagon all the trees that are growing there to-day, and they were thunder-struck. A man can not imagine that it could be done. But it is marvelous how the trees grow there. I do not think you can raise cereals where you have to irrigate and compete with a country that does not. But in all other kinds of crops, vegetables, I think we can raise all kinds of fruits and vegetables. An irrigated country requires more population. The holdings should be small. A small farm will support a good family if it is well irrigated. The system of irrigation is crude. They do not understand it. Some give too much water and some too little. Some farmers might live on 60 acres. But I think it would be better for the country to cut it up into 80 acres; 40 acres would make a good home if well cultivated. Now, on the Payette River the supply of water is abundant without storage, and will water all the land on it. There is a large amount of water there now. But on the Boisé River it would need storage. There is plenty of water here with proper storage facilities to cover the whole country. I am speaking of Lewiston. Around the city of Lewiston they could not raise fruit in the garden without irrigation. They irrigate there altogether.

L. F. Cartee, formerly surveyor-general of Idaho, and a practical horticulturist by irrigation, gave to the Senate committee the results of his own work and observations. He said in substance that—

> Idaho sage-brush land is capable of producing anything that can be raised in this latitude anywhere, not only all the varieties of fruits, but all the cereals. I have forty different varieties of grapes on my place, and they nearly all ripen except the Catawba. That does not ripen because of the shortness of the season. Our grape is of fair quality; better than any of the eastern grapes that we have. A fair crop of wheat on our irrigated land is from 25 to 50 bushels; of oats it is from 30 to 60 bushels; occasionally 70 to 80 bushels, but that is exceptional; barley is the same as wheat—25 to 50 bushels. Timothy hay averages about 2 tons to the acre, and alfalfa returns 6 tons. Red clover will give the same. Potatoes return 600 bushels to the acre. This is the finest apple country in the world. All do well here; you

can hardly find an exception. They grow to a large size and the trees are heavily loaded. Peaches do well, but plumbs and prunes do remarkably well, better than in any country in which I have been. Pears are very good also.

At the same session fruit, still on the branches, was exhibited. One limb, 2 feet in length, had on it 29 peaches, one of which taken off at random measured 8¼ inches one way and 8¾ another. On a branch 14 inches in length 27 large plums were counted. A pear was measured and found to be 11½ and 10½ inches in circumference. These are reported as taken without selection from a large variety.

MONTANA AND WATER STORAGE.

Montana, with its 93,349,200 acres, is not only one of the three largest States—the others being Texas and California—but it is without question the best watered one west of the one hundredth meridian. It is heavily timbered also; its pastoral area is great, and, according to the estimate of Statistician Dodge, its tillable area is not less than 32.9 per cent., or close to one-third of the total.

The river courses that drain the central basin of our land find their beginnings in the sources of the Upper Missouri, with its great tributaries of the Yellowstone, Gallatin, Jefferson, Madison, and a score more important streams that all head in and receive their primal supply from the precipitation and drainage of the upper Rocky Mountain ranges. The valleys are usually narrow and long. The Yellowstone is an example, presenting as it does a tillable valley or bottom area of about 400 miles in length, with an average width of not to exceed 3 miles; in all about 780,000 acres. Such streams, large or small, usually present similar features of deep, narrow valleys, in which the waters appear to be slowly but steadily eroding deeper channels; then comes a precipitous rise to the mesa or bench land of from 25 to 100 or more feet in height. The mesas will widen their sections of the several hydrographic basins to from 8 to 12 miles in width. The secondary table-land or plateau is then reached by steep ascent, making them often as high as from 600 to 1,000 feet above the bottom-land. These mesas and table-lands are everywhere covered with succulent grasses. They are everywhere found to be fertile in capacity, if water can be obtained. It is these facts that make Montana a typical region in which to conserve the waters by storage and subsequent distribution for purposes of irrigation.

The Yellowstone Basin, from a reclaimable area in the lower valley of 780,000 acres, will rise rapidly under a system of scientific engineering to an agricultural capacity of from 3,000,000 to 8,000,000 acres. When storage shall be so advanced and distribution so systematized that the secondary table-lands may be reached and quickened, the largest area named will be readily compassed. Nor does this statement close the possibilities of the drainage or hydrographic basin of the Yellowstone. The tributary valleys found there, many of which are quite large, will furnish an additional 4,000,000 acres to the area of reclamation. This is illustrated in a report made by the authorities of Custer County, within which a large portion of the main Yellowstone Valley is located. That report gives the valley land area at 384,000 acres, and for fifteen other tributary valleys within the county, including the Tongue, Powder, Rosebud, and Otter, it gives their valley areas at 501,600 more acres.

The volume of water to be supplied from the Yellowstone alone is estimated by the same authority for use in the areas under consideration at 906,000 miner's inches per second, flowing under a 6-foot pressure. The testimony warrants the statement that the Yellowstone alone can furnish for irrigation purposes some 4,000,000 miner's inches. With proper storage this may be greatly increased, perhaps doubled. The wisdom of the policy which reserved as a national park the wonderland in which the Yellowstone finds its ample sources may yet be proven in ways heretofore unexpected. The storage of its quickening waters will be greatly simplified by the inability of speculative occupiers of the public lands to exploit those valuable sources. Hundreds of millions of dollars may yet be added to the nation's wealth as a consequence of the National Park reservation.

The Yellowstone is taken as an illustration of the fact that the earlier or primal attempts at irrigation are decidedly wasteful and often provocative of contention, disorder, and litigation. The valley or bottom lands, though the most readily reclaimable by simple local ditches, are seldom, perhaps never, the most desirable for farming purposes. It is always the warm red loams and soils of the mesa and table lands that will furnish the largest crops as a return for industry. It is on these benches, open to the sun, made up of the most fertilizing components and readily washed by water of alkali salts, that the Western farmer will in the not distant future, wherever water is accessible, make from his occupation a return almost as certain and controllable as does to-day the carder of wool and the weaver of cloth.

No cultivation of the soil is possible in Montana without irrigation. Without ample storage of water the reclaimable area will be a limited one; with ample storage it will rise, according to different witnesses and reports, from 20,000,000 to 30,000,000 acres. With irrigation an acre of ground in Montana will exceed in productive value from 3 to 5 acres in the humid or rain-fall States. The average production per acre is estimated as follows: Wheat, 35 bushels; oats, 50; barley, 45; corn, 28; alfalfa, from 4 to 6 tons. The percentage of productive capacity for Montana per acre may be stated as follows:

	Products.		
	Wheat.	Oats.	Corn.
Average number of bushels per acre in Montana	17.8	34.2	26.2
Average for the United States	12.3	22.3	27.0
Average per acre for whole arid region	18.9	24.9	28.9

The number of farms is 1,519, the percentage of agriculturists 20, and the average value of land is a little less than $8 per acre. During the past ten fiscal years 6,904,461 acres of public lands have been disposed of in Montana, of which total 5,304,778 acres have been settled upon, sold, or patented during the past four fiscal years ending June 30, 1889.

The statistics presented as to irrigation ditches were very imperfect. It appears that there were in 1869 of mining ditches 287½ miles, constructed at a cost of $806,500. The present extent, including these, as many have been used for irrigation purposes also, is now estimated at 1,000 miles. There are now partially or wholly completed the following larger or district systems, constructed for rental investment by corporations:

Ditches.	Miles.	Acres to be served.	Estimated cost.
Benton Lake	35	50,000	$175,000
Clarke Fork	38	100,000	140,000
Chestnut Valley	10	25,000	7,000
Dearborn	45	51,000	150,000
Florence	50	10,000	200,000
Gallatin	25	50,000	75,000
Sun River	75	300,000	500,000
Teton	40	35,000	80,000
Total	318	611,000	1,327,000

Under a proper system of irrigation, storage, and distribution land now worth but little beyond the Government price of $1.25 will rise rapidly to $20 and $30 per acre.

EASTERN WASHINGTON AND OREGON.

The States of Washington and Oregon present interesting irrigation and reclamation features. In an area well within the arid region, the extensive mountain lakes found in northwestern Montana, northeastern Washington, and northern Idaho subdue to a considerable degree the regional aridity. The extreme eastern quarter or third of Washington from north to south may properly be classified as subhumid, while the central portion clear to the eastern foot-hills of the Cascades approaches more nearly to a general arid character. Washington, from 117° to 121° of west longitude, or four degrees, will be found a section in which the storage and distribution of water, while not at all times and places therein an absolute necessity, will always need such facilities and find them to greatly enhance its land values and industrial progress. There is a great area almost wholly unreclaimed, formed by the mesa or table-land of the Columbia River Valley and its great tributaries. The Columbia River Plains to the northwest of the North Pacific Railroad will probably require for their arable use an extended series of hydrographic works. That they can be so reclaimed is testified to from many sources. One estimate is made of 8,000,000 acres, another of 12,000,000. Irrigation by private parties or companies has been successfully tried in a number of valleys, viz: The Klamath River Valley, both in Oregon and northern California; the Boisé River Valley, Idaho; the Snake River Valley, Washington and Idaho; the Colville River Valley, Washington, and in the Rogue River Valley, Oregon. The rivers of this region are large and furnish enough water to supply systems of irrigation ditches, which could be supplemented by storage reservoirs if necessary, or when the demands increase. The region around Walla Walla is rich and productive. The Great Plains ot the Columbia, although not so well known, is a promising country. Both regions are poorly supplied with water during the summer months, at least. The Snake River above Lewiston has falls and rapids, and may afford an opportunity of running irrigation ditches to the lower lands below.

All of the great bodies of water named present the usual characteristics of the arid region—deeply eroded channels, low, narrow valleys, abruptly rising bench lands opening widely one or the other side of the river, but seldom on both sides, and then again rising into grass-clad table or plateau lands. At North Yakima and Ellensburgh can be seen the results of irrigation on an extensive scale. The Moxie ranch at the first-named place illustrates in its 7,000 acres, irrigated from the Yakima River at an average cost of $8 per acre, what may be accomplished by private enterprise backed by capital, while at Ellensburgh the Kittitas Valley offers a splendid evidence of neighborhood energy and self-dependence. The Yakima Valley people estimate 200,000 acres of bottom lands for reclamation and at least a million more in available bench lands. The rain-fall of the region is also sufficient to secure a large area of "subirrigated" land. That is to say, where the soil retains below the surface much of the precipitation and drainage that percolates into it.

The production per acre is given of wheat at from 35 to 50 bushels; of oats at 60; of barley from 50 to 80; alfalfa yields from 6 to 10 tons per year, while potatoes will return more than 500 bushels to the acre. One half of eastern Washington needs storage and full facilities of irrigation. The cost will range from $3 to $5 per acre, and there may probably be found an abundance of water for storage. The cost of water in irrigation is about $1.50 per acre.

The Kittitas Valley without water is but a sage-brush desert; irrigated, it becomes a garden spot and produces bountifully of cereals, fruits, and vegetables. About 22,000 acres of land are now under cultivation. All small fruits, as well as apples, plums, pears, etc., grow to perfection; peaches do not do so well, except in localities bordering on the Columbia and Wenatchee Rivers. Vegetables of all kinds and of the finest quality are grown upon every farm.

In these valleys of the Yakima, including the Nachez Valley and the Yakima Valley proper and the valleys tributary to the Yakima, the irrigating season commences in the months of May and June principally. Very little land west of the Columbia River, in what is known as the Columbia River basin, is susceptible of cultivation without irrigation except, perhaps, for hay. Many people produce hay along the river by subirrigation or percolation. The finest store-house of water is the snow-clad mountains. Fort Adams is an everlasting store-house. The waters of the Yakima and the Tietan flow in there in ordinary seasons, and without any storage whatever those would irrigate an extremely large area of country.

In the extreme southeastern section, around Pasco, Walla Walla, and east to Lewiston, in Idaho, there is a region famous for fine fruits and vegetables, in which the use of irrigation adds enormously to the value of the land. It is a region also of accessible and not very deep artesian water, and it illustrates, too, the rapid increase of precipitation at rising altitudes. The average annual rain-fall at Walla Walla is given for five years past at 18 inches; at Dayton, 30 miles distant, it reaches 27 inches. That is a rise of less than 700 feet. To be accurate, the height above sea-level at Walla Walla is stated at 1,000 feet; at Dayton, at 1,675 feet. The advantages offered by this region are testified to by some State census figures, which show that the proportion of settlement in Washington during two years past has been in favor of the section east of the Cascade range. In 1887 there were in Washington 144,000 persons; in 1889 the estimate made from county returns showed 240,000. In the western counties the total population was 142,132; in the eastern counties it was 97,868; an excess for the west of 44,264. The total increase for two years is given as 95,991. Of this, the region between 117 degrees and 121 degrees, or East Washington, got 41,298, while that west of the Cascades got 35,693.

Oregon is estimated to have received 100,000 new settlers during the same two years or less, of whom 60,000 at least have remained east of the one hundred and twenty-first degree of west longitude. During the past twelve fiscal years ending June 30, 1889, these two States show a public land settlement as follows: Washington, 13,335,937.03, and Oregon, 6,149,540.05 acres, or a total of 19,485,477.08 acres. The amount paid into the land offices during the fiscal year of 1888–'89 was, for Oregon, $35,332; and for Washington, $39,538, or $74,870; or a total of one-eighth of the receipts for the whole arid region. Washington has made natural waters public property by constitutional provision.

The arid and subarid sections of Oregon are somewhat more extensive than the similar ones in Washington. Their great feature is the drainage basin of the Columbia River, in the north, with its extensive tributaries—the Deschutes, John Day, White, and Powder Rivers—and on the east the lower valley of the Snake River, which forms the western boundary line of Idaho for two-thirds of its length. Below that is the Oregon portion of the Owyhee River and its branches. In the southwest, the Klamath River and lakes form an extended drainage basin, in which large irrigation operations have already commenced.

IMPORTANCE OF IRRIGATION IN UTAH.

Utah presents an extensive system well under way. A large area has been reclaimed. The value of the work accomplished is seen not only in the valleys near to Salt Lake City, but in all the Mormon settlements within the Territory. The influence of the Mormon polity in directing industrial activity has often been commented upon. In no one thing is it more apparent than in this great work of the conservation and distribution of the water supply. It exhibits several noteworthy features. They are:

(*a*) The treatment of natural water supplies, under legislation, as public property, to be used for the common benefit.

(*b*) The construction of all distributive agencies (artificial) at the cost necessarily of those to be benefited.

(*c*) The incorporation of the expected beneficiaries by neighborhood companies, under general law, and the assessing of costs co-operatively, by means of share purchasing and holding, according to the number of acres to be served by the water so utilized.

(*d*) The distribution of water under stated regulations, which have the effect of law, under the supervision of an officer specially chosen for the purpose.

(*e*) The payment for this authorized use by means of stated rates, levied upon the volume of water used.

The Mormon irrigation laws provide for the proclamation as a water district of any piece of territory which can be commanded by an irrigating ditch, the nomination of water masters, penalties against wasting water, the giving of permission to carry the ditch through any private property upon a fair valuation for the land used, authority to tax for maintenance of channels, and to appoint taxation trustees, whose powers are made very broad with respect to determining what shall be described as land benefited by the construction of the irrigating channels. The law also gives protection to primary water rights, which means that any person who has drawn water from a water-course by means of an irrigating work previous to the proclamation of any locality as a water district, has his right protected as a primary claim up to the quantity of water he was in the actual use of at the date of proclamation. Having covered these points the law has made the way open for the action of private enterprise, which in all cases undertakes the construction. The next step is the formation of a joint-stock company, which may be formed of not less than three individuals, and not more than seven, and further provides that such corporation work shall be exempted from general tax for county and State purposes, to which all other kinds of property are subject. The farmers and others interested then meet in public and arrange the formation of the company and the distribution of shares, and then vote as to whether the tax for maintenance and management purposes, after the main ditch has been completed, shall be upon all the land within the water district or upon "the land to be benefited." They can also confer arbitrary powers upon the assessing trustees, as a difficulty had been found to occur with parties who refused to contribute to the maintenance tax on the plea that they are not taking water, although, owing to favorable positions in relation to either the main or subsidiary ditches, their lands are being effectually irrigated by means of seepage. The shares are always $10 each, and each share represents an acre of land with a perpetual water right to that acre, subject only to the maintenance tax. The company being formed, the farmers, or intending farmers in most cases—for many of the tillers have just arrived as immigrants—of the water districts take up all the shares they can. This is usually a very small percentage of the whole, as they are poor, and their shares are mainly paid for by work in the ditch. After the farmers have taken their shares, the wealthy citizens take the balance amongst themselves, and on goes the making of the ditch, the intending farmers working on their farms at the rate of $20 a month, and the non-working shareholders putting on labor by contract, which amounts to an average of 10 cents per cubic yard, the heavier work in the cañon being by special agreement, according to the difficulties of the work. When the work is completed the farmers have as many water rights as they have taken out shares, and they who have furnished most of the capital then begin to make their profit.

Small farmers generally secure a water right for each acre, but others who hold, say, from 40 to 80 acres, sometimes only take water right sufficient for half their area, working one-half as a tillage-farm and the other as a grazing-block, alternately. A water right means the privilege of taking as much water as the land requires during the irrigating season, and the maintenance tax varies from 10 cents to 16 cents per acre per annum, according to "easiness" or otherwise of the channels. Subsidiary ditches, called laterals, are made by the farmers at their own cost, from side heads fitted with sluices, through which the water-master lets out as much water as may be required during any particular day. Thus there may be ten farmers along a certain lateral holding from 5 to 40 acres of land each, and they may have water rights to cover the whole or any part of their holdings. The water-master knows how many water rights are along each lateral, and every morning he looks at his notice boxes, which are attached to the sluice-heads at the place where the laterals leave the main channel. The farmers generally arrange to irrigate day about, each at the proper time posting up the notice, "I intend to irrigate to-day," and as the water-master knows how many acres are possessed by the person signing, and how many water rights, he is able to make his arrangements accordingly. His water-gauge, which is simply a wooden slat in the lateral sluice-head, graduated so as to let a certain number of cubic feet run through in a given time, is then lifted to the necessary mark, and the water laid on until the irrigation is completed. The gauge is arranged so as to let a cubic foot per second flow through for each hundred acres of land. Thus: If A's notice represents five water rights, B's fifteen, and C's thirty, the water-master knows that fifty water rights want water, and he sets the gauge to run at the rate of half a cubic foot per second. This is not for the purpose of measuring the water, but only as a gauge to arrange the flow to suit the irrigation requirements of the several farmers situated along the lateral.

The time occupied in flooding a certain area differs according to the "lay" and quality of the soil. The water-master soon learns how much time each irrigator usually occupies, and his knowledge on that point, together with the law against wasting water, which is strict, operates to prevent the flow of water longer than is absolutely required. The water-master notes in his book the time of letting the water on, together with the number of water rights that are drawing, and it is his business to visit the irrigators about the proper time, and see about shutting off.

THE WATER LAWS AND PRACTICES.

The legal aspects of Utah irrigation are thus as remarkable as the economic ones. Indeed, they are related to each other, and the laws could hardly have been framed by any other community. But their value extends beyond the locality for which they were framed. Prior appropriation is the foundation, but so modified by the uses of water in the interests of the community as to make of that principle something quite broader and more equitable than has elsewhere been the case. In other words, priority has not been abused in Utah. The county selectmen are *ex officio* water commissioners, with the power to record all appropriation and regulate the distribution of natural water. Appropriators can be persons or corporations. Rights are divided into primary and secondary, the latter being a feature of water legislation peculiar to Utah. A primary right vests under the following circumstances:

(1) Whenever any person or persons shall have taken, diverted, and used any of the unappropriated water of any natural stream, watercourse, lake, or spring, or other natural source of supply.

(2) Whenever any person or persons shall have had the open, peaceable, uninterrupted, and continuous use of water for a period of seven years.

A secondary right to the use of water for any of said purposes is hereby recognized and acknowledged to have vested and accrued (subject to the perfect and complete use of all preliminary rights) to the extent of and reasonable necessity for such use thereof, under any of the following circumstances:

(1) Whenever the whole of the waters of any natural stream, watercourse, lake, spring, or other natural source of supply has been taken, diverted, and used by prior appropriators for a part, or parts, of each year only; and other persons have subsequently appropriated any part, or the whole, of such water during any other part of such year, such person shall be deemed to have acquired a secondary right.

(2) Whenever, at the time of an unusual increase of water exceeding seven years' average flow of such water, at the same season of each year, all the water of such average flow then being used by prior appropriators, and other persons appropriate and use such increase of water, such persons shall be deemed to have acquired a secondary right.

The measurement of water is definitely provided for by "fractional parts of the whole source of supply" or time limit, or by a specific ratio of measurement, or this combined with time limit. Provisions are made for repairs, damages, continuous use and service, against waste, and for the return of unused water to its proper channel; also for pro rata distribution when supply fails in volume, as to equal right of way, and for the organization of local copartnerships or corporate direction. Another act provides for irrigation districts and their lawful control, with trustees, and the powers as to water and its control and use, of any subcivic or county body.

There are two or three systems of distribution. First are the incorporators on the streams, controling it themselves—they agree how it shall be manipulated; second, the county courts that matured and organized irrigating companies; and, third, private corporations, taking out charters the same as any other corporation would, as, for instance, a person or a company of men settle upon a stream and appropriate the water in it. In early times they had sufficient to irrigate what land they would break up. These may be termed the primary owners of the water. Afterward others, finding a surplus of water in the stream, appropriated still further water, and so on until all the water of that stream is taken out. In establishing some streams there is then what is known as the first, second, and third right. The third right, when there is a scarcity of water, shuts off the entire stream, and the second and first rights take the entire stream. The owners of each of those ditches meet and appoint what is called a "water-divider" or "water-master," who has control of the ditch for that year, and whose duty it is to divide the water of the streams into ditches. For instance, if there were four streams drawing water, the farmers would appoint a divider to turn the water of those streams into the ditches, and the water-master take the water as it flows into the ditch and give it to the owners as their rights appear. The private companies so called are incorporations where certificates of stock are issued under the general laws of the Territory. They elect their board of trustees and manage the affairs of the company. Those trustees appoint a water-master, who takes the number of shares each owner of has and divides to each his proportion of the water that comes through a certain ditch from the stream. Those streams are mostly artificial streams, having been taken out from some large body of water. That system prevails largely on the west side of Salt Lake. The stockholders have the land, but the water right can be transferred without transferring the land. It is a water right independently of the land.

Yet the water must be "in place," and in order to use it, the land served by that way must be obtained. As a practical fact a water right, that is, one share in a corporation, represents only the service of water for 1 acre of land. And it is a particular acre in a special place. Therefore the one share of water can only serve that 1 acre of land, or rather any 1 acre within the area to be irrigated by that particular body of water in the service or duty of which one share has been obtained.

In the distribution of water the horary or time system has been adopted. The irrigation survey engineer states that the following forms indicate the method of distribution by "the hour," as is the case in Spain:

No. —.

TIMPANOGOS IRRIGATION TIME TICKET.

Mr. ——— ———. On ——— every alternate week, from — o'clock — m., and until — o'clock — m., ———— amount of stream, all of the water in said ditch.

——— ———,
Water-master.

No. —.

TIMPANOGOS IRRIGATION TIME TICKET.

Mr. ——— ———: You are entitled to the use of water from the Timpanogos Ditch on ——— every alternate week, from —— o'clock — m., and until —— o'clock — m., ———; amount of stream, all of the water in said ditch; when you are required to discontinue to use and turn it off.

——— ———, *Water-master.*
Per ——— ———, *Deputy.*

PROVO CITY, UTAH, ——— ——, 18—.

The annexed blank receipt shows the manner of meeting the water-tax levy on proof of labor performed.

No. ——
Am't of labor, ——
Am't of cash, $——
——
Total, $——
Issued to and received by
—— ——.
Date, ——, 1.8—.

No. ——
Received of —— —— —— days' labor, $——
Cash.................................... ——
——
Total.................................... ——
In full for his water-tax, for the year ending March 1, 188—.
—— ——, *Water-master.*
PROVO CITY, UTAH, —— ——, 188—.

THE PUBLIC DOMAIN IN UTAH.

Within the Territory of Utah will be found several varieties of climate, ranging almost from semi-temperate in the north to semi-tropical in the south. The production of corn is limited; that of wheat and oats is large. Wheat brings 80 cents a bushel and runs from 25 to 30 bushels per acre. Oats bring from $1.16 to $1.60 per hundred pounds. Potatoes will give 300 bushels to the acre. A farm of 40 acres is quite sufficient for profitable cultivation. In the southern portion of the Territory the raising of fruit is claimed to be a success. Artesian water is found in several counties and over large areas.

The disposition of the public land domain in Utah for the past twelve fiscal years outside of mineral lands has been 2,681,605.96 acres. The percentage of Utah in farms is 1.92 of the whole. The entire arid region has but 2.85 per cent. Of tillable land Utah has (whether or not there be water for the same) 45.5 per cent. of its whole area. Of grass it has 18 per cent; of wood-land but 3 per cent. The unproductive area is set down at 11.4 per cent. of the whole. The question of reclamation in Utah then is, as elsewhere, one of mountain precipitation, of subterranean supply, and of artificial water storage and subsequent distribution. The rain-fall ranges from 7 to 17 inches per annum. The snow-fall is from 5 to 25 feet. In the mountains the precipitation is as 3 to 1 in quantity over the lower lands. The average yield of corn per acre is given at 22.5, of wheat at 17.8, and of oats at 26.3 bushels—an average which is close to the normal mean for the whole country. With these figures, it is evident that Utah holds larger promises than its past has achieved.

The most expensive thing in connection with an irrigating work in Utah, as elsewhere, is the main head, where the water is taken from the stream. Sometimes the channel is taken sufficiently far up the cañon to tap the stream without a dam, but in other cases it is found the lesser of two expensive works to dam the stream at a lower point rather than undertake the heavy quarrying or tunneling required higher up. The dams are of various kinds, according to circumstances, but that known to engineers as "the mud-sill" is mostly built over broad, shallow streams, and "the crib" used for deeper and narrower torrents up the cañons.

The usual plan of irrigation is to go well up the cañons and start a channel 10 feet wide by 4 feet deep, and carry this along the side of the cañon, and then around the side of the main range so as to command as large an area of level land as possible. The ditching, except in the rocky portions at the head of the cañon channel, is done by plow and scoop, one of the lightest of the latter implements, worked by a pair of mules, being invariably used. There are two 30-mile-long main ditches led along each side of the Jordan, and one 35 miles long is conducted from a mountain cañon in the direction of Provo, along the foot of the range towards Salt Lake City, thus providing water for a considerable area of country under the ditch.

Each acre of land brought within the influence of the canal is increased in value, and the $10-shares go up in the market. The water enables the working farmer to pay his passage-money back to the Mormon-Church, together with the tithe of all he raises, and further the expenses of his maintenance advanced to him during the construction of the ditches; and yet, after paying all these charges, in addition to, say, 10 cents an acre for maintenance of the ditches, he makes money. Each share in the Provo ditch, for instance, costs $10. That represents an acre of land, with a perpetual water right. Without the water right the land was absolutely valueless. It is now quoted at from $25 to $60 per acre, according to situation.

CONDITIONS AND POSSIBILITIES.

In 1875 there were in the twenty organized counties 2,095¼ miles of principal canals, costing $1,918,174, and 4,888¾ miles of tributary canals, costing $503,320. This was a total construction of 6,984 miles of canals and ditches, at a cost of $2,421,494. The total cultivated area within the district "under water" was 302,766 acres, of which 106,184 acres did not require the application of water at all. Mr. Caine, Delegate in Congress from Utah, under date of December, 1884, estimated that there were in the four most prosperous counties of that Territory irrigation (main) canals, as follows:

Counties.	Main canals.	Estimated cost.
	Miles.	
Weber	165	$300,000
Utah	150	250,000
Cache	175	550,000
Salt Lake	190	1,250,000
Total estimate	680	2,350,000

CLIMATOLOGY OF UTAH.

Prof. Marcus C. Jones, of the Deseret University, at the request of Governor Thomas, presented, in 1889, to the Senate Committee on Irrigation, among other papers, the following review of the Territory:

> The annual rain-fall of this Territory will not exceed 8 inches per annum, and were it not for the lofty mountains storing up the water in snow the Territory could not be inhabited. Therefore the settlements are to be found along the streams which are fed by the snow, and they are located chiefly at the bases of the mountains, though running out into the valleys as far as there is water.
>
> The Wasatch, rising over a mile above the valleys, run from north to south through the Territory, a little west of the middle, till they reach Iron County, where they turn to the southwest and fade away in Nevada. Their average height will not fall far below 10,000 feet above the sea.
>
> Nearly east of Salt Lake City the Uintahs, still loftier than the Wasatch, abut on them and run eastward till they pass out of the Territory. These are so close to the northern edge of Utah that we get little benefit from them, while to the south of them is an Indian reservation. Nearly due east of Utah Lake, and about 40 miles from the Wasatch, the Coal range starts from the Uintahs and runs southward parallel with the Wasatch for 160 miles, when it joins them at Panguitch Lake. These three ranges form the water-shed of Utah, the Coal range and the Uintahs forming the rim of the Great Basin, while the Wasatch performs a similar part below Panguitch.

The Wasatch and Uintahs are narrow, lofty, and rugged, while the Coal range is younger, lower, and broad. The Coal and Wasatch inclose between them some of the most fertile valleys of Utah. The Wasatch reach their culmination near Salt Lake City, and, aided by Great Salt Lake, give the greatest water supply in the Territory. The streams from this source irrigate the bulk of the cultivated area of Utah.

For ease in comprehension Utah may be divided into three divisions, the moist counties, whose rain-fall exceeds 12 inches per annum, the dry counties, with a rainfall of 6 to 12 inches, and the hot counties, with a slight rain-fall and great heat.

The moist counties are Cache, Box Elder, Rich, Morgan, Weber, Davis, Summit, Salt Lake, Utah, Wasatch, Uintah, San Pete, Sevier, and parts of Emery, Garfield, Pi Ute, and San Juan.

The dry counties are Tooele, Juab, Millard, Beaver, Iron, and parts of others.

The hot counties are Washington, Kane, and parts of San Juan, Pi Ute, and Garfield.

THE MOIST COUNTRIES.

Cache County is situated in the middle of the northern end of the Territory, at an elevation of 4,533 to 5,000 feet above the sea. All the arable land is in Cache Valley, which lies between two ranges of mountains, the Wasatch forming the eastern boundary. The water supply is 420.13 cubic feet per second, and comes from eight streams and rivers. The whole supply will be in use next year. The area of the county is 633,600 acres, of which 43,154 were cultivated this year. One thousand seven hundred and ten acres were dry-farmed, and 14,355 acres of crops were lost by lack of water. There are forty canals reported, aggregating 110.5 miles. The irrigating season is 122 days long, and land is irrigated 35 hours per year. The duty of water is less than a cubic foot per second to 100 acres. The average depth of snow in the mountains is 3 feet. The committee report water storage as the only means of increasing the cultivated area, since there are more than 420.13 cubic feet per second running to waste for 243 days, enough to irrigate from 50,000 to 75,000 acres. Many good reservoir sites are mentioned, but details are not given. It is probable that artesian wells can be obtained in some parts of this valley.

Box Elder County.—This lies in the northwest corner of the Territory. The eastern part is very fertile and well supplied with water, but the western and greater part belongs to the dry counties. The area is 2,767,360 acres, of which 53,280 acres are cultivated, and of these latter 19,190 acres are cultivated but not irrigated. The elevation of the fertile parts is 4,215 to 5,000 feet above the sea. There are 12 canals reported, length 76 miles. A branch of the Great Bear River canal is to irrigate a large area in this county. Large quantities of fruit are raised here, and still greater amounts of small grain and hay. The extensive valley of the Bear has been for half a century the recruiting place for overland travelers by team. Artesian wells are very numerous and add greatly to the productive area. Water storage is the main question here. Five reservoir sites are reported in detail, and several others in general. Bear Lake is the natural reservoir for this and Cache County, and will store all the water that will ever flow into it.

Rich County.—This lies at an elevation of 6,000 to 7,000 feet above the sea, in the northeast corner of the Territory, at the eastern base of the mountains. It is high and cold, raising only small grain, hay, etc. It lies all in one valley; is watered chiefly by the Bear River and some streams that flow into the lake. This land takes little water to mature crops, and much produce is raised without irrigation. The soil is sandy. The area of the county is 497,280 acres. There is no report from this county.

Weber County.—This lies south of Cache, extending from Great Salt Lake through the Wasatch to the headwaters of Ogden River. The best portion lies in Salt Lake Valley at an elevation of 4,315 feet, while Ogden Valley, lying along that river, lies east of the Wasatch and is more elevated. The water supply of the county comes from 17 streams and rivers, flowing 323.66 cubic feet per second. There are 117,600 acres under cultivation, of which 29,400 acres are fully irrigated, while the rest is partially irrigated or dry-farmed. The soil is sandy, with clay close to the lake. Five thousand one hundred and seventy-two acres are irrigated from artesian wells. The duty of water is one cubic foot per second for 80 acres, or thereabouts. There are 25 canals, length not given. The irrigating season is 122 to 152 days long. This county is one of the most productive that we have, raising all kinds of fruit and produce that is raised in the Great Basin. The only solution of the water question here is storage. There are over 323.66 cubic feet per second going to waste for 213 days, enough to irrigate 30,000 to 40,000 acres. One reservoir site is reported, of small dimensions, while others are reported from Huntsville and Wheeler's Creek, and there are numerous sites at the head of the Weber.

Davis County.—This county lies wholly west of the Wasatch, being south of Weber and north of Salt Lake Counties and between them and the lake. There is very little waste land in this smallest county in the Territory, whose arable land lies wholly in Salt Lake Valley. This county is well watered close to the mountains by numerous small streams, and lower down by multitudes of artesian wells. Many acres are not irrigated. This county is full of orchards, gardens, and fields, while roots, small grain, and hay are raised in abundance. The elevation is 4,215 to 4,500 feet above the sea. The area is 160,000 acres. The soil is sandy but with clay near the lake. There is no report from this county.

Morgan County.—This lies directly east of Davis, on the east side of the Wasatch, and occupying Weber Valley as far as Croyden. This is elevated nearly 6,000 feet above the sea, and is only adapted to small grain, root crops, and hay. The water supply is fair and the opportunities for storage good. The area is 675,840 acres, of which about 10,000 acres are cultivated. The soil is chiefly sandy.

Summit County.—This county lies almost wholly in the upper valley of the Weber, and includes Parley's Park. It occupies the angle between the Wasatch and the Uintahs, and lies north of the latter. Its ultivated land is elevated 6,000 to 8,500 feet above the sea. It is cold and best adapted to small grain and hay. Much produce is raised without irrigation, and only a small amount of water is required per acre to mature crops. The valley of Weber is a succession of green fields for many miles, while on Chalk Creek and other tributaries are scattered many farms. The area of the county is 2,419,200 acres, of which 7,500 are under cultivation. This county also reports storage of water as the only means of increasing its cultivated area. Deep artesian wells might be successful here. The soil is sandy.

Salt Lake County.—This county lies between the south end of the lake and the Wasatch Mountains, occupying all of the southern end of Salt Lake Valley and lying between the Oquirrh and Wasatch Mountains. This county takes the lead in water supply and position, since the valley is 10 miles wide and 20 miles long, runs north and south, and is watered by the Jordan and by numerous large streams that flow down from the heart of the Wasatch. There are also a few streams flowing from the Oquirrh Mountains. Throughout the lower part of the valley thousands of artesian wells are flowing. The soil is sandy in the upper and clayey in the lower part of the valley. The elevation is 4,215 to 4,500 feet above the sea. The area of the county is 614,400 acres. The cultivated land is 38,587 acres. The water supply is 365.5 to 425.5 cubic feet per second, all in use. The irrigating season is one hundred and twenty-two to one hundred and fifty two days long, and the duty of water is about 1 cubic foot to 80 or 100 acres. The rain-fall during the irrigating season is only 7.882 inches, being more than double that in many other parts of the Territory.

There are 13,668 acres of lucerne raised; hay, 2,215 acres; small grain, 13,566 acres; roots and vegetables, 3,470.5 acres, and fruit, 1,628.5 acres. There are thirty-seven canals with an aggregate length of 213.8⅜ miles. There is enough water running to waste outside of the irrigating season to redeem 44,000 acres. There are eleven reservoir sites in the mountains reported in detail, aggregating 50,250,000 cubic feet, and several others of good size not reported. There are four sites reported in the valleys, and one of them, Utah Lake, if raised 2 feet would irrigate 53,000 acres, and if raised 5 feet would irrigate 133,000 acres. But this lake can never be filled in a dry season; the total inflow last winter was only enough to raise the lake a foot, and for other reasons hereafter given it will never cut much of a figure as a reservoir. The average depth of snow in the mountains is 4 to 10 feet. The relative humidity for the year is 48.3 per cent.; during the irrigating season it is 42.3 per cent. The annual temperature is about 51.2 degrees.

Utah County.—This county lies chiefly in the beautiful Utah Valley with its large fresh-water lake in the center, 80,000 acres in area. Most of the arable land is in this valley, but there is considerable arable land on the Spanish Fork River. The elevation is about 4,600 to 4,800 feet above the sea. Though it is some higher than Salt Lake Valley it is nearly as warm, because of sloping toward the sun. The area of the county is 1,344,000 acres, of which 69,126 acres are cultivated. The irrigating season lasts about 122 days. The duty of water is reported as 40,000 cubic feet per year, but it is probably not less than 1 cubic foot per second for 100 acres. The water supply comes from fourteen streams and one river, whose flow in July was 308 cubic feet per second. There are sixteen canals reported; length, 66.2 miles. There are many artesian wells in the valley. They lost 28,985 acres of crops this year by lack of water. There are eight reservoir sites given in detail in the mountains and two in the valleys; capacity 791,000,000 cubic feet. There are five additional sites given in the valley and nineteen in the mountains; capacity not specified. Enough water runs to waste to irrigate 50,000 acres. About the same amount of rain falls here as in Salt Lake Valley. The average depth of snow in the mountains is 4 feet. The soil in this county is mostly sandy. Along the Spanish Fork River are many farms with an elevation of 5,500 to 6,500 feet above the sea whose supply of water could be greatly increased by deep artesian wells.

Wasatch County.—This lies east of the Wasatch, and the inhabited portion is west of the Coal range, being south of Summit and east of Utah County. The settled part is a triangular valley at the eastern base of the Wasatch, called Provo Valley, since it lies along the Provo River. This is some 6,000 feet above the sea, has 18,000 acres of cultivated land, and 32,000 acres that could be reclaimed by more water. The water supply is not given, but one-half the crops were lost this year by lack of water. There are 14.5 miles of canals reported. Five reservoir sites are reported, capable of irrigating 14,000 acres. This valley raises small grain and hay chiefly. Water storage is a necessity if the present acreage is to be preserved, to say nothing of extending it. The greater portion of this county of 1,344,000 acres lies east of the Coal range on the reservation. There are hundreds of acres there that produce abundant crops of hay when stock is kept off from them.

Uintah County.—This county is situated east of Wasatch, Summit, and Emery Counties. It is mostly an Indian reservation; but just south of the Uintahs is a small cultivated area not on the reservation. The area of the whole county is 4,000,000 acres. The cultivated area is 8,932 acres. The soil is partly sand and partly clay. The elevation of Ashley Valley runs from 4,400 to 5,000 feet. The irrigating season is from 178 to 198 days long, and the duty of water is given as 20,000 to 50,000 cubic feet per acre, but this is doubtless far too small. It takes a trifle more water for clayey than for sandy soil. It takes the same amount of water for small grain as for lucerne, a trifle more for root crops, and one-half as much for orchards. There were 970 acres of crops lost this year from lack of water. The average depth of snow in the mountains is 6 feet. Several good reservoir sites are mentioned. The supply of water in Green River is unlimited, and much land could be reclaimed by proper dams in this river. The supply of water on Ashley and Brush Creeks is quite limited, but could be greatly increased by reservoirs.

San Pete County.—This county occupies an elevated valley between the Wasatch and Coal range, and south of Utah County. It is the valley of the San Pitch River and a part of Thistle Valley. The former runs southward from the head of Thistle Creek for 45 miles till it joins the Sevier Valley. The elevation is perhaps a thousand feet or more higher than Salt Lake Valley, and the rain-fall is less. The water supply come from both sides of the valley in numerous small streams, but the greater number come from the east. This has been called the granary of Utah. The chief product is small grain. The irrigating season lasts 107 to 183 days. The duty of water is about 1 cubic foot per second to 90 acres. Each acre is irrigated 120 hours. Many acres of crops were lost this year through lack of water. The average depth of snow in the mountains is reported as 6 feet. Several reservoir sights are mentioned. The area of this county is 1,164,800 acres. The amount under cultivation is not reported.

Sevier County.—This county occupies the southern part of the great valley which lies east of the Wasatch and west of the Coal range, running from Thistle on the north to Panguitch on the south. This great valley, over 125 miles long, is called the San Pete on the north and the Sevier on the south. It is lowest in the middle where the southward flowing San Pitch and the northward flowing Sevier Rivers unite, and breaking through the Wasatch pass out westward upon the desert in Millard County. The only arable land in this county lies in the Sevier Valley, which in this county is several miles wide and 50 miles long. It is watered chiefly by the Sevier River, but there are many small streams and springs coming from the mountains on either side. The river measured 70 cubic feet per second at Joseph City on July 26, 1889. No other measurements are reported. There were reported eleven canals aggregating 107.5 miles in length. The area of the county is 993,280 acres, of which 25,000 acres are under cultivation; all but 7,000 acres are watered by the Sevier River; 100,000 acres could be irrigated if there were more water. There are 2,634 acres of lucerne raised, 11,982 acres of small grain, 710 acres of root crops and vegetables, and 178 acres of orchards. The elevation of the lower part of the valley is about 5,500 feet and the irrigating season is 244 days long. Some fruit is raised here. The upper part of the valley is from 6,000 to 7,000 feet above the sea, the irrigating season is 122 days long, and small grain and hay are the chief products. The soil is sandy and very productive. There are none of the thinly populated counties that have such possibilities before them as this; for there is enough water to irrigate the whole valley if it is properly stored. The depth of snow in the mountains in winter is about 6 feet. Six reservoir sites of great capacities are reported in the mountains. All the present water supply is utilized. Deep artesian wells are possible in some parts of the valley.

Pi Ute County.—The cultivated portion of this county lies in or near the heart of the Beaver Mountains, south of Sevier County, and at the junction of the Coal range with the Wasatch. The valleys are elevated and cold, being 5,400 to 7,000 feet above the sea. The irrigating season never exceeds one hundred and seventy-three days. The duty of water is not more than one cubic foot to 100 acres. The land is irrigated from twenty to forty-eight hours per annum. The water supply is 217 cubic feet per second; comes from eleven creeks and rivers, and in some localties is not all in use, while in other places 400 acres were lost and many more injured by lack of water. There are 31 canals. Ten reservoir sites are reported of such capacity as to irrigate

15,000 additional acres, more land than there is to cultivate. The average depth of snow in the mountains is 4 to 5 feet. The area of the county is 2,368,000 acres. The cultivated area is 12,135 acres, lying in Sevier, Grass, and Rabbit Valleys. But little fruit is raised in this county.

Garfield County.—The western part of this county also lies in the heart of the Beaver Mountains, and its cultivated valleys are all elevated 5,835 to 6,273 feet above the sea and cold; best adapted to hay and grain. The irrigating season lasts ninety-seven days, and the duty of water is slight; the land is irrigated but twenty-five days during the year. The water supply is not given. There are 34 canals. The area of the county is 2,892,800, of which about 5,000 acres are cultivated. Four reservoir sites are definitely reported, and many others are mentioned; enough to irrigate several times all the arable land in the county. Some of these sites could be used to help out Kane and Washington Counties.

THE DRY COUNTIES.

The larger part of these counties is arable land, and can never be reclaimed because of being destitute of any water, either present or prospective, while the eastern edge of these counties might almost be classed with the moist group.

Box Elder County.—This county lies in the northwest corner of the Territory and is the least arid of them all. The western portion has a few farms and some meager streams, while that portion next to the lake is susceptible of artesian wells and is quite productive. The mountains in this portion are so low and lose their snow so early that water storage is out of the question.

Tooele County.—This county lies west of Great Salt Lake and Salt Lake County. It is very large, containing 4,140,800 acres, of which only 6,250 acres are cultivated, and these lie chiefly in one valley (Tooele). This valley is a broad one, lying between the Oquirrh and Aqui Mountains, from which it receives its water in eight small streams aggregating 78¼ cubic feet per second. These mountains do not rise high enough to give water all the season. This valley is being greatly developed by artesian wells. Rush valley is a magnificent one, being the southern extension of Tooele Valley. There are 200,000 acres that could be redeemed here alone, but there is no surface nor artesian water to be had. Reservoirs might catch some water. Skull Valley is another large tract lying directly west of the Aqui Mountains This is capable of artesian wells, and has a small supply of surface water. It is undeveloped. On the western edge of the county near Deep Creek is some cultivated land. There are 1,000,000 acres of good land that could be redeemed if there were water for it, but by fully developing all resources by storage and otherwise 100,000 acres is an outside limit of the acres that will ever be cultivated in this county with the present rain-fall. The elevation of the valleys is 4,400 to 5,000 feet above the sea. All kinds of fruit and produce can be raised here that are raised in Salt Lake County. The duty of water is 1 cubic foot per second to 80 acres, and the irrigating season runs from 122 to 200 days. Several good reservoir sites are reported. The average depth of snow in the mountains bordering Tooele Valley is 3 feet. The soil is so gravelly near the mountains that fully one-half of the water is lost by seepage before it gets to the fields. Water storage and fluming the canals are the crying needs of this county.

Juab County.—This county lies south of Tooele and runs from the Wasatch to the western boundary. The area is 2,457,600 acres, and fully one-half of it is level land that could be redeemed by water, but outside of artesian wells there is no hope for most of this county. Four thousand acres are reported under cultivation beneath the shadow of Mount Nebo. All kinds of fruit and grain are raised here that the Great Basin produces. The elevation of the valleys is from 5,000 to 5,500. The average depth of snow in Mount Nebo is 3 feet. Several good reservoir sites are reported. Nearly one-half of the crops were lost this year by lack of water. Water storage and artesian wells are the only hope of this county.

Millard County.—This county lies south of Juab and runs from the Wasatch to the western boundary. This is one of the largest counties in the Territory and has the largest amount of arable land of any, if there were only water for it. The area of the county is 4,492,800 acres, and over one-half of it is good land. Artesian wells are being developed in this county, but generally the flow is so slight that the water is valuable only for drinking. The settlements lie along the western base of the Wasatch and along the Sevier River. They are from 5,000 to 6,000 feet above the sea, and produce large quantities of fruit, small grain, and lucerne hay. The irrigating season runs from 90 to 122 days. There are 13,500 acres reported as under cultivation; 1,000 acres were reported as lost and much more as injured by lack of water this year. The soil is sandy near the mountains and clayey in the Sevier Valley. There are 42 miles of canals reported. Water storage is not only an imperative necessity in this county, but it is practicable. Much water runs to waste in the Sevier River; probably triple what is used. There are many good sites along the river where from 1 to 3 square miles of water several feet deep could be held back. Back of Scipio a natural lake, now used as a reservoir, could hold 5 square miles of water of considerable depth. It is said that the Sevier River could be turned into it. There are several good sites in the Wasatch.

Beaver County.—This county has an area of 1,689,600 acres, of which one-fourth is good land; 9,500 acres are reported under cultivation. This county lies south of Millard and runs from the Wasatch to the western boundary. The upper valleys are 6,000 and the lower about 5,000 feet elevation. The irrigating season lasts ninety-one to one hundred and twenty-two days. The land is irrigated twenty-nine to thirty-two hours per year. There are 45 canals; length not given. The settlements lie chiefly along the Beaver River and its tributaries. The average depth of snow in the mountains is reported as 8 feet. The Wasatch here rises to a great height and snow lies on the mountains all the year round; 25 reservoir sites are reported in detail, aggregating 17 square miles, sufficient to irrigate 20,000 acres at least; about 10 of these reservoirs are in the valleys and the remainder in the mountains.

Iron County.—This county lies south of Beaver, on the rim of the Great Basin, running from the Wasatch to Nevada. Its area is 2,102,400 acres, and nearly half of it is arable land, some of it capable of artesian wells, but most of it destitute of water; 6,997 acres are reported under cultivation. The irrigating season is given as 142 to 269 days. The elevation of the valleys runs from 5,400 to 6,100 feet above the sea. The duty of water is given as 1 cubic foot to 65 acres in the more arid valleys and from 160 acres to more than double that in the moist valleys. The water supply comes from 8 small streams, capacity 67.63 cubic feet per second. The land is irrigated from fifteen to forty-two hours per year. If the water could be saved, from 10,000 to 20,000 acres could be redeemed; 14 reservoir sites are reported in detail. Water storage is the only means of developing the agricultural resources of this county. The soil is chiefly clay.

Emery and Uintah Counties.—To this group belong parts of these two counties, which lie between the Green and Grand Rivers. There are many thousands of acres of clayey soil that could be reclaimed by great canals running from these rivers, whose unlimited water supply, greater than all the rest of the Territory put together, will run to waste without assistance is given in constructing such canals. There is no part of the Territory that needs developing more than this. Very deep artesian wells might be successful here.

Emery County.—But a small part of this county belongs to the Dry Counties, still nearly all of the cultivated area lies in that section on the extreme western side of the county. This lies directly east of San Pete and Sevier Counties at the foot of the Coal range. The rain-fall does not exceed 10 inches per annum. The water supply comes from four creeks and one river, breaking through the precipitous eastern face of the Coal range in narrow cañons. The flow of water is 171.15 cubic feet per second. The area of the county is 5,603,680 acres. The cultivated land is 14,825 acres. The soil is a very refractory clay. The duty of water is 1 cubic foot to about 35 acres. Castle Valley is 4,500 above the sea, and the irrigating season is 229 days long. Little Grand Valley is 3,900 feet above the sea, and its irrigating season is 244 days long. There are 34 canals; length not given. One-quarter of the crops was lost this year through lack of water. All the water is in use. The average depth of snow in the mountains is 4 feet. Twelve reservoir sites are definitely reported, and many others are mentioned. There is enough storage to use double the total water supply. Probably 10,000 to 15,000 acres more could be irrigated by saving the waste water. Great suffering often results from scarcity of water in this county. All kinds of crops are raised in this county, even sugar-cane, fruit, pea-nuts, etc. Figs could be raised in the hotter portions.

THE HOT COUNTIES.

These counties are far more arid naturally than the dry counties, since they are farther from the lofty mountains, and most of the arable parts are 2,000 or more feet lower, lying in deep valleys shut out from winds and surrounded by great fields of lava with red hills and a red, sandy soil of unknown depth. The heat here is almost unendurable and the rain-fall is almost nothing. This region is valuable for the fruit and cotton that it raises.

Washington County.—This county is situated in the southwestern corner of the Territory. The area is 1,649,920 acres. Of this, 18,892 acres are cultivated. These are situated along the Virgin River or its tributaries chiefly. It is estimated that 18,900 acres could be redeemed by an increase of the water supply. The lower valleys are 2,700 and the upper 4,000 feet above the sea. In the lower valleys the irrigating season is 197 to 228 days long, in the upper 122 to 177 days. The water supply comes from the Virgin River, four streams and many springs, capacity 191.8 cubic feet per second. In the lower valleys the land is irrigated 84 to 90 hours per year, and the duty of water is 1 cubic foot per second to 20 acres. In the upper valleys the land is irrigated 26 hours per year and the duty of water is 1 cubic foot per second to 60, 80, and 128 acres. There are 31 canals; length not given. One-third of the crops were lost this year by lack of water. It is probable that water enough could be stored to redeem most of the arable land in this county. Vast quantities of water go to waste in the Virgin River in the winter and flood time in spring. The depth of snow in the mountains is 2 to 6 feet. This county raised 30,000 pounds of cotton last year. The Sultana seedless grape is grown here and produces from 3,000 to 5,000 pounds of the finest quality of raisins. Both the hard and soft shell almonds are raised in quantities here as well as figs. It is believed that oranges can be raised here. Olives are grown in this county. Peaches and apricots from this region are very fine. They raise 4 to 5 crops of lucerne per year. A crop of small grain and another of corn are raised from the same land.

Kane County.—This county is more rugged than Washington and more elevated except along the Colorado River. It lies east of Washington. The area is 2,659,200 acres, of which 1,825 acres are cultivated, and 13,350 acres are said to be arable. The irrigating season is 182 days long, and the duty of water is from 37½ to 75 acres to the cubic foot per second. The water supply, exclusive of the limitless Colorado River, is 31 cubic feet per second. There are nine canals; length not given. The crops are greatly damaged by lack of water. Sufficient reservoir sites are reported to irrigate all the arable land in the county. The average depth of snow in the mountains is 4 feet. The crops in this county are much the same as in the foregoing, though more small grain and hay are raised in proportion to the area cultivated.

San Juan County.—This county lies in the southeastern corner of the Territory. Most of it is now proposed to be made an Indian reservation. Its area is 5,809,920 acres. There is a narrow strip of land along the Colorado and San Juan Rivers that will produce the crops of Washington County, and has an unlimited water supply. Most of the cultivated area is 5,000 feet above the sea, near the La Sal Mountains. There are 1,025 acres cultivated. Dry farming is successful in some localities in the mountains. There are good facilities for storage of water.

Other counties.—Small parts of Garfield and Pi Ute Counties situated along the Colorado are capable of raising the same products as Washington County.

To sum up we find there are about 500,000 acres of land under cultivation at the present time. This area could be doubled from the present canals if there were more water and by new canals, etc. The various counties estimate that about 3,500,000 acres could be redeemed. This is doubtless three and a half times too large. The average depth of snow in the mountains is 4 feet. The length of the irrigating season in the moist counties is one hundred and fifty-two days; in the dry counties it is about the same in cultivated areas; in the hot counties it is about two hundred days. The returns are very unsatisfactory in this respect and must be wholly revised. The duty of water is about 80 acres to the cubic foot per second in the moist counties, in the dry counties it is uncertain, and in the lower hot counties it is about 20 acres. The water supply is about 3,000 cubic feet per second for the moist counties, 250 for the dry counties, and 250 for the hot counties; total 3,500 cubic feet per second. This is probably our minimum water supply throughout the dryest years in the counties reported. If we were to add the supply in the Green and Grand Rivers this amount would be more than double. Almost all of the present supply is appropriated during the irrigating season and our Territory must remain at a standstill without water storage. There are 150 reservoir sites reported in detail and nearly as many more mentioned. They vary in capacity from 130 square miles to 1 acre, and from 2 feet to 100 feet deep. About one-third of the crops were lost this year through lack of water.

Utah, Nevada, and Arizona are the most arid portions of the United States, and therefore the preservation and economical use of all their water supply is an imperative necessity. To show how we differ from Colorado and the East, I have prepared a diagram of the average monthly rain-fall of Salt Lake City for thirty-three years, and of Denver, Colo., and Des Moines, Iowa, since the beginning of observations there

During the irrigating season here Des Moines, a place where irrigation is not necessary, has a rain-fall of over 2 acre feet and Denver almost 1 acre foot, while Salt Lake has less than two-thirds of an acre foot, which would make a difference of about 11,000 cubic feet to the acre, which must be made up by that much more water from the streams to irrigate our land as well as that of Colorado is irrigated. But during the same period the relative humidity of Denver is 3 degrees higher and the temperature 2 degrees lower, which would greatly increase the amount of water required to irrigate an acre of land in Utah in proportion to that of Colorado. Besides this, Denver is nearly 50 miles from the crest of the mountains, from which a part of its moisture is derived, while Salt Lake City is but 10 miles and has a lake of 2,000 square miles in area within 7 miles on the other side. These things make Denver fairly representative of northern Colorado in general, while they show Salt Lake City as the place with at least 50 per cent. more rain-fall than the rest of the Territory (save the mountains themselves) and with a very abnormal humidity. Therefore what applies to Salt Lake in the great amount of water required per acre will apply with redoubled force in the dry and hot counties.

We have had evaporating pans located in various parts of the Territory for the last two months, and though these were of necessity placed out of the reach of the wind the evaporation averaged three-tenths of an inch per day, often running up to five-tenths of an inch. Had they been placed where the wind could have reached them the evaporation would have equaled 15 inches per month. The enormous drain upon our water supply can therefore be well understood. This militates against shallow reservoirs in the valleys. If Utah Lake were raised 3 feet its water would all be evaporated during the irrigating season if none flowed in or out. Enough to irrigate 83,000 acres would go up in the air. From records kept in the mountains the evaporation there during the same period was only eight-hundredths of an inch, and never exceeded seventeen-hundredths per day. Therefore reservoirs in the mountains are at least four times as valuable as those in the valleys. We do not yet know the rain-fall in the heart of our mountains, but it will not fall far short of 40 inches nor more than 60 inches per annum. It should be observed that though we have 2 inches more rain-fall in Salt Lake than in Denver, yet but 46 per cent. of it falls during the irrigating season while 73 per cent. of Denver's rain-fall comes when it is needed most.

The possibility of reclaiming Utah by artesian wells has been greatly overestimated. All the wells so far obtained have been found in some one of the basins of the ancient lake of which Great Salt Lake is the saline remainder; the area of that lake never exceeds 18,000 square miles. The clay sediment from that lake makes the impervious cap of those subterranean reservoirs, whose rims are but slightly elevated above the villages, and the reservoirs are fed from the bases of the mountains where the surface water runs over the gravel débris between the mountains and the clay rim. The average depth of these artesian wells in Salt Lake Valley is about 100 feet, in Utah Valley 200, and in Tooele about the same. In Millard County a few wells have been driven with a depth of about 200 feet and a flow of one-half to 10 gallons per minute through 1¼ inch pipe. Since no solid rock is struck in driving these wells they are very liable to clog up in a few years. The flow in Salt Lake Valley will not average 25 gallons per minute, though some wells far exceed that. A well flowing 5 gallons per minute will irrigate an acre of ground.

ARIZONA AND ITS IRRIGATION CHARACTER.

Turning southward, Arizona is found to be making considerable progress. The southern, or Gila Valley portion of the Territory, and its smaller central valleys, offer a considerable area for the farmer when irrigation is applied. The difficulties of the problem are found not only in the newness of the region, as to settlement, but in the want of system and the confusion of ideas as to the lawful use and control of water. The Mormon system would probably bring about in both Arizona and New Mexico the same admirable results that it has secured in Utah. It is estimated that there are in the Territory about 2,800,000 acres of land of the best quality, with surface water sufficient to irrigate the same by a reasonable expenditure on ditches. Of the above area not quite 300,000 acres are in cultivation. There are at least 10,000,000 acres of rich land that could be reclaimed by means of artesian and other wells, if they can be obtained.

For convenience of arrangement in considering its agricultural capabilities, Arizona may be divided into: (1) The Colorado Valley; (2) the valley of the Gila and those of its tributaries, including the Salt River as far north as the thirty-fifth parallel; (3) the Santa Cruz Valley, the isolated locations of Pinal and Pima Counties, and the vicinity of the New Mexico line; (4) the Colorado Chiquito Valley; (5) the southwestern portion of Yavapai County, surrounding Prescott, and the valley of the Rio Verde, with its tributaries.

In one of Lieutenant Wheeler's reports of exploration in Arizona, California, and Nevada, a comparison is made between the capabilities of certain portions of the Territory and those States, which brings to light some important facts. The Arizona portion compared is bounded in longitude by the meridians of 111 degrees and 113 degrees 45 minutes, and in latitude by the parallels of 34 degrees and 35 degrees 40 minutes, which include the southwestern portion of Yavapai County and a small strip of Mohave County, by no means the best agricultural region of the Territory, and scarcely up to the average. This is compared with the eastern portion of southern California, and the southern portion of Nevada, in the same latitude:

	California and Nevada.	Arizona.
	Per cent.	*Per cent.*
Agricultural, irrigable, and arable land	2	25
Timber	6	10
Grazing	88	30
Barren	4	35

In the Colorado Valley the soil is rich in the chemical combinations requisite for fertility, and only in small patches contains too large a proportion of clay. In some places it has also small amounts of chloride of sodium and sulphate of lime. The fertilizing reddish mud resembles that of the Rio Grande and of the Nile, and its quantity varies from 0.1 to 0.5 per cent. (1–1000 to 1–200) of the water, which is good to drink even when considerably colored by the mud. As compared with the aboved-named rivers, it contains less potassa, more phosphoric acid, and much more carbonate of lime, the presence of the latter valuable ingredient being due to the immense limestone beds through which the river flows in the upper part of its course.

The following table (mud from the Colorado having been collected) exhibits a comparative analysis of the mud of these rivers:

	Colorado.	Rio Grande.	Nile.
Hygroscopic water	3.27	1.890	....
Chemically bound water, soluble in hydrochloric acid	1.14	3.122	....
Potash	0.103	0.284	0.166
Soda, with trace of lithia	0.074	0.064	0.022
Lime	....	1.479	1.725
Carbonate of lime	12.50	5.190	....
Magnesia	0.69	0.080	0.046
Oxide of iron	....	3.640	} 8.804
Alumina	2.26	1.308	}
Phosphoric acid	0.146	0.092	0.143
Sulphuric acid	Trace.	Trace.	Trace.
Oxide of manganese	Trace.	....	....
Insoluable in hydrochloric acid	78.1	82.55	....

As to the extent to which the Colorado River could be rendered available for irrigation, it has been appropriately remarked by geologists that the country bordering on the Colorado is the most conspicuous example in the world of overdrainage; for nowhere else do we find a stream that for hundreds of miles cuts its way 500 to 600 feet deep through solid rock. The Colorado, supplied by streams from the mountains, where rain and snow are abundant, cuts its way through a rainless, and therefore desert, region, in which the only changes are those resulting from the direct action of the atmosphere, so that no appreciable débris of any kind is furnished to fill up the excavations continued through millions of years, and only limited by an approximation of the level of the river-bed to that of the waters of the Gulf of California.

Lieutenant Wheeler estimates the area of land drained by the Colorado River and its tributaries to aggregate 242,065 square miles, mostly still owned by the Government.

The Salt River Valley is 25 miles in length by about 14 in width. With its estimated 250,000 acres of rich, alluvial soil, capable of producing 25 to 50 bushels of grain to the acre, it ought easily to support 50,000 inhabitants, if there were a sufficiency of irrigating ditches and artesian wells to fully utilize its natural capabilities.

The valley of the Gila, though cultivated along most of its course, is not available for semi-tropical productions in its upper part on account of October frosts. The White Mountain Indian Reservation (San Carlos) interferes with a continuous white settlement above Florence, as the lands of the Pimas and Maricopas do below it. These latter Indians have cultivated wheat, corn, pumpkins, melons, etc., for centuries, and have always been self-supporting, as well as the Papagoes, farther south, who, however, depend principally on stock.

The Gila bottom merges imperceptibly into the foot-hills, and has an average breadth of from 5 to 10 miles. Its soil is principally alluvial, and will produce two crops yearly. Irrigation is easily effected. The river averages 600 feet in width, and is 3 to 5 feet in depth when there is no rain-fall and no water from the mountains. The banks along the whole of this tract are so low and sloping as to afford unusual facilities for the construction of ditches. Excellent crops of wheat, barley, and vegetables are grown. In the vicinity of Florence is an extensive tract of rich bottom and second-mesa or table-land, on which are now grown the cereals, alfalfa, the sugar cane, and vegetables and fruits generally, including orange and lemon trees. Fruit culture in the Gila Valley is extensive. Cottonwood, ash, and locust are abundant. Farther up the valley the Pueblo Viejo has, with its tributary valley of Ash Creek and others, at least 100,000 acres of good farming land.

On the uplands and farther up the valley itself, near the line of New Mexico, the daily variations in temperature are much less and the frosts begin later. Still farther up its course, within the borders of New Mexico, the Gila River has upon its margins much good agricultural land. The bottom-lands generally are quite rich in potassa and phosphoric acid.

The valley of the Francisco River, a tributary of the Gila, near the line of New Mexico, is good for grazing and timber, and has in general a rich soil. The San Pedro River is a tributary of the Gila, its mouth being between Florence and San Carlos, and its source in the Huachuca Mountains, near the Mexican line. There is good land, good timber, and excellent range for stock. Considerable valley land is now under cultivation, and irrigation is generally required.

The Santa Cruz Valley, though smaller in extent, is equally productive in proportion to its area. It is more compact, and all of it is adapted to semi-tropical fruits, as well as to the vegetables of the temperate zone.

According to information received, about 250 miles of main canals have been completed during the past two years, or are under rapid construction. With the tributary feeders and laterals southern and central Arizona now has completed, or very nearly so at least, about 700 miles of irrigation works. As this Territory has always been considered one of the most unpromising in the dry and mountain regions of this country, these facts are of a cheering character. The most astonishing reports are made of the fertility of the areas "under water."

RAINY SEASONS AND PRODUCTION.

The physical configuration of Arizona shows it to be, as already stated, an overdrained region. This is in itself sufficient to account for the unquestioned aridity of a large portion of the Territory, but settlement and time are proving there, as well as elsewhere within our mountain area, that the supplies of water, with proper conservation and distribution, will be found more important and available than has generally been considered at all probable. In the narrow and precipitous valleys of Central Arizona there are natural reservoirs, of which, with comparatively little outlay, valuable storage basins may be created and force obtained to raise the water high enough for reaching extensive portions of the mesa or table-lands adjoining the river valleys. Several of the minor streams are known to sink, and their recovery and use for industrial purposes will be found a task not difficult to engineering skill.

There are two rainy seasons, in the winter and summer months respectively. In the summer the rains are often violent and torrential in character, disappearing almost as suddenly as they come. In April and May there are often neighborhood showers, seeming to be limited in area, as if the currents in their passage from the Southern Pacific, coming through the Gulf of California, were broken by the higher peaks and whirled in circular eddies over the sections visited. They are known by the Mexicans and Indians as "shepherd rains."

The population is rapidly increasing, especially in the southwestern and central portions of the Territory. The immigration into these sections aggregates 5,000 persons yearly, and the increase for the Territory for the last ten years will average fully 10,000 per annum. The returns from the different counties to the Territorial auditor for the present year show a total valuation of $27,231,424.47.

Arable land with water that sells at from $20 to $75 per acre is assessed at from $5 to $15 per acre. There are assessed 5,985,358 acres in the Territory, about 5,000,000 of which is embraced in the grant to Atlantic and Pacific Railroad, and assessed at 20 cents per acre, which is being sold at from $1 to $10 per acre. The entire valuation on land is $3,285,212.60, on landed improvements $1,931,440.83. There are assessed 552,718 head of cattle; the actual number in the Territory will fall a little short of 2,000,000. The estimated population is by counties as follows:

Yavapai	16,000	Cochise	14,000
Maricopa	16,000	Pima	14,000
Apache	12,000	Pinal	8,000
Mohave	5,000	Yuma	3,000
Gila	5,000		
Graham	12,000	Total	105.000

The lands covered by canals and ditches is in—

	Acres.		Acres
Apache County	6,900	Yuma County	40,000
Yavapai County	40,360	Pima County	7,500
Gila County	7,600	Cochise County	23,500
Pinal County	71,600	Mohave County	1,000
Graham County	47,000		
Maricopa County	321,000	Total	566,460

Of land requiring no irrigation the amount entered and occupied is estimated at 100,000 acres, lying principally in the counties of Apache, Yavapai, Graham, Pima, and Cochise, of which one-half has been cropped the present season.

The value of the agricultural product varies according to locality. In this valley the Salt River hay is baled at $5 per ton; in Yavapai and Apache Counties at $20 to $25. Barley is worth here 75 cents per hundred; in other counties from $1 to $2.50. Fruit here is worth from $20 to $40 per ton; in other counties from $40 to $200. Land in alfalfa or grain here gives a return of from $15 to $25 per acre; in other counties from $30 to $50. Fruit in this and the Gila Valleys gives a return of $100 to $200 per acre, and in other localties more or less according to yield. The value of product from every acre of land cultivated in Arizona can safely be placed at $30, which will be largely increased in the southern valleys as the orange, fig, grape, apricot, and other fruit-trees and vines now being planted come into bearing.

The value of the products of the Territory for 1889 was as follows:

Agricultural and horticultural	$9,207,000
Live-stock—horses, sheep, and cattle	6,000,000
Gold and silver	4,431,500
Copper	2,000,000
Lumber, wool, etc	1,500,000
Total	23,138,500

In the Territory the amount of land that can be reclaimed through a proper system of reservoirs and canals, conserving the storm water for irrigation, is very large, being variously estimated from 6,000,000 to 8,000,000 of acres, fully two-thirds of which, lying below the thirty-fourth parallel and not in the mountains, can be made available for the cultivation of those citrus and deciduous fruits that make horticulture most profitable in all semi-tropical countries.

Mr. Farish, immigration commissioner, from whose report the foregoing is condensed, testified as follows as to fertility:

> We grow as fine lemons as you would wish. Along at Florence they have grown splendid olives. In this valley our olive trees are not far enough advanced to tell anything about; but they have grown them up there. We have planted out here some 22,000 orange trees, experiments in growing that have been successful. Peaches, pears, and apples are not so good. They grow to great perfection so far as size is concerned, but they lack flavor. We grow the crab-apple, prunes, and dates. Every variety of figs is a natural product here. The date is produced here seven years from the seed, and in bunches of from 5 to 25 pounds. And we grow wheat here—I should think about 1,800 to 2,000 pounds to the acre. The yield of barley is from 2,000 to 2,500 pounds to the acre, and sometimes as high as 3,000 and 4,000 pounds. Alfalfa is the principal crop. We cut that from three to four times a year, and we cut from 6 to 8 tons to the acre.

The total area of ditch construction and acreage under water is estimated as follows:

County.	No. of canals.	Length.	Area under ditch.
		Miles.	*Acres.*
Apache	....	24½	12,500
Cochise	....	51	8,300
Graham	....	60	35,000
Maricopa	23	304½	194,400
Pima	36	52	30,000
Pinal	28	50	78,000 * 50,000
Yavapai	....	78	40,000
Yuma	10	120½	81,000
Total	....	740½	529,200

* In Pima Reservation.

These figures are entirely taken from county reports. The ditch system constructing in Yuma County will, when completed, have a total length of 241 miles and an acreage of 207,000. The total cost will be $1,318,000, or nearly $5,500 per mile. The canals under way in Maricopa County will, when completed, cover 404,900 acres and have a total length of 425 miles. Apache County reports 150,000 acres reclaimed, Pima County 2,500,000 acres, and Cochise 310,000 acres. Of the area "under ditch" about two-thirds are actually cultivated.

THE FERTILE SALT RIVER VALLEY.

Maricopa County is the central and, agriculturally speaking, the most important section of Arizona. From a report the following statements are quoted:

In the Salt River Valley the following canals have been taken from the Salt River:

Name.	Length.	Name.	Length.
	Miles.		*Miles.*
Arizona	41	Utah	6
Grand	22	Farmers	5
Maricopa	14	Highland	22
Salt River Valley	18	Dutch Ditch	4
San Francisco	9	Monterey	4
Tempe	19	Griffin	3
Mesa	9		

These water-ways cover in the aggregate 250,000 acres of land, of which 187,500 have been reclaimed and 125,000 acres are annually cultivated.

On the Gila are the following canals which have been completed:

Name.	Length.	Acres.	Name.	Length.	Acres.
	Miles.			*Miles.*	
Buckeye	30	20,000	Gould & Bro.'s	8	3,000
Gila River	8	5,000	Palmer	22	12,000
Enterprise	12	6,000	Citrus	14	5,000

Besides which are the following canals now in process of construction: The monarch ditch, 8 miles long, which will cover 2,000 acres; the Gila River Irrigation Company, which takes the water at Black Butte, below the mouth of the Hassayampa River. The company have 12 miles of their canal completed and propose to put in a dam 1,755 feet long and 75 feet high, and carry the water south and southwest, taking in the entire valley on the south and east sides of the river to the line of Yuma County, making a canal 75 miles long and covering 500,000 acres. The Gila Bend Canal Company starts from Gila Bend on the south side of the river. They have completed 22½ miles of the canal, which is to have a total length of 30 miles and cover 18,000 acres. Under this canal about 3,400 acres have been cultivated this season. The same company are building a large canal, taking the water about 2 miles above and running southwesterly a distance of 50 miles, intending to reclaim 80,000 acres, much of which has been filed upon.

Owing to the dryness of the atmosphere, the evaporation is very great in the valleys. During the summer months it will average about four-tenths of an inch every twenty-four hours, so that reservoirs should, wherever possible, be constructed in the higher altitudes.

In the irrigation of lands it is the general policy of our people to flood them in winter, when water is abundant, which, by creating a reservoir of absorption, make frequent and heavy irrigations unnecessary during the months of June and July, when water is scarce. Since the first settlement of the valley of the Salt River the water has risen 30 feet nearer the surface. In some places fruits and alfalfa are grown without irrigation. It seems reasonable to suppose that when the lands on the high mesas along the foot-hill mountains are more generally cultivated the area of land requiring no irrigation will be very largely extended. Another fact is noticeable: The water used in irrigation, except that lost by evaporation, percolates through the soil and finds its way back to the river. More water flows into the Gila from the Salt River in the dry season, covered by the months of May, June, and July, than before the first canal was built in the valley. Forty miner's inches of water is calculated to make a cubic foot flow per second. One miner's foot is sufficient to cultivate 3 acres in grain or alfalfa, and 5 acres in fruits or vineyard.

The principal grain crops of the county are wheat and barley. The past season there has been produced about 40,000,000 pounds of barley and about 30,000,000 pounds of wheat. The yield of wheat is from 1,200 to 1,800 pounds per acre, and of barley from 1,800 to 3,000 pounds per acre. Sorghum and sugar cane are grown to a considerable extent for the sugar they contain and for feed. Corn is not extensively raised, being confined to a few hundred acres each year. Oats are a native of the soil, and are cut in quantities evey year for hay. Timothy, Bermuda, and blue grass do well, but alfalfa is the principal grass grown. Once rooted, it requires no attention except to irrigate it three or four times during the year; grazed, an acre will support two and a half head of horses during the year, and from ten to twelve head of sheep or hogs. It can be cut from four to five times annually. and yields from 6 to 8 tons to the acre The hay is very nutritious, and as a pasture for all kinds of stock can not be surpassed. Three and four year old steers driven from the ranges upon alfalfa pastures gain, if poor, two pounds per day for the first three months, becomming at the end of that time, most excellent beef in any market.

The mesquite and cottonwood are native trees, but the ash, cork elm, pepper tree, catalpa, willow, umbrella, lombardy poplar, North Carolina poplar, mulberry, palm, magnolia, locust, and tamarack have been introduced with marked success.

Up to five years ago very little fruit of any kind was grown in the county, and that only by way of experiment. Since then the planting of orchards and vineyards has increased every year. It has been fully demonstrated that no better section exists for the growing of nearly all citrus and deciduous fruits. In the Lower Gila Valley lemons, oranges, figs, grapes, and pomegranates can be grown in great perfection, but it is not well adapted to the culture of other fruits. In other portions of the valley, and through the valley of the Salt River, peaches, pears, apricots, pomegranates, figs, French prunes, apples, oranges, almonds, quinces, dates, blackberries, and strawberries, and every variety of grapes, grow in perfection.

There are now planted through the Salt River Valley 8,000 acres in vineyard and 3,000 in orchard trees. Of oranges 200 acres are in cultivation; from experiments made the growing of this fruit will be a success. Olives have been planted in an experimental way. It is too soon to speak confidently as to the results, but as they have been successfully cultivated near Florence, in Pinal County, there seems to be no reason to doubt that good results will attend their culture in this county. Apricots, peaches, and kindred fruits bear heavily, yielding from 300 to 500 pounds per tree. Vineyards in full bearing give from 6 to 8 tons to the acre. Raisins have not yet become an export commodity with us, but will be in a short time; the muscat of Alexandria grown in this valley contains a greater quantity of saccharine matter than elsewhere, and from experiments made in raisin making we are justified in the statement that 3 pounds of this grape will make 1 pound of raisins, which is greater than in any part of this habitable globe. Another advantage which our county has in the prosecution of this industry over raisin districts of Spain or California is that the drying and curing can be done in the open air without damage from rain or dew.

Some experiments have been made in the manufacture of sherry wine, with satisfactory results. All our wines have a strong sherry flavor, and expert viticulturists who have examined into the matter claim this to be the only port and sherry district in America. On this subject the Hon. J. De Barth Shorb, commissioner at large of the State Viticulturist Society of California, writes: "I directed what should be done with one barrel of so-called white wine, from the Salt River Valley, as a matter of experiment, and upon examination a few months later, found, as anticipated, it had turned into a sherry of most excellent quality. I have no hesitation in saying that the Phœnix country is the only port and sherry country in America; so far as known, and with trained judgment in the selection of proper varieties of grapes adapted to your conditions, wines of the highest commercial value, if scientific methods be substituted for those now in vogue in the manufacturing of the wines, will be the inevitable result."

The growing of early and late vegetables will also, when railroad facilities are general, be a source of great profit to the people of this country—a country that produces fresh fruits and vegetables every month in the year; where grown in the open air peaches, figs, tomatoes, and cantaloupes can be gathered in December, and where the soil, a rich alluvial, varying in depth from 10 to 12 feet, inexhaustible in its durable fertility, will assuredly be the center of a great and prosperous community. Such are the mesa lands of this county. When reclaimed all vegetation has most rapid development.

The cottonwood and North Carolina poplar grows from 18 to 20 feet in a season, fruit trees from 12 to 15 feet, grape-vines from 25 to 40 feet.

The Indians occupying a reservation in this county have cultivated their land for two hundred years without apparent injury to the soil and without change of seed. After their crude method of farming they raise better crops of grain than are harvested in any of the wheat-growing districts in the Mississippi Valley.

COLORADO AND IRRIGATION.

Colorado is as notable for the physical data it offers in relation to irrigation as it has already been shown to be in the legal aspects thereof. Prof. L. G. Carpenter, of the State agricultural college, reported in January, 1890, the following as the

Approximate areas "under ditch" in Colorado.

	Area.	Total area.	
	Sq. miles.	*Sq. miles.*	*Acres.*
Division I (Platte Division):			
Platte Valley, below the Poudre	283.21		
Platte Valley, above the Poudre, including Bear and Clear Creeks	551.64		
St. Vrain and Boulder Creeks	294.59		
Big and Little Thompson	134.22		
Cache La Poudre	393.54		
Total from South Platte		1,657.20	1,060,608
From North Platte in North Park	....	101.23	64,787
Division II (Arkansas Division):			
East of Huerfano River	480.08		
Cucharas	94.40		
La Veta and Apache	84.17		
Upper Arkansas and Fontaine	106.91		
		774.56	495,718
Division III (Rio Grande Division)	....	1,564.00	1,000,960
Division IV (San Juan Division), including Dolores, Mancos, Pine, Florida, La Plate Rivers	....	135.00	86,400
Division V (Grand River Division)	....	210.00	134,400
Division VI (Bear and White River Division)	....	110.00	70,400
Total	....	4,552.00	2,913,273

By this table the total amount of land under ditch in Colorado at present is not far from 4,500 square miles, or 3,000,000 acres. The amount of land actually irrigated can not be so reliably estimated at present. It is much less than that under ditch.

Professor Carpenter estimates the total irrigated as not over one-third. This is apparently below the actual results. State Engineer Maxwell had presented in September, 1889, the following figures as a careful statement of the area east of the Rocky Mountains:

Divisions.	No. of districts.	Miles of ditches.	Acres.	
			Under ditch.	Actually irrigated.
No. 1 Platte	14	2,067.36	1,126,800	631,036
No. 2 Arkansas	13	943.30	440,240	116,047
No. 3 Rio Grande	8	1,033.68	596,097	250,263
Total	35	4,044.34	2,163,137	997,346

In the three eastern divisions there are also one hundred and sixty-two reservoirs, with a record capacity of 5,319,939,788 cubic feet, capable of furnishing one acre-foot of water to each of 122,199 acres. The total number of ditches, large and small, in the State is estimated at 2,000, and their mileage at 5,000. The duty of water is placed at 1.45 cubic feet per second for 80 acres. In some sections it is over 100 acres, however.

The State engineer, Mr. Maxwell, has reported the following:

> For the distribution, under the irrigation laws of this State, of the water from the natural streams to the irrigating canals, ditches, and reservoirs, the State is divided into six irrigation divisions and sixty-eight water districts.
>
> In a general way, the first division comprises that portion of the State which is drained by the North and South Platte Rivers, the second division of that portion drained by the Arkansas River, and the third division of that portion drained by the Rio Grande.
>
> These three divisions compose the "Eastern Slope," or all that part of the State which drains into the Gulf of Mexico.

EASTERN SLOPE.

Tabulated statement showing the number of miles of irrigating canals and ditches, the number of acres of land under such canals and ditches, and the number of acres of land actually irrigated by such canals and ditches.

[Compiled from data in the State engineer's office.]

SOUTH PLATTE DIVISION, No. 1.

No. of water district.	Name of principal stream in district.	Ditches.	Under ditches.	Actually irrigated.
		Miles.	*Acres.*	*Acres.*
1 6	South Platte	238. 00	150, 000	39, 719
2	......do	150. 00	174, 000	46, 233
3	Cache le Poudre	340. 75	207, 360	103, 896
4	Big Thompson	236. 66	80, 690	69, 908
5	St. Vrain	225. 50	92, 460	86, 655
6	Bowlder Creek	125. 00	89, 580	72, 895
7	Clear Creek	240. 00	98, 558	66, 405
8	South Platte	206. 50	131, 537	53, 110
9	Bear Creek	50. 00	6, 915	3, 742
23	South Platte	61. 50	23, 270	20, 920
47	North Platte	124. 00	46, 980	41, 080
46	......do	61. 45	24, 330	21, 470
48	......do	8. 00	800	4
	Total	2, 067. 36	1, 126, 800	631, 036

ARKANSAS DIVISION No. 2.

No. of water district.	Name of principal stream in district.	Ditches.	Under ditches.	Actually irrigated.
10	Fountaine que Bouille	53. 00	32, 680	18, 000
11	Arkansas	46. 10	39, 820	34, 780
12	......do	34. 00	33, 760	25, 520
13	Grape Creek	3. 00	600	540
14	Arkansas	92. 50	13, 694	7, 265
15	St. Charles	91. 50	7, 314	4, 543
16	Huerfano	340. 00	32, 129	12, 547
17	Arkansas	167. 50	224, 640	38, 700
18	Apishapa	24. 00	6, 700	6, 000
19	Purgatoire	58. 10	33, 380	25, 660
49 66 67	Various	29. 70	5, 490	2, 492
	Total	943. 30	440, 240	116, 047

RIO GRANDE DIVISION, No. 3 (SAN LUIS VALLEY).*

No. of water district.	Name of principal stream in district.	Ditches.	Under ditches.	Actually irrigated.
20	Rio Grande	300. 00	398, 140	98, 515
21	Alamosa	175. 00	57, 711	45, 093
22	Conejos	160. 00	45, 711	33, 340
24	Culebra and Costilla	(†)	(†)	(†)
25	San Luis Creek	227. 78	42, 425	31, 315
26	Saguache	143. 80	33, 380	28, 000
27	La Garita	5. 60	570	500
35	Trinchera	21. 50	18, 160	13, 500
	Total	1, 033. 68	596, 097	250, 263

* The records relating to this division are not complete.

† No data.

RECAPITULATION.

	Ditches.	Under ditches.	Actually irrigated.
Division No. 1	2, 067. 36	1, 126, 800	631, 036
Division No. 2	943. 30	440, 240	116, 047
Division No. 3	1, 033. 63	596, 097	250, 263
Aggregate	4, 044. 29	2, 163, 137	997, 346

Total area of arid land, 30,000,000 acres.

Colorado (eastern slope).—Tabulated summary of reservoirs so far as the same are of record in the office of the State engineer.

DIVISION No. 1.

District.	No. of reservoirs.	Area.	Capacity.
		Acres.	*Cubic feet.*
First	10	....	27,419,536
Second	8	....	538,787,000
Third	5	....	188,994,950
Fourth	1	....	180,000,000
Fifth	2	....	165,164,080
Seventh	21	....	1,114,089,456
Eighth	14	....	1,688,381,817
Ninth	13	....	263,778,940
Twenty-third	1	....	2,214,323
Total	75	....	3,168,780,082

NOTE.—The above number of cubic feet of water would furnish 1 foot in depth for 72,746 acres.

DIVISION No. 2.

Tenth	29	....	115,937,752
Eleventh	3	....	20,613,408
Fourteenth	17	....	1,011,596,143
Sixteenth	8	....	98,329,398
Seventeenth	20	....	823,524,005
Total	77	....	2,069,000,706

NOTE.—The above amount would furnish 1 foot in depth of water for 47,495 acres.

DIVISION No. 3.

Twenty-second	4	....	16,000,000
Twenty-fifth	2	....	66,000,000
Twenty-sixth	1	....	50,000
Twenty-seventh	3	....	109,000
Total	10	....	82,159,000

NOTE.—The above amount would furnish 1 foot in depth for 1,885 acres.

GENERAL RECAPITULATION.

Division.	No. of reservoirs.	Area.	Capacity.
		Acres.	*Cubic feet.*
First	75	....	3,168,720,082
Second	77	....	2,069,000,706
Third	10	....	82,159,000
Grand aggregate	162	....	5,319,939,788

NOTE.—This total amount of water would furnish 1 foot in depth of water for 122,129 acres.

ITS AGRICULTURAL PRODUCTIVENESS.

Colorado is especially adapted to the production of the grains, grasses, and roots of the temperate zone. The eastern foot-hills are found valuable for the fruits thereof, while in the valleys of the western slopes the finer fruits, such as grapes, apricots, etc., can be profitably raised. In the San Juan, to the southwest, the semi-tropical fruits and crops will be cultivated successfully on the mesa and valley lands.

Of the area of Colorado, 98.2 per cent. is not in farms. Of tillable land the area is 23.8 per cent.; grass land, 29; woodland, 3.8; and the unproductive is rated at 43.4 per cent. Colorado stands as to productivity as follows:

	Bushels per acre.	Average.
Corn	27.7	24.2
Wheat	10.6	12.3
Oats	31.7	27.0

From 1884 to 1889, the public domain lying within the borders of Colorado has been occupied to the total of 9,155,561 acres. This is within less than 1,000,000 acres of the total amount of arable land which, in 1880, the public lands commission declared was the whole arable area left for settlement. It is evident that the specialists do not know all the facts or are able to accurately forecast the future.

ONE OF ITS LARGE IRRIGATED AREAS.

In the San Luis Valley there is 468 miles of ditch. One canal, known as the Rio Grande Canal, is the largest in operation at present in the West. There is 312 miles of ditch system. The canal at the head is 80 feet wide on the bottom, and will finally supply water to about 240,000 acres of land. The conditions and character of the soil of the San Luis Valley, on the Rio Grande River, in the southern part of the State, are different from other sections of Colorado. That valley has an area of 5,000 square miles, and probably 3,000,000 acres could be redeemed if the water is there to do it with. Altogether, in the San Luis Valley, there are above it 1,150 or 1,200 miles of canal, supplying about 1,500,000 acres of land. The water supply is not sufficient to irrigate those lands at all times.

The Rio Grande River carries a large amount of flood water during the summer months. There are probably six weeks during the average year when there will be sufficient water to irrigate the entire valley if it could be relied upon. There are fine sites within the mountains adjacent to the valley for building reservoirs.

In order to redeem that entire area it is necessary to conserve the water. With that area 150,000 or 200,000 people can be supported, but with the present irrigating facilities and water supply not more than 50,000 people. The soil is good. The altitude is about 7,500 feet, but the latitude is such that it gives a good locality for irrigation. The San Luis Valley, the largest valley in the Rocky Mountain region, has a soil somewhat peculiar and different from the soil on the eastern slope of the mountains. It is underlaid by a heavy stratum of drift.

Artesian water is found in the San Luis Valley at a depth of 800 feet, a very full flow of water that will cut a figure sometime in the progress of irrigation; but even with such artesian and all the surface water, the valley will not be reclaimed without storage.

Most of San Luis Valley is still public land, but the State has some 200,000 or 250,000 acres therein. In order to induce capital to vinest, the State has passed a law providing for the sale of the State land in alternate quarter sections at $1.25 per acre to any company that would build a canal large enough to supply the entire area. They require the canal company to make a contract and give a bond and supply that land. Capital is not, however, ready to go in and investigate and make the expensive examination necessary to ascertain whether such canals are feasible. There are a number of canal and other irrigating projects, especially in the western and southwestern portions of the State, that would be undertaken if it could be demonstrated they were feasable, but in order to demonstrate that it would require the expenditure of considerable money.

If the information could be got and promulgated, showing that these schemes are feasible, capital might be induced to go in and construct them. That is especially true in Grand Valley. This valley, extending from Grand Junction over to the valley of the Green, in Utah, embraces a fine section of land, but to build a canal that would reclaim the whole of the land that is irrigable therein would require much money. Reconnaissances have been made to ascertain that, and it was ascertained that the canal would cost probably $2,500,000.

THE HISTORY OF GREELEY AND THE FIRST IRRIGATION COLONY.

Union colony is situated in Weld County, State of Colorado. It was located in the spring of 1870, and the town of Greeley was laid out and building and other improvements commenced at the same time. The town is located in sections 5, 6, 7, and 8, township 5 north, range 65 west of the sixth principal meridian; latitude 40° 25′ north, longitude 27° 48′ west from Washington; elevation above sea-level, 4,800 feet. At the time the colony and town were located the whole country was, with few exceptions, in its natural state, no improvements having been made except in a small way along the river. A few small irrigating ditches had been built to water portions of the low bottom-lands, and sufficient farming had been done by the early settlers to demonstrate the fact that good crops of all kinds usually grown in this latitude could be raised successfully.

The mesas or uplands were regarded as worthless for farming purposes, and only valuable for grazing, many of the best informed expressing the opinion that large and long irrigating canals to water the higher lands would be a failure. In support of this view it was said that the water would seep out and be lost before running in a canal any great distance, and that the land would be quickly exhausted if farmed, and various other reasons why upland farming would be liable to prove unsuccessful were pointed out.

Notwithstanding all the uncertainties that must be encountered, the projectors of "The Union Colony of Colorado," located in the Cache la Poudre Valley, purchased the land they required from private owners, and the Denver Pacific Railway Company homesteaded and pre-empted Government land, laid out the town, and proceeded to build irrigating canals to water the same. About 2,600 acres of land was bought of private owners for $28,000, and 9,300 acres of the railway company for $31,000.

The colonists contracted with the railway company for all the land owned by them lying within the colony limits at an average price of $3 per acre. The Government land was acquired by the colonists under the homestead and pre-emption laws. The total amount of land originally occupied by the colony was about 30,000 acres, and remains about the same. Soon after locating the colony built a fence some 40 miles in length, inclosing all their lands, including the town. This fence is still maintained, having been legalized by an act of the State legislature and being managed by a fence company. Each piece or parcel of land pays an annual tax for its maintenance, the annual assessment being about $16 for each 80 acres, and in like proportion for larger or smaller tracts. No stock of any kind is allowed to run at large inside of this fence, and none have found it necessary to fence their premises, either in town or outside, except for their own convenience. The colony originally divided the land owned by them outside of the town limits into lots of 5, 10, 20, and 40 acres each, according to their proximity to town, and deeded them to members, with perpetual right to water from the irrigating canals, for $150 each.

Other members bought land of the railway company for $3 per acre or homesteaded or pre-empted Government land. To these the colony sold right to water in perpetuity for $160 for each 80 acres. All water rights are taxed annually a sufficient amount to pay for superintendence, maintenance, and improvement of the main canals, generally from $12 to $24 annually for each 80 acres and in proportion for smaller subdivisions. Few of the colony farmers have more than 160 acres; generally they have 80, and in some cases as low as 40 or even 20.

The land occupied by the town, some 800 acres, originally cost the colony about $10 per acre, or $8,000. It was subdivided into about fifteen hundred lots of suitable size and sold to members at an average price of about $300 for each ($50 for corner and $25 for inside lots), making about $45,000 as the amount received by the colony for lots. The cash value of such lots was lawfully $300 each, making $450,000. The outside or farming land originally cost members about $5 per acre with water, and is worth $30 per acre cash, with actual sales at $35 and over for land with no improvements except plowing and ditches, including water right, the colony having long since sold all the land and water owned by them and transferred all their right in the main canal used by the farmers to a corporation composed of farmers operating under it. This company issued its stock to the water-right owners on receiving a deed for their interest, each share of stock representing water for 10 acres. In 1878, when this transfer was made, the par value was $40 for each share, making the value of an 80-acre water right $320. In 1881 the price rose to $100 per share, and it now sells at $100 to $125. This stock has actually cost the original owners about its par value, $40 per share. When land is sold including water, the stock is transferred. Nearly all the larger canals are now owned and managed by corporations who have power to levy and compel payments of assessments and divide the water equitably among the users, thus preventing nearly all the trouble which formerly attended the management of the earlier canals. The water costs the farmer the same whether he is situated near the head or at the terminus of the canals, and the same principle has been adopted in the management of the subditches or laterals, as it has been found that no canal from which a number of individuals receive their water can be successfully operated without a competent head.

Union Colony constructed two irrigating canals and one for power and irrigation. The first canal built was for the purpose of supplying the town and adjacent lands lying along the south side of the river. This is called canal No. 3. This canal was taken from the river about 6 miles west of town, and was run on a grade or fall of about 3 feet per mile. Its original size was 8 feet in width at head, and somewhat smaller opposite town. Its length is 10 miles. It terminates on the delta between the Platte and Cache la Poudre Rivers. As originally constructed it would carry about 50 cubic feet of water per second. Original cost about $10,000. It has since been enlarged and improved, its present capacity being over 100 cubic feet per second. Cost to present time, including dam at head, about $25,000.

The second canal built by the colony was taken out the river, about 15 miles west of town, for the purpose of watering the farming lands north of the river. As originally constructed it was 10 feet in width on the bottom at the head and for the first 5 miles, and gradually diminished in size towards its terminus, its total length being 26 miles. Grade or fall, 3.2 feet per mile; capacity, 110 cubic feet per second. It was calculated to water some 20,000 acres of land. Its first cost was $23,000; has been enlarged from time to time, its capacity now being 585 cubic feet per second. It will furnish water for 25,000 acres in cultivation, with the usual variety of crops. Cost to date, $80,000, or about $3 per acre for land watered by it. It is now 25 feet in width on bottom at head, and for the first 10 miles carries water 4.6 feet in depth, and is 30 miles in length. The number of water rights of 80 acres each is 320, giving over 1.8 cubic feet of water per second for each 80 acres, less about 10 per cent. for evaporation and seepage, or about 1.6 cubic feet per second for useful effect. As new land in wheat requires about 1 cubic foot of water for each square foot of surface for first watering, it would take over twenty-five days to water 80 acres with one water right, but generally only a portion of the tract is sown or planted the first year and less water is required after the first thorough irrigation.

Very much depends on the surface quality of soil and subsoil and amount of natural moisture in the ground, so that no very definite information can be given as to the amount of water necessary to irrigate a certain piece of ground. The usual experience is that a cubic foot of water per second waters from 50 to 60 acres of land sown or planted with the usual variety of crops. In town more than double that quantity of water is used, as the more a stream of water is divided up the less ground it will water. The farmers find it to their advantage to use two or three water rights when irrigating a favorable piece of ground by changing with their neighbors. The Cache la Poudre River, from which the colony ditches are taken, generally furnishes enough water when most is needed. There is generally sufficient snow or rain to start crops in the spring and keep wheat and oats growing until the 1st of June.

During June and July the maximum quantity of water is flowing in the river, and it is during these months that most of the crops must be watered. The amount of water flowing in the river each day is ascertained at a gauging station located above all the canals, and the amount or proportion of the water to which each is entitled being known, the district commissioner or superintendent is enabled to divide the water equitably to all. The river or district commissioner is not usually called on unless there is a short supply of water, which usually occurs in the latter portion of the season. The water commissioner on each canal divides the water to each subditch or lateral, and the users divide it among themselves. Since the present State laws regulating the division and distribution of water were enacted and put in force very little trouble has arisen in regard to the use of water for irrigation purposes.

The maximum amount of water flowing in the river each year is very variable, ranging from less than 2,000 to over 6,000 cubic feet per second. As the canals taken from the river have a capacity and use for over 3,000 cubic feet per second, it will readily be seen that there is an element of uncertainty as to water supply and the future extension of the irrigation system. Water has already been appropriated and canals built sufficient to water over 200,000 acres in this valley, and it is not probable that this amount will be very materially increased. The total amount of water flowing in the river during the year would water more than double this quantity of land, but it can only be utilized by a system of storage reservoirs. Comparatively little has as yet been done in the way of storing water in the State, and it is not probable that much will be done for many years to come. Some natural depressions or basins of moderate capacity are used for this purpose where they chance to be available, but no purely artificial reservoirs worth mentioning have as yet been constructed.

The great expense of building and maintaining large reservoirs makes it extremely improbable that our water system will be much extended in this way. Reservoirs to be of any use must be situated above the land to be watered, and where constructed in this vicinity on a small scale the land lying adjacent to them has generally been spoiled by the seepage. The parties owning land which is damaged by such seepage usually compel the owners of the reservoirs to stop using them for storing water. The influence of irrigation on the humidity of the atmosphere is very slight, being almost entirely local, and on new lands, outside of the irrigating canals, farming would be as certain to prove a failure as it would twenty years ago.

If any climatic change ever occurs in this locality whereby the humidity and annual precipitation is permanently increased, it will not be due to the feeble efforts of man. The annual precipitation about Greeley is from 12 to 20 inches, the average being 15 inches for the last twelve years, as observed in Denver. The destruction of the timber in the western mountains must injuriously affect the water supply during the irrigating season by leaving the snow exposed to the direct rays of the sun, causing it to melt quickly and run off. The advance of the farmers from the East with a solid front, plowing up the entire surface, may produce some change. If the annual rain-fall was double what it now is, farming could not be carried on successfully, except in favored localities, the evaporation being so rapid during the growing season. In Greeley, situated on what is called the second bench or bottom, some 25 feet above the level of the river opposite, gardens and lawns must generally be watered every week or ten days in dry weather, and the farmers do not stop irrigating on account of an occasional shower. Much as such increase of natural moisture may be desired, there is no good reasons for expecting it, though there is a reasonable certainty of producing a more equalizing distribution of local rain fall, through the effects of cultivation on the humidity of the soil, and by the influence of wind-breaks and other tree plantations in destroying the desicating effects of the hot winds.

Although this town and surrounding country has been irrigated for many years, raising the ground water, in portions of both town and country, nearly to the surface, causing it to partially fill many of the cellars under dwelling houses, no malarial diseases have been prevalent. The surface soil is generally a clay or sandy loam, from 5 to 10 feet in depth, underlaid with clear sand or coarse gravel 25 to 30 feet in depth, which affords a good natural medium for the rapid transmission of surface water to lower levels, but within the last few years more water has been run on the surface in town than the natural drainage will carry away; and we are now constructing deep drains to prevent the water from rising above a certain level. Said drains are located from 8 to 10 feet below the surface and have a good fall to the river. Our farmers do not keep much stock, as they do now, as formerly, have outside range for them. Alfalfa is grown by nearly all our farmers and yields heavily. It is usually cut three times, giving from 4 to 7 tons per acre annually.

The usual variety of crops is raised, wheat, corn, oats, and potatoes being the principal ones. Wheat is still the main crop, and the quality and yield are generally good. It produces on an average over 25 bushels per acre, when properly put in and attended to. Average of all sown, about 20 bushels. Corn is quite extensively grown, and yields from 20 to 40 bushels per acre; oats about the same, and potatoes from none to 100 bushels per acre, much depending on soil, season, watering at proper time, blight, bugs, etc. In town and vicinity market gardening is successfully carried on. Of fruits, strawberries and raspberries are the ones mostly grown for profit. Standard apples are a failure, but most varieties of crabs do well. It would be difficult to give the aggregate amount and value of all crops raised in this colony without having the report of the State census, taken last year, which is not now available. Nearly all the land in the colony has been farmed continuously for the last ten years, and much of it longer, but its fertility does not seem to decrease.

Crops, when properly rotated, do as well now as when the land was first broken. Scarcely any fertilizers are used on the farming land, and straw is usually burned to get it out of the way. The water used in irrigating the land carries a great amount of fertilizing matter, which is evenly distributed over the surface, fully replacing what is taken from the soil by the crops grown on it; and it is the general opinion of those most conversant with the subject that the soil is practically inexhaustible.

THE IMPORTANCE OF SMALL FARMS.

Thomas P. Dunbar and J. R. Burton, witnesses before the Senate Committee on Irrigaton, stated as to small farms:

> That they produce a better class of crops, fruit, vegetables, hops, and so on. There is a large demand for hops. I know a man making $300 or $400 an acre on hops, and a man can easily make $100 an acre on alfalfa. To get the best results a man must have a small area and cultivate closely and have a supply of farm-yard manure. Our soil here is very heavily charged with mineral matter and is very deficient in manure material. He must grow a variety of crops. We do not want men to raise a large surplus, but we want large communities and to have the land more closely cultivated, so as to bring our population nearer together, and have them produce everything that men can and need to live upon. That is what brings wealth into any State. All our immigration comes from non-irrigated districts. Everything here is new to such immigrants. The conviction is forced on my mind that a man is better off with 40 acres thoroughly cultivated than 160 acres half cultivated. You can not convince the immigrant of it, however.
>
> My observation is that a man is better off with 40 acres in the arid belt with every foot of it well cultivated, and his crop thoroughly attended to, than he is to have 160 acres skimped over. The man with 40 acres in the arid belt, well cultivated, will make more clear money in the end. I will lend him 25 per cent. more money on 40 acres of well cultivated land than on 160 acres half cultivated. The men that have a section of land have to have machinery and all that. Then a man's water-right will go farther on a small farm. His supply of water would have to be all put on at the same time. One great thing is to protect the land from the rays of the sun to prevent baking. You can not do that with a very large farm. I have often gone into an alfalfa field where the alfalfa grows half an inch a day in the warm weather, and within two or three weeks after it had been irrigated the crop was up 6 inches, which would prevent the land from being dried up. I have picked up there as damp a piece of soil as was wanted. On the other hand, I have been in a wet field that had been irrigated a few days before, when there was nothing to protect it from the rays of the sun, and the soil was baked hard.

With regard to the homestead law, I believe a man should not be allowed to preempt more than 40 acres of land in the arid region. I believe the homestead law ought to be amended so that one person could not acquire more than 40 acres of land under its provisions in the arid region. My reasons for this position are, first, the average farmer could make more money farming 40 acres of land by irrigation than he can a larger amount. The homesteader is a poor man, generally. He must borrow the money, at a very high rate of interest, with which to improve his land and live upon it, to provide himself with the necessary farming implements. He must go in debt for water, and wait for the harvest season for any returns from his toil and expenses. If he has 160 acres, his great desire to improve it all causes him to buy too much water, too much farming machinery—in short, it causes him to shoulder too much debt. His taxes and expenses are greater, and he is not capacitated to farm so much land, and farm it well, and the result is his harvest is no greater than it would have been had he carefully cultivated a smaller tract. Instead of getting out of debt and saving a little spare money to invest in live-stock, or to help develop some other industry in his immediate locality, at the end of ten years he is above the average farmer if his quarter section is not mortgaged and a large share of his earnings does not annually go to the money-loaner.

Then, again, it is far better for the ditch company for the farmers to have small holdings of lands. They are enabled to pay out on their water-rights, or to keep up the water-rentals. But a still greater reason is that, if the homesteader could not secure but 40 acres of land, the opportunity for speculators to secure the land in the arid region by engaging professional homesteaders to prove up and obtain title would be greatly lessened. There are localities where ditches or reservoirs could and would be built but for the fact that speculators have obtained the land in this way. The interest of the ditch company and the land-owner ought to be mutual. Where the land is held by farmers for homes, and especially where the land is cultivated, it is so, and there is but little or no friction between the owners of water and the owners of land.

I also think the law ought to be changed, so as to make the cultivation of the land for a given time requisite to obtain title, rather than occupancy. Land that is cultivated in the arid region must have water. If the farm is once put into a state of cultivation and has a water-right attachment there is no danger but that it will be occupied and forever after be a home for somebody. But under the law as it now is a homesteader may put upon the land a trifling building, ever so small and worthless, sleep there occasionally, but in reality live elsewhere, and in a short time have title from the Government, called a homestead, which in reality remains wild land. The spirit of the homestead law is violated, there is no home upon the land; it is used entirely for speculative purposes. I am not stating an exceptional case. In many localities it has been and now is the rule to obtain what is miscalled a homestead in this way.

THE WATER-LAW SYSTEM OF THE STATE.

Colorado, through its courts as well as legislation, was the first State to recognize the miner's law of prior appropriation of water as applicable, with restraining interpretation, to beneficial use in agriculture. The State has recognized as fundamental the principle of the public nature and property of all natural waters lying within a region so arid that agriculture can not be carried on without the artificial conservation and distribution of the same. It has applied two qualifying interpretations to the doctrine of prior appropriation. One is, that the beneficial use, which is the basis of such appropriation of water, must necessarily be limited in its application by the wants of all other subsequent users; that is to say, that an appropriation made in days when necessity was unknown could not be construed to deprive the members of a growing community of their pro rata share after the first or prior appropriator had received his portion. The other is, that water being public property, the carriers of the same by means of ditches or other methods can claim no ownership or possession in the water itself. Their remuneration is derived from the transportation and distribution through the channels they construct to the lands on which it is needed.

Colorado has also declared that water companies are common carriers, and their legal status to be the same as that of railroads or other transportation corporations. The State, following these lines, early assumed a direct supervision over the whole subject. Its area is divided into six irrigation divisions which are again subdivided into sixty-eight water districts, each one of these representing in the main a distinct drainage or irrigable basin or region, deriving its supply from some common source. The State supreme court announced this doctrine before it was incorporated into the statutes, declaring it to be the common law doctrine for their conditions. Such a decision requires two acts to make it valid; that is, the diversion and use of water for a beneficial purpose.

The statutes of Colorado, therefore, divide the State into irrigation districts. Under these statutes the district courts, which are the highest courts of record next to the supreme court, adjudicate what we call the priorities of right. These districts are generally arranged with reference to the natural streams, and if from the principal natural stream in a district one hundred ditches have been taken, the court proceeds in the method pointed out by statute to determine the dates at which each of these appropriations were made when the ditches were constructed; the size of the ditches; their capacity; the degree of fall of the water. Then a decree is entered which declares these dates, declares these facts, and assigns the priorities to these ditches in accordance with the dates of the diversion. Under these views the use must follow the diversion within a reasonable time. The decrees assign to these ditch priorities in accordance with the dates of the diversion. The use is thus connected with that diversion. The question of reasonable time goes according to circumstances. If the ditch is dug with due diligence and the water is applied reasonably soon the priority relates back to the date of the commencement of the ditch. It must remain a question of fact to be determined at each particular case. This decree also determines the quantity going to each ditch. The decree of a given district must be considered, and the quantity of water assigned to each particular ditch or to all the ditches taken together in the aggregate would constitute the quantity in use or the quantity assigned. If there is not water enough, those having priority under the decree would get it first. In each district there is an irrigation commissioner whose duty it is to superintend the distribution of water according to the decrees of the court. The governor appoints a commissioner for each water district.

FARMERS' WATER SERVICE AND "RIGHTS."

The organization of the water-carrying companies is divided into two classes. The mutual companies generally divide the ditch into shares—each person taking a number of shares—depending upon the extent of his property underneath. The amount of water he gets from the ditch depends in that case upon the number of shares he has in the ditch. It is divided according to the number of shares. The stock companies generally sell the water, or water-rights. "Water rights" is generally taken to mean the supply of water necessary for 80 acres of land. In such companies they agree, if they have water, to give a definite amount of water, not exceeding a certain quantity. There are two general types of contract; first, a contract made by the company with a man to sell him a certain amount of water on certain conditions, provided he keeps up his payments. The second is a water deed, which is given to the man in exchange for the first, when he has carried out the provisions of the first contract. These contracts represent the provisions of nearly all companies.

In most cases farmers have a perpetual water right. Under a few canals they rent water. The prices for perpetual water rights vary with the different canals. In the San Luis Valley they pay $400—that is, $5 an acre for the perpetual right. In the northern part of the State the Larimer and Weld Company have a different price. In the case of the North Poudre it is $15 an acre. The North Poudre also has a charge of $1,200 for a perpetual right. Another prevailing price is $800, and another one is for $1,000. The Arkansas Valley Company charges that much. That is for a perpetual water right, but all subject to an assessment for maintenance. The farmers are assessed for running expenses. Very frequently there is a provision that an assessment for maintenance shall not exceed a certain amount, say $10 for 80 acres, for ordinary assessments. Then there is a provision that in case of a very extraordinary difficulty in that ditch, or extraordinary repairs, they may be subject to a certain maximum assessment, $20 or so. The ditch company is the judge. An extraordinary assessment is rarely charged, even when there are extraordinary difficulties. In smaller ditches the assessment is more, depending somewhat upon the local conditions or the difficulties the company think they may meet. In the case of union ditches, the associates keep the ditches in repair, and the prices are less, because generally the ditches are smaller and the expense of maintenance is less. A small ditch runs itself almost. In the small ones it is perhaps from 5 to 15 cents per acre per year for maintenance. Each large ditch has a superintendent, whose business it is to distribute the water. The stock owners appoint, or in the case of a mutual company, they have a meeting, as every company would have, and make their own arrangements. The superintendent is an officer of the company, and he distributes the water according to the farmer's holdings in the ditch. In the smaller ditches, where they have plenty of water, each man takes all the water he wants.

Colorado has hardly grasped the idea embraced by the district system now being organized in California. To meet the evils and inequities which have grown up in the State as elsewhere, under the corporation system, an agitation has sprung into existence, on the part of the combined farmers, which makes a demand for State possession and ownership of all water ditches and their laterals. The State being a large owner of land has already found it advisable to construct ditches in certain localities in order to make its lands valuable.

THE IRRIGATION CAPACITY OF NEVADA.

The area of this State is 71,737,600 acres, of which the water area is but 1,081,600 acres. The timber is estimated to cover 2,600,000 acres; the pastural area is estimated to be 30,000,000 acres, the mineral area 15,000,000 acres; the desert and saline deposit, 3,656,000 acres, and the agricultural area is placed at 20,000,000 acres. That is the area to be reclaimed, if water can be obtained.

The State board of reclamation, appointed to consider the question of irrigation therein, in the report embodied in your testimony, presents a series of statements by counties, which will show an area of 17,981,000 acres as possible for reclamation, of which area 2,198,000 acres can, in their judgment, be reclaimed by wells and springs that are known to exist. In Esmeralda County, in the southwest, there is an area considered to be reclaimable, and also in White Pine and in Nye County, in the southern and eastern part of the State. There are sixty-five artesian wells in Nevada. The average altitude of the State is considerably over 4,000 feet above the sea-level. It is a mountain bowl surrounded by high ranges, and the fact that there is found even that limited number of artesian wells would indicate the necessity at least of examining into the character of the drainage or under-ground water supplies. There are a large number of important springs.

The trouble with Nevada is, in the main, that the drainage area that will most surely supply the water needed for reclamation is found largely within the limits of other States and Territories. In the north, the rivers head up in the northerly and northwesterly Territories. On the west, the easterly slopes of the Sierras are unquestionably part of the drainage area of Nevada. The great lakes that lie upon the Sierra Nevada are mainly upon the eastern slope of those mountains, and the waters naturally and properly belong to the people of Nevada. Take Lake Tahoe, 78 square miles of its surface (that is, two-fifths) are within the lines of the State of Nevada; the remainder is within the lines of the State of California. Lake Tahoe is ranked with navigable waters and belongs, then, to the Federal Government. It is all on the eastern side of the mountain. The ranges rise from 3,000 to 6,000 feet above it. Lake Tahoe has a drainage area of at least 1,200 square miles; the valley of the Truckee has a large drainage area. From Lake Donner, and the other lakes that are known along that range, water can be obtained. Lake Donner has been surveyed and its boundaries meandered. It is now reserved for irrigation purposes. Sufficient water can be obtained for western Nevada without the loss of a single cubic inch to California. By the storage of water in the mountain lakes alone, enough can be obtained to reclaim from 1,000,000 to 3,000,000 acres of land. Even if it be but 1,000,000 acres it will amply repay all its cost and double at once the values of the State.[*]

That land is worth nothing, or very little more than nothing, now. It would be worth from $15 to $30 an acre if it were watered. That would make as prosperous a community as could be formed within the borders of the Union. Nevada was born during the war, and by her mines hundreds of millions in precious metals have been added to the general wealth of the country. The larger proportion of those who have benefited by that development have left Nevada to struggle through the poverty and indifference that are now surrounding her people. There are now some 300,000 acres under fence and ditch, about 75,000 being cultivated.

---

[*] To the 16 inches stored above the 6,000-foot elevation should be added that which, falling below the 6,000-foot, melts and runs down in the spring and early summer. The average depth of this snow is about 5½ feet, and I estimate its quantity of water from my average found for snow freshly fallen, viz, 1 inch of water to 11 inches of snow. * * * It can be safely estimated that 9,000 square miles of mountainous surface will catch this amount of snow in average winters, thus giving 6 inches of water; this added to the amount falling upon the higher altitudes gives 22 inches of water, the greater part of which can be, by careful planning, made available for irrigation purposes.

There is not less than 4,800 square miles of the Sierra Nevada Mountains which shed water into Nevada. Of this area 250 square miles store annually 14 inches of water; 560 square miles store annually 19 inches of water; 1,330 square miles store annually 36 inches of water. All of which that is not lost by evaporation and percolation comes down into Nevada, giving rise to the Truckee, Carson and Walker Rivers.

I estimate the agricultural lands of Nevada at 21,000 square miles. This area will, I believe, be increased in the future by the addition of many square miles of foot-hills now classed as mountains. Be that as it may, the water supply of Nevada, as I have outlined, is sufficient to furnish each square mile of agricultural land in the State with 42 inches of water per annum.—*U. S. Surveyor-General Irish.*

IRRIGATION CONSTRUCTION IN WYOMING.

Territorial Engineer Mead reported to the Senate Committee on Irrigation the following tabular statement:

Irrigation development by districts.

District.	Total No. of recorded ditches.	Total length as stated.	No. of claims, with statement of length omitted.	Total capacity as given.	No. of ditch claims, omitting statement of capacity.	Total acreage watered as given.	No. of ditch claims, omitting statement of acreage.
1*	643	1,322.385	39	5,911.581	48	482,434.00	89
2	327	582.703	31	6,649.814	53	379,174.64	62
3	282	317.419	91	3,614.078	72	395,563.00	114
4†	....	....	....		....	....	....
5	502	996.398	32	10,422.700	57	440,540.00	50
6	124	196.955	46	1,556.325	36	58,162.00	55
7	322	518.240	50	1,658.905	96	108,976.78	95
8	182	212.510	52	3,095.487	79	35,295.00	96
9	49	91.430	1	342.000	25	42,460.00	3
‡	7	11.905	....	136.800	....	4,180.00	....
Total	2,438	4,249.935	242	20,381.723	466	1,946,875.42	564

*Seven reservoirs additional.
† District No. 4 omitted because of incomplete record.
‡ Unorganized district.

Of this area of nearly 2,000,000 acres not more than 80,000 acres are under cultivation other than for stock purposes.

The best agricultural portion of Wyoming is the northeastern. Only a few years ago agriculture in Johnson County was not considered an industry worthy of consideration. This was the fact in 1881, as the following figures of assessed valuation for that year show:

Cattle in 1881	$1,047,683
Lands in 1881	34,485

The great distance from railroads and the demand for vegetables and grain for home consumption forced the people to experiment with crops. The result was startling, and the sequel was that the business of farming became a leading industry within the next five years. Land "proved up" is assessed for taxation at a value of $3 per acre, including improvements. It is easily worth an average of $10 per acre. The following table of values from the assessment roll of lands shows the increase from 1881 to 1887 in farming lands:

1881	$34,485	1885	$166,032
1882	51,195	1886	229,644
1883	66,160	1887	485,439
1884	147,785		

The real taxable value of this taxable land is at least three times this amount, or in 1887 $1,456,317, which is $408,649 more than the value of the cattle in 1881.

But one-fifth of the lands susceptible of irrigation have been artificially watered. The total area of irrigable lands is estimated at 953,000 acres, and at an average value of $10 an acre would be worth $9,530,000. Its elevation is only about 4,000 feet. Its streams are more frequent and available than any other portion of the Territory. It is also one of the best watered counties in Wyoming, being well supplied with innumerable streams heading in the Big Horn Mountains and flowing generally to the northeast and northwest. The water along the foot-hills is clear, cold, sparkling, and soft. The soil is black and sandy loam, and appears to be capable of producing wonderful crops, with irrigation, of anything that is planted in it.

The agricultural products of the county are wheat, oats, barley, corn, rye, hay, potatoes, vegetables, and fruits. The yields are: Wheat, 20 to 50 bushels per acre; oats, 25 to 75 bushels per acre; barley, 40 to 75 bushels per acre; rye, 20 to 40 bushels per acre; potatoes, 200 to 500 bushels per acre; hay, native blue stem, 1 to 2½ tons per acre; timothy, 2 to 3 tons per acre; alfalfa (lucern), 4 to 6 tons per acre.

As to the future: If one-third of the irrigated lands of this county were sown in wheat, at an average of 30 bushels per acre, it would yield 2,340,000 bushels or 130,400,000 pounds, equal to 7,244 car-loads. If one-third of the area was sown to alfalfa it would produce 192,000 tons annually, and would fatten 58,400 steers, equal to 2,900 car-loads. Not more than one-fifth of the lands susceptible of irrigation have been watered. The possibilities that may be attained when development is complete become enormous.

AGRICULTURE IN THE DAKOTAS.

The year 1889 was one of exceptional drought.* Even so, the Dakotas presented in crops the following results:

	North Dakota.		South Dakota.	
	Acres.	Bushels.	Acres.	Bushels.
Wheat	2,655,991	26,721,660	2,013,726	17,288,432
Oats	450,503	9,746,093	671,839	11,623,615
Corn	30,022	1,000,175	784,655	21,831,898
Barley	3,167	45,487	127,338	1,694,875
Buckwheat	205	2,897	2,828	29,667
Potatoes	16,119	1,401,130	20,537	2,637,132
Flax	57,511	495,202	345,803	2,792,913
Rye	....	....	16,587	255,620

Statement showing monthly, annual, and average precipitation, in inches, as recorded at the U. S. Signal Office, Huron, Dak.

Month.	1881.	1882.	1883.	1884.	1885.	1886.	1887.	1888.	1889.	Total by months since station opened.	Averages by months.
January	....	0.14	0.17	0.09	0.15	0.48	0.33	0.78	1.26	3.40	0.425
February	....	0.25	0.47	0.58	0.22	0.16	1.11	0.52	0.93	4.24	0.530
March	....	0.80	0.42	1.53	0.12	0.62	0.64	1.22	0.19	5.54	0.692
April	....	4.18	2.14	2.70	1.06	3.53	3.72	0.88	3.41	21.61	2.700
May	....	4.50	4.45	2.90	5.20	1.58	1.39	4.98	3.04	28.04	3.505
June	....	5.86	4.33	3.18	5.43	1.90	3.98	1.10	1.04	26.82	3.352
July	†3.58	5.68	5.20	5.11	4.52	1.60	4.96	3.11	3.51	37.47	4.163
August	6.31	1.44	1.77	1.18	3.89	5.62	6.13	3.46	....	29.80	3.725
September	3.11	0.86	1.68	1.26	2.61	1.59	0.15	0.19	....	11.45	1.432
October	2.10	2.37	1.96	1.52	0.98	1.26	0.79	0.29	....	12.27	1.534
November	0.45	0.61	0.05	0.17	1.50	1.18	0.25	0.34	....	4.55	0.569
December	0.06	0.23	0.61	0.62	0.10	0.74	2.09	0.18	....	4.63	0.579
Total	15.61	28.12	23.25	20.64	25.78	20.25	25.54	17.05	13.38	....	....

Total inches for seven complete years, 160.83. Average for seven complete years, 22.98.

†Station opened July 1, 1881.

Average monthly and annual precipitation (rain-fall and melted snow) in the two Dakotas for the periods and localities named below.

Stations.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean annual precipitation for each locality.	Period covered by reports (dates inclusive).
	In.	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	
Fort Abercrombie	0.50	0.09	0.63	1.70	1.80	1.73	1.79	2.18	1.85	0.37	0.60	0.52	13.76	July, 1874, to Oct., 1877. Record of post surgeon (incomplete).
Fort A. Lincoln	0.44	0.64	0.84	2.30	2.45	2.96	1.75	2.14	0.80	1.04	0.49	0.79	16.95	July, 1874, to date. Record of post surgeon.
Alexandria	0.28	1.07	1.12	3.86	3.47	4.20	5.26	3.20	1.18	2.41	0.40	0.82	30.54	March, 1882, to Feb., 1884. Record of voluntary observer.
Fort Bennett	0.73	0.64	1.01	2.20	2.58	3.97	2.17	2.21	1.24	0.69	0.29	0.45	17.85	Oct., 1880, to Nov., 1885. Record of Signal Service.
Bismarck	0.34	0.64	1.05	2.78	2.91	3.40	2.28	2.60	1.24	1.19	0.75	0.77	20.10	Oct., 1874, to date. Record of Signal Service.
Fort Buford	0.55	0.45	0.50	1.28	2.32	2.79	1.75	1.62	0.72	0.96	0.49	0.65	13.91	July, 1874, to date. Record of post surgeon prior to Jan., 1879; Signal Service since.
Deadwood	1.04	1.26	1.99	5.02	4.70	3.69	2.33	2.12	1.38	1.84	1.35	1.50	28.23	Jan., 1878, to date. Record of Signal Service.*
Firesteel	0.55	0.28	5.18	2.12	3.87	2.92	4.38	2.92	3.10	1.00	0.78	0.32	27.60	Feb., 1875, to June, 1877. Record of voluntary observer.
Fort Hale	0.39	1.03	0.96	1.43	3.00	3.71	2.39	2.52	0.70	2.32	0.25	0.49	19.62	Jan., 1879, to May, 1884. Record of post surgeon.
Huron	0.21	0.34	0.70	2.72	3.73	4.14	4.32	3.37	1.85	1.86	0.66	0.39	23.65	July, 1881, to date. Record of Signal Service.
Lower Brule Agency	0.20	0.18	0.82	1.86	1.81	1.80	3.27	2.91	2.01	0.44	0.34	0.79	15.13	Sept., 1875, to Dec., 1878. Record of post surgeon.
Fort Meade	0.71	0.56	1.18	2.80	4.43	2.73	1.98	1.82	0.49	0.73	0.51	0.49	19.22	July, 1879, to date. Record of post surgeon.
Morriston	0.58	1.28	1.36	2.77	4.26	4.69	4.51	3.44	2.17	1.97	0.52	1.04	31.03	July, 1877, to July, 1884. Record of voluntary observer.
Olivet	0.84	1.14	0.94	2.51	4.86	4.57	2.93	3.03	2.14	2.30	0.34	1.26	26.56	June, 1877, to Nov., 1882. Record of voluntary observer.
Pembina	0.46	0.76	1.00	1.59	2.91	3.78	2.53	2.34	1.52	1.67	1.42	0.99	21.91	July, 1874, to date. Record of post surgeon and Signal Service.
Fort Randall	0.44	0.87	1.58	2.74	4.36	5.18	3.67	3.02	2.39	1.83	0.55	1.35	28.99	July, 1874, to date. Record of post surgeon.
Fort Rice	0.24	1.23	1.04	3.60	4.15	2.64	1.51	1.10	1.39	1.24	0.90	0.73	15.01	July, 1874, to Oct., 1878. Record of post surgeon (incomplete).
Richardton	1.50	0.87	1.00	3.41	2.65	4.20	6.98	3.53	1.30	0.83	0.93	0.97	28.17	Feb., 1884, to date. Record of voluntary observer.
Fort Seward	0.05	0.11	0.89	1.15	3.23	3.37	1.87	1.78	1.57	0.65	0.08	0.10	15.08	July, 1874, to Aug., 1877. Record of post surgeon.
Fort Sisseton	0.37	0.40	1.05	2.14	2.63	3.58	3.46	2.37	1.37	1.99	0.61	0.62	17.23	Sept., 1876, to date. Record of post surgeon.
Fort Stevenson	0.37	0.44	1.09	1.34	2.33	4.13	1.70	2.91	1.40	0.96	0.49	0.43	19.11	July, 1874, to May, 1883. Record of post surgeon to Feb., 1879; Signal Service to 1883.
Fort Sully	0.42	0.38	0.72	1.95	2.77	3.42	3.06	2.13	0.94	0.63	0.48	0.59	17.39	July, 1874, to date. Record of Signal Service and post surgeon.
Vermillion	0.96	0.40	1.30	2.97	1.69	2.88	2.35	3.87	2.18	1.58	1.35	0.52	19.19	Jan., 1884, to date. Record of voluntary observer (incomplete).
Fort Wadsworth	1.86	0.58	2.65	2.35	2.26	1.87	1.95	4.12	1.33	1.63	1.45	2.19	25.73	July, 1874, to Aug., 1876. Record of post surgeon.
Webster	1.58	2.89	2.46	4.87	6.18	7.24	6.30	2.53	3.18	4.34	1.86	2.11	44.61	June, 1882, to date. Record of voluntary observer.
Yankton	0.56	0.82	1.29	3.39	4.45	4.81	3.74	3.05	2.93	1.66	0.67	0.72	28.43	April, 1873, to date. Record of Signal Service.
Fort Yates	0.34	0.23	0.46	1.84	1.51	3.34	2.57	1.87	0.75	0.50	0.32	0.57	14.27	Jan., 1882, to date. Record of Signal Service and post surgeon.
Fargo (Moorhead)	0.73	0.92	0.80	2.39	2.97	4.37	4.85	3.42	1.95	2.77	1.22	0.78	27.17	Jan., 1881, to date. Record of Signal Service.
Fort Totten	0.36	0.57	0.90	1.59	2.70	3.40	2.40	2.87	1.03	1.39	0.68	0.62	18.34	July, 1874, to date. Record of post surgeon to Jan., 1884; Signal Service since.
Mean monthly annual precipitation for Territory	0.70	0.72	1.26	2.50	3.20	3.64	3.10	2.65	1.59	1.47	0.71	0.81	22.35	

* Observations taken at Lead City from June to October, inclusive, 1878.

NOTE.—The latest observations included in above calculation are those of December, 1887. The winter of 1888-'89 not being normal, the figures are omitted. The precipitation of 1889 was the smallest ever known.

These observations and others made show that the Dakotas have sufficient rain-fall to mature all crops, if it comes at the right time. This does not always occur, and crops suffer. The table shows 22.35 inches of rain-fall and melted snow for the year. Beginning with January, the month of the year when the least moisture is precipitated, there is a slight increase of snow-fall in February, which is nearly doubled in quantity by the rain and snow-fall in March. In April the average rain-fall is 2.5 inches, or twice the depth of moisture falling in the preceding month. This is increased thirty per cent. in May, the average precipitation of the month being 3.2 inches, while in June, at just the time the rain-fall is most needed to benefit the growing crops in this region of late harvests, the maximum precipitation during any single month of the year is reached, averaging 3.64 inches. During the last half of the year the amount of moisture precipitated each month lessens in about the same ratio as it increases during the first half. By seasons we have the following result: In the winter months the total precipitation averages 2.26 inches; in the spring, 9.96 inches; in the summer, 9.39 inches, and in the fall, 3.77 inches.

There is a difference between the eastern and western sections of the two States. The line of the Missouri River will divide them enough. On the west, irrigation will be needed on a large scale. Storage in reservoirs, distribution by high line canals, is a necessity there. East of the river, small storage, local impound, and wells will be of the greatest value.

The altitude of Dakota above sea-level ranges from 800 feet in the Red River Valley to 2,000 on the high prairies between the large rivers, the average of the Territory being about 1,500 feet. The most elevated section is the Black Hills, where the prairies and table-lands gradually increase in height from 2,000 feet to the culminating points, 7,000 to 8,000 feet above the level of tide-water.

North Dakota has 74,312 square miles and South Dakota 76,620, each one still larger than any one of sixteen of the States. The great size of the Territory can be understood by comparing it with foreign countries, it being larger than England, Scotland, Ireland, and Wales combined, larger than Norway or Italy, twice the size of Turkey, four times as large as Portugal, and ten times the size of Denmark.

The two new States are distinctly a prairie country, yet there are two mountainous regions. The larger of these is known as the Black Hills, and while it laps over into Wyoming, it covers an area in South Dakota of about 4,000 square miles. The highest point of the Black Hills, Harney Peak, reaches an altitude of 8,200 feet above the sea, while other peaks vary from 6,000 to 7,500 feet, the average elevation of the entire region being about 5,000 feet, or from 2,500 to 4,500 feet above the surrounding plains.

The Turtle Mountain region lies in Northern Dakota, and includes an area of 800 square miles along the international boundary line. It consists of ranges of hills hardly high enough to be dignified by the name of mountains, rising, as they do, but a few hundred feet above the surrounding prairies. There are only two prominent peaks, Butte St. Paul and Bear Butte, each about 3,200 feet above the sea, and only 700 feet higher than the rolling plains below. This region, as well as the Black Hills, is well timbered.

The two States have a water surface estimated at about 1,500 square miles. Their principal rivers are the Missouri, James or Dakota, Big Sioux, Vermillion, Red, White, Green, Bad, Cheyenne, Moreau, Grand, Cannon Ball, Heart, Sheyenne, Little Missouri, Mouse, and Maple.

The Missouri, varying in width from one-half of a mile to two miles, is the most important. It flows in a general southeastern direction, through a course, counting its windings, of fully 1,300 miles, dividing the Dakotas into two nearly equal divisions. Analysis has proven the water to be the purest river water in the world. Dakota, with the Red River of the North, the Missouri, makes the navigable waters of the Dakotas.

The area of the two Dakotas is computed at 96,596,480 acres. Indian reservations take up 26,847,105 acres of this great area, soon to be reduced, however, 11,000,000 acres by the opening of the Sioux Reservation. Out of the total there is also to be deducted 7,000,000 acres granted to the Northern Pacific Railroad, and 3,000,000 set apart for a school fund. Up to September 30, 1889, according to report of the various land offices, there has been disposed of 40,184,895 acres, under the various land laws. The unoccupied lands are distributed between the various land districts, four in North Dakota and five in South Dakota, as follows:

North Dakota.

	Acres.
Bismarck land district	11,622,500
Grand Forks land district	560,200
Devils Lake land district	4,182,930
Fargo land district	263,833
Total number of acres	16,629,463

South Dakota.

Huron land district	189,100
Yankton land district	14,097
Rapid City land district	986,189
Mitchell land district	5,000
Aberdeen land district	747,940
Watertown land district	44,960
Total number of acres	1,987,286

There are 3,431,000 acres of unsurveyed land in the Rapid City district to be added to the total of South Dakota, an acreage, too, soon to be increased by the opening of 11,000,000 acres of the Sioux Reservation. From the Aberdeen district, however, a deduction of 113,860 acres located in North Dakota must be made.

Prior to 1862 any land taken up in Dakota was by purchase or preemption, the homestead law not becoming a law until May 20, 1862. From that date to June 30, 1863, there were 75 entries under this act, involving 11,829 acres; in 1864 there were 111 entries; in 1865, 64; in 1866, 154; in 1867, 187; in 1868, 614; in 1869, 523; in 1870, 576; in 1871, 861; in 1872, 1,009; in 1873, 1,297, and in 1874 1,778 entries, involving 288,162 acres. From 1875 to 1889 the entries under the homestead, pre-emption, and timber culture acts have absorbed land as follows:

	Acres.		Acres.		Acres.
1875	205,918	1880	2,268,806	1885	4,547,749
1876	391,645	1881	2,673,213	1886	3,075,085
1877	212,555	1882	4,360,131	1887	2,069,668
1878	1,377,948	1883	7,317,236	1888	1,838,142
1879	1,656,851	1884	11,082,818	1889	2,382,948

AGRICULTURE AND IRRIGATION IN WESTERN KANSAS AND NEBRASKA.

The Great Plains, estimating as such the semi-arid and arid territory between 97° 30′ and 103° 30′ and from British America to the Red River south, that is over 6 degrees, or 400 miles east and west, and north and south about 700 miles, will contain at least 180,000,000 acres.

Profs. Samuel Anghey and C. D. Wilbur, of the University of Nebraska, are scientists of repute, authors and teachers of recognized capacity. Their opportunities of direct observation so well supplement these qualifications that the testimony and views presented by them must be esteemed of a weighty character. The conclusion they arrived at as against the continued aridity of the Great Plains can be stated as follows:

(1) The soil embraced within the area west of the one hundredth meridian "is chemically equal to any similar area of soil taken in any part of the American continent." The professors do not include either Arizona or New Mexico, yet both are equal to the other portions of the area indicated.

(2) Water is the only element lacking to insure complete productiveness.

(3) The homogeneous character of the soil is insured by the fact that it is the result of "the decomposition of primary rocks, old sea deposits, and glacial agencies, acting through long ages over great areas of both mountains and plains."

(4) The practical question to be settled, then, is the supply of moisture.

Messrs. Anghey and Wilbur hold it to be proved beyond reasonable question that "the present rate of increase in rain-fall will in a comparatively short time fit this region for agriculture without the aid of irrigation." They argued at length in the paper mentioned, as also in other publications:

(*a*) "That the actual rain-fall from the ninety-eighth meridian westward, over a considerable area, is sufficient to produce successfully root crops, fruits, and the cereals." Nearly up to the North Platte the rain-fall averages 26 inches per annum, and beyond that for a long distance west it amounts to nearly 16 or 17 inches. It falls, too, in the early summer, when most needed.

(*b*) That the presence of nutritious grasses proves the richness of the soil. The buffalo grass as it disappears is everywhere followed by other species, far more useful, belonging to the same family of plants as the edible grains. The spontaneity and variety of the native flora on the Great Plains are also indicative of the richness and adaptability of the soil.

(*c*) Holding that the moisture and rain-fall are gradually increasing from east to west, Messrs. Anghey and Wilbur declare—

(1) That actual tests, taken in large number, show the practicability of "grass and grain growth in the major part of the lands of the United States domain excepting actual rocky areas.

(2) It is also shown by "the western march of grass and grain growth" in Nebraska almost to the western limits of the State, 350 miles from the Missouri River; in Kansas clear up to the one hundredth meridian and (except as to grain on the uplands, or water-shed regions, and in some parts along the valleys of the Arkansas and Smoky Hill; a long distance beyond that line, and in Dakota up to the foot-hill ranges of the dorsal mountains.

(3) That the actual increase of the rain-fall is clearly demonstrated by observations taken over a period long enough to give consecutiveness to the deductions made.

After citing various authorities, Messrs. Anghey and Wilbur sum up their conclusions in the following manner:

> Observation, experiment, and the highest scientific authority demonstrate that climates in the West are becoming moister and that rain-fall is increasing steadily.

This increase must extend steadily until the plains east of Denver and Laramie receive sufficient rain-fall to produce farm products.

For these reasons we are compelled to say that any evidence of present dryness, where dryness exists, is evidence only for the present and should not be used to cover these areas with the undeserved reproach or curse of desert lands.

By the term "these regions" Messrs. Aughey and Wilbur refer to the area usually designated as the "Great Plains," lying between the ninety-eighth west meridian and the higher foot-hills of the frontal range of the Rocky Mountains, though they appear to have more especially in their minds the more limited but still great basin of the Republican River, embracing a large portion of central and northwestern Kansas and the area contiguous thereto in Nebraska.

IN SOUTHWEST KANSAS.

Within the last ten years over 500 miles of irrigating ditches have been constructed in the Arkansas Valley west of the one hundredth meredian, in Kansas. These ditches are capable of supplying water for the irrigation of more than 100,000 acres of land in Ford, Gray, Finney, Kearney, and Hamilton Counties; but, owing to the failure of the water supply in the Arkansas River for the last two or three years, the ditches have not been used to their full capacity. This failure of water was caused mainly by the paucity of snow-fall in the Rocky Mountains in the winters of 1887 and 1888, and the severe droughts which have prevailed between the one hundredth meridian and mountains for the last three seasons. We think the current opinion that the numerous irrigating ditches which have been recently constructed along the Arkansas Valley in Colorado exhaust the water in the river before it reaches the Kansas line is largely erroneous. During the summer of 1889 there was more water in the Arkansas River at Dodge City than at Coolidge, near the State line. There was more at Wichita than at Dodge City, and more flowing water in the channel in the 200 miles in Kansas than in the 200 miles west of the Colorado line. That the supply of water is inexhaustible has been frequently demonstrated by pumping water from wells located in the valley. The two most noted experiments were made last year at the wells which supply the water-works at Dodge City and at Garden City. These wells are 22 feet and 19 feet in diameter; respectively, and about 20 feet deep; the water rises to within 4 feet of the surface of the ground. Over 1,000,000 gallons have been pumped out of the Dodge City well in a single day without lowering the water to any appreciable extent. At the Garden City well the water-works pump, with a capacity of 600 gallons per minute, and a Huffer irrigation pump, with a capacity of 500 gallons per minute, were both worked to their utmost limit for a period of four hours without lowering the water in the well. Numerous other experiments of a similar nature have been made.

IRRIGATION VALUES AND CONDITIONS.

Civil Engineer Tweeddale, of Kansas, writes as follows:

The question of the supply of any desired quantity of water for irrigation from the underflow being assured, we will consider the subject of its procurement, etc., in the following order: First, the quantity of water required for irrigation, generally and specifically; second, the manner of its procurement from the under-ground current; third, the cost of plant for procurement and distribution; fourth, the results of irrigation and a comparison of it with "dry farming" when the rain-fall is deficient, and also when it is ordinarily considered ample for "dry farming," together with a comparison of the methods in general use of distributing the water from open ditches by means of rills opened and closed with shovels or hoes; and of distributing pumped water from pipes by means of hose and hydraulic monitors attached to plugs or hydrants.

First. The quantity of water required for profitable agriculture depends upon the nature of the soil, character of the crops, and the position of the district in relation to the surrounding country. Thus in the case of a permeable soil with considerable declivity the water deposited upon it will pass off rapidly, perhaps even before serving for the germination of the seed or the nutriment of the plant. If, however, the soil be retentive and the site low as compared with its surroundings, the soil may become so saturated with water that germination and growth may be greatly impeded. The conditions necessary for the germination of seed and the growth of plants are moisture, air, and a certain degree of heat. In a clayey, impervious soil an excess of water will act injuriously by reason of the absence of air and heat. In the case under consideration, the soil being impervious and the ground having sufficient declivity to give surface drainage, the discharge will be large. Add to this an elevated temperature, a clear sky, and dry air—in brief, a normal drought—and we have all the conditions which require frequent and plentiful waterings. In the process of vegetation water is the medium through which plants obtain nourishment. The water, charged with the organic and mineral substances in a state of solution which constitute the food for plants, is drawn up through the roots; these substances are assimilated and the water thrown off through the leaves. Many experiments have been made to determine the amount of water transpired by plants. M. E. Risler, a Swiss philosopher, has recently given a good deal of attention to this subject. He operated both in the laboratory and by observing the flow from the drains of a field especially arranged for such observation. He gives the daily consumption of water for different kinds of crops as follows:

	Inch.	
Lucern grass	0.134	to 0.267
Meadow grass	0.122	0.287
Oats	0.140	0.193
Indian corn	0.110	1.570
Clover	1.140	
Vineyard	0.035	0.031
Wheat	0.106	0.110
Rye	0.091	
Potatoes	0.028	0.055
Oak trees	0.038	0.030
Fir trees	0.020	0.043

Schlieden, at Jena, found for a mixture of clover and oats grown in earth contained in an iron box, which was weighed at intervals to determine the evaporation, a consumption of about 0.0984 inch per day from the time of sowing until the time of harvesting, a period of one hundred and twenty-nine days—13 inches nearly. Very careful experiments on this subject have been in progress for several years at the observatory of Mountsouris, in France. The grain is grown in earth contained in metallic boxes, and similar boxes without grain are used to determine the evaporation. In some cases the earth was dried and weighed both before sowing and after harvesting. The results obtained were essentially as above given. It was found that to produce one pound of wheat required the expenditure of from 800 pounds to 2,400 pounds of water, the lesser quantity being when the soil was fertile. In the case of wheat the maximum consumption of water occurred at the period of flowering, after which it diminished to the ripening, and then ceased.

From the above table it appears that a field of grain (as wheat, oats, or rye) may absorb, between seeding and harvesting, 15 inches of water, while grass may absorb 37 inches during a period of growth of one hundred and thirty days. This question of the effect of water on fertility explains the difference observed in the yield of different fields of grain at the same time, and of different yields of the same field in different years. It also serves to explain some points in hydrology, as to the effect of the destruction of forests on the flow of streams. The table shows that the quantity of water transpired by the leaves of cereals is greatly in excess of that by the leaves of forest trees, which proves that the clearing and cultivating of forests do actually diminish the quantity of water in the streams. It also explains how lands rich in the chemical constituents of certain grains produce large crops with a small rain-fall, as in the case of northern Dakota and Minnesota, where, with a rain-fall of but 17 inches, 30 and 35 bushels of wheat to the acre is not an uncommon yield.

* * * * * * *

The advantages in favor of irrigation are: not only are the crops much larger, but they are entirely unaffected by drought or wet; and being harvested under a clear sky are in good condition, and therefore, being of superior quality, command higher prices. As a rule, persons living on irrigated lands, having regular occupation, are more thrifty; their crops are certain, regardless of seasons; having larger and more certain incomes, their earnings are expended in increased comforts—all of which increases the business of railroads. And now that the competition between rival lines has destroyed the profits of through traffic, dependence must be placed on local business, which for that reason must be developed, resulting in the charges for the hauling of coal used for pumping being the least possible. As the effect of an extensive system of irrigation is toward small holdings and a dense population, the result will be increased business. It is estimated that 1 acre of irrigated land produces, directly and indirectly, more than 1 ton of railroad freight annually, or more than two hundred times as much as the same land used for grazing cattle, as the effect of any considerable amount of irrigation would, by increasing the humidity, tend to a reclamation of the unirrigated desert, and in a measure affect the humidity of the whole area

Perhaps the clearest and most simply stated description of irrigation as at present practiced among us is the following, from the pen of Orange Judd, the veteran editor of the Prairie Farmer:

> Irrigation in the present use of the term means the artificial application of water to the soil, by several methods. There is the "main canal" or ditch, which brings water taken from streams that may be a mile or two or scores of miles away. A "lateral" comes out of one side, and extends several rods, or even miles, to the upper side of a field, into a plow furrow nearly on a level, and the water in this case spreads out each way. From this head furrow very small ones are made with a hoe, or quicker with a small single-horse plow. They are run in such direction, required by the lay of the land, as will give them only a slight descent. A hoe or shovel full of earth into the plow furrow at each entrance of these little ditches keeps them closed. When the land needs water the little "gate," or sliding board at the canal, is raised as far as needed to let in the required amount of water. This is raised or lowered from time to time, as seen to be necessary. The large plow furrow being filled with water, the irrigator opens or closes the upper ends of the small furrows by taking out a shovel or hoeful of earth. The operator walks over the field, and where water enough is not flowing out in any place, he, with a shovel or hoe, clips off a bit of earth from the side of the small ditch or furrow, or stops the flow at any point by throwing in a trifle of soil. In this way he can, in an hour or two, give an entire field what would be equal to a heavy soaking rain. This may be done so deeply down, one or even two feet, that the growing crop may flourish through the hottest season or drought without another irrigation.
>
> Where water goes deep down it is only very slowly evaporated from the surface, while the roots of the crop grow downward so far as to find a good deal of natural moisture in the soil. Usually only two, or at most three, such irrigations are needed on a wheat crop, grown on a soil which is literally a dry ash heap. The number of irrigations and the amount of water at each flowing depend a good deal upon the character of the subsoil. Some land requires only a single flowing, along in May or June. Sometimes a flooding about the heading-out time will produce very heavy grain kernels. Sometimes the ground is well flooded before the seed is sown, and once or twice afterward, unless there is an unusual fall of rain. Most farmers using irrigation rather prefer no rain. Having a supply of water in the canal to use whenever needed, they prefer continual hot sunshine, which pushes growth forward most rapidly.
>
> In most of the irrigable, arid regions, these canals are taken out high up a river or stream which is fed by the melting of snows on the mountain tops in May, June, and July, just the time when plenty of water in the canal is most needed. The canals are carried along with a descent of 1½ to 2 feet per mile, winding around hills or uneven ground to maintain a uniform grade. If the ground and the stream descend rapidly the canal may thus be carried scores of miles, and at its end be 20, 50, 100, or more feet above the parent stream. The side canals are taken out at different places, and similarly carried over or around uneven land, so that a single main canal may irrigate tens or hundreds of thousands of acres, for example a canal from a stream in the Rocky Mountains, by following the sides of knolls, valleys, and hills, may take water hundreds of miles to supply the parched farms in Eastern Colorado.

It was asserted by the Public Land Commission in 1880 that the arable area of the United States would be all taken up by 1883. Francis A. Walker said the same thing; other writers and publicists also repeated it. Yet the Land Office reports show that since 1883, and up to June 30, 1889, 109,377,858.14 acres of public lands have been disposed, within the States of California, Colorado, Nevada, Oregon, Kansas, Nebraska, Washington, Montana, North and South Dakota, Idaho, and Wyoming, and the Territories of Arizona, New Mexico, and Utah, alone. Of this total certainly 60,000,000 acres are within the arid region proper, and the major portion of the balance was located and settled within the semi-arid sections, and all of this was classed as "agricultural."

IRRIGATION ENGINEERING PROBLEMS.

STORAGE OF THE STORM AND MOUNTAIN WATERS.—RESTORATION OF DRAINAGE, UNDERFLOW, AND SEEPAGE SUPPLIES.—RESERVOIRS, CANALS, WELLS, SUB-DAMS, FARM STORAGE, ETC., ETC.

PART II.

In the work of irrigation survey, at present there seems to be two distinct points to be aimed at. In a great measure the running waters within the arid region are being rapidly consumed. The points are, first, the conservation of the storm or surplus waters, which must necessarily be stored in the high altitudes of that region, and, secondly, the restoration for use in agriculture of the waters under the earth.

These two divisions at the present moment seem to be the essential purposes for which engineering efforts should be made. It is suggested that the great area lying east of the Rocky Mountains—the plains and foot hills—from the 97th practically to the 104th degree of west longitude must come first, because of the great population that has gone in there, and of the large amount of struggle and of pecuniary effort that have been made by them, and owing to the condition in which they are being constantly placed by reason of the insecurity or uncertainty of the water supply. These conditions arise, not so much by the deficiency of the water supply, taking the years through, as by its unequal and unsuitable division. What is called the great plains region has, for the work of reclamation, at present, to be now considered, upon the ground that a large part of the population to be benefited by irrigation are to be found there.

The problems involved in that fact are, of course, two-fold, as in the whole field: These are the storage of the surplus waters in the Rocky Mountains proper and in the valleys of the streams flowing there, and the obtaining of an adequate knowledge of the waters within the earth, so as to make plans and lay out the best methods for their economic use in the near future.

The artesian water-belt, the most remarkable of which is found in the central valley of the Dakotas, is first to be considered. Second, comes the underflow or sheet water of the river valleys. Then one of the most important is the general seepage or drainage waters found to exist in the gravel and sandy strata just below the alluvium, all through the central portions of the plains, and which, it is believed, by shallow openings or wells can be collected so as to be restored to the surface and distributed by mechanical or pumping power. In this connection the testimony of Mr. George H. West, of Greeley, Colo., relating both to west Kansas and eastern Colorado is of great value in relation to this purely American application of mechanical power in the use and distribution of water for irrigation. Mr. West says:

THE DRAINAGE SUPPLY.

In the southwest section of Kansas, south of the third standard parallel and west of the ninety-eighth meridian, embracing an area of 16,520,000 acres, it is claimed that there are fully 15,000,000 acres suitable for agricultural purposes, relying for its best results upon irrigation.

At least 90 per cent. of this land is underlaid by subterranean flows or reservoirs of water, available from wells by means of mechanical power. The application of an economical method of raising this water would produce more immediate and general benefits than any other system, making from 60 to 75 per cent. of the entire area at once reclaimable by private enterprise.

Along the Cimarron River and its tributaries are 350,000 acres of first bottom lands, with abundance of water within 20 feet of the surface; while at least 500,000 acres in the Arkansas Valley will afford an exhaustless supply of water for ordinary irrigating purposes at 10 feet. The valleys of the Beaver, White Woman, Pawnee, Walnut, and their tributaries will afford 1,000,000 more acres of land, with an ample water supply from 15 to 30 feet. Outside of the valleys sheet water is found, from 30 feet to 100 feet, with an average depth of about 60 feet; excepting limited areas, including portions of nearly every county west of the ninety-ninth meridian. Embracing nearly all of Haskell County and a narrow strip west through the counties of Grant and Stanton, and east through Gray, Ford, Kiowa, and Pratt, extends what is known as the deep-water belt, or high divide. Another such area extends west through the counties of Garfield, Finney, Kearney, and Hamilton, along the fourth standard parallel. In these belts water lies at depths generally exceeding 100 feet. Outside these narrow belts the larger portion of the entire area is underlaid by a water supply, available to a mechanical method of raising it. The water is almost universally found running through gravel beds with a uniform current towards the east. Neither coal or wood is found in this territory. Prices are governed by the length of haul and competition between lines of railroad. At Garden City the best Cañon City coal sells at the scales for $6.75 per ton, Trinidad coal $5.90, and Cañon City pea coal $4.65 per ton.

No pumping system or irrigation has been tried, and the surface streams are totally inadequate to furnish an extensive water supply for a system of canals. The Arkansas River is the only stream that can be utilized in that manner. The present demand upon it renders farming more hazardous than will justify further development in that direction without the application of a storager-eservoir system, or in tapping the water-bearing strata with underground canals—taking advantage of the universal trend eastward. Such a system will be necessary to reclaim the high divides mentioned in this report, and will call for reservoirs of enormous capacity, as those lands being uniformly unbroken, storage-basins must be made at great distances from the areas to be watered.

The underground water supply will rapidly increase instead of diminish, as the water used will largely be absorbed by the soil and percolation from above be added to the present sources. The water lost by evaporation will be replenished by the rain that will be enabled to soak into the soil, instead of wasting upon the impenetrable sod of our prairies. Kansas farming has demonstrated that breaking the sod and continued cultivation of the soil will eventually result in the complete saturation of that dry soil, which almost invariably exists from the sod to the sheet water. The almost entire absence of clay beds and other impenetrable substrata will permit of the complete saturation of the soil down to the present water-levels, making a storage-reservoir of incalculable magnitude, proportionately increased by each additional demand upon it, and capillary attraction, now almost entirely absent, will soon be established.

By determining at once the practicability of mechanical means of raising water from our wells these results can be acccomplished by private enterprise in time to benefit the classes who must need aid and encouragement, and who are utterly unable to wait upon the action of the Government in devising and executing a more elaborate system of storage and canals. A pumping system will permit of individual enterprise and general adoption at once. Any system dependent upon the construction of expensive canals, reservoirs, sub-drainage, or other methods involves unavoidable delay of governmental action, or in inducing capital to come to our relief. To demonstrate that a pumping system can be practically and economically applied will greatly reduce the area of arid lands to be reclaimed, and afford a proportionate increase of the available water for that purpose.

THE WATER-BEARING GRAVELS.

The valleys of Colorado on the eastern plateau have all been formed by denudation; the streams from the mountains have left on the bed rock deposits of sand and gravel filled with water, varying in thickness from a few inches to 64 feet at Eaton, Colo. This bed of water-bearing sand and gravel in the Cache-la-Poudre Valley extends from Greeley to the foot of Chalk Bluffs, 39 miles north and 1,220 feet higher. This increase of altitude is of value. Near the foot-hills large bowlders lie next the bed-rock, and farther east on the plains their size decreases regularly to large stones, coarse gravel and sand, all filled with water. From the surface to bed-rock the conditions are reversed, and below the soil we reach quicksand or sand, then fine gravel, coarse gravel, large stones, etc. Water is usually found on the plateau east of the mountains as soon as the gravel is reached, and back from the rivers for miles in the valleys water is usually found beneath the surface at the same level as in the surface streams. The water-bearing strata near the surface is comparatively narrow at the foot-hills, but widens out many miles as we reach the valleys, where the surface streams have less fall to the mile. Since the construction and use of irrigation ditches the amount of water in the gravel strata has greatly increased, often standing much higher than the level of water in the natural streams, and coming to the surface as seepage in lakes and ponds.

The distance from the surface to the subterranean water varies from a few feet to more than 50 feet in the valleys of the Cache-la-Poudre, South Platte, and Big Thompson Rivers and their tributaries. At Greeley, in the river valley proper, water is found from 4 to 16 feet from the surface, and the water-bearing gravel is 44 feet thick; at Eaton, 8 miles north, this water strata is 20 to 25 feet from the surface and is 64 feet in depth; at Pierce, 10 miles still farther north, this water strata is 30 feet from the surface, and continuing 20 miles again north, to the Maynard Flats, near Carr Station, water is but 8 feet from the surface, in gravel. The depth of the water-bearing strata in the latter locations have not been determined. Water is found also in gravel on Crow Creek and Little Crow Flats, 40 to 50 miles northeast from Greeley, at varying depths from 4 to 20 feet, in large quantities. At Denver bed-rock comes to within a few feet of the surface, and good results have not been obtained; but large amounts of water are found in the sands of Cherry Creek and in the valleys adjacent thereto. North from Denver, along the South Platte Valley, water is found at varying depths from 8 to 30 feet, and the water-bearing gravel is 50 feet thick at Brighton, 55 feet at Fort Lupton, 60 feet at Platteville, and 86 feet at Evans; 100 miles still east, at Sterling, Colo., water is 4 to 20 feet from the surface, in sand and gravel. The gravel there is much smaller than at other localities named, and there is more quicksand above it.

The amount of water that may be stored in a cubic foot of sand or gravel, when fully saturated, has been ascertained by careful experiment to be as follows: Fine sand 2 gallons, coarse sand 2½ gallons, sand and fine gravel 3 gallons, coarse gravel and small stones the size of hen's eggs 3.6 gallons. As a cubic foot contains 7.5 American gallons, it will be seen that very large gravel beds contain fully one-half water. Water is found in all the dry creeks and the valleys adjacent thereto in northern Colorado, east of the mountains, at varying depths from 2 to 20 feet. Actual tests have been made verifying this matter on Lone Tree, Big Crow, Little Crow, Wild Cat, Pawnee, Lewis, and Cedar Creeks north of the South Platte River, and on Cherry Creek, Sand Creek, Lost Creek, Box Elder, Kiowa, Bijou, Big Beaver, and Little Beaver south of this river. As investigation goes on the area of land known to have underground reservoirs of water at a nominal depth from the surface is largely increased.

This gravel is very coarse, in places as large as your fist. That lies together irregularly, and there are great spaces or cavities between the pieces. As we pump the tendency is to throw this stuff out and open up great channels, and then there is a rush in of water. On the Albert Howard well, which is 70 feet deep and gives 22 feet of water for irrigation, there are two pumps for the 200 acres, and the water is lowered about 11 feet in pumping twelve hours per day. That leaves 11 feet to draw on. The amount of water underneath in these gravel beds seems to be enormous. Where we have found 12 feet of water in that stratum we have not put in any pumps yet that have pumped it dry. At Platteville, about 20 miles south of here, they have 60 feet of that gravel stratum, and nearer to Denver they have 50 or 55 feet in different locations.

We have under Greeley 46 feet of gravel stratum filled with water. We have first four to six feet of surface drift or soil, and below that comes this gravel filled with water, which extends down 46 feet farther to bed-rock. On the Platte Piver, east of here, we have 84 feet of that gravel stratum filled with water. We find that in many of these dry creeks or arroyos there is water at a slight depth and also in the flats. At Crow Creek, 40 to 45 miles northeast of here, where there is only a little water in places coming to the surface, they find large quantities of water there at from 4 to 15 feet below the surface over a large area.

In twenty counties in Colorado, lying east of the base line, which runs through Pueblo, there are some 25,000,00 acres of land. Fully 20,000,000 acres of this is suitable for cultivation, and probably one-fourth of this, or 5,000,000 acres, are underlaid with an ample water supply near the surface, available for use for irrigation by mechanical power—that by lifting or pumping.

THE UNDERFLOW WATERS.

Mr. W. Tweeddale, civil engineer, of Topeka, in broaching a plan for distributing water for irrigation by means of electricity, has this to say about the rain-fall on the plains:

> In Texas, with 20 inches of rain-fall, "dry farming" is not profitable; while in Dakota, Minnesota, and Nebraska 16 inches of rain-fall gives good results. The reason for this is that in Texas the temperature is high, and the rain-fall uniformly distributed throughout the year, while in the above-named States the temperature is much lower, and there is a well-defined rainy season giving 72 per cent. of the annual rain-fall during the spring and summer, while Texas has but 50 per cent. during the same time; for which reason 15 inches in the above States will be equivalent to 20 inches in Texas, with the further difference in their favor due to much lower temperature. The relative value of rain-fall for agriculture in the different localities will appear from a comparison of the tables of rain-fall at eight selected stations in Texas, three in western Kansas, and eight in Dakota, Minnesota, and Nebraska. Of the annual rain-fall of these several stations, the amount that falls during the spring and summer is as follows: In Texas, 55 per cent.; western Kansas, 65 per cent.; Dakota, Minnesota, and Nebraska, 72 per cent.; from which it will be seen that the proportional part of rain-fall in western Kansas during the growing season is intermediate between that of Texas and the above-mentioned three States; and while that in western Kansas is but 11 per cent. less than in the above three States, the difference in effectiveness is much greater by reason of difference in temperature.
>
> In a consideration of the subject of rain-fall, it must be borne in mind that in the so-called "subarid" region there is a great liability for many seasons in a long series of years to be without sufficient rain-fall to make agriculture profitable, in which case the whole supply of water for irrigation must be procured artificially. And as it is the certainty of results alone that will justify the investment of capital in new enterprises, it follows that in any scheme for furnishing water for irrigation estimates of cost must be based on being able whenever required to furnish the whole amount of water necessary for the profitable raising of any particular crop.

In designing storage reservoirs of limited extent, account must be taken of the minimum annual and minimum periodic rain-fall. It sometimes happens that the annual rain-fall continues to be less than the general mean through cycles of three or four years. Computations based on a number of selected stations of largest observation in the United States, extending throughout the whole country, give the average annual rain-fall of the least three-years cycle, at any one of these points, as 67 per cent. of the mean annual rain-fall at the same point, and the greatest three-years low cycle as 97 per cent. of the mean annual rain-fall at the same point. Taking 16 inches as the mean annual rain-fall at Fort Dodge, the mean annual rain-fall of the low cycle will be 67 per cent. of 16, equals 10 inches. Of this amount, favorably situated gathering grounds of unbroken prairie will furnish at least 60 per cent. This will give a depth of 6 inches of water over the whole area drained for collection in a reservoir. Taking 16 inches depth of water over the area irrigated as the requirement in addition to the proportional part of 16 inches of rain-fall, and we have 16 divided by 6, equals 2⅔; *i. e.*, the water from 2⅔ acres of drainage area will furnish sufficient water to irrigate one acre of land. Doubling this amount for contingencies (as evaporation and seepage), and 5⅓ acres will suffice for one acre. On this basis the owner of a favorably-situated quarter-section of land can collect in a reservoir the required amount of water to irrigate 30 acres, which will allow 15 acres for agriculture, 15 for meadow, and 130 for grazing. The reservoir should be made deep, to prevent loss by evaporation. Should the gathering-ground be large, and owned by a number of persons, a reservoir of greater capacity might be constructed, and by purchase or exchange with each other, a unit of forty acres of irrigable land might be secured to each, with diminished cost per acre.

When, however, there is no suitable site for a reservoir, the rain-fall from the gathering-ground will run onto and be absorbed by the porous soil of the bottom lands. Pure sand, when saturated with water, will contain from 30 to 40 per cent. of its bulk, while gravel contains 25 per cent. The eminent scientist, Sterry Hunt, estimates that one square mile of sandstone 100 feet thick will contain, when saturated, water sufficient to sustain a flow of one cubic foot per minute for a period of thirteen years. Sandy soil at a certain depth is always saturated with water, which rises, after large accessions from rain, nearly to the surface of the ground, and falls again during periods of drought. In a region of sand and gravel a fall of 6 feet in the ground-water will give a discharge into the streams of from 40,000,000 to 50,000,000 cubic feet per square mile of ground. The water so held constitutes the reserve which goes to maintain the dry-weather flow of streams.

The water in the ground, like that in the streams, is in constant motion, although its rate is by comparison with that of streams very slow. The quantity of water flowing in an open channel 100 feet wide and 6 feet deep, with a fall of 1 foot per mile, is about 1,000,000,000 of gallons per day. The quantity flowing through a channel of the same dimensions and fall, filled with gravel, will not exceed 600 gallons at the same time. This extreme slowness with which the ground-water moves serves as a regulating sluice to the ground reservoir, securing it against rapid exhaustion.

From the above it is evident that the water stored in the porous soil of the bottom lands is the source of the water supply of the Arkansas River valley, rather than the flowage of the river, which in fact for a portion of the year acts as a drain to the valley rather than as a supply to the under-current. The longitudinal fall of the ground-water in the valley in western Kansas is about 7 feet per mile. The writer found by measurement that the fall of the ground-water from the Arkansas River to Cow Creek, a distance of 2 miles, near Hutchinson, was 8½ feet per mile. Observations made during the construction of water-works for cities show that in ordinary sand and gravelly soil a fall of 7 feet per mile will give a rate of motion of the ground-water of about 1 foot per hour.

ARTESIAN WELLS AND THEIR ECONOMIC VALUE.

An artesian well is one in which an artificial vertical shaft is filled to overflowing by water, which enters it at some distance below the surface of the ground. The water may spout up with force and rise higher than the surface or it may barely reach the point at which it flows over. The conditions under which this can occur are the same as those which govern the supply of water to the upper rooms of buildings in cities. The reservoir with which the water-mains are connected must be higher than the place supplied; for the same reason the stand-pipe which takes the place of a reservoir in towns located in a level country must be higher than the tops of the highest buildings. This is made necessary by a well-known principle in hydrostatics, that a fluid will not rise in an iron tube higher than its source. There are some artesian wells whose flow is due to other than hydrostatic pressure here described, viz, to gas pressure and rock pressure, but these forces need no illustration. In nature the channel through which the water flows is more like a sponge than the orifice of a pipe. It is porous rock, sandstone, conglomerate, gravel, sand, or limestone more or less cracked or broken. The walls of a natural pipe must be impermeable and usually beds of clay or clay-shale serve this purpose. To get the head of water the beds of sandstone, shale, etc., must have a dip, *i. e.*, they must be higher at one part than another. The best conditions are when the rock strata take a basin formation, highest on the edge of, circular area, and a well sunk in the middle of the basin. It is to be understood that all the waters of the land are meteoric waters, having their origin in the rains and snows. If then the rain falls on porous rock on the upturned edge of a basin, which within the basin is overlaid and underlaid with impervious clays, a well sunk at or near the middle would be artesian.

The basin form is, however, comparatively rare in nature, but continuous dip of rocks in one direction is by no means uncommon, so that the form of a trough is more often found. If the relative position of porous and impervious rocks is the same, artesian wells may be found on the slope or at the lowest point. The general dip of the geological strata on the plains is from west to east, by south, as is also the slope of the surface of the country. The conditions for finding artesian wells are thus widely distributed.

Prof. P. H. Van Diest, of Denver, Colo., who has had an almost world-wide experience as an engineer in connection with artesian waters and wells, gives some interesting data, as a basis for the consideration of the economic uses of such supplies. He says:

> I have had something to do in India with artesian borings and gathered some statistics about the amount of water which percolates the lower strata. In the Paris and London basins, by careful observation it was ascertained that a third of the water-fall on a certain extent of land gives a certain flow; that another one-third evaporates and is taken off by the plants, and that the last third percolates to the lower strata. How far that is the case here is difficult to know because there are no observations taken. That is the experience, however, in London, England, and Paris, France, where considerable artesian water has been got. Similar observations have been made in India. Batavia is now supplied with artesian waters after surveys made by me. No observations are made here, and it is difficult to say what the case is. From the very sandy condition of a great deal of the outcropping rocks in the arable regions of Colorado, a good deal must percolate to great depths. That is proven to be the case in Denver, the Denver basin having observations made in it to some extent.
>
> The conclusion is that there must be considerable water running down to the lower strata. By borings that have been made (about two hundred flowing wells having been bored) we have observed that there are three different flows. Speaking of those flows, I would say that the upper flows, to which many wells have been bored, are very limited. The lower flows take water from a greater extent of country. Much trouble has occurred in the artesian diggings by the bad construction of the tubing. There are a great many of such basins here all along the foot-hills, and it has been proven that there is much loss, as, for instance, in the San Luis Valley, where they have had flows of water to a great amount. There would be a chance to apply water for irrigation. The same is the case in the San Bernardino Valley, in California, where over two thousand artesian wells are aiding in irrigation. They are under regulations, so that during the night they must be closed off with stop-cocks. Thus there is no *unnecessary* water flowing off. There are many streams that run east from here, such as the Bijo, the Badger, and other creeks, which at their best are all running streams and have considerable water. Over distances of 20 to 30 miles they are entirely sunk and lost. The Platte Valley is increased farther down in its flow. Without seeing it directly here, the volume of water in the Platte is increasing. It

must be that the water from some of the mountains flows invisibly away, probably not at a very great depth. Perhaps at 15 or 20 feet deep there may be an impermeable layer and that it flows under the surface away. I think that that water could be made useful by pipes from a distance out, carrying the pipes to a place where the water is needed. Certainly a great deal of land could be redeemed by the percolation of water which is now lost.

SPRINGS, UNDERFLOW, AND LOST STREAMS.

In eastern New Mexico there is an extensive region of large springs, showing the existence of water under ground that comes by artesian force or otherwise to the surface. When we come to northern Texas, and to what are known as the Staked Plains and the Panhandle region of that State, there are in existence to-day a great body of wells some of which are artesian in character, but there are many that flow so near to the surface and with such force that it is evident that if these wells were sunk deeper they would have the artesian quality; they would strike that stream. It is a general belief that the water under the Staked Plains, the water from which these wells are supplied, has the character of a flowing stream. Some experiments have been made in the neighborhood of Marienfelt, Odessa, and Midland, on the Texas Pacific Railroad, which seem to indicate the correctness of that theory. The altitude lowers abruptly, and the land is of a totally different character. Beyond the westerly limit of the Staked Plains the land is all of a distinctively arid character, as arid as Nevada or Arizona. It has no precipitation exceeding 8 to 11 inches of fall per annum. But throughout northwestern Texas there is unquestionably a large underground water supply. The springs which come to the surface, the evidence of the wells upon Staked Plains and in the Panhandle region, indicate this. Indeed, the testimony all goes to show that there is supply sufficient if it could be brought to the surface to answer the purposes, by small storage, of almost that entire region.

In southern Arizona there are areas of underground supply that can be developed. The Santa Cruz River, for example, flows under ground to Maricopa, in the Gila Valley. It runs into the Gila River near that point. The Santa Cruz River rises a few miles below the southern line of the United States, in Mexico. It runs almost directly north to Tucson. Nine miles beyond Tucson it is lost under ground, and then for some 87 miles it flows under ground, until it enters the Gila and helps to swell that river. The valley of the Santa Cruz contains about 1,140,000 acres, a very large proportion of which, if there were water for it, could actually be brought under the most efficient horticultural use. It is a region admirably adapted for fruit. At the Mission of Tumacacori, and at Tubac, Calabasas, and other places, there are the remains of fruit gardens that the missionaries planted and used. In years past all the semi-tropical fruits have been growing on some farms that were maintained there against the Apaches The Santa Cruz River should be taken out, as near its source as possible, and distributed by means of high-line canals.

The land is very fertile. The river has a great drainage area at its head. It is fed by several very important small streams on both sides, and if it were taken out and placed in a new channel, and distributed over the valley, the entire region at and below Calabasas, for some 10 or 12 miles wide and 150 miles long, could be made a perfect garden. We used to fancy in years gone by, in traveling over the Cienega, north of Tucson, that we could hear the waters running under ground.

We do not know whether that was a correct inference or not. Eastward, and lying beyond the Dragoon Mountains, will be found the San Simon Valley, or plain, known in the olden days as the principal route southward of the Apaches. Water can be got in the San Simon and Sulphur Valleys anywhere at from 8 to 40 feet below the surface. All through, in this low table-land, will be found wet places—the Mexicans call them cienagas. There are a number of ranches in that valley now supplied by such waters, either from wells or tanks and ponds. The San Pedro River also, between the San Simon and the Santa Cruz, rises in Mexico, as the Santa Cruz does, and can be, by storage near its head, made of much greater service than is now the case. Upon the plateau on which Tombstone is situated they have some artesian water. There are two flowing wells at that place.

Crossing into New Mexico, over the Chiracahua Mountains and beyond the eastern foot-hills of that range, Deming is reached and the table-land around it. Water has been found there within 25 or 30 or 40 feet of the surface. It is an important railroad junction. It is so near that slight pumping brings it to the surface, and makes it valuable for the small irrigation, for fruit and gardens, that is going on in that region. From what can be learned in relation to it it would be possible to develop the whole well and under-flow water there, and create a storage system which would bring a large proportion of that mesa or bench-land under cultivation for grass and root crops as well as for fruit. Through this region and up to the lower foot-hills water can almost always be found a short distance from the surface. Most of these little valleys of that region could be reclaimed by the use of small storage.

THE DAKOTA WELLS.

In no section of the United States can there be found so many artesian wells, of as great pressure and supplying as immense a volume of water, as those flowing in North and South Dakota. They are chiefly in the valley of the James River, and are in successful operation from Yankton on the extreme southern boundary of the territory to Grafton on the north, covering a distance of nearly 500 miles. In Yankton over a dozen wells, from a depth of 550 to 600 feet, pour forth a bountiful supply of water, the increase in the number of wells not having the least effect on the flow or pressure from the underground source.

There is nothing strange in the flow of artesian wells. The principle is precisely that of a reservoir system of water works, or of the artificial fountain. By storing a supply of water in a basin at some high point and carrying it in pipes to a lower level convenient water power is obtained. Nature has constructed a vast system of underground waterworks on the same plan, the pervious strata of sand rock underlying the earth's surface at various depths serving as pipes to convey the water from a distant reservoir or source of supply.

There are now more than one hundred wells in the two Dakota States, of remarkable pressure and supply. This does not include numerous flowing wells. At Yankton various factories now utilize the force furnished by the pressure of the underground current. Wells cost from $4,000 to $6,000. The pressure varies in different localities from 30 to 180 pounds to the square inch, and the flow from 50 gallons to 4,000 gallons a minute. The Woonsocket well (South Dakota) is much larger. The water is more or less mineralized, but the constituents are such as have imparted to the water undoubted hygienic and remedial properties, analyses showing the presence of carbonates and sulphates of iron, lime, magnesia, soda, sodium, potash, etc. Artesian water is almost invariably soft, and of excellent quality for general household purposes. The temperature of the water partakes of the internal heat of the earth.

The records kept by well-borers, showing the penetration of various strata, establish the fact that the Dakota geological formation contains all the essential features which scientists state are pre-requisites to flowing wells. The water is found in coarse-grained sand rock, which has above it a confining stratum of shale, clay, or lime rock.

WHAT THE BORINGS SHOW.

Yankton.	Feet.	Grafton.	Feet.
Yellow clay	45	Black loam	3
Chalk rock	40	White clay	25
Shale	160	Blue clay	250
Hard rock	3	Hardpan	20
Shale	105	Limestone	137
Sand rock	20	Quicksand	20
Shale	37	White sand	45
Hard rock	3	Slate	3
Sand rock	15	Water-bearing rock	25
Shale	17	Red rock or shale	60
Quicksand	30	Blue shale	16
Hard sand rock	4	Pink shale	11
Shale	27	Gravel	49
Hard rock	2	Red shale	46
Coal	1	Soapstone	188
Shale	26	Sandstone	5
Sand rock	10	Granite	12
Quicksand	15	Total	915
Shale	20		
Soft sand rock	30		
Total	610		

According to Professor Chamberlin, president of the Wisconsin (Madison) State University, and other geologists, the artesian wells in the Dakotas are situated east of the one hundred and first meridian, and, with the exception of the one at Pierre, they are east of the one hundredth meridian. They occur in great numbers in the Red River Valley, making a belt through the Dakotas, with adjacent portions of Minnesota and Manitoba, and making a second nearly parallel belt running from Yankton northward to Devil's Lake.

The successful wells of the Dakotas, thus far bored, can be arranged in four groups, with reference to the geological horizons from which they derive their water supply. These are, (1) wells of little depth which do not pass through the drift; numerous in the Red River Valley; (2) those which penetrate to the Cambrian rocks, as at Grafton, N. Dak.; (3) those deriving their water supply from the middle or upper portion of the Cretaceous, illustrated by a single well in the western part of Cass County, and by several wells in the Red River Valley which pass through the drift; (4) those penetrating to the Dakota sandstone, the basal member of the Cretaceous. This group is important, and is illustrated by numerous wells ranging from Vermillion and Yankton northward to Devil's Lake. The available data concerning these are given in the following

Table of elevations, depth, pressure, etc.

Locality.	Depth.	No. of wells.	Diameter of bore.	Temperature.	Pressure (per square inch).	Elevation (surface above sea).	Surface of Dakota (above sea). °*Fah.*
	Feet.		*Inches.*	*Feet.*	*Pounds.*	*Feet.*	*Feet.*
Vermillion	350					1,150	
Yankton	610	15	6	62	32	1,196	616
Do	165				110	1,196	
Yankton vicinity		15				1,196	
Tyndall	600				122	1,418	
Mitchell	1,300					1,301	
Plankinton	1,500				140	1,528	
Kimball	1,100				95	1,788	
Chamberlain						1,363	
Letcher	600					1,300	
Woonsocket	1,300				250	1,308	
Artesian City						1,313	
Vilas						1,480	
Huron*	863		6	60	170	1,285	422
Brookings	900					1,636	
Miller	1,148		6	[illegible]	125	1,587	438
Highmore	1,552		5	68	25	1,890	338
Harold	1,300				80	1,801	
Hitchcock	965		3½—4½		186-218	1,139	
Redfield						1,300	
Frankfort						1,296	
Faulkton	1,300					1,595	
Gettysburgh	1,300					2,982	
Ashton	915		6	55	50	1,296	381
Andover	1,070		4½	61	90	1,476	406
Groton	960		5		187	1,301	341
Aberdeen	908	Many.	5$\frac{3}{16}$	60	140-160	1,300	306
Columbia	965		4⅝	60	176	1,304	339
Ipswich	1,270		6	65	70	1,530	260-300
Ellendale	1,087		4-5-6	65	125	1,453	366
Jamestown	1,476	2	6	70	95	1,400	50
Jamestown vicinity	1,321						
Devil's Lake	1,511		3½			1,470	39

Head, supply, dnd irrigation duty.

Locality.	Artesian head (above sea).	Water supply (per minute).	Areas irrigable by direct flow, allowing 4 inches for 3 miles.	Character of water.
	Feet.	*Galls.*	*Acres.*	
Vermillion		80	95	
Yankton	1,270	3,000	3,570	Slightly hard, drinkable, used in boilers.
Letcher		Large.		
Vilas				In process.
Huron	1,678	1,400	1,666	
Brookings		None.		Said to end in granite. Minnesota geological survey thinks this doubtful.
Miller	1,876	1,000	1,190	Excellent; good for all purposes.
Highmore	1,948	14	16.6	Soft and of good quality.
Pierre				In process.
Hitchcock				Used for irrigation.
Faulkton			71	Abandoned; drilling another.
Ashton	1,411	60		
Andover	1,684	300	357	
Groton	1,733			
Aberdeen	1,670	3,500	4,165	
Columbia	1,708	4,000	4,760	Soft.
Ipswich	1,692			Soft (slightly brackish).
Ellendale	1,742	600	714	Soft; not pleasant to the taste.
Jamestown	1,690	375	446	
Jamestown vicinity				Abandoned.
Devil's Lake	1,575	40	47	

One hundred gallons per minute will give 4 inches of water to 119.3 acres in three months.

*Two miles southwest is a large farm well, in depth, pressure, and volume, equal to the Huron town well, which is to be used for the irrigation of a large farm.

The wells enumerated above derive their water from the Dakota sandstone. Those at Vermillion and Yankton were begun in the Fort Benton. The remainder were begun in the Fort Pierre and pass through the Fort Benton.

The North Dakota wells not included in the classes already noted are as follows:

Location.	Depth.	Strata penetrated.	Water supply.
	Feet.		
Grafton	915	Passed through stratified rocks to granite.	1,000 gallons per minute.
Tower City	670	Fort Pierre shales to Niobrara horizon.	9½ gallons per minute; rises 33 feet.
Casselton and vicinity	317-350	Passed through the drift into Cretaceous rocks.	Brackish alkaline, copious.
Amenia and vicinity	250-279	......do	Do.
Blanchard and vicinity (six wells)	300	......do	Do.
Mayville	395	......do	Do.

All of the wells enumerated in the last table, excepting the one at Tower City, are situated in the Red River Valley, and passing through the glacial drift enter older formations.

The one at Grafton passes through the Cambrain and into the granites beneath. Water was first reached at the depth of 503 feet; 400 feet deeper and resting on granite, a second sandstone stratum was reached which contained saline water. The well was continued 12 feet into the granite, but was subsequently filled so as to receive water only from the first water-bearing strata reached.

The remainder of the wells in the Red River Valley which pass through the drift are supposed to derive their supply from the middle portion of the Cretaceous.

The thickness of the Dakota sandstone as given by F. V. Hayden at its outcrop about the Black Hills is 400 feet. At Lincoln, Nebr., as stated by Professor Hicks, it is 204 feet. Along its outcrops it is a porous sandstone sometimes passing into a conglomerate, and where it has been penetrated by borings in the Dakotas it is very friable and open in structure. Its thickness, porosity, and extent, as well as its attitude, so far as is known are all in favor of its being an abundant source of artesian water.

The formations which occur in the general region under discussion, as given by F. V. Hayden, are as follows:

Thickness of strata above the Dakota sandstone.

Name.	Character of strata.	Thickness.
		Feet.
Loup River beds	Fine loose sand, with some layers of limestone	300-400
White River group	White and light drab clays, with some cavities of sandstone and local layers of limestone.	1,000
Wind River deposits	Exposed principally in Nebraska	1,500-2,000
"Fort Union," Laramie	Sandstone with shale	2,000-10,000
Fox Hill	Gray ferruginous and yellow sandstone and arenaceous clays.	500
Fort Pierre	Dark gray plastic clays above; dark beds of very fine unctuous clay, containing much carbonaceous matter with veins and seams of gypsum, etc., below.	700
Niobrara	Lead gray calcareous marls above; light yellowish and whitish limestones below.	200
Fort Benton	Dark gray laminated clays, sometimes alternating near the upper part with layers of light gray limestone.	800
Dakota	Yellowish, reddish, and occasionally white sandstone, with alternations of various colored clays and beds of lignite.	400

The surface throughout the region occupied by the Dakotas has been greatly eroded and it is not probable that the entire series as given above anywhere exists. It is to be expected also that the strata above the Dakota sandstone may be found of variable thickness and lithological character. These considerations as well as the secondary structure of the Great Plains would have to be investigated in order to predict for any locality at what depth the water-boring strata might be reached. Some of the wells in eastern Dakota derive their water supply from middle Cretaceous. The conditions to the west of where these wells are located seem equally favorable for obtaining flowing water from this horizon. It is to be expected, however, that water derived from these strata would be less pure than from the Dakota sandstone and consequently of doubtful value for irrigation. The Laramie may also be expected to yield artesian water.

Beneath the Dakota along the western outcrops there are shales and other impervious strata belonging to the Triassic system. It is to be expected that these coarse Triassic beds will carry water, but the great depth at which they occur underneath the Great Plains probably renders their consideration as a source of water supply necessary; besides, the Triassic strata are so highly charged with easily soluble salts that water derived from them would be too alkaline and saline for irrigation or domestic use.

NOTE.—These statements were made up in the U. S. Geological Survey by various geologists, gathered from many authorities, and presented by Director John W. Powell to the United States Senate Special Committee on Irrigation as his conclusions.

WELLS IN NEBRASKA.

Record has been found of but four artesian wells, one at St. Helena, a short distance below Yankton; one at Omaha; one at Lincoln, a mineral water; and one at Brownville, in Nemaha County, in the southeastern part of the State.

That at St. Helena derives its waters from the Dakota sandstones, at a depth of 400 feet, and in reality belongs to the system of South Dakota. The flow is copious.

The wells at Omaha, 750 feet, Lincoln, 985, and Brownville, 1,001 feet, derive their water from various strata in the Coal Measures. Of these the well at Omaha affords pure, fresh water. The Lincoln well yielded fresh water (not artesian) at a depth of 100 feet; a strong brine at 244 feet, the base of the Dakota, and medicinal water at 544 feet. The last is the water used. The flow is strong. Of the Brownville well no record of its water can be found.

These statements are made on Director Powell's authority. Professor Hicks, State geologist, says:

> The artesian water of Nebraska is the best I ever saw. The belt runs somewhat west of north. That belt strikes Nebraska. In Knox County there is excellent artesian water to be found and at very moderate expense, but it is not in the belt that needs it. That artesian water is going to be of great value for power, if for nothing else. You can get a great water-power by boring into the earth. In the western region, where irrigation is most needed, the results of exploration for deep artesian waters have so far been negative.

AN ESTIMATE FROM COMPETENT AUTHORITY.

Capt. George M. Wheeler, E. C., U. S. A., retired, expressed the belief that of the reclaimable areas of this country 15 per cent. will be irrigated by artesian wells. He believes 200,000,000 acres can be reclaimed.

The following table is the result of the observations of Geologists Mudge, Hay, and St. John, and of evidence taken before the United States Senate committee:

No.	Geological horizon.	Location.	Depth.	Caliber.	Delivery per minute.	Remarks.
			Feet.	*In.*	*Galls.*	
1	Tertiary........	Edward's well, Meade Co.	155	....	36.00	Pure.
2	....do	......do	165	....	32.4	Do.
3	....do	......do	185	....	29.6	Do.
4	....do	Mart's well, Meade Co....	140	....	66.6	Do.
5	....do	Bower's well, Meade Co ..	125	....	37.3	Pure; waters rise 15-20 feet above surface. Temperature Meade Co. wells 60° F.
6	....do	Norman's well, Meade Co.	127	....	37.3	
7	....do	Cox well, Meade County..	175	....	9	Pure.
8	....do	......do	142	....	9	Do.
9-68	....do	60 other wells, Meade Co..	50-175	....	1-30	Do.
69	Tertiary ?.......	Norton, Norton County...	....	....	....	No data; may be Dakota; depends on depth.
70	....do	Hoxie, Sheridan County..	....	....	....	
71	Dakota	Smith Centre, Smith Co ..	....	....	....	No data; may be Tertiary; depends on depth.
72	....do	Great Spirit Spring, Mitchell County.	....	....	....	Natural artesian flow.
73	....do	Miltonvale, Cloud County.	....	....	....	No data as to water.
74	....do	Wa Keeney, Trego Co....	....	....	....	Do.
75	....do	Hays City, Ellis County..	....	....	....	Do.
76	....do	Great Bend, Barton Co....	344	....	6.75	Saline; well bored to 1,400 feet, but water from 344 feet; rises 30 feet above surface.
77	....do	Kinsley, Edwards County.	....	....	....	No data as to water.
78	....do	Dodge City, Ford County.	....	....	....	Do.
79	....do	Santa Fé, Haskell County	....	....	....	Do.
80	....do	Ulysses, Grant County ...	....	....	....	Do.
81	....do	Opera House, Coolidge, Hamilton County,	239	....	45	Pure; water rises 15-20 feet above surface; now choked, owing to Opera-House fire. Temperature 61° F.
82	....do	Peck's well, Coolidge, Hamilton County.	298	6	100	Pure and medicinal; water rises 15-20 feet above surface; medicinal properties slight. Temperature 61° F.
83	....do	Border's well, near Coolidge, Hamilton County.	200	....	8	Pure; water rises 15-20 feet above surface; used for irrigation. Temperature 61° F.
84	....do	Burt's well, near Coolidge, Hamilton County.	275	....	35	Do.
85	....do	Nolan's well, near Coolidge, Hamilton County.	240	....	53	Do.
86	....do	Rich's well, near Coolidge, Hamilton County.	240	....	50	Do.
87	....do	Syracuse, Hamilton Co ...	1,000	....	....	Water rose only to 96 feet below surfare.
88	....do	Ashland, Clark County ...	....	....	....	No data as to water.
89	Triassic	Richfield, Morton County.	600	....	6.3	Pure and medicinal; mineralization slight. Temperature 66° F. Dakota furnished no flow; penetrated Trias 265 feet; water from 570 feet.
90	....do	Larned, Pawnee County ..	750	....	250	Saline and medicinal; water spouts 10-15 feet high. Temperature 65° F.
91	Carboniferous ..	Russell, Russell County...	977	....	Good .	Saline; may be Triassic.
92	....do	Winfield, Cowley County.	1,200	....	..do ...	Saline; rises 6 feet above surface.

WELLS IN WESTERN TEXAS.

List of wells.

No.	Geological horizon.	Location.	Depth.	Caliber.	Delivery.	Remarks.
			Feet.	*In.*		
1	Tertiary	Carrizo Springs, Dimmit County.	175	4	Good	Pure.
2	Lower Cretaceous (probably Dakota)	Cotulla, La Salle County	1,008		do	Medicinal; jets above surface. 6 ft.; water alkaline-saline. Temperature 86° Fah.
3	do	San Antonio, Bexar Co	225		do	Pure.
4	do	San Antonio (near), Bexar County.	450		do	Pure and medicinal; could be used for medicinal purposes.
5	do	Dallas, Dallas County	750		do	Pure.
6	do	Fort Worth, Tarrant Co	350		do	Do.
7	do	Weatherford, Parker Co				No data as to water.
8	do	Canadian, Hemphill Co				
9	do	Tascosa, Oldham County				
10	do	Armstrong, Armstrong Co				
11	do	Mobeetie, Wheeler County				
12	do	Clarendon, Donley County				
13	do	Childress County				
14	do	Cottle County				
15	do	Floyd County				
16	do	Margaret, Hardeman Co				
17	do	Crosby County				
18	do	Pepper's Ranch, Kent Co.				
19	do	Haskell, Haskell County				
20	do	Anson, Jones County				
21	do	Roby, Fisher County				
22	do	Snyder, Scurry County				
23	do	Dawson County				
24	do	Trent, Taylor County				
25	do	Sweet Water, Nolan County				
26	do	Colorado, Mitchell County				
27	do	Big Springs, Howard Co				
28	do	Marienfeld, Martin Co				
29	do	Midland, Midland County				
30	do	Glasscock County				
31	do	Coke County				
32	do	San Angelo, Tom Green County.				
33	do	Centralia, Tom Green Co				
34	do	Aroya, Ward County				
35	do	Toyah, Reeves County				
36	do	Wild Horse, El Paso Co				
37	Carboniferous	Wichita Falls, Wichita County.				
38	do	Archer, Archer County				
39	do	Henrietta, Clay County				
40	do	Montague, Montague Co				
41	do	Throckmorton, Throckmorton County.				
42	do	Jacksborough, Jack Co				
43	do	Palo Pinto, Palo Pinto Co.				
44	do	do				
45	do	Albany, Shackelford Co				
46	do	Abilene, Taylor County				
47	do	Tebo, Taylor County				
48	do	Baird, Callahan County				
49	do	Eastland, Eastland Co				
50	do	Eastland County				
51	do	do				
52	do	Stephenville, Erath Co				
53	do	Comanche, Comanche Co				
54	do	Coleman, Coleman Co				
55	do	do				
56	do	Runnels, Runnels Co				
57	do	San Saba, San Saba Co				

Mr. Frank E. Roesler, of Dallas, Tex., who has devoted much time and study to questions involved in the economic uses of well-water, especially in irrigation, describes as follows the water supply by wells of the Staked Plains region:

The "underground water" is generally found at varying depth. At Marienfeld, on the eastern edge of the plain, at from 60 to 90 feet; at Germania, 10 miles west, at 45

> to 60 feet; at Midland, 20 miles west, at 35 to 50 feet; at Odessa, 40 miles west, at 30 to 60 feet; at Douro, near western edge of the plain, none. In a few localities "joint clay," a water-proof material, on which the "underground" water rests, comes close to the surface. No water was found, though this material has often been penetrated to the depth of 500 feet. A few of the surface wells are brackish and several salty, but generally the water is good. Several springs containing soda, sulphur, or gypsum water, as well as a few wet weather salt lakes, are also found on the plain. The only permanent running stream on the Staked Plain is "Running Water," in Dickens County, a bright, sparkling stream that suddenly breaks out of the ground, ripples over a pebbly bottom for a distance of 10 miles, and then mysteriously disappears, like many other streams west of the Pecos River, notably Leòn Wells, Comanche Springs, Escondido, Limpia, and Toyah Creek, or the underground river near Castle Mountain, in Crane County, which is working its way to daylight by washing away the roof covering it, occasionally causing a part of it to fall in. A similar stream exists in the northern part of Crocket County, which was not known to exist a few years ago, though a recent cave in exposed an abundant water supply 20 feet below the surface.
>
> Nearly all the wells dug or bored in the "underground" water, under the limestone, show a tendency to rise above the point where the water was first reached. In some localities a rise of 20 to 30 feet was observed, showing that the supply is under considerable pressure. Borings at Odessa have shown five separate layers or deposits of water to exist between the surface and the "joint clay" 100 feet below. Between the Staked Plain and the Pecos River is an ancient fresh-water lake basin, known as the "White Sand Hills," which is covered with numerous ponds of pure fresh water. The supply is permanent, and said to be inexhaustible. The railway wells at Monahans, in this locality, furnish an immense supply. Altitude, 2,620 feet. The wells west of this and to the Pecos draw their supply from the seepage of the Pecos River. East of the Staked Plain the water supply in wells is variable as to quantity, quality, and depth. In Howard County good water is abundant in the southern part, rather deep in the northern part, and brackish in the town of Big Spring. In Mitchell County generally good at 30 to 50 feet, sometimes strongly alkaline. Several wells bored are capable of furnishing 9,000 gallons of water per hour continuously. At a depth of 200 to 300 feet super-saturated salt brine, claimed to be chemically pure, is found in inexhaustible quantity, and a fine grade of salt is manufactured. The Colorado River carries water in its bed nearly all year round. Its water here is said to be brackish and salty. A chemical examination will have to determine whether or not the water can be used for purposes of irrigation.

THE STAKED PLAINS.

Mr. Roesler gives in this connection some data bearing on the practical use of wells:

> On the Staked Plain but very little water will be needed, but when needed is needed badly. Continuous irrigation is not required. In the history of every crop there is a critical moment in which it is determined whether or not the farmer shall have a full crop, a half crop, or a failure. A rain-fall to-day makes his crop, a rain-fall two weeks hence does him no good. One or two, or possibly three, irrigations during the year, each equaling a two-inch rain-fall, would bring him a great harvest. More than that he will hardly need. In 1888 and 1889 he made a full crop without irrigation; in 1886 and 1887 he did not get his seed back, though the rain-fall of each year, if properly distributed, would have made splendid crops.
>
> The acreage that can be irrigated from a 6-inch bored well in a dry year by using a 10-foot windmill will be about five acres, varying with the rain-fall. By the use of a suitable storage-tank the capacity of the plant may possibly be doubled, but at all events the acreage irrigated is very small compared with the cost of the outfit, which runs between $200 and $350. Five acres under irrigation by a $200 plant will cost the owner $40 per acre, and if he borrows the money, paying 10 per cent. interest, he practically pays a water rent of $4 per annum.
>
> This expense is for water alone. If the farmer plants trees and grape-vines he must have rabbit-proof fencing, which may cost him $10 per acre additional. Comparatively few new settlers will be financially able to incur such expense as is necessary for a good water plant, and if they do succeed in securing their water supply it will be at such cost per acre that very high-priced crops must be grown and successfully marketed to meet the interest on the investment to be profitable. The raising of the cereals and forage crops by irrigation will, therefore, be entirely out of the question, but if the cost of the water supply can be reduced, the growing of early vegetables, fine table grapes, early fruits, raisins, prunes, and the making of wine can be made profitable.

The estimates on a section of land near Mildland or Odessa, where the presence of water in sufficient quantity has been determined by previous tests, are given as follows:

640 acres of land, at $3 per acre	$1,920.00
704 fence posts, at 15 cents	105.60
1,408 stays 1 x 6 (704 feet of lumber)	35.00
7,200 pounds Glidden barbed wire, at 5½ cents	396.00
21,220 feet 30-inch netting, 1½ inch mesh, No. 19 wire	462.00
Freight on same	50.00
4 gates, staples, hardware	75.00
30 adobe or box houses, at $150 each	4,500.00
27,040 young fruit trees and freight, at 10 cents, for 160 acres	2,704.00
64,000 young rooted grape-vines, at 5 cents, for 160 acres	3,200.00
Office of superintendent	250.00
Salary of superintendent three years, at $720	2,160.00
Wages, five farm laborers two years of three hundred days, at $1.25 per day	3,750.00
Surveying, freights, commissions, advertising, etc	2,200.00
Farming implements, live-stock, etc	500.00
	22,307.60

The total cost of improvement per acre will be $34.85, or $22,307.60 for the section. All of the land is put in tillable condition, but only one-half is planted in trees and vines. There is a delightful uncertainty as to quantity of water obtainable, size and capacity of wells, windmills, and storage tanks required. The estimate will vary with each section of land used, The estimate on a certain section of land which the writer has in mind is as follows:

Seven dug wells, tunneled in water-bearing strata, at $1,200	$8,400
Seven 30-foot windmills, pumps, towers, etc., at $700	4,900
Ten storage tanks, at $350	3,500
Six miles of wooden flumes, etc.; 95,000 feet lumber, at $25	2,500
	19,300

An average cost of $31.10 per acre for water. Adding together the cost of the improvements, $22,307.60, and the cost of water supply, $19,300, we have a total cost of $41,607.60, or $65.01 per acre.

WELLS IN THE NORTHWEST.

At Miles City, Mont., fourteen artesian wells have been successfully bored. The depth is from 535 feet or less. The average bore is 4 inches. On the other side of the Yellowstone River a flowing well was obtained at 50 feet, the elevation being 600 feet above the river. The water in these wells is chiefly used for garden irrigation and domestic uses. At Helena the city is supplied from deep artesian wells. In the vicinity, however, artesian water has been obtained at a depth of 160 feet. It yields 200 gallons per minute, is of good, clear character, and is used for irrigation to a limited extent. At Billings a well over 1,000 feet in depth is in operation.

Artesian water has been found and utilized by wells at Oxford, Boise City, Idaho, Pasco and Roslyn in Washington, and at Warm Springs, Oregon.

WELLS IN UTAH.

This Territory furnishes some valuable evidence of the use of artesian and flowing wells in agricultural operations, but it is stated by experts that such evidence is overestimated. The wells so far found are in some one of the basins of the ancient lake of which Great Salt Lake is the present remainder. In his official report to the Senate committee, Governor Thomas said:

> The clay sediment from that lake makes the impervious cap of those subterranean reservoirs, whose rims are but slightly elevated above the villages, and the reservoirs are fed from the bases of the mountains where the surface water runs over the gravel débris between the mountains and the clay rim. The average depth of these arte-

sian wells in Salt Lake Valley is about 100 feet, in Utah Valley 200, and in Tooele about the same. In Millard County a few wells have been driven with a depth of about 200 feet and a flow of one-half to 10 gallons per minute through 1¼ inch pipe. Since no solid rock is struck in driving these wells they are very liable to clog up in a few years. The flow in Salt Lake Valley will not average 25 gallons per minute, though some wells far exceed that. A well flowing 5 gallons per minute will irrigate an acre of ground.

Utah County reported that artesian water can be had for all the land on the west side of the valley. Prof. M. E. Jones does not think that the Utah wells are of true artesian character. He said:

> In Utah it is very different. The artesian wells or basins are very large, some of them occupying, perhaps, 100 square miles; but the water is obtainable only around on the edge, and when you get out to the middle of the valley, you are so far away from the source of the supply that you will get only about half a gallon a minute, which is only enough for drinking purposes. We can not, therefore, depend on artesian wells in this vicinity for an increase of our water supply.

There are over five thousand of the small artesian or surface-flowing wells in the Territory. Certainly 20,000 acres are now irrigated by them.

WELLS IN NEVADA.

The State claims a considerable area of artesian waters. From a report made by the State board of reclamation, after a reference to the large number of mineral springs in the State, the following is quoted:

> Nevada occupies a prominent place as a mineral-spring State; both hot and cold springs are found in every county. The warm and hot springs are found mainly in connection with geological fault-lines or fractures of the strata. Can we not, from these facts, reasonably conclude that the sinking of artesian wells would not only be advisable, but that the probabilities of obtaining large streams of water therefrom are great?
>
> There were, in 1888, sixty-five wells sunk in our State, ranging in depth from 109 to 310 feet, twenty-five of which were 6 inches in diameter, averaging in flow about 20 gallons per minute.
>
> The others have a diameter of 3 and 4 inches, and vary in flow from 11¼ to 33 gallons per minute.

[From surveyor-general's report, 1887-'88.]

County.	Artesian wells—1888.			
	Number.	Depth.	Size of pipe.	Flowing capacity 24 hours.
		Feet.	*Inches.*	*Gallons.*
Churchill	2	1 .. 300 1..2,100	4	2,000
Douglas	2	1....225 1....310	3	43,200
Elko				
Esmeralda	1			
Humboldt				
Lander	25	150 to 200	6	*28,800
Lincoln				
Lyon				
Nye				
Ormsby	35	1....109 1....150 1....138	3	48,960 15,000 15,000

*Average.

Three counties, Storey, White Pine, and Washoe, have no wells to report. It is claimed that the following areas are underlaid with artesian water, which may be made available for irrigation:

County.	Valley.	Square miles.
Eureka	Diamond	500
	Grubb, Monitor, and Antelope	500
White Pine	Newark	200
Nye	Pahrimp	1,750
		2,950

That is, a total of 1,888,000 acres. The number of springs (mineral) reported in Nevada is 115. There are also a large number of nonmineralized springs, some of which are of large size. One is reported, the water from which irrigates 2,500 acres of land.

IN CALIFORNIA.

A large number of artesian and flowing wells are developed in this State, and they are extensively used in agriculture and horticulture for irrigation. The wells whose waters rise to the surface, flowing probably from the primary and secondary water beds, are very numerous in the foot-hills, central valley, and bay regions of the State. They irrigate all gardens and considerable areas of orchard. In the coast counties south of San Francisco such wells are common; their sources being everywhere accessible. In the eastern sections or rims of the San Joaquin, San Fernando, San Bernardino, and other valleys, on the Mohave Desert, and along the edge of the Colorado Desert, artesian and flowing water belts have been extensively developed. Some of them are of large extent and considerable volume. In Tulare and Kern Counties there are large districts supplied entirely by artesian water. Some of the wells are of great volume. One at Delano, Kern County, for example, is reported as capable of irrigating for alfalfa and grain some 20,000 acres. Used for fruit land, then, the duty would be nearly double.

In the San Fernando Basin, in both Los Angeles and San Bernardino Counties there are already nearly two hundred wells developed for irrigation use. They play an important part in Riverside, and its related colonies; at Chino, where 20,000 acres are irrigated by them; at Romona, Cucamonga, Temescal, Vivienda, and in fact are found in all the irrigated areas, colony lands, ranches, or small holdings.

The San Bernardino Basin is important as a well region, over five hundred being made use of for irrigation purposes. At Old Riverside* there are fifteen wells in use, flowing 300 miner's inches a second. An average flow of 20 miner's inches per second is sufficient for 1 acre.

---

*THE SAN BERNARDINO BASIN.

[From Hall's Irrigation in Southern California.]

The water supply for the pipe-line works is derived and expected to be derived from artesian wells in the San Bernardino basin, at a point three quarters of a mile south of the river bank, and about 1½ miles east of Warm Creek mouth. The ground elevation here is about 995 feet above the sea, about 115 feet above the highest point in, and 180 feet above the general elevation of the central portion of Riverside town. Here on a plat of 7½ acres, just within the recognized lower limit of the artesian basin, and near to the famous Hunt artesian-spring, seven artesian wells, each 11 inches in diameter, have been bored, six of them to depths varying from 111 to 120 feet, and one to a depth of 215 feet. Their flow ranges from 18 to 28 miner's inches to the well, and the total supply is 163 miner's inches. The work of boring other wells is in prog-

The average flow per well in this basin has been estimated at over 47 such inches, making a service of 2½ acres per well. With the careful economy of water now practiced by small storage tanks and pipe distribution it is quite certain that the area of duty may be easily doubled. The one thousand artesian wells now flowing in southern California will therefore have an irrigated service of at least 5,000 acres. A curious fact has been developed, showing the dependence on the mountain drainage of the arterial veins and basins. The seasonal ebb and flow of volume in these wells is quite regular and marked in amount. Ex-State Engineer Hall thus describes the artesian supplies of the region:

ITS RAINFALL AND ARTERIAL DRAINAGE.

It is a known fact that along the upper edge of the plain—at Highlands, near the extreme eastern end of the valley, at Etiwanda farther west, and other places, where observations have been made—the rainfall is about double that which is found on the plains but a few miles away. And so, precipitation is not here affected so much by altitude as by the presence of the wall-like mass of mountains which obstructs the movements of the clouds, and holds them until they bank up to the point of releasing their vapors.

Speaking now only of that portion of the mountains within San Bernardino County, with the exception of the region lying on the sides of San Bernardino peak and Grayback, drained respectively by Mill Creek and the Santa Ana River, and the region out of which comes Lytle Creek, all of the mountain catchment areas are such as shed their waters with remarkable promptitude. The drain slopes are exceedingly steep, oftentimes, in the main cañons even, 200 to 300 feet per mile; and on the southern face of the range, although in the cañons there is a wooded growth, those accumulations of vegetable molds and soils which are recognized as holding waters, and giving them out in the form of surface drainages, are limited in extent.

At some time, in the geological history of this country, it has been subjected to an immensely greater rainfall than it receives at present; such that enormous torrents, comparatively speaking, have come out of these mountain cañons, and piled great masses of bowlders and gravels before them. The principal streams have built veritable ridges far out into the plain in front of their cañon mouths, which slope not only forward, but sideways; and looking at the base of the mountain across the valley from south to north, one sees the profile of the plain as it rests against the mountain's base, with hills out upon which the streams come, and valleys in between. The heads of these ridges, next the cañons are, of course, composed of specially permeable detritus, which extends up into the cañons, filling the deep bed-rock cuttings with

---

ress, and it is intended to continue it until a flow exceeding 225 miner's inches is secured. The wells are located at 50-foot spaces in two diverging lines 50 to 200 feet apart. Their waters, received into a little cement basin around each well, are collected by means of small flumes into a shallow, masonry-lined, circular reservoir 30 feet in diameter, across which is an overflow weir, and over this the water drops in a thin sheet, thus becoming somewhat aerated before entering the pipe.

Summary.

Group.	No.	Diameter.	Average depth.	Flow.
		Inches.	*Feet.*	*Miner's inches.*
A	2	7	140	135
B	6	7	150	256
C	4	7	150	44
D	4	10	220	329
	16	....	....	764
Scattered	4	7	....	60
Hunt	9	7	115	130
	29	....	....	954

masses of broken matter, ranging from sand grains up to rocks of many tons weight. Into such beds a large portion of the waters of these streams sink, and percolating through the interstices, and running through the openings in the débris, find entrance into the old channels of former streams in the permeable layers under the plain, long since closed over by layers of material less permeable and which have become closely cemented. Such is the source of artesian waters which are found to rise in the bottoms of the basins throughout the country. The San Bernardino valley, or basin as we have called it, is a very well marked formation of this class. Again, the land at the foot of the great Cucamonga plain and resting against the Coast Range, which is herein called the Rincon basin, is another such formation.

Into the San Bernardino basin from the west a part of the waters of Lytle Creek find passage through gravels, which it has deposited in channels here and there at different periods in its existence, and which are more or less permeable. A large part of those of the Cajon pass stream sink farther up, and find their lodgment also in the artesian strata of this basin. From the east the Santa Ana river comes through a wide cañon, filled, no one knows how deep, with such débris; and a share of its waters contribute also by this means to the artesian supply. While the streams like City Creek, Twin Creeks, Devil's Cañon, and others, which come to the valley at its northern edge, seldom ever course beyond a few hundred yards into the plain, and there sink to the same great receptacle—the subterranean gravel-filled channels.

The artesian basin of the Rincon and Chino is fed by the sinking waters of San Antonio, Cucamonga, and other cañons which run into the upper edge of the Cucamonga plain, 10 miles or more away, and 1,000 feet higher. While the uprising of waters in the neighborhood of Pomona is but their liberation from some old channels and beds of San Antonio Creek on their way down under the plain towards the Rincon.

The arterial drainage of this whole country is one everywhere complicated by the artesian feature thus outlined. The Santa Ana River sinks and rises, and sinks again rapidly in its course, and receives tributaries under ground, so that it would be difficult to identify waters rising below with those which have sunk at any specified locality above. It is the main drainage way of all this country, however, and the entire arterial drainage output of the great San Bernardino Valley, speaking now of the whole region which has just been described, and not of San Bernardino basin alone, is probably by way of the Santa Ana Cañon above or beneath its sands, through the Coast Range.

IN SAN DIEGO COUNTY.

The Upper San Jacinto Valley, in San Diego County, is the only basin explored. The limits of the artesian belt have been well defined by borings, and comprise about 10,000 acres. There are now one hundred and nine flowing wells, and as yet the flow [illegible] existing wells has been slightly, if at all, affected by the new ones:

The characteristics of all the artesian basins of southern California are here reproduced. The water-bearing strata are six or more in number, and lie at a depth of from 12 to 500 feet below the surface. They are not uniformly distributed over the area of the belt; that is to say, they apparently follow old river channels, whose courses are not clearly traced out, and there is a measure of uncertainty in boring a well as to which of the water-bearing strata will be encountered. The generality of the wells bored are about 200 feet in depth. Some of them have the strong flow of 20 to 50 miner's inches. The head of pressure forces the water to heights varying from 5 to 18 feet from the surface, and it is customary to control the flow by extending the casing or pipe a short distance higher than the water will rise, and tap it again when the water is required by a valve on the side near the surface, a convenient arrangement. Attempts have been made to strike flowing water on the Lower San Jacinto plains, at various places, without success.

IN COLORADO.

A very marked artesian basin is that of which Denver is the center. There are about four hundred wells within its limits, of which about sixty are returned as used in irrigation service. The area under them is unreported at present, but it is known to be of considerable extent. Other development is in progress in the State.

IN WYOMING.

On Laramie Plains, artesian water has been struck. Some thirty wells are developed. There are other developments under way and great hopes are entertained of the future economic value of artesian water in this State.

No such development has yet been had in New Mexico and Arizona, yet the indications are excellent.

THE USE OF WELL WATERS.

Prof. George E. Culver, of the State University, Vermillion, S. Dak., who serves the United States artesian well investigation as its Dakota geologist, has made some calculations of value in relation to the use of water in irrigation, which are given here:

One inch of rainfall gives 860 barrels to the acre.
One inch of rainfall gives 550,400 barrels to the section.
One inch of rainfall gives 19,814,000 barrels to the township.

The average rainfall of the Missouri valley is about 20 inches, probably a little more in the region under discussion. Multiplying the number in the above table by 20, we have the following results:

Twenty inches of rainfall gives 17,200 barrels to the acre.
Twenty inches of rainfall gives 1,100,800 barrels to the section.
Twenty inches of rainfall gives 39,628,800 barrels to the township.

Suppose it is desirable to double this amount by means of wells, and suppose a well flowing 100 barrels a minute be taken as a standard. Such a well furnishes:

One hundred barrels a minute, 6,000 barrels an hour, 144,000 barrels per day, 52,560,000 barrels per year.

Making the division, we find that it would require seven such wells in each township, provided that all the water is used in the township, none escaping to the lower levels. It is not probable that this latter would be true. Nor is it believed that it would be necessary to double the present rainfall. One-half that amount under control would be ample.

Director Powell, of the U. S. Geological Survey, presented to the Senate Committee on Irrigation, in offering data as to wells already quoted, the following views:

ECONOMIC LIMITATION ACCORDING TO DIRECTOR POWELL.

Artesian reservoirs can never furnish waters for agriculture on a scale of sufficient magnitude to be considered as an important source of supply. The amount of waters which porous rocks will supply is always very insignificant compared with the amount necessary for irrigating any great tract of land. More than half the agriculture of the world is dependent on irrigation. Of this, a very insignificant amount depends on artesian wells. There are wells here and there in Europe, Asia, Africa, and America, and in some of the great islands, but altogether they furnish a very small amount of water for agriculture. If all the artesian wells used for irrigation in the world were assembled in Dakota they would not irrigate a county of land. But there are other serious reasons why the attention of the people of the great plains should not be directed too confidently to this resource. It is the experience with artesian wells everywhere throughout the world that if too many are bored in any basin all are destroyed thereby. In the northern Illinois district, it was hoped that the great city of Chicago could be supplied with water for domestic purposes by artesian wells, but experimentation proved that, while a few good wells could be secured, a great number was impossible; that the supply of water would be absolutely inadequate for the wants of the city; and so the authorities were compelled to resort to the lake for their supply. Now, to irrigate the site of the city of Chicago would take more water than to supply it for domestic purposes; so that the artesian wells of that district would be entirely inadequate to irrigate an area as large as the city, or perhaps one-fifth or even one-tenth of the area. Some years ago it was pointed out that the city of Denver and the region round about was the site of an artesian basin. The first well site proved to be very valuable, and the desire to secure water for domestic purposes therefrom led to their multiplication. More than three hundred have now been bored, and gradually with the progress of the boring the collapse of the wells has resulted, and now all the wells have to pumped; there is little or no flowing water from them. These instances might be multiplied all over the world, and the experience of mankind entirely testifies that it would be unwise to encourage the people of any district of country to depend upon artesian waters for irrigation on any large scale for farming. Waters for domestic purposes, for irrigating gardens, and for supplying stock ranches may thus be obtained in many regions, and the supply of water that can thus be furnished is of value; but when considered as a source for agriculture, for the cultivation of fields and large tracts of country, it will always be inadequate; and it is unwise to encourage any people to engage in agriculture on a large scale and depend on irrigation from artesian wells.

For the district of which I am now speaking, extending from the British to the Mexican line in a broad belt across the plains on both sides of the hundredth meridian, the people will ultimately be compelled to depend upon another source of supply, and one so important that in comparison therewith the artesian supply sinks into insignificance and seems hardly to be worthy the mention. I refer to the use of the storm waters. One-third of the agriculture carried on by irrigation throughout the world is prosecuted by the storage and use of storm waters, and the experience of mankind in this respect is replete with lessons that can not be neglected. The region to which this is especially applicable is the subhumid region. It differs from what I have called the arid region in that it generally has a greater rain-fall, distributed more evenly over the country, as it is not interrupted by great mountains where the precipitation is concentrated, having from 15 to 22 inches of rain-fall in the average year; sometimes more, sometimes less. There are many years when agriculture is prosperous without irrigation; there are others when it fails without an artificial supply of water. Gradually with the progress of agricultural development it is possible to cover the country with storage basins, or tanks as they are usually termed, in which water may be held to be used in seasons of drought. By this means the farmers may be able to tide over the dry years, and farming may be made prosperous and highly remunerative thereby from year to year. It is in this direction that the attention of the people of that region should be turned. There is another source of water for that country of far greater importance than that of artesian fountains, but far less than that of the storm waters. I refer to sand reservoirs along the channels of the streams, especially of the great rivers. In that region of country the stream valleys are often great beds of sand, into which sinks the water which comes from the distant mountains, and into which sink the storm waters that come from the adjacent hills. Experience in other countries shows that this source of supply is worthy of consideration, and the experiments now in progress in the Arkansas Valley give indications of like character.

REASON FOR AN INQUIRY.

The need is imperative and the investigation one that should be carried on even if appropriations are not made for the full topographical-geological surveys alleged to be so absolutely necessary. There is an immense area under cultivation in the arid sections of the world, the waters for fructifying which are drawn from wells and painfully distributed by the most primitive use of man and animal power. It has been estimated that in British India alone 20,000 wells are used for agricultural irrigation. An estimate has been made that the areas so watered support at least twenty million persons. Ceylon, Japan, China, Persia, all settled portions of Central Asia, the entire plateau region of Arabia (in which there is not a single surface stream and on which several millions live, in comparative prosperity for an Asiatic people), Syria, large portions of northern Africa, from Egypt to Morocco, are all largely irrigated by water supplies drawn from wells. It is a subject that has never been investigated, but even a cursory examination will satisfy an inquirer that at least fifty million persons are supported from agriculture carried on by means of the use of wells in irrigation.

It is quite certain that there is no occasion to dogmatize in advance of systematic examination for or against the economic value in arid agriculture of wells and underflow waters, artesian or otherwise.

THE STORAGE OF WATER.

The engineering questions involved in the distribution of the waters "in sight," in the preparation for and process of storing and impounding of the high altitude supplies—snow, storm, and torrential—now largely lost in the ground, and in the subsequent distribution are not so involved and "scientific" in character that the "plain" people may not understand them when properly informed.

In regard to high altitude work it must be borne in mind that what we now really know of the precipitation over the whole of this region relates more to the valleys and the table-land than to any other part. All meteorological or weather service reports have been simply for the purposes of local trade and traffic. We have had no system of observations of a definite and distinct character in regard to the mountain ranges. The rain chart presented in the last census by Mr. Gannet, and which has been improved by later observations, shows the only record that of rain-fall definitely from the ninety-eighth degree to the Pacific Ocean will range from 3½ inches at certain points, as at Yuma and on the Colorado Desert, or going from the east to the west, from 20 inches down to 8 and 9 in the basin, and up again to 18 and 20 or 24 on the Pacific coast. It is known as a matter of fact, though not as a recorded series of observations, that the rain-fall and snow precipitation on the mountains is from 30 to 60 inches in excess of what it is in the valleys below. The average snow-fall on the Sierras will be from 60 to 70 feet of loose snow, giving us on the basis of 11 inches of snow to 1 of water from 5 to 6 cubic feet of water. All, or nearly all, of this water runs to waste. At least 40 per cent. of it passes away in evaporation, and the remainder into the ground. Probably the largest portion disappears below.

The United States Irrigation Survey reports up to the close of 1889 the storage capacity of reservoir sites so far surveyed to be as follows:

Locality.	Capacity.	Delivery.
	Acre-feet.	*Acre-feet.*
Colorado	228,200	334,200
California	445,000	55,000
Idaho and western Wyoming	1,500,000	3,220,000
Montana	715,500	2,165,500
Utah	62,800	56,300
Total	2,951,500	5,831,000

From the statement made before the Senate committee by the Director of the Geological Survey of the total amount of lands "selected" as irrigable in the following States and Territories, the following figures (in acres) are given:

Montana	11,500,000	
Idaho	10,900,000	
Utah	2,200,000	
		24,600,000
"Segregated" as irrigable:		
California	1,800,000	
New Mexico, on the Rio Grande and Rio Grande Valley	5,200,000	
		7,000,000
Total		31,600,000

FOREST TREES AND THEIR CONSERVATION.

The subject of forestry is a part of the investigation of the question of the irrigation of the arid region and its importance can not be overrated. for "it is the discovery of a new continent, by knowledge, skill, science, and art." Possessing 75,000,000 acres of forests, little or no attention has been paid to the subject until very lately, and that only tentatively, by Congress. Our forests are wasted by fire and neglect, which by a judicious and economical management could be conserved and increased, and by their conservation and increase humidity will follow with new areas of rain. Trees act as a protection from the dry winds, and when planted and cultivated in narrow belts of timber shelter the crop from the wind-break and lower the rate of evaporation.

The following table, condensed from the report of Mr. B. E. Fernow, chief of forestry division in the Department of Agriculture, approximates the ratio of mountain land and plains and gives the forest area:

Rocky Mountain region.

	Area.	Mountain.	Plains.	Total forest.	Mountain forest.
	Sq. miles.	*Sq. miles.*	*Sq. miles.*	*Sq. miles.*	*Sq. miles.*
Montana	145,776	54,776	91,000	26,285	24,810
Colorado	100,200	61,129	39,070	16,625	15,400
Wyoming	100,366	78,466	21,900	12,060	11,580
New Mexico	122,500	75,510	46,990	12,500	8,285
	468,842	269,881	198,960	67,470	60,075

SUMMARY.

	Square miles.	Acres.
Total mountain forest	60,075	38,448,000
Total forest	67,470 198,960 269,881 468,842	43,180,800 127,334,406 172,723,840 300,058,850

Mountain forests equal 22.23 per cent. of mountain area.

Mountain forests equal 92 per cent. of total forest.

Little has been done in forestry planting. From the same report of the chief of the forestry division the following condensed statement shows the number of entries under the timber-culture:

Total number of acres entered from 1873 to 1888, inclusive	38,958,558.45
Total number of acres entered from 1873 to 1888, inclusive, final proof and entry could have been made in 1888 or earlier	9,346,661.03
Total number of acres on which final proof was made, or 8 per cent. of possible number	784,037.23
Total number of acres planted	784,037÷16=49,002
Total number of trees declared to have been planted and cultivated	38,076,350

or less than one tree for each acre entered for timber culture.

The valuable report of B. E. Fernow, chief of forestry division of the Department of Agriculture, bristles with facts upon this most important subject, the handmaid of practical irrigation.

The intimate relation of the forests to the water supply necessary for irrigation will soon force itself upon the consideration of those living in the Rocky Mountain region, and it is well set forth in a recent statement of Mr. Nettleton, State engineer of Colorado, who says:

> It is estimated that 60 inches of water fall annually on the eastern slope of the Rocky Mountains in the form of snow and rain; 80 per cent. of this falls during the winter and spring months. That which falls late in the autumn and early in winter is most available for irrigation, as it becomes solid, almost like ice, and melts slowly under the summer's sun, affording a steady flow through the irrigating season. Snows falling in late spring melt rapidly, and the waters run down the rivers unused. Although about fifty mountain peaks in Colorado reach an elevation of over 14,000 feet, yet the snow nearly all disappears every season, small quantities only remaining in

small patches here and there. On this account there are at present no glaciers in the Rocky Mountains. The cold mountains condense the moisture in the country adjacent, thereby robbing the plains of their quota of moisture.

Hence the necessity for irrigation. It is quite easy to foretell the probable amount of water for irrigation purposes for the coming season by watching the amount of snow-fall in the mountains.

Farmers living from 20 to 30 miles from the mountains, or where they can watch the snow-fall on the main range of the mountains, have learned to gauge their crops by the time the snow falls and the quantity. If the snow falls early, they expect water for late crops. If the snow falls principally in the spring months, they fear short water in summer and fall, and plant or sow accordingly.

There can be no doubt about the influence that cutting or burning the timber on the mountains has on the flow of our streams. They will on this account become more intermittent in their flow, which is a drawback to the irrigation interests of the State. The preservation of the mountain forests should be encouraged.

To sum up simply, then; the questions concerned and issues involved in the reclamation of our arid West, may be stated in the following propositions:

First. The use of the rain-fall in what are properly known as rain belts, by the most effective methods of cultivation, and the selection of suitable plants, especially those with long tap roots.

Second. The exhaustion of the supply furnished by rivers and creeks in their passage through the drains, by means of irrigation works, such as are already in extensive use. Most of our streams can be used up to the full amount of their annual discharge.

Third. The enlargement of the existing supply by the storage at higher elevations of water which passes away in spring floods. The building of numerous catch-basins throughout the plains to save the rain-fall which is wasted, so far as the lands near by are concerned, will add greatly in the supply furnished by running streams. There are natural depressions everywhere which can be utilized at very slight cost, and with entire immunity from risks of dangerous floods. Congress has already surveys to ascertain the most available sites and methods for accomplishing this plan.

Fourth. The sinking of galleries or tunnels below the surface of streams, even when they are practically dry, and utilizing by canals the underground currents. Pure filtered water at Cheyenne, Wyo., for the supply of the city, without pumping or much expense, is so furnished from a small stream nearly dry in summer. The utilization of surface water does not exhaust the supply for irrigation. The application involves waste. The fugitive waters sinking into the ground pass into the depressions which make the water-ways, and gradually swell the scanty streams at lower levels, or course their way toward the sea through the sands below the river beds. Thus a part of the water of irrigation canals is gathered a second time to do the work of irrigation.

Fifth. By the use of stationary pumps of sufficient power, in lifting such underground currents to the surface from bed-rock, for application to surrounding lands.

Sixth. By artesian wells, which have hitherto proved too expensive for use in irrigation.

To these six may be added the small storage or farm tank system, which can be effectually utilized on our plains region.

IRRIGATION CONSTRUCTION.

ITS PLANS, PROJECTS, SYSTEMS, WORKS, FORMS, CONTRACTS, AND MANAGEMENT, PRESENT AND PROSPECTIVE.

PART III.

PROJECT FOR A DAM ON SALT RIVER, ARIZONA.

Mr. Wm. M. Breckenridge, county surveyor of Maricopa, presented a plan to the Senate Committee. He said the location settled on is at the mouth of Tonto Creek, a little above the mouth of Mazatzan Cañon. Mazatzal range cuts through the Upper Salt River. It makes a big cañon, with mountains on each side 1,500 feet high. The slope is one to one; that is, perpendicular for 100 feet. The water is thrown back eastward 16 miles on the Salt River, where it boxes again in the Sierra Ancha. For the first 2 miles from the mouth of Tonto Creek, point of construction already suggested, the average width is 2,640 feet, and the average depth would be 180 feet, calling the proposed dam 280 feet high. The next 2½ miles opens out into a valley, the average width being 2 miles and depth 140 feet. The river then narrows up at Steamboat Rock, 4½ miles above, so that it is only a quarter of a mile wide, with an average anticipated depth of 130 feet. Then above the Steamboat Rock passage for the next 10½ miles the average width is 2 miles, and the average depth will be 70 feet. Tonto Creek, with a width of 1¼ miles, could be made to obtain an average depth of 80 feet. There is ample space at a box cañon coming in from the south, where a waste-weir could be built, so that the river, when it arrived at a certain height, might run over that and not into the dam. By it, enough water can be stored to reclaim all the desert mesa land lying north of the Gila River between Phœnix and the Colorado River at Yuma. Sufficient quantities of water annually flow through the Salt River to fill this reservoir several times. It is our belief also that, by the selection of suitable reservoir sites along the Gila, water enough can be stored to reclaim all the lands south thereof in this county. The Agua Fria, where it enters the Salt River Valley, in the dryest season carries a stream of several thousand inches of water. If properly utilized there is sufficient in this river to irrigate all the land, some 75,000 acres, lying between it and Cave Creek, and by a reservoir the land could be made available.

THE PROPOSED PANTANO RESERVOIRS.

Engineer F. W. Oury, of Tucson, Ariz., outlines an extensive project for dams, reservoir, and diverting, at a point on the Southern Pacific Railroad, a few miles from Tucson. He says:

Location.—The sites for the proposed dams are located on the water-course commonly known as the Pantano Wash. Dam No. 1 is situated at the junction of the Cienega and Davidson's Cañon, about 23 miles southeast of the city of Tucson, where still stand the ruins of the Cienega station on the old overland stage route. About 5 miles down the cañon, where the Southern Pacific Railroad track leaves the edge of the wash to go onto the mesa, is the site for Dam No. 2. Dam No. 3 is still farther down, about 2 miles from the preceding one.

Water supply.—Water runs throughout the year as far down as Dam No. 2, but in such small quantities as not to be a very important factor as a source of supply. Hence, it must depend on the freshets which come along this water-course, caused by the rain-fall over the country which it drains and which occur during the rainy seasons, summer and winter.

Drainage.—The Pantano Wash rises in a range of low mountains about 50 miles southeast of Tucson, known as the "Canelas," and runs, with innumerable bends and crooks, in a northwesterly direction, until it empties, near Fort Lowell, into the Rillito Creek; thence westerly until it reaches the Santa Cruz River. It thus drains a portion of all the mountains in eastern and southeastern Pima County, with the exception of the Patagonias. We shall refer, however, only to that portion of the water-shed, the water from which flows into the Pantano Wash above the points selected as sites for dams.

Reservoir sites.—In examining the San Pedro Valley there are but two points where reservoirs can be built to an advantage:

First. On the lower portion of the valley, at a point where the foot-hills come close together, with solid rock upon each side and bottom. This is known as the Nigger Ben place, and is about 15 miles below or north of the town of Benson, where a dam 350 feet in length and 40 feet high will overflow an area of a mile square and average 10 feet deep, or a storage capacity of 278,784,000 cubic feet. The area of bottom-land and low table-land that could be irrigated by the construction of this dam would be in Cochise County over 3,000.

The second reservoir site on the valley, 1¼ miles above Charleston, and 26 miles above Benson, where the foot-hills come down to the river forming solid rock banks for over a hundred feet high, where a dam 60 feet in height and 400 feet long would store over 300,000,000 cubic feet of water.

There are several places along this valley where there are broad stretches of almost level bottom-lands where under-ground dams (that is, trenches at right angles to the valley cut to bed-rock or clay and filled with concrete) could be placed, that would raise the under-ground current to such a point that thousands of acres could be brought under cultivation without irrigation and save the expense of ditches and the great loss by evaporation.

A cursory glance at the eroded condition of the banks of the San Pedro will convince a person at once that vast bodies of water run down this cañon. Great dykes of hard rock have literally been cut through by the water, large cotton-wood trees have been uprooted and carried down the stream, railroad ties, bridge timbers, iron bolts, and even steel rails are to be found miles away from where they were originally placed. So great was the damage done to the track of the Southern Pacific Railroad yearly that the company had, for the sake of economy, at great expense, to elevate its road beyond the reach of the waters from this wash. At a point where the cañon is over 200 feet wide water marks from a recent freshet still remain which are 20 feet above the lowest point of the channel. These are conclusive proofs of the fact that enormous quantities of waters flow to waste annually, whereas if it could be properly stored in a system of reservoirs it would be sufficient to irrigate thousands of acres of land which are now worthless, and which would forever remain so unless reclaimed by the waters from this cañon, because the topography of the country would not permit its being brought from any other stream or wash.

Dams.—*No.* 1.—At this point a large dyke of hard volcanic rock crops out on the left bank, continues on the surface until it reaches the bed of the creek, then sinks beneath the sandy bottom, to appear again on the right bank of the main channel. At the extreme right end of the dam is also to be found solid rock, so that this dam, if constructed, would have three natural and solid abutments upon which to rest, namely, one on each end and one in the middle. Besides, the indications are such that bed-rock can not be far distant from the surface of the sand. Therefore at this point a very strong dam could easily be built and, as we shall see afterwards, at a comparatively moderate cost.

The total length of this dam is 1,052 feet, and its greatest height is 67.5 feet. Its heights at different points are as follows: Commencing from the left, the first 200 feet in length would average 20 feet, the following 50 feet would be about 45 feet high, the next 200 feet, being the main channel of the wash, would reach a height of 67 feet, while the remaining 600 feet would average no more than 35 feet.

In addition to the main dam, a small one would have to be built. Its length is 150 feet, and its average height through that distance would be about 6 feet.

Above the site of Dam No. 1, along the Cienega Cañon and for a short distance up Davidson's Cañon, the waters have worn through the sediment which they had previously deposited, which averages 150 feet in width and 15 feet in depth. The fall of the Cienega Cañon in this locality is about 40 feet per mile; that of Davidson's Cañon about 50 feet per mile. The dam, then, being only about 34 feet above the broad basin of the cañons, would back the water along the Cienega Cañon for about 4,400 feet, and up the Davidson Cañon for about 3,700 feet. The basin of the former cañon averages about 2,000 feet in width; that of the latter about 800 feet. Hence, to speak generally, this dam would create two rectangular sheets of water, one 4,400 by 2,000, and the other 3,700 by 800, or, more accurately, as found by survey, the water would cover in the Cienega an area of 9,160,073 square feet, or 210.3 acres to an average depth of 26.47 feet, taking into account the deep channel already spoken of. In the Davidson Cañon a lake would be formed containing an area of 2,784,340 square feet—63.92 acres—having an average depth of 20.50 feet.

Therefore the capacity of this reservoir would be equal to 299,580,795 cubic feet, or 2,241,019,947 gallons; in other words, it would take a ditch with an average width of 8 feet and an average depth of 2 feet, running at the average velocity of 35.6 feet per minute, 365 days to empty the contents of this reservoir, it having been once filled and no more water coming into it during the time that it is being emptied. Again, this amount of water, if spread out over a level plain, would cover 82,529 acres, or 515 one quarter sections, 1 inch deep. It has been mentioned that the waters have deposited sediment in the basins of both the Cienega and Davidson's Cañon; in fact, the soil in these basins is nothing more than this sedimentary deposit.

Dam No. 2.—This dam, too, would have solid abutments upon which to rest, and although bed-rock is not seen upon the surface in the bed of the stream it is evident that it is only covered by the sand. The span, besides, being so short, this dam could be made not only the strongest, but the least expensive. It will be seen from the diagrams that its total length is 418 feet and its greatest height is 43.43 feet, and as the banks on both sides are so steep, the dam will average a height of 40 feet through its entire length. The fall of the wash at this point is something more than 40 feet per mile; hence, the dam would back the water up stream not quite 1 mile. The basin also is comparatively narrow and therefore would not make a very large reservoir. According to surveys the water would cover an area of 2,923,658 square feet, or 67.12 acres, to an average depth of 22.37 feet. Therefore its capacity would be 65,391,298 cubic feet, or only about one-fourth as much water as that caught by Dam No. 1. This is a small quantity of water, but it will be seen hereafter how this dam is an indispensable accompaniment to the success of the large dam, No. 3.

Dam No. 3.—The banks of the Pautano Wash after leaving the point for Dam No. 2 are of a gravelly nature, more or less strongly cemented together. At places where the current of the main channel cuts into the sides a hard conglomerate, somewhat of the nature of "caliche," is exposed. At no point, however, do we find croppings of solid rock. Dam No. 3 would not have the natural rock supports of dams Nos. 1 and 2. It is doubtful, too, whether bed-rock would be reached in the construction of this dam; hence we can anticipate a loss by seepage underground. However, if a puddle wall of clay or some other good material were built through the sand until it reaches the conglomerate to which reference has been made, and which is quite impermeable to water, this loss could be, if not altogether stopped, at least very greatly diminished. The red sandy clay from which the Indians make their "ollas" and which abounds in the mesas in the vicinity, would be a most excellent material with which to build such a puddle wall.

The total length of this dam is 2,640 feet, or exactly one-half mile, and its greatest height is 73.96 feet. For 600 feet it would have an average height of about 50 feet, and for the remaining distance its height would average nearly 70 feet. It would back the water up the cañon a distance of 7,500 feet, the average width of the basin being about 3,000 feet. As found by our surveys, this reservoir would extend over an area of 22,400,017 square feet, or 514.23 acres, having an average depth of 33.53 feet; that is, it would contain 752,169,384.8 cubic feet of water. It will be noted that this amount is over twice as much as that which the other two reservoirs would hold. It would take one year to discharge this amount of water through a ditch 12 feet wide by 4 feet deep and running at a velocity of 29.42 feet per minute; or if this quantity of water were spread 6 inches deep over a level plain it would cover 34,484.26 acres, or 53.88 square miles; that is to say, it would flood a strip of level land 25 miles long by 2⅛ miles wide, 6 inches deep.

IN YUMA COUNTY, ARIZONA.

The most available site for a dam 100 feet in height is at a point on the river about half a mile above the South Gila Canal Company's head-gate. Solid bluffs of dolomite (limestone) 111 to 125 feet above the present water-level and distant 1,595 feet from each other are found at this point. The width of 1,595 feet given is the distance between the bluffs at the 100-foot flow-line, or proposed top of dam. The storage capacity of the cañon extending about 1¼ miles up the river from the dam to Oatman

Flat is comparatively small, for the average width on the 100-foot flow-line is but one-half a mile, with steep bluffs on either side.

Above this one-half mile point the bottoms widen out to an average width of 1½ miles for 3 miles, forming what is called Oatman Flat, with an area of 4.7 square miles on the 100-foot contour. At the head of Oatman Flat the bottoms narrow to about three-quarters of a mile, and then widen out and form Cottonwood Flat, the main storage basin, with a length of 8 miles and a width of 4½ miles, with an area of 35.2 square miles. About 2 miles above the head of Cottonwood Flat, at Rock Islands, the bottom narrows to a width of about 2,000 feet, including an island 500 feet wide, and above this point they again widen to 3 miles. The length of this basin will be 8½ miles, with an area of 8½ square miles.

The depth of the water at the lower Rock Island will be 40 feet. The average fall in the river from this point to the dam, some 14 miles by the river channel, is 4.3 feet per mile. The river has a much greater grade above the Rock Islands.

The distance from the islands to Gila Bend is about 20 miles. The total area of the three basins is as follows:

	Square miles.
Oatman Flat	4.7
Cottonwood Flat	35.2
Gila Bend Flat	8.5
Total flowage (with 100-foot dam)	48.4

As there will be considerable evaporation from a body of water in this hot summer climate, estimated at half an inch a day for six months, equal to 7½ feet, I assume the average available depth to be 35 feet, which with an area of 48.4 square miles will store 47,227,009,600 cubic feet. This will give a daily supply for six months of 262,372,200 cubic feet, equal to 151,835 miners' inches of the California standard.

The proposed storage reservoir is situated on the Gila River about 100 miles northeast of the town of Yuma and a few miles east of the boundary line of the county. At this point the river is subject to heavy floods that will insure the filling of the reservoir every winter and spring, the heavy flow lasting until the 1st of May.

About the 1st of June the works would be called upon to make good the diminishing supply in the Gila. This draft would be at its maximum in July and August. The evaporation in this climate is very great, but the engineer has allowed amply for the losses thereby incurred. The depth of evaporation in inches averaged for every month in the year, as shown by the Signal Service records at Yuma, is as follows:

	Inches.		Inches.
January	4.4	August	10.2
February	5.2	September	8.2
March	6.6	October	8.2
April	9.6	November	5.5
May	9.6	December	4.6
June	12.6		
July	11.0	Total	95.7

The rain-fall is practically insignificant. The monthly fall in inches, averaged for eleven years, is given herewith:

	Inches.		Inches.
January	0.403	August	0.496
February	0.532	September	0.060
March	0.217	October	0.124
April	0.120	November	0.180
May	0.062	December	0.403
June	Inappreciable		
July	0.155	Total	2.752

The drainage basin supplying the river is known to be enormous and its service constant during certain months. At the lowest rate of calculation in use in California—1 inch to 4 acres—the amount of water stored would suffice to irrigate over 600,000 acres. Rock suitable for the construction of a masonry dam is found in unlimited quantities adjacent to the proposed site. Elsewhere we have endeavored to show that large and constant water supplies are imperatively needed. While it is true that the several canals along the Gila cover considerable areas, it is also true that the Oatman Cañon reservoir will bring very much larger tracts under control, and, therefore, an increased population, much larger property valuation, vastly augmented agricultural output, and consequently greater prosperity. With storage works of the described capacity a permanent summer supply of water could be relied upon to thoroughly irrigate most of the accessible arable land in southern Yuma County lying below the reservoir, and thus remove the present cause of non-development of this fertile section. It has been explained that about 25 per cent. of the valley land is overflowed by the river during certain regular periods. The establishment of such works would also reclaim the bottoms by storing the surplus water that would otherwise, at such seasons, flood the surface, and do great injury.

CONCLUSION.—With this report a topographical map, drawn by Mr. Lewis A. Hicks, C. E., is submitted, showing the entire lower Gila Valley from Oatman Cañon westward to the Colorado River, and also all the lands between the Gila River and the Sonora frontier. Two lines are drawn, the first indicating the extent of the area that would be capable of producing at least one crop of cereals or forage each year, supposing the dam to contain 25 feet of water. This second line shows the limit of the fruit belt, but the area between these two lines will be valuable for the raising of all forage plants, sugar-beets, etc. Below their junction all the land shown will be available. The varied topographical features are faithfully and intelligently delineated and will greatly assist in a correct understanding of the subject treated in these pages.

The vast importance of the inquiries set in motion by the Senatorial committee, and their direct bearing upon our own surroundings, are fully understood by the people of Yuma County, who highly appreciate the opportunity of placing before their distinguished visitors such data concerning the quantity and quality of the lands, the necessity and future possibilities of irrigation, the number and extent of canals, the rivers and water supply, the climate and its influence upon the early maturity of crops, the products, the transportation facilities, and finally, the need of water-storage reservoirs and selection of appropriate sites as, it is hoped, may meet their purposes. If this has been accomplished, the citizens' executive committee will consider their duty as satisfactorily performed.

That the western portion of valley or bottom lands of the Colorado River, properly irrigated, can be made one of the finest farming sections of the United States is no longer a question among those who have investigated the subject.

In the Annual Report of Indian Affairs in Arizona, 1867, I find the following:

> The experiences of this season have proved beyond doubt, were evidence on the subject still wanting, the thorough capability of the lands of the Colorado River Valley for all the purposes of agriculture in every case where water can be made to reach the surface. To depend upon the annual overflow is somewhat hazardous, for lands reached by it one year may not be again for several, or they may be so deeply submerged as to be unavailable for planting during the season. There are thousands of acres in the reservation which the overflow from the river never reaches, but which the artificial application of water would render as productive as any of the lands that are naturally overflowed.

All experience from that time up to the present proves the correctness of the ideas of that paragraph.

THE SWEETWATER DAM, SAN DIEGO COUNTY, CAL.*

BY JAMES D. SCHUYLER, M. AM. SOC. C. E.

The question of an adequate water supply for irrigation as well as for the domestic use of cities and towns is one which in San Diego County, Cal., necessarily involves storage reservoirs. The streams of the county are of an intermittent character. The mountain ranges in which they head and from which they flow to the coast do not generally exceed 6,000 to 6,500 feet in elevation—an altitude too low in the latitude of San Diego to maintain perpetual snow upon their summits, or even to retain such proportion of the water precipitation as comes in the form of snow (not usually more than 10 per cent.) for more than a few days or weeks. As a result the streams are torrential in winter and carry large volumes of water, but in summer and fall, when most needed for irrigation, are almost dry for 20 to 30 miles of their lower course, with the exception of certain seasons of such unusual rain-fall that no irrigation is required—seasons that come at rare intervals. Ordinarily the streams in summer reverse the usual order of nature, and are largest at the small end, and to get a water supply the engineer must either go far back into the mountains and gather together a number of small living streams and springs and pipe them out long distances, or construct dam and storage reservoirs to retain the winter floods. Fortunately nature has compensated for the existing conditions by providing numerous favorable sites for such construction, and every stream of importance in the county has available sites for storage dams of large capacity. A number of water companies are engaged in preparing for extensive works of this character, which, when completed, will provide irrigation facilities for several hundred thousand acres of land otherwise unproductive.

---

*Summarized from "Transactions of the American Society of Civil Service Engineers," November, 1888.

This era of development was inaugurated but recently, and the first completed work of the character is the Sweetwater Dam and Reservoir and extensive pipe system reaching out from it.

The circumstances which led to the building of the dam were that the San Diego Land and Town Company (a first cousin of the Atchison, Topeka and Santa Fé Railway) owned a large body of fertile and desirable mesa and valley lands bordering on San Diego Bay, adjacent to San Diego on the south, which were unsalable without water to irrigate them. These lands constitute the greater part of the "Rancho de la Nacion," including the town site of National City, which also languished with thirst. The Sweetwater River passes nearly through the center of the lands, and is of the nature described—intermittent in flow, at least for many miles above its mouth.

The first storm or two of the rainy season is absorbed by the thirsty earth, and the stream generally does not begin flowing into the bay until late in December or in January. After each heavy storm thereafter its volume will reach 500 to 1,000 cubic feet per second for a few days, and within a fortnight recede to 10 cubic feet per second.

The last severe storms of the rainy season are usually in March, and the flow of the stream will generally dwindle to 1 or 2 cubic feet per second by June 1, which amount may be maintained through the remainder of the year, but not always. The large supply running to waste each year, followed by months of scarcity, naturally suggested storage, and the first cañon above the mouth of the stream was selected as the place to accomplish the object. This narrow gorge, 7 miles east of the bay, is a deep and narrow cut, half a mile in length, through a dike of trap rock or trachyte that intersected the valley of the Sweetwater, leaving above it a broad level valley some 3 miles long, one-quarter to three-quarters of a mile in width. This is the site of the reservoir formed by the dam built at the head of the gorge.

The construction of this dam was decided upon and work begun in November, 1886. The original plan designed was a narrow wall of concrete masonry, 50 feet high, 10 feet wide at bottom, 3 feet on top, arched up-stream. On the upper side an embankment of loose earth was to be filled in against the masonry wall to its full height. After two months' work had developed the character of the design, the plan was disapproved by the management, and the writer was called upon to design a suitable structure and execute its construction. Some $35,000 had already been expended, and in order to utilize as much of the old work as possible the new structure was planned to rest upon and incase the foundations already laid. This decision influenced to some extent the radius of the arch of the new dam, as well as its position relative to the axis of the cañon, and the location of the anchorage on the sides. In other words, to avoid throwing away the work already done, the new work was adapted to the old in a way that ultimately increased the length of the dam on the crest somewhat more than would have been necessary by shifting the point of radius to one side of the central axis of the cañon, and making the radius somewhat shorter than it otherwise would have been. An engineer is sometimes driven to adaptations of this sort against his judgment, to save, or to give the appearance of saving, the pockets of his employers.

The modifications of the original plan were radical ones. The combination of earth and masonry was rejected, as it seemed to the writer that water alone was sufficiently heavy for the masonry wall to support without adding the last straw on the camel's back, of a mass of saturated earth. A gravity profile was adopted, and rubble masonry formed of blocks of stone up to 4 tons weight was substituted for bastard concrete composed of cement mortar, with small stones rammed into it, which had been previously used. So much of the old plan was retained, however, as to form an embankment 50 feet wide on top, 10 to 15 feet high across the cañon, against the face of the wall, but clay well rammed in layers was substituted for the silt and quicksand loosely dumped, with which the dam was formerly being made. The object of this clay filling was to cut off possible seams in the bed rock underneath the dam and reduce the pressure on the structure. The top of the embankment is 70 feet below the top of the dam.

The foundation.—After the bowlders, sand, and gravel had been stripped from the base of the dam on either side of the old work, the bed-rock was found to be very irregular in surface, presenting the appearance of a number of pyramids and cones thrown heterogeneously together, but bound solidly in one mass and well polished by attrition. The rock was very close in texture and exceedingly hard. No attempt was made to cut out the bed in the level benches, as the unevenness of the bottom, as nature left it, gave the assurance that whatever movement might occur in the structure built on such a base there could be no possibility of its slipping or sliding on the base. Wherever there were seams in the rock they were invariably occupied by roots, and the excavation was carried down till the seams pinched out and the roots disappeared. The rock was then thoroughly scrubbed by hand, and a thin grout of pure cement applied with brooms, filling the minutest crevices and angles in the rock, before starting the masonry.

The side walls of the cañon required more excavation to reach a satisfactory anchorage than the bottom. The north side was composed of shattered rock scored with innumerable seams filled with red clay. In this material the excavation was carried to a depth (perpendicular to the slope) of 20 to 25 feet before a solid ledge free from seams was encountered. This ledge lay with a slope nearly parallel with the surface slope, and in direction so nearly parallel to the radial line of the curve of the dam that it could not have been better placed to receive the arch thrust and formed a natural skew-back. This was carefully stripped and treated with cement grout in the same manner as the base.

The abutment on the south side was against the end of a dike of trap-rock, crossing over the hills to the south in a direction nearly parallel to a line passing through the center of radius and dipping westward at an angle of about 10 degrees from the vertical. After cutting into the face of this rock 5 to 10 feet all seamy, loose material was stripped away, and a bedding that was deemed sufficiently good was obtained, although the rock was not as free from seams nor as solid in mass as the north abutment. However, the entire foundation is an admirable one, of rock in place throughout.

The plan.—The original height of 50 feet was arbitrarily adopted at the beginning of the work, without any special investigation of the quantity of water to be stored by a dam of that height, but was "guessed" to be sufficient for present necessities, and the estimate of its cost was considered to be about the limit of the expenditure the company cared to make on an experimental scheme. There was an immediate and pressing need for water, the rainy season was passing, and it was desired to get up a part of the structure as rapidly as possible in order to catch a partial supply for the coming summer. Accordingly, in compliance with this desire, the foundation was rapidly laid and the structure hurriedly carried up to a point where it was safe to begin catchment. The base of the dam was laid with a width of 36 feet, and at a height of about 15 feet above the lowest course it was drawn in to a thickness of 24 feet. At this level (whose elevation above tide is 140 feet) the lowest pipes pass through the dam. Above this level the structure was carried to a height of 45 feet, with a top width of 5 feet, base as stated of 24 feet, face batter (up-stream) of 1 to 6. In anticipation of a probable addition to the height of the dam in future, the back was built in three steps, to give an opportunity of bonding the new work to the old. The profile of this portion of the structure is shown in Plate XXX. It was a gravity profile, whose line of pressure passed within the inner third of the base. It was constructed in arch form, convex to the stream, on a radius of 225 feet on the face line at top.

During construction the stream was carried in a conduit 30 inches square through the masonry near the bottom of the original creek bed. But one storm of the season of 1886-'87 (a dry one) swelled the creek sufficiently to exceed the capacity of this conduit, and then it rose and ran over the top of the masonry for two days only, without injury. This occurred February 14 and 15, 1887, when the flow reached a maximum of about 500 cubic feet per second. The gate at the upper end of the conduit was finally closed April 20, 1887, and the conduit was filled solid with masonry from below. From that time until June 1, the catchment was about 80,000,000 gallons.

By the 1st of June the structure, as planned, was completed to the height of 60 feet above the bottom, 10 feet higher than the height originally contemplated. It contained about 7,500 cubic yards of masonry and had cost, all told (including the preliminary experiments), about $100,000. Meantime, surveys of the reservoir basin and water-shed had developed the fact that the 60-foot dam would impound 1,221,000,000 gallons, whereas its extension to 90 feet in height would give a capacity of nearly five times that quantity, or 5,882,000,000 gallons. Also that the area of the water-shed tributary to the dam is about 186 square miles, of which one-third is above an elevation of 3,000 feet, and between that elevation and 6,500 feet. The water-shed was evidently ample to justify the hope that the greater reservoir would be filled almost every year of ordinary rain-fall. The increased volume of water stored would so largely extend the utility of the works, and give so considerable increase in security against the disasters following a severe drought, that the increased expense of extending the height of the dam while the working force and plant were on the ground and fully organized, seemed to be immediately justifiable. These arguments were embodied in a report, which was favorably considered by the directors of the company, and orders were given, about a fortnight before the 60-foot dam was completed, to extend the structure to a height of 90 feet.

This somewhat extended account of the growth of the enterprise from small beginnings is necessary to an understanding of the causes that led to the building of the structure in two sections rather than as a mass. The fact is that the work was nearly half done before all the conditions were thoroughly understood—conditions which ordinarily in works of such magnitude and importance are known, studied, and exhaustively discussed preliminary to the beginning of any work whatever.

In designing the plan of the higher structure, greater reliance was placed upon the arched form than in the lower dam, then approaching completion. The profile adopted was one which theoretically gave stability by its own gravity, but without as large a factor of safety. The line of pressure falls about the center of the lower third. It was reasoned that, as the foundation was as near perfection as can be generally found, apprehension on that score was unnecessary—and the source of the failure of such of the great masonry dams of the world as have given way—insecure foundation—need not be regarded as a factor in this case. If one can imagine a monolith to be carved in the form of a true arch, of such weight and dimension that any section of it is capable of withstanding the pressure of quiet water against it to its full height, without sliding or overturning, and such a monolith be firmly wedged between the rock-bound walls of a narrow cañon, the possibility of its being ruptured, displaced, or destroyed from water pressure alone can not readily be conceived. Now, if by the use of rich cement mortar and the best of building stone a structure be formed of the same dimensions and in the same position, which in time becomes virtually a monolith, based on the firmest of bed-rock, its stability must be equally assuring to the mind.

The dimensions adopted were the following: Base, 46 feet; top thickness, 12 feet; height, 90 feet; radius of arch, 222 feet on line of face at top. The face batter of 1 to 6 was carried to within 6 feet of the top; thence to the top of the parapet wall, vertical. The batter on the back started at the top with 1 to 3 for 28 feet; thence 1 to 4 for 32 feet; thence 1 to 6 to the coping.

The construction.—When the new work was begun at the base of the completed structure, special care was taken to secure a perfect footing for the toe. When the foundation was stripped it was found that there was a slight leakage at various points along the bottom of the masonry, amounting altogether to about 10,000 gallons daily. The only perceptible leakage through the masonry was along the sides of the waste conduit, which had been recently filled in, although there were moist spots all along near the bottom.

All the leakage was entirely cut off by the new work, although it was necessary to carry up small well-holes alongside the old masonry to within about 15 feet of the level of the water surface in the reservoir, and keep them pumped out, before it was safe to close them entirely. Water was standing in the reservoir at a height of about 35 feet above the base of the dam, and the small quantity of leakage, and the ease with which it was stopped, was considered a favorable test of the superior quality of the masonry.

The stone used was of two grades, a dark blue and a gray metamorphic rock, impregnated with iron. The gray stone is full of minute quartz crystals, and is of slightly less specific gravity than the blue stone, which carries more iron. It was obtained from a quarry opened in the face of a vertical cliff over 100 feet high, situated 800 feet below the dam. It has no well-defined cleavage, and broke out in irregular masses, although generally having one or more tolerably smooth faces. Numerous tests of its specific gravity gave its weight as 175 to 200 pounds per cubic foot. The average weight of the masonry in place was estimated at 164 pounds per cubic foot, which was the value used in the calculation of stability and strains.

Portland cement of the best obtainable quality was used in the proportion of one part of cement to three parts of sharp river sand. For the upper 4 feet next to the water a richer mixture of one to two was used. The sand was clean, sharp, and of the most suitable degree of coarseness to make the best of mortar.

• • • • • • •

The cost of the flowage tract for the reservoir is not included in the above. A little over one-half the land cost $16,426.93. The remainder is in litigation under an action of condemnation. A San Diego jury, under the stimulus of "boom" prices, awarded the owner $280 an acre, or a little over $100,000 for land, one-third of which was worthless, and the remainder unimproved. This judgment is being contested before the Supreme Court. The clearing and grubbing of about 300 acres of the reservoir basin cost $10,808.46.

The wasteway.—This important adjunct to the dam was carefully considered and proportioned to carry the probable maximum flow of the stream that may be presented for discharge, with a full reservoir. It is located at the south end of the structure, and is 40 feet in length by 5 feet in depth, divided into eight bays of 5 feet each. These bays are formed by piers of masonry, set at right angles to the flow, and provided with recesses on the upper face, in which loose flash-boards of 2-inch plank rest on an incline of 35 degrees from the vertical. Any set of boards may be removed from top to bottom, or the water may be held at successive levels from the top to the bottom of the weir by removing the top boards all the way across. The water falling over the wier drops into a series of pools, 3 feet deep, which relieve the structure of shock, and passes down an inclined plane with a fall of 1 to 10, until it is carried away from the dam a distance of 50 feet, and then plunges into the cañon below. The capacity of the wasteway is about 1,500 cubic feet per second. This may be increased to about 1,800 cubic feet per second by opening a 30-inch blow-off gate in the main pipe below the dam.

The inlet tower.—This structure is located 50 feet above the dam, nearly opposite its center. It is built of masonry, with cement morter mixed two to one, plastered outside and in with two coats of mortar mixed with one of sand to one of cement. It is 16 feet square at the base for a height of 10 feet, where its form is changed to a hexagon, with walls of a uniform thickness of 3 feet to the top. Each of the sides of the hexagon measure 3 feet on the interior face. Into the walls of the tower are built seven cast-iron elbows, at an elevation of 10 feet apart from bottom to top, the upper one being 10 feet below high-water line. The bell-mouths of the elbows open upward, and are ordinarily closed with a plain valve or cover of iron. The design is to draw water from the surface at whatever stage it may be. When any one cover is removed, a basket screen is lowered in its place, fitting closely into the mouth of the elbow. Three pipes pass through the dam and enter the tower at the bottom. The two lowest pipes are of cast-iron, 14 and 18 inches in diameter respectively, and lie side by side. They are encased in concrete throughout, from the tower to the dam. On top of them is built a conduit of masonry with a circular orifice 40 inches in diameter, formed of walls 30 inches in diameter, in double arches. This conduit leads from the interior of the tower to the center of the dam, where it joins a pipe of ¼-inch boiler-iron, 36 inches in diameter, leading to the main gate immediately below the dam, and from this gate is carried the main pipe line down the valley. The smaller pipes are not at present used, except to supply a hydraulic ram throwing water to the keeper's house on the hill, 150 feet above, and to drain the tower when all the valves are shut. They are intended to be used for supplying a turbine and pump to throw water to a higher level than the dam will now reach.

As an illustration of the fact that masonry laid in Portland cement in the proportion of two of sand to one of cement may be made water-tight with care exercised in laying, this tower, and the conduit leading from it, may be cited. When they are empty the pressure from the outside at present is somewhat more than 20 pounds per square inch on the conduit and at the bottom of the tower, and there is no leakage in either of them.

The reservoir.—Red clay soil constitutes the bed of the reservoir basin, or the major portion, outside of the old river-bed and bottoms, and is of an impervious nature. The following table of area and contents of reservoir is presented:

Contour elevation.	Area.	Contents.	Contour elevation.	Area.	Contents.
Feet.	*Acres.*	*Gallons.*	*Feet.*	*Acres.*	*Gallons.*
145 (level of lowest outlet valve in tower)	3.51	....	180	200.77	835,851,000
150	10.72	11,640,000	185	272.22	1,221,365,000
155	17.12	30,577,000	190	326.96	1,710,583,000
160	43.10	79,631,000	195	397.85	2,302,261,000
165	75.21	175,819,000	200	463.80	3,005,642,000
170	113.40	329,546,000	205	538.94	3,824,197,000
175	153.75	547,069,000	210	630.94	4,778,549,000
			215	721.86	5,882,278,000

The table shows that 80 per cent. of the capacity of the reservoir is within the upper 30 feet of height, and that 40 per cent. is within the last 10 feet. This fact reduces within small limits the fluctuation of head on the mains after the reservoir is once filled, and constitutes one of the reasons for increasing the height of the structure, as it enables the establishment of the probable limit of irrigation on the lands below, at a line not lower than 25 to 35 feet from the top of the dam. The irrigable area was thus largely increased, by reason of the decrease in fluctuation of depth in the reservoir.

* * * * * * * *

The distributing system.—From the dam to the lower end of the cañon, 1,600 feet, the main pipe is 36 inches in diameter, and covered with masonry laid in lime mortar, plastered with cement. From this point it is reduced to 30 inches diameter, and follows the valley for 5 miles, and thence rises to the top of the Chula Vista mesa, 92 feet above sea-level. Its entire length is 29,800 feet, and at its terminus the water is divided into two 24-inch pipes, one running south 1 mile, the other west half a mile, where it is reduced to 18 inches diameter, and is carried northward to and through National City.

At the terminus of the 36-inch main a blow-off gate is located, to be used as a relief to the wasteway of the dam in case of a sudden flood which might exceed the capacity of the wasteway, or to draw off the water from the reservoir if, for any cause, it was desired to do so.

Wrought-iron pipes were used throughout. The total length of mains and laterals that have been laid is 58 miles, with 5¼ miles on hand to be laid this season. They are of three classes, viz, straight double riveted pipe; converse lock joint, kalamined lap-welded tube; and spiral riveted pipe. About 16 per cent. of the pipe was of the first-class, 72 per cent. of the second, and 12 per cent. of the third.

The introduction of spiral pipe into the system was unfortunate, as it does not stand the test of transportation across the continent, and will have to be taken up and specially treated to make it water-tight. It will answer very well for subirrigation, if it could be properly controlled, but as it is laid in streets and avenues that system is not desirable or conducive to comfort in traveling.

The total cost of the pipe lines was as follows:

Pipe	$301,928.80
Freight	39,183.03
Distribution	6,271.06
Gates	1,849.62
Materials, tools, etc	5,932.57
Right of way and miscellaneous expenses	2,968.00
Pipe laying	144,630.78
Total	502,763.86

Probable duty of the works.—One of the most interesting questions to the stockholders of the company is the result that may be reasonably expected in the way of irrigation from such a reservoir. The assumption is made that in average years, say three out of five, the water-shed will yield a sufficient supply to fill the reservoir, besides maintaining the consumption through the rainy season, thus starting on the irrigation season about May 1 with a full reservoir. From May 1 to October 1 is the average season of irrigation—about 150 days. Where pipe distribution is in use, a fair average allowance in southern California is a duty of 10 acres per miner's inch (500 acres per cubic foot per second). There are instances of a much higher duty having been attained—a duty of even 40 acres per miner's inch having been accomplished in one place. Alloting 700,000,000 gallons for the annual consumption of National City, and for loss by evaporation during the summer months, the remainder would yield a flow of 2,000 miner's inches per day for 200 days; with a duty of 10 acres per inch, this amount would irrigate 20,000 acres. In the course of time it is expected that a duty as high as 20 acres per inch will be reached, in which event a reservoir full may be extended over two years' time, and still irrigate 20,000 acres, and afford a domestic supply to the town of National City.

Water rights, giving to the purchaser simply the privilege of becoming a customer for water, have been sold on the San Diego Flume Company flume at the rate of $2,000 per miner's inch. At this rate the value of the irrigation supply of the reservoir is $4,000,000. The construction of the works has already added a value of $1,500,000 to the principal tract of 5,000 acres which has been supplied with a complete system of water-pipes and another million to the value of town property in National City, and lands in its immediate vicinity.

A BOLD PROJECT.

It is proposed to permanently lower Tulare Lake to 15 feet below the present level, which will reclaim 375,000 acres, including swamp land, all now under water or subject to frequent overflow. This is to be effected by a canal of 12 feet average depth, which is to extend from Tulare Lake to a junction with the San Joaquin River at the head of navigation, distance about 40 miles north from the lake. The line of the canal will be through the present swamp which extends north from the lake. The level of the river at the junction is 48 feet below the level of the lake, and thus affords a sufficient fall for the discharge of the surplus water of the lake proposed to be drained. An additional outlet is also afforded by a projected west side irrigation scheme, which is to take water from the canal for the irrigation of over 400,000 acres of valley lands, the proposed canal forming, with Tulare Lake, a continuous inland water-way of over 70 miles. It is expected by its affluent discharge of water into the Upper San Joaquin River to so improve navigation as to utilize it for heavy freight.

VALUE OF THE PIPE SYSTEM.

Civil Engineer F. Eaton, of Los Angeles, makes the following statement relative to pipe service:

The duty of our streams would be extended by extending the present ditches by pipe systems. Experience has taught us that by economizing the water it is not only the water that we save in seepage alone, but the distribution. The convenience that these pipe systems offer in the distribution of water is a great economizer. We find that we can get along with a half or third the water that we get in running it around in ditches. It was thought that the San Gabriel was being used up by irrigating 2,000 acres; but it has been used since for irrigating 12,000 acres; and it can be increased by the pipe system. The duty of one-fiftieth of a cubic foot per second throughout the valley under the pipe system would be 1 inch to 10 acres; that is, for vegetables and all kinds of crops. It depends altogether on the character of the soil. A soil that is well subdrained, that is composed of gravel, will require much less water. Such subsoil is a natural drain, and for that reason water will go a great deal farther on that kind of land than it will on an impervious subsoil. Taking the average in the San Gabriel Valley, with 10 inches you can irrigate all kinds of crops, orange trees, and all kinds of vegetables. The cost runs from $15 to $50 per acre. The cement pipes are not cheaper than the pressure pipes, because it requires a good many more of them, and they are not so convenient as the pressure pipes. We generally use 16 iron. It is practically the sixteenth of an inch thick. A 4-inch pipe is more difficult to make than a 16-inch. We put asphaltum on, but it is impossible to keep it from being knocked off in spots, and those spots rust there. We can not inspect them closely enough to get at them all and paint them over. In ordinary soil, where there is no alkali, it will wear fifteen or sixteen years. I put in pipes fifteen years ago that are doing service now. The Pasadena pipes were 11 inches with 18 iron. That system was put in in 1873, and served up to this year. We have not many storage facilities up in the mountains. They are confined practically to the foot-hills and the valleys. We have to bring our water down and make our reservoirs in the valley. In Bear Valley the reservoir will contain 60,000,000,000 cubic feet when it is fully developed, and I am told there are a number of similar ones up there; but the cañons are too precipitious.

KERN COUNTY, CALIFORNIA, AND ITS IRRIGATION WORKS.

The average discharge of Kern River is 2,700 cubic feet per second. The maximum discharge during the rainy season and during the melting of the mountain snow is 19,041 cubic feet per second. There are eight months of the maximum flow or high water, from December to July, inclusive. The actual discharge of Kern River the last of May, 1883, by calculations made, was found to be equal to a depth of 1½ inches per month from the whole area or catchment of 3,445 square miles. This gives a depth of 3 inches per month for irrigation over 1,200 square miles, or 768,000 acres. The discharge is doubtless much larger from the middle of February to April, when water is most needed for irrigation. By close calculation it is found that 1 cubic foot per second will irrigate 160 acres.

In this valley, and mainly on Kern Island, are more than thirty canals, some of them with branches and all with distributing ditches, and several with many, the main canals aggregating some 300 miles in length and covering nearly 475,000 acres, which can be irrigated. About 150,000 acres are now irrigated. On these irrigated lands, with good care, alfalfa gives four and five crops a year, yielding at least 2 tons to the acre each crop, making an annual yield of 8 to 10 tons to the acre besides affording some pasture. As a rule it is cut every six weeks for eight months in the year. Several years ago, when this irrigating system was first inaugurated, it cost 50 cents per acre to irrigate land. Science and art, with much study and labor, have so far perfected this system of irrigation that now the cost varies from 2 to 10 cents per acre, as a rule averaging from 2 cents or 3 cents to 5 cents under favorable conditions.

The canal of the Kern River Water and Irrigating Company, known as the Beardsley Canal, the highest on the river, being the most northeasterly of this great system, is taken from the northerly bank in the southeast quarter of section 3, T. 29 S., R. 28 E. It is 8 miles in length 15 feet wide on the bottom, and 2½ feet deep. It has 10 miles of distributing ditches. It appropriates 47,030 miner's inches under a 4-inch pressure, equivalent to 938 cubic feet per second. This location was made December 2, 1873.

The McCord Canal is taken from the northerly bank of the river in the northeast quarter of section 18, T. 29 S., R. 28 E. The main canal is 4½ miles long, with three branches, having a total length of 10 miles and 15 miles of distributing ditches. The main canal is 20 feet wide on the bottom and 2 and 3 feet deep. This, with the Beardsley, is the means of supply for that portion of the district above the Calloway Canal. It appropriates 5,000 inches, equivalent to 100 cubic feet per second. This location was made March 20, 1875.

The Calloway Canal belongs to the Kern River Land and Canal Company, and is the largest and most important in the system. It comes out of the northerly bank of the river a short distance above the Southern Pacific Railroad Company's bridge, in the southeast quarter, section 13, T. 29 S., R. 27 E. It is 32 miles long, 80 feet wide on the bottom, and 120 on the surface, with banks 7 feet high and 10 to 16 feet wide on top, with inside slope of 4 to 1, and outside 2 to 1. On the west bank there is a delightful driveway the full length. It has a depth of about 6 feet. The grade is eight-tenths of a foot per mile. In 30 miles it crosses Poso Creek by means of a weir 150 feet in length, built in the bed of the creek, and connecting at either end with the lower bank of the canal. This arrangement admits of the use of the winter waters of Poso Creek by diverting them into the canal. It has some sixty-five distributing ditches, from 8 to 20 feet wide on the bottom, averaging 16 feet, and from 1 to 9 miles long, the aggregate length being about 150 miles. These branches have banks 3½ feet high, intended for 3 feet of water, with slopes 3 to 1, and a grade of $1\frac{6}{10}$ feet per mile, giving to each a capacity of $196\frac{5}{10}$ cubic feet per second. The importance of this canal is seen when we state that it covers about 200,000 acres of land. The head-gate at the point of diversion from the river is 100 feet long, built of redwood lumber, 6 by 6 struts, 4 by 6 side posts, and 2-inch flooring. The foundation is 20 feet wide up and down the stream, and has three rows of sheet piling, 4 by 8 Oregon pine, driven to a depth of from 12 to 16 feet, with intermediate or anchor piles of the same dimensions and material to which the sills, 4 by 8, redwood are spiked. There are 25 bays, and the gate-boards are 2 by 6 redwood. The top of the gate is 8 feet from the floor. The gate extends from the right bank out into the stream, and is connected with the weir by an artificial abutment. The weir extends from this abutment southerly across the river, and is 400 feet long, being of similar construction to the head-gate, the only difference being that the gate-boards are twice as long, reaching across the bays. By means of the gate-boards, which are movable, the water is under complete control, and can be regulated at will. The Calloway appropriates 74,000 inches of water, equivalent to 1,476 cubic feet per second. The location was made May 4, 1875.

The McCaffrey Ditch, sharing the head-gate of the Calloway Canal, is 3 miles long, 7 to 8 feet wide on the bottom and is 2½ feet deep. It irrigates the land between the Calloway and the river. The appropriation is 1,296 inches, equivalent to 26 cubic feet per second. The date of location is October 31, 1874.

The head-gate of the Emery Ditch is in the northeast quarter of section 22, T. 29 S., R. 27 E. It is 3 miles long, 6 to 8 feet wide on the bottom, and 2 feet deep. It appropriates 2,000 inches, equivalent to 40 cubic feet per second. Located December 2, 1876.

The Jones and Tuckey Ditch begins in the northeast quarter of section 32, T. 29 S., R. 27 E. It is 4 miles in length, 10 feet wide on the bottom, and 2 feet deep. The appropriation is 1,000 inches, equivalent to 20 cubic feet per second. Located June 24, 1876.

The Railroad Canal, commencing near the corner of southwest quarter of section 31, T. 29 S., R. 27 E., is 3,000 feet long. It is 40 feet wide on the bottom, and 2 feet deep. It empties into Goose Lake slough. It appropriates 31,075 inches, equivalent to 620 cubic feet per second. Its location dates July 24, 1874.

The head gate of the Wible Canal is in the northwest quarter of section 6, T. 30, S., R. 27 E., and running about 1,000 feet, it discharges into Goose Lake Canal, and by means of this canal and Goose Lake slough, its waters are conveyed to the lands to be irrigated. It is 40 feet wide on the bottom, and 2 feet deep. Its appropriation is 5,040 inches, and its capacity 300 cubic feet per second. Located May 1, 1875.

The property of the Goose Lake Canal Company is taken from the northerly bank of Kern River, in the northeast quarter of section 1, T. 30 S., R. 26 E., and runs thence northwesterly 4½ miles, emptying into Goose Lake slough. Flowing through this slough the water is taken out at different points along the slough in ditches. It is 140 feet wide on the bottom and 3 feet deep. It appropriates 90,000 inches, equivalent to 1,795 cubic feet per second. It was located July 13, 1875. The Railroad, Wible, and Goose Lake Canals all empty into the Goose Lake slough, and use it as a common channel to carry their waters to the adjoining lands as far down as Goose Lake, a distance of 22 miles.

The Pioneer Canal, owned by the Pioneer Canal Company, has its head-gate in the northeast quarter of section 1, T. 30 S., R. 26 E. It has a length westerly of 11½ miles, being 60 feet wide on the bottom and 3 feet deep. This canal flows through the entire lengh of the McClung ranch, which is wholly irrigated by it and its principal distributing branch, the Pottinger Ditch, 16 feet wide. It also passes through the Buena Vista ranch, furnishing mainly its irrigating waters. Its appropriation is 20,074 inches, equivalent to 400 cubic feet per second. This canal was located April 26, 1873.

The head-gate of the Edwards Ditch is in the northwest quarter of section 1, T. 30 S., R. 26 E. It is 2 miles long, 10 to 12 feet wide on the bottom, and 1 foot deep. It appropriates 1,440 inches, equivalent to 20 cubic feet per second, and was located December 21, 1874.

The James and Dixon Canal is owned by the James and Dixon Canal Company. It commences in the southeast quarter of section 3, T. 30 S., R. 26 E., and runs in a westerly direction about 12 miles. It is 30 feet wide on the bottom and 3 feet deep. Its appropriation is 14,000 inches, equivalent to 279 cubic feet per second. Its location dates April 19, 1873.

The Johnson Ditch is owned by the Lower New Kern River Irrigating Company, and begins in the southeast quarter of section 3, T. 30 S., R. 26 E., a few feet below the James and Dixon Canal, with which its waters join in a shallow slough, a few hundred feet below. Its course is southwesterly about 4 miles. It is 30 feet wide on the bottom and 3 feet deep. It appropriates 8,640 inches, equivalent to 172 cubic feet per second. It was located June 12, 1873.

The Ash Ditch is near the Johnson, and is taken from the river in southeast quarter of section 3, T. 30 S., R. 26 E., and is 1 mile in length, 3 feet wide on the bottom, and 2 feet deep. It has a discharging capacity of 24 cubic feet per second.

The May Ditch leaves a short arm of the river in the northwest corner of the southwest quarter of section 18, T. 30 S., R. 26 E. It is 2 miles long, 8 feet wide on the bottom, and 2 feet deep. Its appropriation is 4,000 inches, equivalent to 80 cubic feet per second. Its location was made November 29, 1873.

The Joice Canal is taken from the river in the northeast corner of the southwest quarter of section 23, T. 30 S., R. 25 E. It is nearly 4 miles long, 12 feet wide on the bottom, and 2 feet deep. It appropriates 6,250 inches of water, equivalent to 129 cubic feet per second. Its location was made May 26, 1873.

The Dixon Canal is a branch of the Joice Canal, diverting the water from the latter for about 2½ miles, and then it branches out to the northward, irrigating lands on the borders of the reclaimed swamp-land district. It is 8 feet wide on the bottom and 4 feet deep. The appropriation is 3,456 inches, equivalent to 69 cubic feet per second. Its location dates April 13, 1875.

The foregoing canals and ditches are all on the north side of the New Kern River, or now Kern River proper. Those on the south side, about the same number, are located on both sides of Old River. The first one in order on the river, locating at the highest point on the left bank of the stream, is the property of the Kern Island Irrigating Canal Company, called the Kern Island Canal.

It is taken from Kern River near the southeast corner of the southwest quarter of section 9, T. 29 S., R. 28 E., about 2½ miles northeast of Bakersfield, through which town it passes. It is 18 miles long, with a width at the head-gate of 48½ feet on the bottom and a depth of 4 feet. It terminates at Kern Lake. At Bakersfield the canal makes a vertical fall of nearly 20 feet, furnishing water power for a large flouring mill. This important canal has two main branches, the town branch, supplying Bakersfield and vicinity, having a length of 2 miles, and a central branch, diverging from the canal south of the town, and running nearly parallel to it, varying from one-half to 2 miles distant, for a distance of 10 miles in a southerly direction. This branch has a width of 20 feet on the bottom, and a depth of 3 feet, with slopes of 3 to 1. The central branch has nineteen drops in the distance of 10 miles, placed at intervals of half a mile. The Kern Island and its branches have thirty-one lateral ditches, besides a connecting ditch with the Stine Canal, having a total length of over 80 miles. The Kern Island Canal appropriates 20,000 inches, equivalent to 400 cubic feet per second. Its location dates from the latter part of 1870.

Next below the Kern Island is the Old South Fork Canal. It is taken from the river in the central northern part of the northeast quarter of section 17, T. 29 S., R. 28 E., about three-fourths of a mile below the head-gate of the Kern Island Canal. It runs 3 miles southwesterly into the bed of the Old South Fork of Kern River, in which its waters are conveyed to Kern Lake in a nearly southerly direction. The canal has a width of 26 feet on the bottom, and is from 2 to 3 feet deep. Its distributing ditches aggregate 7 miles, one of the principal of which is the Cotton Ranch Ditch, irrigating 1,100 acres of alluvial bottom lands, north of and adjoining Bakersfield. Most of the water diverted into the Old South Fork is turned into the Panama Slough, and again diverted below by the Panama Ditch. This canal is also used at times as a feeder for the Kern Island Canal. The appropriation is 3,800 inches, equivalent to 75 cubic feet per second.

The Farmers' Canal, owned by the Farmers' Canal Company, takes its water from the river in the northeast quarter of section 24, T. 29 S., R. 27 E., about 200 feet above the Southern Pacific Railroad bridge across Kern River with a 48 feet opening, fronting parallel with the river, the water entering the canal at right angles with the stream. The first artificial channel to the Panama Slough is about three-quarters of a mile in length. The total length of the main channel is about 15 miles, consisting wholly of natural sloughs. It has 4 miles of branch constructions, varying from 10 to 20 feet in width. It has 30 miles of distributing ditches. The artificial channel is 50 feet wide on the bottom and 3 feet deep, and the natural channel varies from 20 to 50 feet in width, with a depth of 6 to 10 feet, having nearly vertical banks. The soil through which it passes is generally a firm, clayey loam, and permits natural irrigation of adjacent lands by percolation. A great deal of this land along the old channel is thus kept constantly moist and requires no irrigation. It appropriates 14,400 inches, equivalent to 287 feet per second. Its location was made April 29, 1873.

The Castro Ditch derives its water at the junction of Old and Kern Rivers, in the northeast quarter of section 26, T. 29 S., R. 27 E. It is 16 feet wide on the bottom, 2 feet deep, and 5 miles long. It crosses Panama Slough, and irrigates a small amount of land east of that channel. The appropriation is 1,000 inches, equivalent to 20 cubic feet per second.

The Stine Canal, belonging to the Stine Canal Company, has its head-gate also at the junction of Old and Kern Rivers, adjoining that of Castro, in the northeast quarter of section 26, T. 29 S., R. 27 E. It occupies the bed of Old River for the distance of half a mile. This canal is 80 feet wide on the bottom, 3 feet deep, and 15 miles long. It has two main branches, with numerous forks, varying in width from 12 to 20 feet on the bottom, and having an aggregate length of 32½ miles, and 41½ miles of distributing ditches. It is next in importance, in this system, to the Kern Island Canal, and shares with the Farmers' Canal in irrigating T. 30 and 31 S., R. 27 E., besides supplying water for other lands west and south. Its appropriation is 55,980 inches, equivalent to 1,117 cubic feet per second. It was located December 12, 1872.

The Anderson Canal heads also in the northeast quarter of section 26, T. 29 S., R. 27 E., at the junction of Old and Kern Rivers. Its head-gate connects with those of the Stine and Castro, and the same system of wing-dams serves for all. The canal runs southwesterly 4 miles, is 15 feet wide on the bottom, and 2½ feet deep. This canal is used exclusively for irrigating Stockdale ranch, located about 5½ miles southwest of Bakersfield. Its appropriation is 5,057 inches, equivalent to 101 cubic feet per second. The location was made October 9, 1872.

The Gates Canal, owned by the Gates Canal Company, is taken out of Kern River, in the southwest quarter of section 26, T. 29 S., R. 27 E., and runs in a southwesterly direction 2½ miles. It is 12 feet wide on the bottom and 2½ feet deep. It also is used exclusively in irrigating Stockdale ranch. Its appropriation is 5,057 inches, equivalent to 101 cubic feet per second. This canal was located originally without record early in 1872, and relocated October 7, 1878.

The Buena Vista Canal belongs to the Buena Vista Canal Company. Its head-gate is in the northeast quarter of section 33, T. 29 S., R. 27 E., and runs southwesterly through Bellevue ranch, located about 8 miles west of Bakersfield. It is 13¾ miles long, 30 feet wide on the bottom, and 3 feet deep. It has numerous ditches of various dimensions. Its appropriation is 14,000 inches, equivalent to 279 cubic feet per second. Its location was July 15, 1870.

The James Canal, which is the property of the James Canal Company, heads in the northeast quarter of section 33, T. 29 S., R. 27 E. It runs southwesterly 17¼ miles, is 60 feet wide on the bottom the first 3 miles and 40 feet the remaining distance, and is 3 feet deep. This canal also flows through Bellevue ranch, supplying water for this ranch and all lands still farther south and west. The amount of appropriation is 19,730 inches, equivalent to 394 cubic feet per second. Date of location, October 15, 1871.

The Plunkett Canal, belonging to the Plunkett Canal Company, commences in the northwest quarter of section 33, T. 29 S., R. 27 E. It runs southwesterly through Bellevue ranch, and is used exclusively for it. Amount of appropriation is 5,057 inches, equivalent to 101 cubic feet per second. Date of location, December 31, 1872. It is 3¾ miles long, 12 feet wide on the bottom, and 2½ feet deep.

The Meacham Canal is the property of the Meacham Canal Company, commencing in the northwest quarter of section 6, T. 30 S., R. 27 E., and flows through Bellevue ranch southwesterly about 4 miles. It is 12 feet wide on the bottom and 3 feet deep. Its appropriation of water is 1,500 inches, equivalent to 30 cubic feet per second. It was located April 15, 1873.

The Wilson Canal commences at a point on Kern River, near the head-gate of the Meacham Canal, in the northwest quarter of section 6, T. 30 S., R. 27 E., and also flows through Bellevue ranch 2½ miles in a southwesterly direction, and is 5 feet wide on the bottom and 2 feet deep. It appropriates 500 inches, equivalent to 10 cubic feet per second, and was located August 15, 1874.

The Henley Canal begins in the southeast quarter of section 9, T. 30 S., R. 26 E., and runs southwesterly 2½ miles. It is 3 feet wide on the bottom and 2 feet deep. The amount of the appropriation is 2,880 inches, equivalent to 57 cubic feet per second. Its location dates January 29, 1874.

The Frazer Canal takes its waters out of the Kern River, in the northeast quarter of section 16, T. 39 S., R. 26 E. It flows southwesterly 2¼ miles, and is 5 feet wide on the bottom, with a depth of 1½ feet. It appropriates 2,600 inches, equivalent to 52 cubic feet per second. It was located April 15, 1873.

The Kern Valley Water Company has two main canals for the reclamation of swamp land in District No. 21, in Buena Vista Slough, and a distributing canal. The principal canal is that on the west side of the district, following, generally, the border of the swamp lands for a distance of 24 miles. At its head it is 125 feet wide on the bottom, 7 feet deep, with sides sloping from 3 to 1 and from 7 to 1, and a grade of nine-tenths of a foot per mile. The grade is very irregular, and we give it in detail. For one-half mile the grade is nine-tenths of a foot; 9 miles, it is 2 feet; one-half mile, $2\frac{5}{10}$ feet; and 1¼ miles, level; vertical drop, $1\frac{8}{10}$ feet; 1 mile, 8 feet; 2 miles, level.

Below this main channel, a parallel distributing canal, 30 feet wide on the bottom and 2 feet deep, was constructed about 10 miles long. On the east side of the swamp a canal about 6 miles long was constructed for irrigation purposes, having a width on the bottom of 25 feet, a depth of 3 to 5 feet, and side slopes of 3 to 1. The appropriation of water of the Kern Valley Water Company is 100,000 inches, equivalent to 1,995 cubic feet per second, and its location dates April 7, 1877. The appropriation of the Kern Valley, east side, is 30,000 inches, equivalent to 599 cubic feet per second, and the location dates April 9, 1877.

Résumé of the canal system of Kern Valley.

Name of canal.	Length.	Appropriation.	
	Miles.	*Miner's inch.*	*Cubic feet.*
Beardsley	8	47, 230	938
McCord	14½	5, 000	100
Calloway	32	74, 000	1, 476
McCaffry	3	1, 296	26
Emery	3	2, 000	40
Jones Tuckey	4	1, 000	20
Railroad	¾	31, 075	620
Wible	¼	5, 040	100
Goose Lake	4½	90, 000	1, 795
Pioneer	11¼	20, 074	400
Edwards	2	1, 440	29
James and Dixon	3	14, 000	279
Johnson	4	8, 640	172
Ashe	1	1, 200	24
May	2	4, 000	80
Joice	4	6, 250	125
Dixon	2½	3, 456	69
Total	99¾	315, 701	6, 293
Kern Island	30	20, 000	400
Old South Fork	3	3, 800	75
Farmers'	19¾	14 400	287
Castro	5	1, 300	20
Stine	47½	55, 980	1, 117
Anderson	4	5, 057	101
Gates	2½	5, 057	101
Buena Vista	13½	14, 000	279
James	17¼	19, 730	394
Plunkett	3¾	5, 057	101
Meacham	4	1, 500	30
Wilson	2½	500	10
Henley	2½	2, 880	57
Frazer	2¼	2, 600	52
Kern Valley Water Company	40	130, 000	2, 594
Total	197¼	281, 561	5, 618
Grand total	297⁹⁄₁₀	597, 262	11, 911

The rains of winter and the melting snows of summer on the upper Sierra thus maintain a full flow in Kern River for about two-thirds of the year, the period covering the greatest demand for irrigation. Kern River has a slope through the valley of 6 to 8 feet per mile, and lies in a shallow, sandy bed, with banks of sandy soil 3 to 6 feet high. These are favorable conditions, and enable water to be taken out at almost any point at comparatively small cost. Few permanent, costly dams, or very expensive head-works have been found necessary; a simple wing-dam of sand and brush, running out into the channel of the river at an acute angle up the stream, serves every purpose, in most cases, for diverting water into the canals, there being only five weir extensions across the river in the whole system.

Then, again, the slope of the irrigable lands of the valley is so great there is no difficulty in running canals in almost any direction over them, nor in distributing water in the smaller ditches, or in draining it off. It is therefore peculiarly favorable for irrigation, yet the soil is too friable to permit of canals of any considerable size taking the natural slope of the ground without serious erosion and damage.

The grade over these sloping plains is regulated by "drops" or weirs, placed at proper intervals, with movable weir-boards, which are also convenient and necessary for raising water to enter distributing ditches.

These drops are constructed similarly to the canal head-works, and are characterized by an absence of ponderous gates for regulating the water and extreme lightness of timber used, studying the greatest economy in material. Head-gates are a necessity when the water is taken out of the river to control the admission of water to the canal. They are made entirely of wood, there being no stone readily accessible in this vicinity. The better class of these head-gates are constructed upon a foundation of anchor-piles driven into the sand as far as possible, with sheet-piling of 2-inch planks at the upper and lower sides of the structure.

Weirs, as before indicated, are constructed not only for drops, but for raising water for entering distributing ditches. Side gates are at the head of distributing ditches for the purpose of admitting water from the canal into such ditches. They are constructed upon the same principle as head-gates.

The canal flume is the usually constructed flume for carrying one stream of water over another across a gulch or ravine.

Wing dams are built of brush and in the river, from the lower side of the mouth of the canal up the stream, at an acute angle with the current, to turn the waters of the river into the canal.

Waste-gates are built at the heads of canals and also along their course to let off any oversupply of water. Inverted siphons are put into canals for the purpose of carrying their waters under another canal.

A module is put into a gate or other structure for the measurement of water.

There are four general classes of irrigation as conducted in California.

First method.—Constituting irrigation of vines and trees, as practiced in some portions of Los Angeles and San Diego counties, under which the water is conducted through pipes having openings at each different vine or tree to be irrigated, all of these small distributing pipes being supplied from one large pipe. This of course is a highly expensive mode of irrigation, and one which can not be practiced except where an exceedingly small amount of water must be utilized to the greatest degree possible and where the results as derived therefrom are of great benefit.

Second method.—By building ditches at stated distances apart, the land being irrigated by the seepage or percolation of water through the soil, from one ditch to another. This method is applicable only in districts having a loose soil, through which the water can easily pass, and is not to any extent valuable for use in Kern County, where such conditions do not exist.

Third method.—By building the ditches on the ridges or highest ground in the land to be irrigated, and from them running the water downhill and holding it back by means of small temporary checks, or, in cases of vines or trees, running the water downhill through plow furrows. This method of irrigating is well adapted to the irrigation of orchards and vineyards, thereby utilizing the water to good advantage; but in the irrigation of grass or alfalfa land, or in other cases where it is desirable to cover simultaneously a large area of land, it has been found to be more expensive than, and in the irrigation history of Kern County, has generally been supplanted by, the fourth method.

Fourth method.—By building ditches at stated distances apart, running downhill with the slope of the country, and between them building permanent levees on contour lines, the latter being distributed with the grade at varying distances of fall, as desired, of 6, 9, 12, 18, or 24 inches.

This is the cheapest method of irrigating where there is an abundance of water and where the area owned, controlled, or irrigated by any one man is large.

The above descriptions under the first, second, and third modes of irrigation clearly indicate the manner in which the water is handled, and to the uninitiated no explanation is therefore needed, except as connected with the fourth mode, which has most generally been adopted in Kern County. In the second, third, and fourth modes of irrigating the diversion of the water from the river, creek, spring, reservoir, or other general source of supply where large areas are to be irrigated is required to be made into one general conducting ditch, from which the smaller distributing ditches diverge, conducting the water to the lands to be irrigated.

DIFFERENT SYSTEMS.

Subsoils dams are frequently constructed in California with the object of cutting off the subterranean flow of water in channels whose beds soon become dry on the surface. It is first ascertained by sinking shafts across the channel whether water is thus passing subterraneously. This will be observable in some cases by floating substances traversing the shaft, but if the flow is very slow it may not be detected by this means, and coloring the water with a dye will show it by a replacement of the colored by pure water passing through the shaft. A subterraneous water flow is frequently brought to the surface by impervious strata traversing its course. Localties in which this occurs are the best sites for weirs. It is not probable that such natural bars are to be found in the plains, far removed from the source of supply, and to produce them artificially in such situations would necessitate very deep and probably very extended walls. The trial shafts should therefore be made where the valley is well defined in character.

Of course these submerged dams can only bring water to the surface of the channel where the latter is of sand or gravel through which the water would rise, forming an artesian supply. Where the surface of the bed is of sand, in which the water could be again lost, the elevated water would of course be diverted to an impervious channel provided for it. Where such subterranean water can be intercepted a considerable supply might be expected for some months after the water ceased to flow previous to the interception, for doubtless in many cases a considerable proportion of the rain-fall is absorbed and given off gradually to subterranean strata.

Subterranean currents have also in several instances been interrupted by means of tunnels run in from the surface 2,000 and 3,000 feet, the flow being planked to form a flume and the water then conducted to open channels. Tunnels of this character are at Ontario and at Passadena, where a second tunnel was driven at a higher level, completely cutting off the supply from the first enterprise. At Riverside it has been ascertained that there is a large subdrainage in the low land forming the bank of the river. A level channel for half a mile, cutting across this drainage so that the flow shall be intercepted, will give perfectly clear water, sufficient for the canal supply. Should half a mile not be sufficient it can be extended.

Flumes are used where it would cost considerably more to convey water in an excavated channel, or where the soil is gravelly, and the loss by percolation would be great. Ravines are crossed by flumes or pipes. The objection urged against flumes is their continual cost for repair, and danger of destruction by fire. Where they are used, and practicable, they are set on a heavier grade than channels 30 to 35 feet per mile, and are of proportionally smaller area than channels with less grade. They should be constructed in straight lines if possible. Curves where required should be carefully set out, so that the flume may discharge its maximum quantity. Many canals have miles of fluming in California. In the ordinary style of construction sills, posts, and ties support and strengthen the work at every 4 feet. The posts are let into the ties and sills. The sills extend 20 inches beyond the posts, to which side-braces are nailed to strengthen the structure. Where flumes are not supported on trestles, but rest on an excavated ledge, it is desirable still to use the stringers, which should be placed just outside the posts, so that water leaking from the sides will drop clear of them. Main supports, such as trestles, are placed 8 feet apart. Planking should be either redwood or heart sugar pine.

A flume at Riverside is 900 feet long, the section being 8 feet by 2 feet 6 inches, the sills rest on concrete blocks made *in situ*, molds being over the spot where the block is required, and concrete consolidated into it. Its greatest height is 42 feet; the total cost, $6,200; waste-gate at the upper end cost $200. This is necessary in case of repairs being required. The connection with the land at either end is 15 feet long, with sets of flanges projecting 5 feet on either side, and a 16-inch plank underneath. The joints are covered with a solution of asphalt in turpentine, which is elastic and does not crack. This protection would not be necessary if carefully joined redwood were used.

A flume at Los Angeles, constructed by Mr. F. Eaton, is both economical of material and strong in design. Here Oregon timber was used. The joints were left open one-sixteenth of an inch, and chamfered, and the inside swabbed with asphalt. The planks were 16 feet long, breaking joints at 8 feet. Cattle-troughs are made on the same plan from 8 to 16 feet long.

Flumes are often constructed, instead of small channels, where the soil is porous and the quantity of water limited. These are made of three planks, in lengths about 10 feet, and butt-jointed (the joint being covered and connected by a 3-inch by 1-inch piece), and are laid to a grade of 10 feet to the mile or more. Holes are made in them opposite each tree or furrow that requires water, a stop is placed in the flume below the length to be irrigated, and the plugs removed from the holes when the water is to be delivered.

The Bear River Canal flume is 500 feet long, with section of 5 feet by 3 feet, and a fall of 10 feet per mile. Flumes are extensively used in hilly districts for drainage across the land, and a waste flume is inserted opposite the drainage, permitting the water in excess of the channel's capacity to escape. A flume is sometimes carried inside a larger one, the smaller one delivering the water at a higher level, or to another irrigator, so that the two supplies may be kept separate.

The asbestine system.—The inventors of this system hold that in a region where no rain falls during the long summer the only proper way to irrigate orchards, vineyards, etc., is to apply the water below the surface of the ground, keeping the surface dry. The asbestine system consists in conducting the water in concrete pipes below the reach of the plow along each row of trees. At each tree a plug is set in the upper side of the pipe, each plug having a small hole through which, and nowhere else, the water escapes, falling on the outside of the pipe and being taken into the soil by capillary attraction. It saves from three-fourths to nine-tenths the water used in surface irrigation. It is under perfect control, and can be applied wherever irrigation is needed.

There is no need of summer cultivation, either before or after irrigating. The surface of the ground is always dry in summer, hence exempt from the unavoidable chill of surface irrigation. The soil is never excessively wet and can not bake, but remains moist, loose, and at nearly uniform temperature, promoting a long summer growth. Anything that the soil lacks as plant-food (manure, lime, etc.) can be easily, directly, and economically applied in liquid form. The pest of the vineyard, phylloxera, can be thus easily reached. No grading is necessary, as the system works as well on hill-sides and undulating land as on ground uniformly sloping.

If, through carlessness, muddy water is let into the pipe, and sediment collects, one or more of the lower plugs can be taken out, and the water passed rapidly through. The pipes will thus be cleaned. If the water is kept in motion, the sediment it contains should not be deposited. On the Briggs farm, in the Sacramento Valley, the pipes, 4 inches in diameter, are made on the place by an ingenious machine, from cement and fine gravel in the proportion of three-fourths of the latter to one-fourth of the former, and are laid at a depth of 20 inches down the center, between each second row of vines, with an opening for the escape of the water in the upper side of the pipe every 30 feet. The pipe-making machine is so constructed as to travel along the trench, making and laying the pipe in one operation, after which the earth is covered in with a guard over the vent-holes to prevent choking.

The water supply, raised when required from a neighboring stream by steam-engine and centrifugal pump, is commanded by sluice-doors at various points, to admit of the water being laid on or shut off at pleasure; but excellent as the system is in theory, Mr. Briggs has not yet managed to get it to work with thorough satisfaction.

Mr. Holt, of Riverside, has devised a different mode of letting the water escape from the pipes. To prevent the holes in the plugs becoming occasionally closed by roots finding their way into them, a section of about 6 inches long is cut out of the continuous pipe where the plugged hole would be, and a square hole, about 6 inches by 6 inches, sunk below the gap in the pipe. A tile, in the form of a saddle, 9 inches long, covers the gap, and the water escapes between the two surfaces. The advantage of this plan is that if roots do find their way between the two faces they are easily cleaned away by cutting them. The hole below the gap catches any silt that may pass down the pipe. This most economical system of irrigation should be especially suited to cases in which water is very scarce, as where it is raised by wind-power. The water will spread over a circular area of 16 feet diameter in four or five hours. Subirrigation is practiced largely in Japan.

Pipes and conduits.—Where water is scarce, and has to be conveyed long distances in channels excavated in the soil, exposing it to too great a loss, impervious channels and pipes of various kinds have been resorted to to convey it to land that was valueless without it. This has caused the adoption of a variety of materials to render conduits impervious and of various modes of application of water by their means. The following impervious conduits are used: (1) Wooden flumes; (2) lined channels; (3) wrought-iron riveted asphalted pipes; (4) wrought-iron laminated asphalted pipes; (5) terra-cotta pipes; (6) cemented pipes; (7) asphalt pipes.

Lined channels.—The Zanja Madre Channel at Los Angeles was lined with concrete, and had a cross-section of a segment of an ellipse, with a diameter of 5 feet and a depth of 3½ feet. The thickness of concrete was 6 inches. The ingredients were hydraulic lime, two parts; clean, sharp sand, three parts; pebbles, 1 inch in diameter, four parts; small stones, 2 to 3 inches in diameter, four parts; large stone, not exceeding 5 inches in diameter, four parts; cost $2 per linear foot.

A tunnel conveying water to Los Angeles was lined on the bottom with concrete 4 inches thick, forming a semicircle of 4 feet diameter. The cost was 75 cents per linear foot, with cement at about $4 per cask. Wrought-iron riveted and asphalted pipes are extensively used in Los Angeles County for irrigation. They are jointed, stove-pipe fashion, and when not subjected to too great pressure are set with red or white lead.

Wrought-iron laminated asphalted pipes are made of two shells of sheet-iron. These shells are made of one sheet of iron 8 feet long, rolled and lapped 1 inch, and united by a composition solder. They are half the thickness of iron that would be necessary for the ordinary sheet-iron pipe. The inner shell is telescoped into the outer shell whilst immersed in hot asphalt, specially prepared, giving a thickness between the sheets one-sixteenth of an inch, or more, if desired, thus making an impassable barrier to corrosion from outside or inside. The outside and inside coatings are also substantial. This produces a solid shell 8 feet long, with an inner surface free from all excrescences.

The pipe is also made double, of one sheet, by rolling a sheet that is twice the width of the single sheet until the edges will lap with a thickness of iron between them; the lap is riveted. This is dipped in asphalt, but it can not have the intermediate lamina of asphalt, which is the main advantage of the laminated over the single sheet-iron pipe. Both these descriptions of pipes are jointed end to end, an inner sleeve being fixed in the shop. In laying, the end is dipped in hot asphalt and an outer sleeve is also dipped and pressed on by a clamp over the point until the asphalt is set. Bends and branches are of cast-iron, as in the ordinary sheet-iron pipe, and the joints are made with cement.

The 4-inch laminated pipe has been tested up to 500 pounds per square inch. Its price is about 25 cents per linear foot. The double-rolled pipe is about 17 cents per foot. The construction of the latter is much simpler, and the asphalt has been found a perfect protection from rust, so there is no necessity for the lamination. Terra-cotta pipes would be excluded by their price, except for some special purpose, such as sewerage or culverts, for use under roads, etc. Concrete pipes, where good sand is obtainable, and no pressure is required, are extensively used.

At Ontario Colony, San Bernardino County, an irrigation enterprise has been started, which is mainly dependent on concrete pipes for conveying the water from the cañon. Thirty miles of 12-inch concrete pipe have been laid here, at a cost of about 43 cents per linear foot for making. The ingredients are cement, sand, and gravel, in the proportion of one of cement to four of clean, sharp sand, and gravel. The gravel may be as large as half the thickness of the shell of the pipe.

The pipes are formed in molds of sheet-iron. These consist of two sheet-iron cylinders, an inner and an outer, both of which can be expanded and contracted by means of a bar fixed parallel to the joint from which four arms project, connected with the outer edge of the joint so as to close and open it. Between these cylinders is a cast iron ring, forming the base. This cast-iron ring is shaped to mold the end of the pipe to form a socket. The inner cylinder or core is kept central at its base by being inside the cast-iron base. It is centered above by hand until sufficient of the concrete mixture has been consolidated around it to keep it so. The filling is then completed, being put in in small quantities at a time. and consolidated with an iron rammer. The upper end of the pipe is shaped to form a spigot by means of a cast-iron ring that is worked round by hand. A 6-inch diameter 2-foot-long pipe is made at the rate of one length per minute by three men. Only as much of the mixture must be made at one time as can be used within ten minutes after mixing, or its setting qualities will be injured. The newly-made pipe is removed from the mold or the mold from it on the drying area, the base being left for it to stand on until sufficiently set to handle. In handling the larger-sized sections a clip with handles is used, and another for laying.

The pipes made with mixture of one to four are not guarantied to stand pressure, but with a slight increase, and well consolidated, they will stand a considerable head. They are cheaper than any other pipes when suitable sand and gravel are obtainable near the site where they are to be used. A continuous pipe-making machine, for making a continuous concrete pipe in a trench excavated to the required depth for subirrigation, consists of a cylinder of the size of the pipe required, in which an india-rubber core is moved backwards and forwards by a lever, the concrete material being thrown into a funnel fixed at right angles to the pipe-making cylinder. By this means three men can make over 1,000 feet of 2-inch piping in ten hours. This system is not much used.

Asphalt-concrete pipes are made as described for concrete pipes, and are superior to them, being perfectly impervious and capable of withstanding much greater pressure. The proportion of sand to asphalt and the other ingredients could not be ascertained, but the quantity of the sand need not be limited, as in cement concrete, for the larger the quantity of sand used the harder and better the pipes. The pipes are united by heating them so as to form a continuous pipe, as strong at the joints as in another part. Where the ground is yielding they are laid on piles driven 6 feet into the ground, and a plank laid on top of the piles upon which the pipe rests.

The Highland Park Water-Works, Los Angeles, for irrigation and domestic supply.—The source of the supply is the Arroyo Seco, a torrent which runs a few days only after each rain-fall, and springs, yielding during the dry months about .68 cubic feet per second. There are 400 acres supplied by the system, which must necessarily depend for its irrigation on the flood flow; hence a storage reservoir is necessary of sufficient capacity to store the rain-fall as it occurs, to be applied to the land during the intervals of dry weather, which through the rainy season average about fifteen days each. Allowing 2 inches depth as the minimum for each irrigation, 400 acres would require eighteen and one-seventh million gallons. The reservoir capacity is 20,000,000 gallons, and is connected with the main pipe, so that any excess over the distribution flows into the reservoir, and of course when the supply from the source is less than the pressure from the reservoir the distribution receives the water from the latter. The reservoir is therefore the head to which the supply pressure is due unless the reservoir main valve be closed, when the head at the source would furnish the pressure.

This system is capable of supplying 12 inches depth of water over the 400 acres during the year, in addition to the rain-fall, which averages 12 inches, and falls between the months of November and May. The land thus receives 24 inches depth of water, which is ample in this country for most products required, excepting oranges and alfalfa. The main pipe is 8 inches in diameter, asphalted wrought-iron, and the distribution pipes are of the same material, and from 2 inches to 6 inches in diameter. Each lot takes its supply through a 2-inch pipe. The effective pressure is 40 pounds per square inch. The land is irrigated by furrows, and service-pipes are laid over the ground in some cases, so that each tree can be watered from a rubber hose into a check of from 5 feet to 12 feet diameter, according to the age of the trees.

The head works are temporary, consisting of a wooden trough 100 feet long. This is laid in the bowlder bed of the channels, with the top of the sides slightly below the bed line. It is anchored by cleats fastened to its bottom, that extend 3 feet from the sides. These are covered, and the trough filled with bowlders, the water flowing between the bowlders. The trough at its lower end is connected with a 10-inch cement pipe. The temporary wooden flume will be replaced by a perforated wrought-iron pipe that will extend 100 feet, 5 feet below the shingle and bowlder bed, the water being dammed back by a submerged weir, causing the water that the pipe is capable of carrying to be drawn off by it; the water will thus be filtered of anything that can now pass between the bowlders. The cost of this scheme was $21,300.

The Ontario colony.—This colony is an example of utilizing waste land and water to the maximum of benefit. It is situated on the sloping land from the foot-hills of the Sierra Madre Mountains, where San Bernardino and Los Angeles Counties join, the San Antonio Cañon or Valley giving a perpetual supply of water from the mountain snows in the summer, and from rain which falls on the lower slopes and hills in the cold months. The soil was analyzed and examined as to its productive capability, and found to be peculiarly adapted for the growth of vines and fruit-trees. The climate was also favorable. Having purchased the land and the water rights, the colonists distributed the water by means of cement pipes over the whole tract, divided into 10-acre lots, so that each lot should be supplied at the highest point. To accomplish all this has cost about $170,000. This includes roads, streets, railway station, hotel, college, dam, and 27 miles of pipes, masonry-lined channel and tunnel, iron pipes for supply of township, etc.

A dam diverts the surface water from the channel, but as a large quantity passes below the bed, a tunnel 3,000 feet long has been driven across this drainage and leads it into a masonry-lined channel, which is 6,000 feet long. The water is taken from this channel by the cement pipes, but a reservoir will be constructed to store the surplus water not required during the non-irrigating season, and the pipes will then connect with it. It is intended here to use the laminated wrought-iron pipe, preferring it to the single-shell riveted pipe. The water is delivered and measured from the cement pipes by means of a vertical connection, at which point a valve is fixed, consisting of a cast-iron plate, with an aperture the size of the pipe in it, and a groove for the valve to slide in. This valve is simply a plate of cast-iron with a wrought-iron lifting-rod. The tunnel referred to was decided on after sinking experimental shafts across the valley and then ascertaining that there was such a subterranean flow that a light substance, such as a chip of wood, would be carried to the bottom of the shaft.

This mode of intercepting water has been frequently resorted to with the most surprising results. The quantity of water used for irrigating by the pipe system is 1 cubic foot of water per second to every 50 acres. The value of 1 cubic foot of water per second where it can be applied, as here, to fruit-growing, is estimated at $50,000. The unit of measure is one-fiftieth of a cubic foot, and is termed an inch of water, and is measured by the discharge through an aperture 1 inch square in a 1-inch plank under a 4-inch pressure. The discharge of a stream for irrigating purposes is estimated for the mid-summer period, that is from the 15th of July to the 1st of August, when it is at its lowest.

LAKE HEMET WATER COMPANY, SAN DIEGO.

District and work.—The general project of the Lake Hemet Water Company contemplates the storage of water in Hemet Valley for supply to the stream at time of low flow, and the diversion of such waters, together with other waters of south fork, from a point just above the mouth of Strawberry Fork, and conducting them by means of pipe line for the irrigation of lands at the head of San Jacinto Plain, in the valley below the lands of the Fairview company. The district commanded is, practically, nearly the entire San Jacinto Valley.

Delivery and distribution works.—From a temporary diverting dam of brush in the south fork of the San Jacinto River, at the point above indicated, a 21½-inch sheet-iron pipe conducts water several hundred feet to a large sand-box, arranged in various compartments; thence the main pipe, 13 inches diameter, extends down the bed of the cañon a total distance of 16,091 feet, to a relief box, into which it empties freely at an elevation of about 500 feet below its head. From the reilef box a 22-inch riveted iron pipe extends to a point beyond the mouth of the cañon, a distance of about 10,250 feet. For purposes of temporary supply, an 8 inch pipe has been laid thence, a distance of 22,790 feet, to about a central point in a tract of 10,000 acres, owned by the Hemet Land Company, which is an associate organization with the Lake Hemet Water Company. But it is intended to replace this 8-inch pipe by an extension of the 22-inch pipe at an early date. The total length of pipe thus far laid, including some 5,000 feet of lateral distribution pipe, is about 54,900 feet, or nearly 10.4 miles. The weight of iron used has been from No. 16 up to No. 12 in thickness, and the total cost has been about $45,000. The pipe-laying down the cañon of the river proved to be a tedious and expensive job, for the reason that a succession of large boulders was encountered in the trench, many of which had to be blasted, and many removed with derricks and powerful pulleys, and for the further reason that the bed of the creek had to be crossed four times.

Storage reservoir; Hemet Valley.—The main resource of the company in the way of water supply is to be the projected reservoir of Hemet Valley, 20 miles above the town of San Jacinto, at an elevation of 4,300 feet. The south fork leaves the valley through a cañon, only about 60 feet wide at the bottom, with walls of granite, vertical on one side for 100 feet in height, and on the other sloping at a very steep angle. At a height of 120 feet above the base, at the most favorable dam site, the width across the cañon is but 200 feet, and at 150 feet, it is less than 300 feet. Granite of the best quality is at hand; sand, sharp and clean, may be had convenient; an abundance of pine timber is growing in the valley and on the hills all about the site, and water, whose power may be utilized for much of the work, is flowing in the stream. Taking all these convenient materials and facilities, and the character of the dam site into consideration, there are few localities in the State more favorable for the construction of a high-storage dam. The reservoir basin is a capacious one, but not notably so, as the following table of contents, at successive levels, will indicate:

Elevations of water plane.		Corresponding areas of reservoir surface.	Capacity of reservoir above base of dam.	
Above base of dam.	Above lowest outlet.			
Feet.	*Feet.*	*Acres.*	*Cubic feet.*	*Mill. gallons.*
30	*10	.37	112,000	.84
40	20	2.70	1,769,00	13.23
50	30	12.50	5,342,500	40.06
60	40	27.94	14,155,000	105.88
70	50	50.45	31,232,000	233.62
80	60	90.61	61,953,000	463.41
90	70	115.96	111,947,000	837.35
100	80	176.76	175,708,500	1,314.40
110	90	238.70	266,197,500	1,991.16
120	100	349.80	389,374,000	2,911.62
150	130	......	....	†6,000

*Figures in this column are approximations only. † Approximation.

SAN DIEGO RIVER WORKS AND PROJECTS.

The commanding position occupied by the works under construction by the San Diego Flume Company, their far-reaching design in accumulating from different sources the waters of distant streams, their costliness, the wide extent of the district commanded, and the fact that they terminate at the city of San Diego, which may receive its supply at high pressure on the summits of its greatest elevations, render them in many respects more important to the prosperity of the region than any other.

District and works.—As far as they have been outlined the works consist of a storage reservoir on the headwaters of the Bowlder Creek tributary of the San Diego River, a diverting dam of masonry in the river proper, and a line of flume 36 miles in length—skirting the cañon's side for 21 miles, then circling south of the valley of El Cajon, and finally emerging upon the mesa 10 miles east of the city of San Diego. The plans of the company contemplate the diversion of the headwaters of the Tia Juana and Sweetwater Rivers on the south, and the San Dieguito on the north, into the head of the main flume, the construction of various additional storage reservoirs in the mountains, and a distributary reservoir at the end of the flume, the development of tributaries of the San Diego by tunnels under their beds and gathering them into the main conduit by smaller lateral flumes, and the distribution of the water from the end of the main flume by pipe lines over the mesa.

Storage reservoir.—The main dependence of the works for a summer and fall supply is at present the Cuyamaca reservoir, located 43 miles northeast of San Diego in the Cuyamaca Mountains, at an altitude of 4,500 feet. The water shed of this reservoir is about 15 square miles in area, draining two of the highest peaks of the range. The reservoir is formed by an earthen dam 635 feet long on top, 40 feet in height, thrown across the outlet of a broad, flat mountain valley. From the eastern rim of the water-shed the country drops abruptly into the desert. The hills on this side are low and barren. The two Cuyamaca peaks on the west are clothed with forests of pine and oak.

Cuyamaca dam.—The site of the dam was one which had all the surface indications of solid rock. The whole surface was covered with loose granite bowlders, and before sinking test pits, preparations and plans had been made for building a masonry dam. The excavation for foundation developed a bed of clay instead of bed-rock as anticipated, and an abundance of good clay being found in the immediate neighborhood, the plans were changed and an earth-work dam built. A puddle trench was cut under the center of the embankment, and the clay filling built up in layers. The embankment has a base of 115 feet, inside slope of two to one, outside slope of one and one-half to one, top width 15 feet. The high water mark is fixed at 5 feet below the top, at which point a waste-way 50 feet wide is placed on one side. The water-face of the dam is covered with stone riprap laid, dry, 8 inches in thickness.

The outlet culvert is of masonry 3½ feet wide by 4 feet 6 inches high inside, 120 feet long, its bottom placed at the level of the original surface with a fall of 3½ feet in its length. At the upper end it opens into the base of a circular brick tower 8 feet in diameter outside, 5 feet in diameter inside, and carried to the level of the top of the dam. This tower is provided with two gates of wood, closing openings 3 feet wide by 4 feet 6 inches high. The lowest opening is at the bottom of the tower, the second 15 feet 9 inches higher, immediately above the lower. These gates slide up and down in wooden grooves, and as they are to be moved by chains or ropes, are not convenient, particularly when they are to be closed quickly under pressure. An iron gate is provided inside the tower to close the head of the outlet culvert.

Diversion and delivery works.—The diversion is made from the San Diego River about 31 miles from its mouth, at an elevation of about 800 feet above sea-level, and where the stream, falling at the rate of about 30 feet per mile, is in an open cañon flanked by barren mountain slopes rugged and steep.

San Diego diverting dam.—The diverting dam is built of masonry of of the following dimensions: Maximum height, 34.5 feet; length, 447.5 feet; width at top, 5 feet; up-stream batter, 1½ feet in 20 feet; back batter, 7 feet in 20; width at base, 18 feet. The dam contains 4,000 cubic yards of masonry, and required 2,410 barrels of cement. The average depth of excavation in the bowlders that formed the bed of the stream was 10 to 12 feet, and the foundation rests upon the soft, disintegrating granite, forming the bed-rock of the country. This material may be readily cut with the pick and crumbles on exposure to air. After the dam was completed and tested, the leakage was considered excessive, and the upper face was again stripped to the foundation, and an apron of masonry 2 feet thick was sunk to a depth of some 6 feet lower than the original base. The wall was then repointed and partially plastered on the face. The top of the dam is at an altitude of 813.5 feet. In alignment the dam has an angle in the center whose apex is pointed up-stream. Otherwise the structure is straight, depending upon the weight of its mass for stability.

The head of the flume passes through the wall with wooden gates to control the water. The level of the flume-bed is 9 feet below the top of the dam, or 4 feet below the overflow weir. The main waste-weir is 210 feet long, with a secondary weir 20 feet long. The floor of these weirs is of pine plank spiked to timbers that are bolted to the masonry. In addition to the overflow waste-weirs, there are two culverts passing through the dam for draining the basin above. One of these is 2.5 feet square, 7 feet below the grade of the flume, the other 3 feet square, 8 feet lower than the first.

Main conduit; flume line.—The flume is set on a bed cut in the mountain side, except where it is supported on trestling. All fills are made with loose rock laid with some care on the outer face. Its total length is 36 miles. The grade is 4.75 feet per mile.

Tunnels.—There are eight tunnels upon the work, lined with masonry on the sides, timbered overhead, except in solid rock, and plastered with cement on bottom and sides, of a total length of 4,168 feet. The tunnels are finished 6 feet wide by 6 feet 1 inch high in the clear. In loose material the sides are walled up with masonry 12 inches thick to a height of 4 feet, on top of which rests timbering, 6 by 8 inches, with lagging of 3-inch plank; the bottom and sides being finished smoothly with cement.

Flume.—The flume is made in rectangular form, 5 feet 10 inches wide by 3 feet 10 inches deep, in the clear. The bottom and sides are of 2-inch redwood plank, planed on the inside. The frames, placed at intervals of 4 feet, consist of a sill 4 by 6 inches by 12 feet, two posts 4 by 4 inches by 4 feet, and two diagonal braces 2 by 4 inches, 3 feet 3 inches long. The substructure where it rests on the ground consists of mudsills of redwood, 2 by 12 inches by 9 feet, two stringers 4 by 6 inches, one under each side of the flume box, and a block 8 inches long supporting the sill in the center. Where on trestle, the sills of the flume rest on three longitudinal stringers, two of which are 4 by 12 inches, and one in center 6 by 12 inches. The trestle bents are placed 16 feet apart, and for trestles up to 20 feet in height, consist of two posts 8 by 8 inches set on a batter of one to six, a cap 8 by 8 inches by 6 feet, a sill 8 by 8 inches of proper length, and two diagonal sway braces 2 by 10 inches. For higher trestles, more posts are introduced, and trussed bridges carry the flume over the deepest gorges that are crossed. Ten million feet of timber will be consumed in the structure. The flume has a theoretical capacity when filled within 3 inches of the top of 110 cubic feet per second, or about 5,500 miner's inches. The flume for its full length of 36.6 miles is now carrying water, with sideboards 16 inches high; the remaining boards for full completion are to be added later.

Distribution system; pipes and reservoir.—From the end of the flume to San Diego the main pipe line will be 9 miles in length to the top of the mesa overlooking the city. A branch pipe 1 mile in length will deliver surplus water to a reservoir to be constructed for storing the unused delivery. A main 4 miles long will be required to tap this reservoir and join the through line below. This reservoir is called the city reservoir, and will have a capacity of 761,000,000 gallons, covering an area of 100 acres. It will be formed by a masonry dam 50 feet high, located in a narrow gorge through blue trap rock, whose width at a height of 30 feet is but 50 feet. Its elevation above sea-level is 460 feet at the base.

BEAR VALLEY LAND AND WATER COMPANY'S WORKS.

Bear Valley and Bear Creek.—Immediately north of the San Bernardino Peak and Grayback Mountain, extending in an easterly and westerly direction, at at elevation from 4,500 to 5,000 feet, lies the valley of the upper Santa Ana River. Overlooking this and bordering it on the north is a long rugged mountain ridge, whose crest-line holds 7,200 to 7,700 feet of altitude. Next north of this, with its axis in the same direction and about 4½ miles from the main mountains on the south, we find Bear Valley, a remarkably large and flat mountain basin, about 6,200 to 6,300 feet above the sea, and 21 miles in a straight line from San Bernardino.

Storage reservoir.—This valley has the appearance of once having held a lake whose waters, at an elevation of 125 feet above its bottom, overflowed at the east end into the head of a cañon which leads away into the Colorado desert. Now, however, we find a deep and narrow rock-bound gorge leading out of its other extremity, and, cutting southerly around the west end of the Central Mountain ridge, before mentioned, joining the cañon of the Santa Ana River about 10 miles above its outlet into San Bernardino Valley. This gorge holds Bear Creek, at whose point of departure from the valley a dam has been built, whereby the basin has been made, or remade, a lake.

The bottom plane of the valley is 12 miles long, and varies between a few hundred yards and a mile in width. Its lower end was narrow and rock-bound; then, a couple of miles or more above the dam site, it opened out into a couple of beautiful meadows, whose level plains, 700 to 800 acres in area, were 30 to 45 feet above the outlet; and at the upper end of the valley is another such flat, covering about 800 acres, and 20 to 30 feet still higher. At 60 feet of elevation above the base of the dam a water-plane would reach 5.9 miles up the valley and have an average width of .6 of a mile, covering 2,252 acres in area. At 120 feet of elevation the length would be 11.5 miles, the mean width 1.1 miles, and the area submerged 7,850 acres.

Water-shed and precipitation.—The water-shed tributary to this valley is 40 to 45 square miles in area. On the south lies the central ridge already described, and heavily timbered on its slope towards Bear Valley. North and west is a well-timbered, but not abrupt, mountain 1,000 to 1,500 feet above the valley. Northeast are rolling hills, 500 to 700 feet above the valley, and sparsely timbered; while the east end is closed in from the desert slope by a comparatively barren range of hills, whose altitude ranges from 200 to 500 feet above the valley.

The rock of the country is, for the most part, granite, of which huge bowlders and massive ledges crop out around the slope, particularly near the western end. Limestone is found near the eastern end, and some good lime has been there burned. Although the country is much broken and shattered in its rock formation, there is a good layer of soil over most of it, and the bottom of the valley itself is well clothed in this respect, as attested by the rich meadows which ordinarily remain moist and green the year round—receiving little streams from the wooded hillsides, and having some springs along their margins. It was feared in some quarters that the reservoir would not hold water—that it would escape in enormous quantities through the rock rifts and seams. But this fear has proven groundless.

Bear Valley is in the midst of the heaviest down-pour belt in southern California. The clouds collect around and bank up against the high peaks of San Bernardino and Grayback, and spread over into the Bear Valley water-shed. Holding so great an altitude, its precipitation is largely received in the form of snow, which in the wooded and shaded portions of its sides lies for several months. The data of local rain-fall will be given in a division of this report devoted to water supply in southern California.

Bear Valley dam.—The dam is at the extreme western end of the valley, at the head of the narrow, rock-bound gorge, which drops rapidly away. Founded on granite, where the channel was 60 to 75 feet wide, and abutting against granitic mountain sides, at the top line it is about 300 feet in length, in the form of an arch, having a radius of 335 feet; and it is 64 feet in height from extreme base to top of coping.

In cross section it is remarkable. The top is but 3 to 3.2 feet wide; the lower face vertical for 48 feet, and the upper face battered so that 48 feet down the structure is 8.5 feet thick. At this plane there is an offset up and down stream—the dam increases in thickness to 12 or 13 feet—and thence has a slight batter on both faces, so that at the extreme foundation it has a thickness of 20 feet.

This structure is of granite, rough ashlar masonry on both faces, and broken coursed rubble in the interior, all laid in a cement mortar and grouting. The square stones show dimensions ranging from 3 to 5 feet in length, 1½ to 2½ feet in width, and 1 to 2 feet in thickness, with others, of course, smaller. Its total volume is about 3,300 or 3,400 cubic yards.

At the time construction commenced, in the fall of 1883, there was no water running out of the valley, and but little was encountered in sinking 3 or 4 feet for the dam foundation, so that small difficulty was had in this work. That season the wall was brought up to the level of the bench, 16 feet above the extreme foundation plane, for about half of its length. It was desired to make some show of impounding water the first year and to test the water-producing capacity of the shed; so a temporary earthen dam was put across the valley just below the wide marshes, about 2 miles above the main dam site. This embankment was 5 to 6 feet high and was calculated to bank water over 500 to 600 acres to an average depth of 3 or 4 feet. The move was quite a fortunate one, for the water thus held back during the winter of 1883-'84 furnished a supply, which, being gradually let out from this temporary reservoir, during the summer, enabled the constructors to keep a lake surface of sufficient depth and extent behind the new wall to afford, by means of flat-boats, an economical way of transporting stone from the quarries.

The rock was quarried from the outcropping masses of granite along the edge of the valley and near the level of the proposed lake, from 100 yards to three-quarters of a mile above the dam-site. That for the first season's work was obtained near at hand and delivered on sleds, but that for the second season's work, comprising the great mass of the dam, was transported on flats and put into the work by means of derricks on large rafts floated close against the upper face of the wall.

At the north end the dam foundation was cut into the loose, sloping mountain side, to a bed-rock base. The south end abuts against a massive, nearly perpendicular ledge or point of granite standing near 100 feet out into the cañon. This point in reality forms a part of the dam. Over it a flood escape-way has been cut 20 feet in width, and with a plane 8.5 feet below the level of the extreme crest of the dam coping.

Through the bed-rock immediately below the foundation plane, about one-third of the length of the structure from the southern end, about 9.5 feet above its extreme base plane, is a cutting which forms a culvert 3 by 3.5 feet in aperture, opening out below into a masonry pool, from which it was expected to measure the water over a weir. This culvert gradually becomes narrower towards the upper end. On the upper face of the structure the culvert is closed with masonry to a gate opening of 20 by 24 inches, over which is an iron sliding gate on brass bearings, worked by a screw at the top of an iron rod, which extends up through the water in a 6-inch lapwelded pipe, serving as a guide, to a wooden platform built out from the coping of the dam. Subsequently this culvert opening was lined over a movable mold with concrete, so that the opening is now 2 feet by 3 feet, with an arched top. There is no gate tower; no provision for drawing water at less pressure; no safeguard or regulator on the one outlet provided other than the one gate.

In the matter of abutment, the dam for about 20 to 30 feet at each side is gradually made thicker, so that it rests against the rock of the country at 1.5 to 2.2 times its normal thickness. The coping stones are 3 feet long, generally 1½ feet thick, and 2 to 2½ feet wide, resting lengthwise across the top of the structure. The finish work and coping stones have not been put on for the full length, so that for more than half the length the top is 3 to 4 feet below the intended plane of completion.

The first year after construction, with the water plane at 40 to 45 feet, there was a little leakage at the south end, near or under the base, which it is claimed came through rifts through the granite point against which the structure there rests; and there was a remarkably free sweating and efflorescence of lime on the lower face over the whole structure, nearly up to the water-line. It is understood that the sweating phenomenon has now to a great extent ceased. There has been some expansive movement to the structure—attested by the reported fact that the cope stones which do not extend all the way across show a separation at some of the joints, to be accounted for only as the result of expansion and subsequent contraction. Otherwise the structure appears to rest just as placed, and thus far serves its purpose; the water having been for a time within a foot of the finished part of its top, and having constantly stood well up on it for a considerable period, as hereinafter written.

The company, desirous of securing greater reservoir capacity, has in contemplation an enlargement of this work. Indeed, it is proposed to provide for storage to the 100-foot plane above the present foundation, which, successfully and permanently done, would make this a truly notable reservoir and very valuable property. There have been no plans or definite ideas, even, as yet put forward for the enlarged work. Engineers familiar with such construction will see that, under the circumstances, it is a problem not without much embarrassment and grave responsibility.

Reservoir space and water-supply.—The reservoir site was surveyed preliminarily by the State engineering department in 1880, and it was reported that a dam 45 feet in height would impound water over an area of about 1,500 acres, to a volume of about 650,000,000 cubic feet, and that a dam 60 feet in height would create a reservoir space about 2,300 acres in area, and about 1,850,000,000 cubic feet in volume. The dam subsequently built is not exactly at the location where the section of 1880 was made, so that the figures of the latter and more detailed survey made by the Bear Valley Company do not tally precisely with those of the preliminary reconnaissance, but they are close enough to prove each substantially correct.

At different elevations of the water plane the areas of reservoir surface and capacities of reservoir space are as follows:

Elevations of water plane.		Corresponding areas of reservoir surface.	Capacities of reservoir: Totals above ground surface.	
Above base of dam.	Above outlet.			
Feet.	*Feet.*	*Acres.*	*Cubic feet.*	*Mill. galls.*
5	....	0.75	65,000	.48
10	0	4.95	631,000	4.72
15	5	10.23	2,271,000	16.99
20	10	34.93	6,921,900	51.78
25	15	141.36	17,898,450	133.87
30	20	294.54	67,850,600	507.52
35	25	427.79	145,808,450	1,090.65
40	30	1,060.01	312,153,521	2,334.91
45	35	1,425.02	581,855,607	4,352.28
50	40	1,691.41	920,824,487	6,887.77
53	43	1,858.99	1,152,729,883	8,622.41
55	45	1,960.49	1,307,277,775	9,778.44
57	47	2,069.26	1,482,801,898	11,091.36
60	50	2,251.50	1,763,166,320	13,188.38
65	55	2,532.00	2,283,791,020	17,082.76
70	60	2,812.00	2,834,253.750	21,199.22
80	70	3,300.00	4,161,190,000	31,125.70

PROJECTS OF THE NORTH POUDRE LAND AND CANAL COMPANY.

The superintendent, Mr. J. C. Ulrich, states: Our principal work is developing some reservoirs on the canal line up on the plains, located 40 miles north of Fort Collins. There are natural depressions on the plains, and we make a cut from those natural depressions; then a pipe is put in the cut and "fills" are built which will retain the water that is afterward drawn off to irrigate the land. The object is to store the excess and use the same when the need requires. They are to be filled when the rivers are high, and the amount of water used by other ditches is small. At present we have four reservoirs constructed, with an aggregate capacity of 175,000,000 cubic feet. When the system is completed, we expect to serve probably seven or eight times as much as we can at present irrigate. The North Poudre Land and Canal Company's Canal is about 25 miles in length. It is 16 feet wide on the bottom, with an average depth of about 4 feet. It has a grade of about 2½ feet to the mile on the first 7 miles and 4 feet on the rest of it, on the lower division. We estimate that it will carry about 300 cubic feet per second. The first 7 miles are in the mountains or foot-hills, and after getting out on the plains we strike the land which we expect to irrigate. One has an area of about 100 acres and a depth of 14 feet. The next reservoir brings two "fills" together, containing each about 35 acres, about 9 feet deep. The third contains 160 acres 26 feet deep. That is as far as we have completed the system at present. Then, below the last one I have mentioned (south of it), is a chain of proposed reservoirs, aggregating something like 2,500 acres. The total cost of this ditch was about $175,000. It will take about $50,000 to complete the reservoirs. By an expenditure of $50,000 we increase seven or eight fold the capacity of a ditch that cost $175,000.

Dam at head of North Poudre Canal.—This dam is 30 feet 6 inches high in the center, and 150 feet broad at the top, and is formed in two parts. The face, which gives the necessary stability against floods, consists of crib-work and stones; the back, which renders the dam watertight, is a vertical panel, or diaphragm of timber, backed with earth, small stones, gravel and mud, thrown in without puddling. The crib-work is formed of round logs 10 inches, at least, in diameter, joined at ends, as in ordinary log huts, with dove-tail or tongue joints. The cribs are 10 feet long on the face, and are fastened together with 18-inch tree-nails, 2 inches in diameter. The cribs are radiated to form, when laid close together across the stream, curved ties of 200 feet, 216 feet, and 232 feet radius on the face. There are three of these tiers 6 feet asunder. The interior of these cribs, and the spaces between the stones, and the interior surfaces, are faced with large selected blocks of stone, carefully laid so as to overlap each other like slates or tiles of a house, and without mortar. The arrises are protected by 12-inch square balks, securely bolted to the cribs. The timber diaphragm is carried 4 feet higher than the cribs and stone-work of the tallest tier, to form a slash-board, which can be removed in sections in case it is found liable to be damaged by ice. The center portion of the dam for a length of 60 feet is carried 2 feet higher than the sides, to throw the bulk of the stream onto natural benches of solid quartz rocks on the sides, and thereby to protect the greater part of face, and especially the toe in the center of the stream, from the abrading power of the water.

The total cost of this dam was $7,250. The dam was founded on stone and débris, the depth of which had not been sounded, but it was hoped that the clay thrown in the back of the dam, combined with the silting up of the river, would have the effect of stopping the flow of the water, and the result justified the expectation. This dam is not intended for storage purposes, but is simply a weir for raising the water high enough to enter the flumes and tunnels. The canal regulators are ordinary sluices, inserted in the flumes about 100 feet below the dam.

The objections that are urged against timbers being used are met by the fact that the massive stone, or masonry in cement, which would have been requisite to secure the mass of material used, would have been too costly. The cost, $7,250, was very low for a weir 144 feet long, but the foundations were not necessarily extensive, and the source of supply of stone and timber was at hand.

Montezuma Valley, in southwest Colorado, is the seat of a great irrigation enterprise. It is described as follows: The valley is about 30 miles long, running from northeast to southwest, and is nearly 10 miles wide. The water is to be taken out of the Dolores River at the northeast end of the valley. The State has located about 26,000 acres of land in the valley, and probably about 10,000 or 15,000 acres have been located by actual settlers, leaving between 50,000 and 100,000 acres yet unclaimed. The locations are principally at the upper end of the valley, near the tunnel.

The Grand River canal, in western Colorado, has a width at the bottom of 35 feet, on the top of 50 feet, and a depth of 5 feet for the first 10 miles. The size then diminishes until for the last 2½ miles the width is 16 feet on the bottom, and the depth 3 feet. The grade is .035 per hundred, or a little over 22 inches to the mile. The banks are given a slope of 1½ to 1, are 3 feet wide on top and 2 feet above the water surface. There are several drops, one of 6 feet, one of 13 feet, and one of 35 feet, while down the valley about 14 miles there is a final fall of about 14 feet. Just above the second fall a lateral canal has been carried out on the upper level, a distance of 17 miles down the valley, carrying 3 feet of water. The location of the head is so favorable that a full head of water can be taken out of the river at its lowest stage of supply, so that water in this canal, in consequence of the volume running in winter season, can be in operation the year around, a fact very important in Grand Valley, where it is assumed that late irrigation will be advisable and early irrigation a necessity for the germination of seed. The flumes, head-gate and waste-weirs have been built in the most substantial manner.

KANSAS AND THE UPPER ARKANSAS VALLEY "UNDERFLOW."

From records kept at Dodge City during the last eighteen years, and from information gathered from other reliable sources, we believe it is safe to depend on an abundant supply of water for irrigation in the Arkansas Valley in at least seven years out of ten. If these same climatic conditions are to be looked for in the future, would it not be wise to make some provision for these three years of drought? Manifestly so, if the conditions are present which will render such a provision possible. Various methods of utilizing the underflow of the Arkansas River to supply the irrigating ditches with water, which the river failed to furnish during seasons of deficiency in precipitation, have been discussed. That the supply of water is inexhaustible has been frequently demonstrated by pumping water from wells located in the valley. The two most noted experiments were made last year at the wells which supply the water-works at Dodge City and at Garden City. These wells are 22 feet and 19 feet in diameter, respectively, and about 20 feet deep; the water rises to within 4 feet of the surface of the ground. Over 1,000,000 gallons have been pumped out of the Dodge City well in a single day without lowering the water to any appreciable extent. At the Garden City well the water-works pump, with a capacity of 600 gallons per minute, and a Huffer irrigation pump, with a capacity of 500 gallons per minute, were both worked to their utmost limit for a period of four hours without lowering the water in the well. Numerous other experiments of a similar nature have been made.

The South Dodge Canal Company was organized last year with a capital of $250,000. The officers of the company are E. E. Soule, president, G. G. Gilbert, vice-president, and J. W. Gilbert, secretary. This company has secured the right of way for 35 miles of irrigating ditch on the south side of the Arkansas River. Fifteen miles of the ditch have already been completed. It will be known as the South Dodge Canal. Nearly 100,000 acres of valuable lands may be irrigated by this canal. The ditch extends from Howell Station, 8 miles west of Dodge City, to Ford City, a distance of about 35 miles. The original survey provides for taking water from the Arkansas River at the south bank, opposite Howell Station. It is at the head of the South Dodge Canal that the experiments are being conducted for securing a flow of water in an open channel from a reservoir to which the water is supplied by the underflow of the Arkansas Valley.

The reservoir, or head of the canal, is located about 60 rods from the river bank. At a point 1⅜ mile from the head the ditch was built exactly at grade—*i. e.*, the bottom of the ditch is on a level with the surface of the ground, the bank of the canal being levees about 8 feet high. Commencing at the grade point the excavation of the upper end of the ditch was begun, due allowance being made for the proper fall. At a distance of about half a mile the water-bearing stratum of sand was reached, the bottom of the ditch at that point being about 4 feet below grade. After reaching this sand the soil was then stripped off to the head of the ditch, the work all being done by teams and scrapers. The ditch, at a point 2,000 feet from its head, is 30 feet wide at the surface of the ground. This increases to 60 feet at the head of the ditch. For this entire distance of 2,000 feet both sides of the ditch are protected by sheet-piling.

The company did not expect to secure a flow of water at this stage of the excavation, but contrary to their expectations the water began to accumulate and run in a strong current down the ditch and in such a quantity that it was necessary to put in a head-gate and cut-off at the grade point 1⅜ miles from the head of the reservoir. The flow extended over 8 miles, and as far as the ditch had been completed at that time. Since the head-gate and cut-off have been put in no water is allowed to pass below it in the ditch, but is turned off at the side of the ditch and runs in an open channel to the river, which at that point is about 100 yards from the ditch. The writer measured the flow of water at the point where it falls over the river bank, and found the stream to be 4½ feet wide and 13 inches deep. It will be remembered that this result has been obtained without any reservoir yet being constructed.

The head of the ditch, as before described, will constitute the reservoir, and will be 60 feet wide at the upper end, 30 feet at the lower, and 2,000 feet in length. The sand will be excavated by a dredging-machine, which was placed in position on Saturday, February 1.

Owing to the extreme cold weather which has prevailed during a greater part of that month the work of excavating the reservoir progressed very slowly. Over 200 feet was completed by the 7th instant.

The excavation was begun at the upper end. Two dredging-machines are in operation, and if the weather is favorable the work will be completed by the 25th of this month. The flow of water has increased largely, and is now fully 2,000 gallons per minute. If the water continues to rise to the same height at which it has been found impossible to reduce it in small wells by pumping, the profile and survey of the ditch provides for a stream of water 5 feet in depth at the grade point before mentioned. The managers feel confident that this supply can be secured.

As an experiment, the work has been a complete success; the water will, and does, flow in an open channel from the underflow of the Arkansas Valley; the channel does not fill with sand, and manifests no disposition to do so.

The Gilbert Bros. have had the general management of the constructing of these ditches. On the 7th the Eureka Ditch, 96 miles in length, was full of water, besides over fifty storage reservoirs of from 5 to 40 acres in area. The Dodge City Canal and the Eureka Ditch will both be furnished with reservoirs for supplying water from the underflow of the Arkansas River this season.*

PROPOSED UTILIZATION OF THE SIERRA LAKES.

In western Nevada the use as reservoirs of the Sierra Lakes, etc., has been projected on a massive scale. Without indorsement the outlined plans are presented. In surveying Donner Lake and the valley an elevation of 20 feet above the present lake is obtained. This will make a reservoir of over 5 square miles, with an average depth of 40 feet, holding an estimated volume of 5,575,680,000 cubic feet of water in a natural land-locked basin. The elevation is 5,885 feet above sea level.

The outlet will be by a high-line canal along the benches on the north side of Truckee to the plateaus north and northeast of the place and to the east of Boca and Verdi, crossing Prosser Creek and the Little Truckee River. There can be selected reservoirs at that point in which water enough can be stored to fill Dog Valley. This will ultimately become available for the valleys and plateaus north and east of Reno. A dam across the Truckee River about 1 mile above the Central Pacific depot is also located to make a reservoir 3 miles in length along the Truckee Valley. The outlet from this reservoir will be on the south side of the Truckee River, along the benches and high foot-hills south of Truckee City, around the Marquis plateau and meadows into Marquis Creek, which flows into the Truckee River near Boca, about 10 miles below Truckee. This canal through Truckee and along the hill-sides may also afford an excellent water-power for mills, etc., for a mile or more before being used on the plateaus, and again entering the Truckee River offer an ample supply for Truckee meadows, or it can be carried by a higher-line canal to and around the Washoe Basin here in western Nevada.

This dam, with the reservoir it will create in the Truckee, taken in connection with Lake Donner, will store, the two together, nearly or quite 6,000,000,000 cubic feet; quite sufficient for the supply of all lands now under ditch or available therefor; as well as the reclamation of at least 1,000,000 acres more. Lake Tahoe, by a dam at its outlet near Tahoe City, can readily be raised 8 feet. It has a drainage basin tributary to its supply of at least 5,000 square miles. Lake Tahoe should be held in reserve—the great storage reservoir which will meet extraordinary needs. Over one-third of its area is within the boundary-lines of Nevada. A tunnel has been proposed to lead into the Carson Valley, by which the water thus stored can be drawn from its depths, at least 1,000 feet below its surface. Three lines across the Sierras between Lake Tahoe and Carson Valley have been run, the best being near the southeast portion of lake Tahoe and the head of Carson Valley, all in the State of Nevada, locating a tunnel 10 by 10 feet, with a crown of 2 feet in center. The open cut from Lake Tahoe to the entrance of the tunnel will be 4,200 feet; the length of tunnel 17,331 feet, or 3.45 miles, the cut and tunnel having a grade of 2 feet per mile. The exit of the tunnel on the Carson Valley or east side is to be 1,500 feet above the valley.

---

* Date of March, 1890.

The output of this tunnel can be carried both north and south along the foot-hills and carried to any portion of the upper Carson Valley, and thence into the Carson River. In addition to the great benefit to be derived from the placing of this water upon the Carson Valley lands, a magnificent water-power can be secured and utilized along the east side of these mountains, and dynamos charged so that this power can be transmitted to Carson and Empire where the Virginia City mills are located, and the water used over again in Douglas, Ormsby, Washoe, Lyon, and Churchill Counties, all of them in Nevada. It is a perfectly feasible and not an expensive project either. A dam will have to be located also at the outlet of Lake Tahoe on the west side at Tahoe City to raise the lake 8 feet. The inlet to the canal and tunnel is located so as to receive 20 feet depth of water at high-water mark. This will give 200 square miles of surface water 20 feet deep, equal to 111,513,600,000 cubic feet. The lake will never be more than 12 feet lower than the present height. This grand reserve reservoir can be turned either into the Carson or Truckee basins. The elevation is 6,200 feet.

Hope Valley, at the head of the West Fork of the Carson, is found to be an admirable location for a large reservoir. By making a dam 150 feet high a surface area of not less than 5 square miles with an average depth of 50 feet can be secured. This dam we located at the foot of the Carson Valley and at the head of Hope Cañon, which has a granite ledge on both sides. For the first 100 feet in height it has a narrow gorge of 200 feet at bottom and 800 feet in width at top, with rock benches about 500 feet on either side above the first 100 feet. This is a land-locked valley about 5 miles in length, an average of 1 mile in width, 7,658 feet above the sea, and will hold 6,969,600,000 cubic feet of water, with average depth of 50 feet. This reservoir will require two outlets to be cut in rock on both sides, and the water can be then turned into the river below. This is the West Fork of the Carson River. It would conduct the water 6 miles down Hope Cañon to a diverting dam to be located about 1 mile above the mouth of the cañon, where a canal on the left or north side of the river would conduct the amount of water required along the foot-hills at the base of the mountain and north of the cañon at any desired height as far north as Sheridan or Genoa, and distribute it then down the foot-hills and into the valley until it reaches the West Fork of the Carson River. From this same diverting dam, 1 mile above the mouth of Hope Cañon, on its right bank, another canal can be constructed along the right bank of the West Fork of the Carson River, with a sufficient grade to conduct any portion of this water from the Hope Valley Reservoir across Diamond Valley 2 miles in length; this is located at the foot of Hope Cañon.

with an elevation of 5,481 feet, then through Dutch Valley, with an elevation of 5,277 feet, and this also about 2 miles in length; thence into Long Valley, which has an elevation of 5,078 feet above the sea and about 200 feet above the head of Carson Valley. There are already three ditches running from Hope Cañon and conveying water through Diamond Valley to Dutch Valley, whose natural drainage is into Long Valley. One of these ditches can be enlarged into a canal, and the flood and natural water from the West Fork of the Carson can be secured to Long Valley, which is a good, natural, safe location for a grand receiving reservoir; all outside of any river channel.

With a dam 100 feet in height at a narrow neck of Long Valley about 1 mile above the head of Carson Valley nearly or quite 4 square miles of surface water with an average depth of 50 feet can be obtained. This will give 5,625,680,000 cubic feet of water for distribution by a canal on the east side of the Carson Valley, which will supply not only the Empire Mills, but also all that the 100,000 acres of land on the east side of the Carson River (that now has no water for irrigation) may require. A canal from the left side of this dam out on the benches at the head of the Carson Valley may be supplied from this same source. The east or main fork of the Carson River runs almost parallel with Long Valley for the 3 miles east before debouching into the Carson Valley proper. At Horse Shoe Bend, a point about 2 miles from its mouth, there is a narrow saddle ridge, where with an overflow dam across the East Fork or main river can be turned through a tunnel or cut of about 1,000 feet in length. This will turn the water through a 10 by 10 feet tunnel or cut 10 feet wide at bottom and with its slopes of 1 to 1.

Pleasant Valley, on the Middle Fork of the Carson, in Alpine County, Cal., 12 miles south of Hope Valley, which is about 3 miles in length and 1 mile in width, can be made from 40 to 50 feet in depth as a reservoir, with a water-shed of 50 square miles, and it has good rocky flanks at the lower end of the valley. This location is 3 miles above Markleville, Cal., and in it can be stored 3,345,408,000 cubic feet of water. Below this reservoir and above Markleville are the waters from Burnside Lake, Hot Springs Creek, Charity Valley, and other mountain creeks. At Markleville, 18 miles above Long Valley, the East and Middle Forks of the Carson unite, thus making the East Fork the main Carson River, so that by the diversion of the East Fork at Horse Shoe Bend, Long Valley can receive the water of all the branches of the Carson to its full or maximum capacity. Twelve miles above the junction of the Main and East Forks of the Carson River Silver Creek joins the East Fork. Five miles farther southeast Wolf Creek empties into the East Fork. One mile above the mouth of Wolf Creek is a meadow, where from 1 to 2 square miles surface of water can be stored with a depth of 40 feet. Two miles above Wolf Creek, at Silver King Valley, on the East Fork of the Carson, another reservoir can be located with a water surface of 2 square miles. Now, all the above-named reservoir sites in Alpine County are above 6,000 feet elevation. Other sites have been examined, but found impracticable. The water-shed for the Carson River and its branches is fully 1,000 square miles.

At Wadsworth, Nev., 34 miles below Reno, the Truckee River turns north and sinks into Pyramid Lake, 15 miles from Wadsworth. At a point on the Truckee 5 miles west of Wadsworth an admirable location for a diverting dam is found, which can be built of stone in rocky bluffs 116 feet higher than the water surface at the Wadsworth bridge. A dam and reservoir has also been located there, and our men are running levels for canals on either side of said river to conduct the water out on the plateaus and benches north, east, northeast, and southeast from Wadsworth. The bridge, which is now 30 feet high, can be filled up, and a 10 by 10 feet outlet and canal put in on each end of the bridge to guard against any possible flood or overflow or accident. This water can be extended along the benches if required.

By storage of the flood waters at the head of the Carson and Truckee Basins and other water-sheds along the eastern slopes of the Sierras at least 500,000 acres of fertile lands in California and not less than 2,500,000 acres of good arable lands in western Nevada can be reclaimed and cultivated; all this in addition to the area now under cultivation. It will be seen that the aggregate amount of water in the reservoirs already selected is estimated at 133,229,968,000 cubic feet of water, and from the best information obtainable the reservoir can be filled annually from natural water-sheds. The demand for water in this State is at the rate of 1 cubic inch per acre, and is much in excess of that generally required in the State of California. The estimated amount for the reservoirs now located will furnish an acre-foot for 3,000,000 acres of land. I am convinced that we shall be able to find reservoir sites that will hold an amount sufficient for another 2,000,000 acres of land; that is, having an acre-foot of water for each acre. This will make 5,000,000 acres that can be reclaimed in this division by the storage of water sufficient therefor. The waters of the Truckee and Carson and auxiliary springs have been carefully gauged daily, giving the velocity and quantity and discharge in cubic feet per second. A sample of the gauging of the Truckee River at Essex above the ditches and canals is as follows:

	Name.	Mean velocity.	Discharge.
			Cubic feet.
May 20	Truckee at Essex	2,670	2,336.67
22	......do	2,767	2,511.94
28	......do	1,983	1,716.25
June 20	......do	358,549	250.49
May 22	Dog Creek	....	6.89
24	Prosser Creek	....	312.52
June 21	......do	....	64.33

IRRIGATION ON THE RIO PECOS, NEW MEXICO.

The Rio Pecos rises in the northern part of New Mexico, northeast Santa Fé.

It flows in a southeasterly direction to the neighborhood of Fort Sumner, and then a little east of south across the Territorial line into Texas, finally forming a junction with the Rio Grande.

It is a mountain stream, subject to alternate flood and drought, until it reaches the neighborhood of Roswell, N. Mex.; thence for 100 miles, in a due south line, it runs a tortuous course of probably 250 miles, receiving at intervals large quantities of spring water.

These springs generally flow into it along its bed, following the general limestone strata of the country.

They represent the drainage from the eastern slopes of the Capitan, Sierra Blanca, Sacramento, and the Guadalupe Mountains, and the waters of the upper river which disappear below Fort Sumner.

Careful measurements show that the permanent supply is sufficient to fill both of the canals now in course of construction, and calculated to carry 1,600 cubic feet per second, or 80,000 miner's inches.

The drainage area, or catchment basin of the Rio Pecos, within the Territory of New Mexico, and available for irrigation purposes, is approximately 20,000 square miles, at varying altitudes from 3,000 to 11,000 feet, and extending across four degress of latitude from the thirty-second to the thirty-sixth parallel.

The lands of the valley between Roswell and the Territorial line subject to irrigation are of the choicest limestone soil, and the total area between the foot-hills on the west and the river is nearly or quite 1,000,000 acres. Of this fully 400,000 acres are below the level at which it is practicable to deliver water from the Pecos.

The 40 miles of the Northern canal, now under contract, will cover about 75,000 acres of bottom and mesa land, and more than that area can be covered by extending the canal farther south.

The Southern canal is much the larger one, and will irrigate more than 100,000 acres on the west side of the river, north of the Texas line, while there is practically unlimited area that can be made available, by extending south of that line. Several bodies of choice land can also be covered on the east side of the river if desirable.

The Northern canal is being constructed 30 feet wide on the bottom, with sides sloping 1½ to 1 foot, and to carry water 5 feet deep, taking its supply from the Hondo, the principal tributary of the Rio Pecos, below the junction of the North Spring and Barenda Rivers, deriving its chief supply from permanent springs of great volume. Three miles from its head it crosses and receives the waters of the South Spring River, and is deepened to 6 feet to accommodate the increased supply at that point. These streams are all fed by permanent springs.

The Southern canal was constructed a distance of 11 miles, with the capacity to irrigate 30,000 acres. It is being enlarged to 45 feet wide at bottom, 63 feet at the top, and 6 feet deep, and by careful computation is intended to utilize all the available water of the river during the entire irrigating season. Its length within New Mexico will be 55 miles.

It is taken from the east side of the Rio Pecos a few miles below Seven Rivers. Although the waters of the Pecos are sometimes enlarged by floods, at the point where this canal is taken from the river, a dam 3 feet high, built at trifling expense, suffices to turn the water to fill the canal. It is controlled by head-gates, and the fall of the river is so great at that point that the rise does not exceed 6 feet—indeed, it never gets out of its banks. The river is a succession of rapids, and the fall within 6 miles amounts to as much as 50 feet. Very much of the water can be utilized at the crossings of arroyos for water-power, and then be discharged so as to cover large areas of agricultural land, without any loss of water. The canals are secure from floods. On the Hondo the reservoir at the dam backs fully half a mile up-stream, making dead water, and giving perfect control.

BLANKS AND FORMS USED IN DITCH MANAGEMENT.

[Northern Colorado Irrigation Company, Denver, Colo.]

RULES FOR EMPLOYÉS ON THE PLATTE CANAL.

D. W. Payne, division superintendent.

Division No. 1.

This division of the canal commences at ——— ——— and ends at ——— ———.

You are specially under the orders and directions of the engineer, and you are to carry out faithfully and promptly all his instructions. You will frequently and closely examine every part of the canal in your division, and enter in your weekly report any remarks that you may think necessary regarding the general condition of the works. Should there be a necessity for immediate attention to any part of the canal, report immediately on the telephone to the office, or if before 9 o'clock a. m. or after 4 o'clock p. m. ring the number on the telephone for the engineer. Failing to get an answer from the engineer ring the manager's number.

Should a serious leak, or break, or overflow occur, you will immediately make every effort to stop it, and to accomplish this you may hire such assistance as may be necessary and close at hand. Open the nearest waste gates above the leak, or break, or overflow, and if necessary to have all the water shut out of the canal, telephone to Denver to any of the three calls there. Should the accident be one that you can overcome without great difficulty, do not lose time by leaving it and trying to telephone, but get such assistance as may be nearest. If necessary, send or go to the nearest telephone and give notice to the engineer.

All employés on the canal are required to promptly render assistance to each other whenever there is any necessity for so doing. Each division superintendent shall keep a daily record of the depth of water on the guage or guages in his division, and will report the same to the engineer by telephone daily.

Each division superintendent shall provide himself with a suitable horse and cart, if such conveyance be required, and shall at all times carry with him a shovel, hammer, nails, screw-driver, wrench, measuring rule, and telephone tools, all of which, except the horse and cart, and feed for horse, will be provided by the company. In addition to these tools, there should be on each division oakum and sacks, and division superintendents will promptly notify the engineer when additional supplies are needed.

Expenses.—Except in cases of emergency, such as leaks, breaks, or overflows, or danger of any of these, no materials or tools shall be purchased or obtained on the credit of the company, except by the engineer or on his order, and no labor shall be employed except in emergencies as above stated, without first having the authority of the engineer. In all cases where laborers or mechanics are employed, the person in charge of the division where the work is being done shall keep a full and complete record of the time each person is employed and the wages to be paid, unless the engineer shall place some other person in charge of the work.

All payments for wages or hire of any kind and for material shall be made at the office of the company in Denver, and then only upon properly stated and certified accounts first approved by the president or manager.

Care of property.—All property of the company must be carefully watched and protected on each division by the division superintendent, and he shall be responsible for locks, keys, gate-pins, tools, bolts, bars, or other effects. He shall report promptly to the engineer or manager all cases where the property of the company has in any way been tampered with or damaged, such as the cutting or breaking of gates or weirs, or interference in any way with the banks of the canal or flumes. He shall also report all cases where any damage has resulted to the property of others by reason of overflow or breaks, or in any other way.

Distribution of water.—Such water as may from time to time be in the canal shall be divided pro rata to all persons entitled thereto by reason of their ownership of water rights, and each person in charge of a division shall in the most impartial and careful manner turn water out of their respective gates in strict accordance with the directions given from time to time by the engineer or from the manager's office, and under no circumstances is any person to be allowed to open a gate or in any way to obtain more water than the quantity stated in the directions. The gate on every outlet must at all times be kept locked and the division superintendent must at all times carry the keys with him. He shall carefully inspect all gates, weirs, and outlets every day to see if all be in good order; also to discover if the gates are being tampered with, and he shall measure and record every day the depth of water flowing over each weir, and enter the same in the reports prepared for such purpose. Look sharply for persons having duplicate keys.

All outlets are to be kept free and clear of drift-wood and all other floating matter, and the gates should be frequently examined to see if there be a free flow under them; also that no wedges have been driven under them by persons trying to get more water.

Do not accept the statement of any person about water; all instructions pertaining thereto will be given on the telephone, or in writing, from the proper authority.

Report promptly the name of any person who offers any bribe or any inducement to get more water than is then being allowed under the directions given you.

Whenever there is a rise in the water in the canal, not caused by floods from the prairie, the quantity running over the weirs in the lateral ditches should not be allowed to increase by reason of the greater pressure on the outlets. The gates in the outlets should be partly closed down so as to give just the same depth of water over the weirs as was running before the rise, unless orders contrary to this have been given from proper authority. In almost every instance when more waste is taken into the canal from the river, the extra quantity is intended for the divisions at the end of the canal. When a sudden great rise occurs in the canal by reason of flood water from the prairies, caused by a storm, make haste to the water gates and open them, also let out at all the outlets in the canal as much water as the lateral ditches will fairly carry without overflowing or doing any damage.

Whenever there are indications of a storm and a flood, the waste-gates should be opened before the flood comes. Good judgment and prompt action in emergencies of this kind will determine the efficiency and earnestness of the employé in the duties assigned to him.

Whenever you see that water is being allowed to run to waste by any irrigator, reduce the quantity running over the weir to the extent of such waste. If you see that a lateral ditch is broken, and the water is running to waste, shut off the water and notify the superintendent of the lateral or some person who is using water from it. Make a record of your action in every case of the two above kinds, and state the particulars in your weekly report.

NOTE.—There must not be any absence from duty unless permission first be obtained from the engineer or manager.

There must not be any scolding with, or rough language applied to, farmers or users of water. You can perform your duty better without this. If any one assaults you without just provocation the company will assist you in a prosecution.

Any case of intoxication or any neglect of duty, or apparent indolence or indifference on the part of an employé will be met with prompt dismissal.

All reports must be carefully and accurately made, so that, if necessary, they can be sworn to.

S. J. GILMORE, *Manager.*
GEORGE G. ANDERSON, *Engineer.*

THE NORTHERN COLORADO IRRIGATION COMPANY.

Record of depths of water at the weir, at the city limits of Denver, for the week ending Saturday, ——, 188—, at 6 o'clock p. m.

Day.	7 a. m., depth in inches.	6 p. m., depth in inches.	Average depth per day.	Discharge in cubic feet.	Total quantity in gallons.	
Sunday						
Monday						
Tuesday						
Wednesday						
Thursday						
Friday						
Saturday						

I certify that the depths of water entered above in the first two columns are true and correct.

—— ——.

I certify that the depths given above in the first two columns and the average depths given in the third column show a total delivery of water for the week ending as above, of —— cubic feet, or the equivalent of —— gallons.

—— ——,
—— ——.

Record of depth of water on weirs in third division for the week ending Saturday, September 16, 1888.

Outlet number.	Sunday.	Monday.	Tuesday.	Wednesday.	Thursday.	Friday.	Saturday.
47	No water in the ditch.	Do.	Do.	Do.	Do.	Do.	Do.
48							
49							
50							
51							
52							
53							
54							
55							
56							
57							
58							
59							
60							
61							
62							
63							
64							
65							
66							
67							
68							
69							
70							
71							
72							
73							
74							
75							
76							
77							
78							

I certify that the depths of water entered above are true and correct.

THOS. EVANS,
Division Superintendent.

Record of depths of water in flumes, etc., for the week ending Saturday, ——— 18—.

Location.	Sunday.	Monday.	Tuesday.	Wednesday.	Thursday.	Friday.	Saturday.
Dam							
Cañon Flume							
Plum Creek							
Bennett Gulch							
Little Dry							
Cherry Creek							
Section 1 Check							
Dryer's Check							

I certify that the depths of water entered above are as telephoned to me daily by the respective division men.

——— ———,
——— ———

Report of services performed during week ending Saturday evening, ——, 18—, by ——

Sunday,

Monday,

Tuesday,

Wednesday,

Thursday,

Friday,

Saturday,

The Northern Colorado Irrigation Company. Report of services performed by —— ——, for week ending Saturday evening, ——, 18—.

[Fill in every evening, and not wait to end of week, when you may have forgotten particulars.]

NOTE.—This report may be made in pencil. It need not include all the little details of work, but should be sufficiently full to clearly indicate what was done each day. It should be sent by mail, or otherwise, at the first opportunity, to

S. J. GILMORE,
Manager, Denver, Colo.

BLANK WATER CONTRACT FORMS AS USED IN COLORADO.

No. I.

Know all men by these presents, that the —— —— Canal Company, a corporation existing under the laws of the State of Colorado, of the first part, and ——, of the county of —— and State of Colorado, of the second part, for and in consideration of the sum of $—— to be paid as hereinafter specified, and in consideration of the mutual covenants and agreements in this contract contained, to be performed and kept, the said company hereby agrees to carry and convey for the use of the second part—, —— statutory inches of water in and through the canal of said company, subject to the following terms and conditions, to which the said part— of the second part, —— heirs and assigns, hereby expressly agree:

I. The said company agrees to carry and convey the said water in its said canal for the use and benefit of the said second part—, —— heirs or assigns, continuously during the irrigating season, except as hereinafter provided, and at no other time, unless with the consent of said company thereto in writing.

II. Said water shall be used only for irrigating and domestic purposes on the following described tract of land, and none other, to wit: —— ——, and under no circumstances shall said water, or any portion thereof, be used for mining, milling, or mechanical power, or for any other purpose not directly connected or incident to the purposes herein specified.

III. Said company expressly reserves to itself the right to distribute the water from its said canal in accordance with such rights and priorities as are or may hereafter be established or decreed; and this contract is received by the part— of the second part subject to such priorities.

IV. The said second part—, —— heirs or assigns, shall not permit said water, nor any portion thereof carried as aforesaid, to run to waste, but as soon as a sufficient quantity shall have been used for the purposes herein allowed and contracted for, the said second part—,——heirs or assigns, shall shut off said water and keep the same shut and turned off until the same shall be again needed for the purposes aforesaid. But in no case shall the amount of water taken or received by said second part—, —— heirs or assigns, exceed the quantity first herein referred to, and said company hereby reserves the right at any time to shut off the water herein mentioned whenever it shall find that the said part— of the second part — — wasting it or not using it in accordance with the agreements herein contained on the land above mentioned.

V. The said company shall deliver said water at such point or points along the line of said canal or ditch, or from any of its reservoirs, laterals, either or all, as it may determine to be the most practicable, and the manner of withdrawing and regulating the supply of said water from said company's ditch and reservoirs shall be prescribed by said company, and shall at all times be under its control, as determined and directed by the said company. The head-gates, flumes, weirs, or other arrangements or devices, and all measuring boxes and devices through which the water hereby contracted to be carried shall be drawn and measured from said company's ditch or reservoirs, shall be made and placed in position by the said company but at the cost of said second part—, who shall also be liable for the expense of keeping the same in good repair and condition; and the said company may collect and enforce the payment of all sums expended for said purposes in the same manner as prescribed for collecting and enforcing assessments.

VI. The said first party agrees to keep and maintain said main canal or ditch and any and all of its reservoirs and laterals in good order and condition, and in case of accident to the same, to repair the injury thereby occasioned, as soon as practicable and expedient; and the company shall have a right to assess the said second part— for its expenses of maintaining, repairing, and operating said canal, and any and all reservoirs and laterals connected therewith, including taxes and legal assessments on said canal, a sum not exceeding —— per statutory inch hereby contracted to be carried, per annum; and in addition thereto may, when necessary by reason of accident, assess all owners or holders of water rights, pro rata, such sums as may be necessary to repair the injuries so occasioned, —— the amount of all assessments herein provided for shall be determined and levied by said company by resolution of its board of directors, and the company also reserves to itself the right by like resolution to establish and enforce such rules and regulations, and to provide and declare such penalties as it may deem necessary and expedient for the purpose of enforcing and collecting said assessments or any part thereof. Said assessments shall be due and payable at such time as may be fixed by the board of directors of the first party, and the second part— hereby agree— to duly pay the same, and further agree— that the failure to pay the same or any part therof within sixty days after notice of the levy of any assessment (which notice may be either personal or by registered letter addressed to the second part—at ——, Colorado) shall, at the option of the board of directors of the first party, constitute a forfeiture of all the rights of second part— as provided in paragraph XIII of this agreement.

VII. The said first party shall have, and the said second part— hereby grant — to the said first party, a right of way across said above described land of the width of —— feet for the main canal as now located and a right of way for the laterals of said first party as now located, of the width of —— feet, and also the right of roadway on the banks of the canal and main laterals; and in case a fence is constructed by said second part — across said roadway —— shall construct and maintain a gateway across said bank, when said first party requests, in which case said first party shall close said gate when opened by it.

VIII. It is hereby distinctly understood and agreed by and between the parties hereto, that in case the first party shall be unable to carry and distribute a volume of water equal to the estimated capacity of its canal, either from casual, unforeseen, or unavoidable accidents, or from any cause beyond the control of said first party, or if the volume of water prove insufficient from drought or from any other cause beyond the control of said company, the company shall not be liable in any way for the shortness or deficiency of supply so occasioned, or any loss or damage resulting therefrom by reason of any of said causes. If, however, by reason of such causes, or any of them, the supply of water be insufficient to furnish an amount equal to all the water rights then outstanding, the said company shall have the power and the right to distribute such water as may flow through said canal to the holders of such water rights pro rata, or may alternate the same; and for the purpose of so doing may establish and enforce such rules as it may deem necessary or expedient. And the second part — for —— and —— heirs and assigns, agree— in consideration aforesaid, to waive, and hereby do— waive, any claim for loss or damage by reason of any leakage, overflow, or breaking of said company's canals, or any of its reservoirs, lakes, or laterals, either upon the land aforesaid or any other tract belonging to the part— of the second part, provided the same is not caused by the negligence of said company.

IX. The said company agrees that when it shall have sold and have outstanding and in force a number of water rights equal to the estimated capacity of the company's canal, or sooner, at its option, it will then transfer to the holder of each water right, who shall have complied with the terms and conditions of this contract, without further consideration, such a proportion of the number of shares of the capital stock of the said —— company as the number of water rights held by —— bears to the whole number of water rights held or outstanding in the canal of the company, or as near thereto as may be possible without making fractions of shares, and which said shares the second part— agree— to accept: *Provided, however,* That such transfer is to be made only on the express condition that the first party shall thereupon and thereafter be absolutely released from any and all obligations or liabilities arising out of the ownership, operation, management, or control of said canal, or out of any contract (including this) pertaining to the distribution of water therefrom, which said obligations shall be assumed by said holders of water rights, who shall pay all expenses incident to such transfer; which said condition the said second part—, in consideration thereof and of these presents, for —— and —— heirs and assigns do— hereby accept. Such transfer shall only be made when the canal is in good order and unencumbered.

X. It is further agreed that the irrigating season shall commence April 15 and continue to November 1st of each and every year, and that thereafter water shall be conveyed for domestic purposes whenever reasonably practicable; subject to the right of said first party to shut off the water in order to repair or enlarge or extend said canal.

XI. The payment of the consideration heretofore specified herein shall be as follows: ——— dollars upon the ensealing and delivery of this contract, payment of which is hereby acknowledged, and the balance in ——— payments at the times and in the manner following, that is to say:

	Day.	Month.	Year.	Principal.	Interest.	Amount.	Remarks.
First deferred payment....	......	....	....	....	....	....	....
Second deferred payment..	......	....	....	....	....	....	....
Third deferred payment...	......	....	....	....	....	....	....
Fourth deferred payment..	......	....	....	....	....	....	....
Fifth deferred payment....	......	....	....	....	....	....	....
Sixth deferred payment....	......	....	....	....	....	....	....
Seventh deferred payment.	......	....	....	....	....	....	....
Eighth deferred payment..	......	....	....	....	....	....	....

Said deferred payments shall bear interest at the rate of —— per cent. per annum, payable annually, and shall bear interest after maturity at the rate of —— per cent. per annum, and the second part— in consideration of the premises hereby agree— that —— will make punctual payment of the above sums, and each of the same, together with the interest thereon as the same respectively become due; and that —— will regularly and seasonably pay all assessments that may be imposed by said company for the purposes aforesaid as above agreed.

XII. In case the second part ——, legal representatives, heirs or assigns, shall pay the several sums of money punctually, and at the times above limited, and shall strictly and literally perform all and singular the agreements and stipulations aforesaid after their true tenor and intent, then this contract shall be and operate as a contract entitling said second part— in perpetuity to the enjoyment of the right hereby granted, subject, however, to the same assessments and forfeitures for nonpayment as herein provided.

XIII. And it is hereby agreed and covenanted by the parties hereto that time and punctuality are essential elements of this contract. And in case the second part— shall fail to make the payments aforesaid, and each of them, or shall fail to pay any assessment which may be levied as provided in paragraphs V and VI hereof, punctually and upon the strict terms and times above limited for the payments and assessments herein provided for, or likewise to observe, perform, and complete, all and each of said agreements and stipulations aforesaid strictly and literally, without any failure or default, then this contract, so far as it may bind the first party, shall become null and void, the water may be immediately shut off, and all rights and interests hereby created or then existing in favor of the second part,—, —— heirs or assigns, or derived from this contract shall utterly cease and determine, and all equitable and legal interest in the right hereby contracted for shall revert to and revest in said first party, without any declaration of forfeiture or any other act of said first party to be performed, and without any right of said second part—of reclamation or compensation for moneys paid or services performed, as absolutely, fully, and perfectly as if this contract had never been made: *Provided*, That said first party shall give to said second part— heirs or assigns, sixty days' notice, either personal or by mail, of the said second part—, —— heirs or assigns, being in arrears upon said payments, or any of them, or the interest thereon, which notice, if by mail, shall be sufficient, if by registered letter addressed to said second part— at ——— Colorado.

XIV. It is also stipulated and agreed that no assignment of the rights of the second part— under this contract, whether by conveyance or lease of all or part of said lands, or by operation of law, or otherwise, shall be binding on the first party, so as to require it to carry for or deliver to such assignee any of the amount of water herein contracted to be carried and delivered unless the first party shall consent thereto in writing; and provided, that no assignment whatever shall be binding as to the first party herein until the same is endorsed upon these presents and consented to in writing upon these presents by the said company: *And provided further*, That nothing herein contained shall be taken to bind the party of the first part herein to release the second part— in case of such assignment, from any liabilities to said first party under this contract. The endorsement upon these presents of the company's consent to the assignment by the party— of the second part of this contract and of —— rights hereunder will be made by said company upon request of the part— of the second part, provided all payments, assessments, and charges herein provided for which may have become due at or prior to the time of such request shall have been fully paid.

XV. It is further stipulated and agreed that nothing in the foregoing provisions as to relocation and assignment shall be taken to bind the first party to convey or deliver water in less amount than 5 statutory inches for any one tract of land.

XVI. It is also stipulated and agreed that from and after the execution hereof, the said second part— may enter into the use and enjoyment of water flowing through said canal, its reservoirs or laterals, to the extent of the rights above contracted for as fully as though fully paid for, but subject, however, to all the terms, limitations, and conditions above set forth.

In witness whereof, the —— —— Canal Company, party of the first part, has hereunto caused its corporate name to be subscribed by its president, and attested by its secretary, and its corporate seal to be affixed hereto as well as to a duplicate hereof, and the part— of the second part —— hereunto subscribed —— name— and affixed —— seal— hereto, as well as to a duplicate hereof, this the —— day of —— A. D. 18—.

—— —— COMPANY.
By —— —— *President.*

Attested by:
—— —— *Secretary*

—— —— [SEAL.]
Address, —— ——
—— —— [SEAL.]
Address, —— ——

ASSIGNMENT.

—— ——, the within-named purchaser, for and in consideration of —— dollars, do hereby assign and transfer all —— right, title, interest, and claim in and to the within-described rights to water unto —— ——, of ——, county of —— and State of ——, heirs and assigns, forever; and —— do hereby authorize and empower the —— —— Company to receive from the said —— —— all unpaid balances due to said company, in part consideration for said water rights.

Given under —— hand and seal this —— day of ——, A. D. 18—.

It is expressly understood that in consenting to recognize this assignment the officers of this company do not exempt the original purchaser from any of his liabilities under the contract, but will protect the rights of the assignee, provided he complies with its obligations.

—— ——. [SEAL.]

Countersigned.

—— ——,
President.
—— ——,
Secretary.

STATE OF COLORADO,
County of ——, *ss:*

Before me, —— —— in and for said county, this day personally came —— ——, known to me to be the identical person described in the within agreement, and who executed the foregoing assignment, and acknowledged that —— signed, sealed, and delivered the same as —— free and voluntary act and deed, for the uses and purposes therein set forth.

Given under my hand and —— seal of office this —— day of ——, A. D. 18—.

—— ——.

My commission expires ——, 18—.

Received ——, 189—, of —— —— the sum of —— dollars, amount of first deferred payment, on the within contract.

—— ——.

[Receipts similar to the above for the second to the eighth payments, inclusive, follow.]

(Indorsement:) No. ——. Agreement to carry —— inches of water. The —— —— with —— ——.

No. II.

Know all men by these presents, that the —— —— Canal Company, a corporation existing under the laws of the State of Colorado, of the first part, and —— ——, of the county of —— and State of Colorado, of the second part, for and in consideration of the sum of $—— to be paid as hereinafter specified, and in consideration of the mutual covenants and agreements in this contract contained, to be performed and kept, the said company hereby agrees to sell unto the second party a water right for —— statutory inches of water flowing through the canal of said company, subject to the following terms and conditions, to which the said party of the second part, —— heirs and assigns, hereby expressly agree:

I. The said company agrees to furnish the said water to the said second party, —— heirs or assigns, continuously during the irrigating season, except as hereinafter provided, and at no other time, unless with the consent of said company thereto in writing.

II. Said water shall be used only for irrigating and domestic purposes on the following described tract of land, and none other, to wit: —— —— and under no circumstances shall said water, or any portion thereof, be used for mining, milling, or mechanical power, or for any other purpose not directly connected or incident to the purposes hereinafter specified.

III. Said company expressly reserves to itself the right to distribute the water from its said canal in accordance with such rights and priorities as are or may hereafter be established or decreed; and this deed is received by the party of the second part subject to such priorities.

IV. The said second party, —— heirs or assigns, shall not permit said water, nor any portion thereof furnished as aforesaid, to run to waste, but as soon as a sufficient quantity shall have been used for the purposes herein allowed and contracted for, the said second party, —— heirs or assigns, shall shut off said water and keep the same shut and turned off until the same shall be again needed for the purposes aforesaid. But in no case shall the amount of water taken or received by said second party, —— heirs or assigns, exceed the quantity first herein referred to, and said company hereby reserves the right at any time to shut off the water herein mentioned whenever it shall find that the said part— of the second part —— wasting it or not using it on the land above-mentioned.

V. The said company shall deliver said water at such point or points along the line of said canal or ditch, or from any of its reservoirs, laterals, either or all, as it may determine to be the most practicable, and the manner of withdrawing and regulating the supply of said water from said company's ditch and reservoirs shall be prescribed by said company, and shall at all times be under its control, as determined and directed by the said company. The head-gates, flumes, weirs, or other arrangements or devices through which the water hereby sold shall be drawn from said company's ditch or reservoirs, shall be made and placed in position by the said company, but at the cost of said second part— who shall also be liable for the expense of keeping the same in good repair and condition; and the said company may collect and enforce the payment of all sums expended for said purposes in the same manner as prescribed for collecting and enforcing assessments.

VI. The said first party agrees to keep and maintain said main canal or ditch and any and all of its reservoirs and laterals in good order and condition, and in case of accident to the same, to repair the injury thereby occasioned, as soon as practicable and expedient; and the company shall have a right to assess the said second part— for its expenses of maintaining, repairing, and operating said canal and any and all reservoirs and laterals connected therewith, including taxes and legal assessments on said canal, a sum not exceeding —— per statutory inch hereby contracted to be supplied per annum; and in addition thereto may, when necessary by reason of accident, assess all owners or holders of water rights, pro rata, such sums as may be necessary to repair the injuries so occasioned. The amount of all assessments herein provided for shall be determined and levied by said company by resolution of its board of directors, and the company also reserves to itself the right by like resolution to establish and enforce such rules and regulations, and to provide and declare such penalties as it may deem necessary and expedient for the purpose of enforcing and collecting said assessments, or any part thereof. Said assessments shall be due and payable at such time as may be fixed by the board of directors of the first party, and the second part— hereby agree— to duly pay the same, and further agree— that the failure to pay the same or any part thereof within sixty days after notice of the levy of any assessment (which notice may be either personal or by registered letter addressed to the second party at ——, Colorado) shall, at the option of the board of directors of the first party, constitute a forfeiture of all the rights of the second part— as provided in paragraph XIV of this agreement.

VII. The said first party shall have, and the said second part— hereby grant— to the said first party, a right of way across said above described land of the width of —— for the main canal or laterals of said first party as now located, and also the right of roadway on the banks of the canal and main laterals; and in case a fence is constructed by said second part— across said roadway —— shall construct and maintain a gateway across said bank, when said first party requests, in which case said first party shall close said gate when opened by it.

VIII. It is hereby distinctly understood and agreed by and between the parties hereto, that in case the first party shall be unable to carry and distribute a volume of water equal to the estimated capacity of its canal, either from casual, unforeseen, or unavoidable accidents, or from any cause beyond the control of said first party, or if the volume of water prove insufficient from drouth or from any other cause beyond the control of said company, the company shall not be liable in any way for the shortness or deficiency of supply so occasioned, or any loss or damage resulting therefrom, by reason of any of said causes. If, however, by reason of such causes, or any of them, the supply of water be insufficient to furnish an amount equal to all the water rights then outstanding, the said company shall have the power and the right to distribute such water as may flow through said canal to the holders of such water rights pro rata, or may alternate the same; and for the purpose of so doing may establish and enforce such rules as it may deem necessary or expedient. And the second part— for ——— and —— heirs and assigns, agree—, in consideration aforesaid, to waive, and hereby do waive, any claim for loss or damage by reason of any leakage, overflow, or breaking of said company's canals, or any of its reservoirs, lakes, or laterals, either upon the land aforesaid or any other tract belonging to the part— of the second part.

IX. The said company agrees that when it shall have sold and have outstanding and in force a number of water rights equal to the estimated capacity of the company's canal, or sooner at its option, it will then transfer to the holder of each water right, who shall have complied with the terms and conditions of this contract without further consideration, such a proportion of the number of the shares of the capital stock of the said ——— ——— company as the number of water rights held by —— bears to the whole number of water rights held or outstanding in the canal of the company, or as near thereto as may be possible without making fractions of shares, and which said shares the second part — agree— to accept: *Provided however*, That such transfer is to be made only on the express condition that the first party shall thereupon and thereafter be absolutely released from any and all obligations or liabilities arising out of the ownership, operation, management, or control of said canal, or out of any contract (including this) pertaining to the distribution of water therefrom, which said obligations shall be assumed by said holders of water rights, who shall pay all expenses incident to such transfer; which said condition the said second part— in consideration thereof and of these presents, for ——— and —— heirs and assigns do— hereby accept. Such transfer shall only be made when the canal is in good order and unencumbered.

X. It is further agreed that the irrigating season shall commence April 15 and continue to November 1 of each and every year, and that thereafter water shall be conveyed for domestic purposes whenever reasonably practicable; subject to the right of said first party to shut off the water in order to repair or enlarge or extend said canal.

XI. The payment of the consideration heretofore specified herein shall be as follows: —— dollars upon the ensealing and delivery of this contract, payment of which is hereby acknowleged, and the balance in —— payments at the times and in the manner following, that is to say:

	Day.	Month.	Year.	Principal.	Interest.	Amount.	Remarks.
First deferred payment....							
Second deferred payment..							
Third deferred payment...							
Fourth deferred payment..							
Fifth deferred payment....							
Sixth deferred payment....							
Seventh deferred payment.							
Eighth deferred payment..							

Said deferred payments shall bear interest at the rate of —— per cent. per annum, payable annually, and shall bear interest after maturity at the rate of —— per cent. per annum, and the second part—, in consideration of the premises, hereby agree— that —— will make punctual payment of the above sums, and each of the same, together with the interest thereon, as the same respectively become due; and that —— will regularly and seasonably pay all assessments that may be imposed by said company, for the purposes aforesaid, as above agreed.

XII. In case the second part —— legal representatives, heirs or assigns, shall pay the several sums of money punctually, and at the times above limited, and shall strictly and literally perform all and singular —— agreements and stipulations aforesaid after their true tenor and intent, then the first party shall cause to be made and executed unto the second part —— heirs or assigns, a deed conveying the water-right above described in fee-simple; subject, however, to the same assessments and forfeitures for non-payment as herein provided.

XIII. The first party claims and reserves a strip of land of the width necessary and sufficient for the right of way of the canals of the first party, and for enlarging and repairing and superintending the same where any such canal is located upon or contiguous to the premises, hereby claiming and reserving the right of way across said lands for lateral canals where the same are or may become necessary and expedient for the purpose of conveying water from the main canals of first party to the lands below, whether such laterals are constructed by the first party, or by persons owning such lower lands; provided that the laterals aforesaid shall be constructed under the supervision of and upon such lands only as are selected by the first party.

XIV. And it is hereby agreed and covenanted by the parties hereto that time and punctuality are essential elements of this contract. And in case the second part— shall fail to make the payments aforesaid, and each of them, or shall fail to pay any assessment which may be levied, as provided in paragraphs V and VI hereof, punctually and upon the strict terms and times above limited for the payments and assessments herein provided for, or likewise to observe, perform, and complete all and each of said agreements and stipulations aforesaid strictly and literally without any failure or default, then this contract, so far as it may bind the first party, shall become null and void, the water may be immediately shut off, and all rights and interests hereby created or then existing in favor of the second part —— heirs or assigns, or derived from —— —— shall utterly cease and determine, and all equitable and legal interest in the water-right —— —— hereby contracted to be conveyed shall revert to and revest in said first party, without any declaration of forfeiture or any other act of said first party to be performed, and without any right of said second part— of reclamation or compensation for moneys paid or services performed, as absolutely, fully, and perfectly as if this contract had never been made: *Provided*, That said first party shall give to said second part—, —— heirs or assigns, sixty days' notice, either personally or by mail, of the said second part —— heirs or assigns, being in arrears upon said payments, or any of them, or the interest thereon, which notice, if by mail, shall be sufficient, if by registered letter addressed to said second part— at ——, Colorado.

And it is further stipulated that no assignment of the premises shall be valid unless the same shall be indorsed hereon, and no agreements, or conditions or relations between the said second part— and —— assigns, or any other person acquiring title or interest from or through ——, shall preclude the first party from the right to convey the premises to the second part— or —— assigns, on the surrender of this agreement and the payment of the unpaid portion of the purchase money which may be due to the first party.

XV. It is also stipulated and agreed that from and after the execution hereof, the said second part — may enter into the use and enjoyment of water flowing through said canal, its reservoirs or laterals to the extent of the right, above contracted to be conveyed, as fully as though fully paid for, but subject, however, to all the terms, limitations and conditions above set forth.

In witness whereof, the —— —— Company, party of the first part, has hereunto caused its corporate name to be subscribed by its president, and attested by its secretary and its corporate seal to be affixed hereto as well as to a duplicate hereof, and the part— of the second part —— —— subscribed —— —— name— and affixed —— seal— hereto, as well as to a duplicate hereof, this the —— day —— A. D. 18—.

—— —— COMPANY,
By —— —— *President.*

Attested by—

—— —— *Secretary.*

—— —— [SEAL.]
Address: —— ——
—— —— [SEAL.]
Address: —— ——
—— —— [SEAL.]
Address: —— ——

ASSIGNMENT.

—— ——, the within-named purchaser, for and in consideration of —— dollars, do — hereby assign and transfer all —— right, title, interest and claim in and to the within-described rights to water unto —— —— of ——, county of ——, and State of ——, heirs and assigns, forever. And —— do — hereby authorize and empower the —— —— Company, to receive from the said —— —— all unpaid balances due to said Company, in part consideration for said water rights and upon the final payment of all the purchase money and a full compliance of all the requirements contained in the within agreement, to execute, or cause to be executed, to the said ——— ——— heirs and assigns, a deed of said water rights, instead of to ———.

Given under —— hand and seal, this —— day of ———, A. D., 18—.

It is expressly understood that in consenting to recognize this assignment, the officers of this Company do not exempt the original purchaser from any of his liabilities under the contract, but will protect the rights of the assignee, provided he complies with its obligations.

——— ———, [SEAL.]

Countersigned:

——— ———,
President.

——— ———,
Secretary.

STATE OF COLORADO,
County of ———, *ss.*

Before me ——— ———, in and for said county, this day personally came ——— ———, known to me to be the identical person— described in the within agreement, and who executed the foregoing assignment, and acknowledged that —— signed, sealed, and delivered the same as —— free and voluntary act and deed, for the uses and purposes herein set forth.

Given under my hand and —— seal of office, this —— day of ———, A. D. 18—.

My commission expires ———, 18—.

——— ———.

Received ———, 189—, of ——— ——— the sum of —— dollars, amount of first deferred payment on the within contract.

——— ———.

[Receipts similar to the above for the second to the eighth payments, inclusive, follow.]

(Indorsement.) No. ——. Agreement for sale of water right. The ——— ——— with ——— ——— for —— statutory inches.

No. III.

THE FORT MORGAN LAND AND CANAL COMPANY.

This agreement, made this —— day of ———, in the year 18—, between the Fort Morgan Land and Canal Company, a corporation existing under the laws of the State of Colorado, as the first party, and ——— ———, of the county of Weld, and State of Colorado, as the second party, witnesseth:

I. That in consideration of and subject to the stipulations herein contained, and the payments to be made as hereinafter specified, the first party hereby agrees to sell unto the second party —— heirs or assigns, —— water right —— to the use of water, flowing through the canal of said first party; each water right to be sufficient to irrigate 80 acres of land, but not to exceed 1.40 cubic feet of water per second of time, which the first party agrees to furnish to the second party —— heirs or assigns, during the irrigating season, except as hereinafter provided, and at no other time, for domestic purposes and for irrigating the following-described land, situate in the county of Weld, and State of Colorado, viz: ——— ———.

II. Said second party ——— heirs or assigns, shall not permit said water or any portion thereof, furnished as aforesaid, to run to waste, provided, however, that owners of water rights from the said canal may temporarily, for mutual convenience for irrigating purposes only, use their water in combination upon their several lands, but never upon lands for which the first party has not sold its full quota of water, on a basis of one water right to 80 acres of land.

III. Said first party shall deliver said water at such point or points along the line of said canal, or from any of its reservoirs, either or all, as it may determine from time to time to be most practicable; and the location of all headgates, and the manner of withdrawing and regulating the supply of water from said company's canals and reservoirs, shall be prescribed by said company, and shall at all times be under its control.

IV. Said first party agrees to keep and maintain said canal and any and all of its reservoirs in good order and condition, and in case of accident to the same to repair the injury thereby occasioned as soon as practicable and expedient; and the company shall have a right to assess said second party, for the expense of maintaining, repairing and superintending said canal and any and all reservoirs connected therewith, a sum not exceeding $10 per water right sold, per annum, and in addition thereto may, when necessary by reason of accident, assess all owners or holders of water rights pro rata such sums, not exceeding $10 in any one year for each water right, as may be necessary to repair the damages so occasioned. The amount, manner of collection, and time of payment of all assessments herein provided for shall be determined by said company; and the company also reserves to itself the right to establish and enforce such rules and regulations, and to provide and declare such penalties as are necessary and expedient for the purpose of enforcing and collecting said assessments, or any part thereof.

V. It is further expressly understood and agreed that when the first party shall have sold and have outstanding and in force water rights, fully paid up, equal to the full capacity of its canal (or sooner at its option), it will distribute pro rata the stock of said company among the holders of water rights so sold and the first party as owners of unsold water rights (if any), and the second party agrees to merge —— water right —— in this contract, and the first party, in the exercise of said option, to merge all its water rights then remaining unsold, if any, severally, into the capital stock of said company, in equitable proportions to the water right— so merged.

VI. It is hereby distinctly understood and agreed by and between the parties hereto, that in case the canal of said first party shall be unable to convey and distribute a volume of water equal to the estimated capacity, either from any accident, or from lack of supply in the South Platte River, or from any other cause beyond the control of said first party, then the first party shall not be liable for the shortness or deficiency of supply so occasioned, or any losses or damages resulting therefrom. It is further agreed that during a deficiency in the water supply of such canal, from any of the causes aforesaid, the first party shall have the right to divide the diminished supply pro rata, among the holders of water rights under said canal, and for the purpose of so doing may establish and enforce such rules and regulations as are necessary and expedient. And the second party, for —— and —— heirs and assigns agree— in consideration aforesaid to waive, and do hereby waive, any claim for loss or damage by reason of any leakage or overflow of said canal, or any of its reservoirs, lakes, or laterals, not resulting from the negligence of the first party, either upon the land aforesaid or any other tract belonging to said second party.

VII. In consideration of foregoing promises, covenants, and agreements of the said party of the first part, the second party agrees to pay unto the said first party the sum of ——— dollars with interest, payable annually, at the rate of 10 per cent. per annum. Payment has been made and received of ——— dollars, and the remaining principal, with the annually accruing interest, shall be paid at the office of the first party in Denver, Colo., in ——— payments, at the times and in the manner following, that is to say:

	Day.	Month.	Year.	Principal.	Interest.	Amount.	Remarks.
First deferred payment....	......	....	....	....	....	....	....
Second deferred payment..	......	....	....	....	....	....	....
Third deferred payment...	......	....	....	....	....	....	....
Fourth deferred payment..	......	....	....	....	....	....	....
Fifth deferred payment....	......	....	....	....	....	....	....
Sixth deferred payment....	......	....	....	....	....	....	....

And the second party, in consideration of the premises, hereby agrees that —— will make punctual payments of the above sums, as each of the same respectively becomes due, and that —— will regularly and seasonably pay all assessments that may hereafter be imposed by said company for the purposes aforesaid. And when the said party of the second part or —— assigns, shall have fully paid the consideration for the water rights herein conveyed, with interest thereon according to the terms of this contract, the absolute title to said water rights, free and clear of all incumbrances, shall be thereby vested in the said party of the second part, and his assigns without any further or other deed of conveyance whatsoever.

VIII. The second party for —— heirs and assigns further agree— to pay to the first party or its assigns, on such terms and regulations as its board of trustees may from time to time prescribe and determine —— proportional part of the expenses of maintaining and repairing the general fence, constructed to inclose a large tract of land lying under said canal; and said second party for —— heirs and assigns further expressly agrees, in consideration of these presents, that —— will not permit any live stock in —— possession or under —— control to run at large within such general fence; and any violation of this agreement shall render the second party —— personal representatives or assigns, liable in damages to the first party, as trustee for the benefit of any persons and their privies in interest, who may be injured by reason of depredations of live stock so allowed to run at large in violation hereof.

IX. And it is hereby covenanted and agreed by the parties hereto, that time and punctuality are material and essential elements of this contract, and that in case said party of the second part shall fail or neglect to make the payments aforesaid, and each of them, at the time and times herein stipulated, then all rights, privileges, and benefits accrued or accruing under the terms of this contract in favor of said party of the second part or —— heirs or assigns, shall utterly cease and determine after thirty days' notice of such default being given by deposit thereof in the post-office at Denver, addressed to said party of the second part at his last known post-office address, or by personal service of such notice, at the option of said party of the first part, and without any right of said party of the second part of reclamation or compensation for moneys paid or services performed, as absolutely, fully, and perfectly as if this contract had never been made; and all moneys theretofore paid by said party of the second part to said party of the first part under the provisions of this contract shall belong to, and be retained by, said party of the first part as liquidated damages for the breach hereof.

It is further expressly and distinctly agreed and understood that this contract shall not be construed or operate to convey or vest any interest whatever in the water right hereinbefore mentioned until said party of the second part shall have fully performed each and every of the covenants and agreements herein contained, for the payment of the aforesaid consideration and purchase price, and shall not be assigned until fully paid up, without the consent of the first party indorsed hereon.

In witness whereof, The Fort Morgan Land and Canal Company has hereunto caused its corporate name to be subscribed by its president and attested by its secretary and its corporate seal to be affixed, and the second party —— subscribed —— name and affixed —— seal hereto, the day and year first above written.

THE FORT MORGAN LAND AND CANAL COMPANY,
By ——— ———,
President.

Attested by:

——— ———,
Secretary.

——— ——— [SEAL.]
——— ——— [SEAL.]
——— ——— [SEAL.]

ASSIGNMENT.

——— ———, the within named purchaser, for and in consideration of ——— dollars, do— hereby assign and transfer all —— right, title, interest, and claim in and to the within described rights to water unto ——— ———, of ———, county of ——— and State of ———, heirs and assigns forever. And —— do— hereby authorize and empower The Fort Morgan Land and Canal Company to receive from the said ——— ——— all unpaid balances due to said company, in part consideration for said water rights, and upon the final payment of all the purchase money, and a full compliance with all the requirements contained in the within agreement, to execute, or cause to be executed, to the said ——— ———, heirs and assigns, a deed of said water rights, instead of to ——— ———.

Given under —— hand— and seal— this —— day of ———, A. D. 18—.

It is expressly understood that in consenting to recognize this assignment, the officers of this company do not intend to exempt the original purchaser from any of his liabilities under the contract, but to protect the rights of the assignee, provided he complies with its obligations.

——— ———. [SEAL.]

Countersigned:

——— ———,
President.
——— ———,
Secretary.

STATE OF COLORADO,
County of ———, *ss:*

Before me, ——— ———, in and for said county, this day personally came ——— ———, known to me to be the identical person— described in the within agreement, and who executed the foregoing assignment, and acknowledged that —— signed, sealed, and delivered the same as —— free and voluntary act and deed for the use and purposes herein set forth.

Given under my hand and —— seal of office this —— day of ———, A. D. 18—.

——— ———.

Received ——— 18 —, of ——— ———, the sum of ——— dollars, amount of first deferred payment on the within contract.

——— ———.

[Receipts similar to the above for the second to the sixth, inclusive, follow.]

(Indorsement:) No. ——— Agreement for sale of water right. The Fort Morgan Land and Canal Company with ——— ———.

AREAS UNDER DITCH AND CULTIVATED.

STATISTICS OF RECLAMATION IN ARIZONA, CALIFORNIA, COLORADO IDAHO, KANSAS, MONTANA, NEBRASKA, NEVADA, NEW MEXICO, OREGON, SOUTH DAKOTA, UTAH, WASHINGTON, AND WYOMING.

PART IV.

Reliable statistics of irrigation are as yet unknown. Approximate statements, reasonably correct, are all that can be now obtained. The recent (1889) investigation of the United States Senate special Committee on Irrigation and the Reclamation of Arid Lands have given a basis for statements before impossible, in spite of statements that have been widely published that inquiries have been made and data collected under official scientific direction for the past ten years. Nothing of the sort has been done, except as a very general incidence of certain geological and topographical work carried on in the arid West.

The first real attempt to obtain data on American irrigation was made in the preparation of this report, when in 1884–'85 the Department of Agriculture authorized such inquiry under the editor of this report. In 1886 the Senate directed the publication of a first edition thereof. In the following session of Congress an inquiry was ordered. In the following year an appropriation of $100,000 was made for the purpose of organizing an irrigation survey. The next session that appropriation was increased to $250,000, making in all $350,000 up to the date of this publication.

The Senate, upon the motion of Hon. William M. Stewart, of Nevada, appointed a special committee to investigate the subject, Mr. Stewart being made chairman. On the 1st of August, 1889, at St. Paul, Minn., the field inquiry began. In the following fifty-two days the committee visited eighteen States and Territories, held fifty-eight sessions, heard several hundred witnesses, traveled in all over 15,000 miles, closing their inquiry at Washington; holding eight sessions there for testimony and hearing there eighteen witnesses in all; a majority and minority report was made; bills introduced, and four volumes of testimony, covering in all 1,990 pages, were printed.

The following tabulations then are quoted from the report of the majority, with additional data presented by other authorities.

Beginning with the Dakotas, it is estimated that there are about 100,000 acres "under ditch" in southwest Dakota—that is the Black Hills section—of which about 15,000 acres are under cultivation, the balance being in grass.

Irrigation ditches and areas in Idaho.

Counties in which irrigation now exists.	No. of completed ditches.	Ditches.	Irrigated in 1889.	Estimated No. of acres irrigable.
		Miles.	*Acres.*	
Ada	*62	*448	60,000	900,000
Alturas	10	18	14,500	118,000
Bear Lake	69	206	21,500	39,000
Bingham, north	†16	253	215,000	2,236,000
Bingham, south	70	264	29,250	267,500
Boisé	‡20	60	83,500	....
Cassia	298	299	82,000	656,400
Elmore	‡50	‡25	10,000	230,000
Logan	‡65	‡125	50,000	1,250,000
Lemhi	250	‡300	9,715	500,000
Oneida	‡65	‡100	38,700	196,000
Owyhee	66	153	21,275	348,500
Washington	‡270	§34 ‡133	40,000	500,000
Total	1,311	2,418	715,500	7,141,400

---

* This includes three ditch systems, embracing 207 miles, incompleted when estimates were made.

† The sixteen ditches given do not include the laterals. At an average estimate of 400 acres per ditch the mileage would be over 600.

‡ Estimated on the basis of 2 miles per ditch serving 400 acres. This is near enough for an approximate estimate; below rather than above the facts.

§ The 34 miles are the definite lengths given of new ditch systems; the balance is an estimate.

The Geological Survey estimates 740,350 acres as irrigated in 1889.

The Society of Civil Engineers presented for Montana a report which is tabulated as follows:

Irrigation ditches and areas in Montana.

No.	County.	Area.	Supposed under cultivation.	Supposed can be cultivated by irrigation.
		Sq. miles.	*Acres.*	*Acres.*
1	Beaver Head	3,740	80,000	250,000
2	Cascade	2,570	30,000	600,000
3	Choteau	28,930	50,000	5,000,000
4	Crow Reservation	7,450		1,500,000
5	Custer	22,380	20,000	3,000,000
6	Dawson	25,650	50,000	4,000,000
7	Deer Lodge	4,700	100,000	250,000
8	Fergus	7,415	100,000	1,500,000
9	Gallatin	2,900	100,000	400,000
10	Jefferson	2,060	25,000	250,000
11	Lewis and Clarke	1,700	50,000	400,000
12	Madison	4,546	100,000	400,000
13	Meagher	7,100	25,000	500,000
14	Missoula	19,500	150,000	600,000
15	Park	4,740	15,000	500,000
16	Silver Bow	700	1,000	40,000
17	Yellowstone	3,300	50,000	500,000
	Total	146,000	996,000	19,790,000

Other statistics show that there were in 1869, of mining ditches 287½ miles constructed, at a cost of $806,500. The present extent, including these—as many have been used for irrigation purposes also—is now estimated at 1,000 miles. There are now partially or wholly completed the following larger or district systems, constructed for rental investment by corporations:

Corporation ditches.	Miles.	Acres to be served.	Estimated cost.
Benton Lake	35	50,000	$175,000
Clarke's Fork	38	100,000	140,000
Chestnut Valley	10	25,000	7,000
Dearborn	45	51,000	150,000
Florence	50	10,000	200,000
Gallatin	25	50,000	75,000
Sun River	75	300,000	500,000
Teton	40	35,000	80,000
Total	318	611,000	1,327,000

Report to the U. S. Geological Survey by R. S. Tarr, estimates 500,000 acres under cultivation. Assessors return made the total 348,102 acres. The statistics of the committee show the following:

Irrigation ditches and areas in Utah.

Counties reported.	Irrigated areas in acres. 1889.	No. of canals.	Miles of canals.
Beaver	9,500	*32	*96
Box Elder	17,500	12	*76
Cache	41,444	40	110
Emery	14,825	*34	102
Garfield	5,000	*17	*51
Iron	6,997	*23	*69
Juab	4,000	*13	*39
Kane	1,825	9	*18
Millard	13,500	42	*120
Morgan	8,648	*29	*87
Pi Ute	12,135	31	*93
Rich	42,811	*143	*429
Salt Lake	38,587	37	*213
San Juan	1,025	4	12
San Pete	3,500	*12	*36
Sevier	17,619	*60	*180
Summit	8,500	*28	*84
Tooele	6,250	*21	*63
Uintah	8,933	*30	*90
Utah	69,126	*346	*1,488
Wasatch	18,000	60	180
Washington	18,802	31	186
Weber	44,052	25	5
Total	412,669	1,079	3,903

*These are estimates made on a uniform basis of 300 acres to each ditch and of laterals 3 miles in length.

The Mormon Church returns of irrigation quoted by Major Powell, for 1889, puts the land "under irrigation" at 802,456 acres, that is, "under ditch." Actually irrigated that year the area is given at 371,437 by farming 66,191 arable, but not irrigated 2,525,403 acres.

For Oregon, estimates of the U. S. Geological Survey presented by the Director to the committee are here given:

Irrigation ditches and areas in Oregon.

[Report of W. G. Steel, June 27, 1889.]

County.	Irrigated.	Under ditches.	County.	Irrigated.	Under ditches.
	Acres.	*Acres.*		*Acres.*	*Acres.*
Baker	5,000	10,000	Malheur	40,000	60,000
Crook	8,000	8,000	Morrow	6,000	18,500
Gilliam	3,000	5,000	Umatilla	5,000	7,000
Grant	10,000	10,000	Union	5,000	8,000
Harney	20,000	20,000	Wallowa	7,000	10,000
Klamath	5,000	30,000			
Lake	5,000	5,000	Total	119,000	191,500

Eastern Washington's irrigated area is given by the committee at 75,000 acres "under ditch," and 50,000 acres as irrigated. That of Nevada is stated at 142,000 acres under ditch, of which 75,000 are cultivated by irrigation.

For the Golden States returns are conflicting, but the following is a fair statement of—

*Irrigation ditches and areas in California.**

	Ditches.	Cost per mile.	Total cost.
	Miles.		
In the San Joaquin Valley, counties of Fresno, Merced, Kern, and Tulare	800	$5,400	$4,320,000
In the counties of Los Angeles, Orange, and San Bernardino	500	6,000	3,000,000
In San Diego County	36	19,613	706,068
In the remaining part of the State, twenty-four counties, where irrigation is practiced	1,700	640	1,128,000
Counting one-third of the mining ditches in the State as available and used for small irrigation, we have	289	3,188	921,221
Total	3,825	....	10,375,289

Without question the total valuation or cost is much below the true figures. Much of the data on which the estimates are based is taken from the assessors' returns made for the purpose of taxation. They can therefore be doubled. That will give a total cost of at least $20,000,000.

The acreage is as difficult to arrive at with certainty, but it can be fairly and moderately stated as follows:

	Acres.
In the San Joaquin counties:	
In farm crops	1,000,000
In vines	13,000
In fruit trees	16,000
	1,029,000
In the southern counties:	
In farm crops	580,000
In vines	45,000
In fruit trees	85,000
	710,000
In the balance of State (irrigated):	
In farm crops	1,500,000
In vines	25,000
In fruit trees	30,000
	1,555,000

The total acreage wholly under ditch and now irrigated is fairly within the annexed totals:

	Acres.
In farm crops	3,080,000
In vines	83,000
In fruit trees	131,000
Total	3,294,000

If all the areas directly cultivated by the aid of natural subirrigation, etc., be added, the total area in California will certainly be not less than 3,500,000 acres. The point of interest, however, in these figures is the profitable character of such cultivation, especially in the matter of fruit-raising.

---

* From report of majority of Senate Committee on Irrigation, 1890.

Major Powell's statement, from "Irrigation in United States," first edition, 1886, gives these figures—

	Acres.
Under ditches, constructed or projected	6,000,000
Irrigated, etc.	3,000,000

The same authority reports the following—

Irrigation ditches and areas in Arizona.

County.	No. of canals.	Length.	Area under ditch.
		Miles.	*Acres.*
Apache	....	24½	12,500
Cochise	....	51	8,300
Graham	....	60	35,000
Maricopa	23	304½	194,400
Pima	36	52	30,000
Pinal	28	50	78,000 *50,000
Yavapai	....	78	40,000
Yuma	10	120½	81,000
Total	....	740½	529,200

* In Pima Reservation.

These figures are entirely taken from county reports. The ditch system constructing in Yuma County will, when completed, have a total length of 241 miles and an acreage of 207,000. The total cost will be $1,318,000, or nearly $5,500 per mile. The canals under way in Maricopa County will, when completed, cover 404,900 acres and have a total length of 425 miles. Apache County reports 150,000 acres reclaimed, Pima County 2,500,000 acres, and Cochise 310,000 acres. Of the area "under ditch" about two-thirds are actually cultivated. For Arizona the Geological Survey estimates all reclaimable, 1,650,000 acres; under ditch, 455,600 acres; actually cultivated, 203,080 acres. Engineer Newell for the same territory estimates only 175,000 acres as cultivated through irrigation.

Western Texas, that is the arid section west of the one hundredth meridian, has been making rapid strides. Its total area irrigated and under ditch, after careful inquiry is placed at 200,000 acres "under ditch" and 125,000 actually cultivated.

Southwest Kansas in 1889 suffered largely from the drought. "Under ditch" were 300,000 acres, nearly all in the Upper Arkansas Valley, while but 75,000 acres were cultivated by actual irrigation.

The following table gives the official census figures of 1885:

Irrigation ditches and areas in New Mexico.

Number of farms	10,511
Number of acres (improved, estimated)	500,000
Area reclaimable in acres	13,965,000

Under date of June 24, 1889, T. B. Mills, of Las Vegas, N. Mex., makes the following estimate:

County.	Under ditch.	County.	Under ditch.
	Acres.		*Acres.*
Bernalillo	12,421	Santa Fé	9,820
Colfax	183,400	Sierra	8,673
Doña Aña	37,621	San Juan	20,000
Grant	8,721	Socorro	73,464
Lincoln	100,000	Taos	84,763
Mora	51,279	Valencia	26,420
Rio Arriba	29,623		
San Miguel	38,241	Total	638,455

Projected ditches and ditches under construction will serve in addition, 722,000 acres.

A most careful student and engineer, L. G. Carpenter, professor of irrigation engineering and meteorologist in the State Agricultural College, presented in his annual college report (January, 1890) the following approximate estimate of—

Irrigation ditches and areas in Colorado.

	Area.	Total area.	
	Sq. miles.	*Sq. miles.*	*Acres.*
Division I (Platte Division):			
Platte Valley, below the Poudre	283.21		
Platte Valley, above the Poudre, including Bear and Clear Creeks.	551.64		
St. Vrain and Boulder Creeks	294.59		
Big and Little Thompson	134.22		
Cache La Poudre	393.54		
Total from South Platte		1,657.20	1,060,608
From North Platte in North Park	....	101.23	64,787
Division II (Arkansas Division):			
East of the Huerfano River	489.08		
Cucharas	94.40		
La Veta and Apache	84.17		
Upper Arkansas and Fontaine	106.91		
		774.56	495,718
Division III (Rio Grande Division)	....	1,564.00	1,000,960
Division IV (San Juan Division), including Dolores, Mancos, Pine, Florida, La Plata Rivers	....	135.00	86,400
Division V (Grand River Division)	....	210.00	134,400
Division VI (Bear and White River Division)	....	110.00	70,400
Total	....	4,552.00	2,913,273

By this table the total amount of land under ditch in Colorado at present is not far from 4,500 square miles, or 3,000,000 acres. The amount of land actually irrigated can not be so reliably estimated at present. It is much less than that under ditch.

Professor Carpenter estimates the total irrigated as not over one-third. This is apparently below the actual results. State Engineer Maxwell reported the following figures as a careful statement of the area east of the Rocky Mountains:

Divisions.	No. of districts.	Miles of ditches.	Acres.	
			Under ditch.	Actually irrigated.
No. 1 Platte	14	2,067.36	1,126,800	631,036
No. 2 Arkansas	13	943.30	440,240	116,047
No. 3 Rio Grande	8	1,033.68	596,097	250,263
Total	35	4,044.34	2,163,137	997,346

In the three eastern divisions there are also one hundred and sixty-two reservoirs, with a record capacity of 5,319,939,788 cubic feet, capable of furnishing 1 acre-foot of water to each of 122,199 acres. The total number of ditches, large and small, in the State is estimated at 2,000, and their mileage at 5,000. The duty of water is placed at 1.45 cubic feet per second for 80 acres. In some sections it is over 100 acres, however.

West of the range in the Grand River, Mesa County, Uncompahgre, and other sections, there were 110,000 acres actually irrigated. The estimate of E. S. Nettleton, the leading engineer of the State, reached for 1889, one of water scarcity, to 1,300,000 acres. From the various enterprises now in progress and for which it is claimed water can be obtained, the area under ditch in the present will not be less than 4,000,000 acres.

There are over four hundred mountain streams within the borders of Wyoming, and the mountain area from which they flow contains at least 35,000 square miles, 22,400,000 acres. The Territorial engineer, Elwood Mead, claims as a moderate computation, that the annual precipitation on these storm-condensers and moisture-stores will average not less than 3 solid feet of water. This estimate contains 60,000,000 acre-feet; an amount sufficient, at the rate per annum of 1 acre-foot for 80 acres, to irrigate 10,000,000 acres of land. The precipitation is there, the mountains offer unequaled opportunities for storage, the numerous watercourses can be rendered available with added artificial facilities for full distribution, and the land will present, with its broad levels and fertile qualities, an easy work for the engineer and ample return to the farmer.

Irrigation ditches and areas in Wyoming.

District.	Total No. of recorded ditches.	Total length as stated.	No. of claims, with statement of length omitted.	Total capacity as given.	No. of ditch claims, omitting statement of capacity.	Total acreage watered as given.	No. of ditch claims, omitting statement of acreage.
1*†	643	1,322.385	29	5,911.584	48	482,434.00	89
2	327	582.793	31	6,619.841	53	379,164.64	62
3	282	317.419	91	3,644.078	72	395,563.00	114
4‡	....	....	....	....	....	....	....
5	502	996.398	32	10,422.700	57	440,540.00	50
6	124	196.955	46	1,556.325	36	58,162.00	55
7	322	518.240	50	1,658.905	96	168,976.78	95
8	182	212.410	52	3,095.487	79	35,396.00	96
9	49	91.430	1	342.000	25	42,460.00	3
§	7	11.905	....	136.800	....	4,180.00	....
Total	2,438	4,249.935	242	20,381.723	466	1,946,875.42	564

*Engineer Mead's report.
† Seven reservoirs additional.
‡ District No. 4 omitted because of incomplete record.
§ Unorganized district.

Of this area of nearly 2,000,000 acres not more than 80,000 acres are under cultivation other than for stock purposes.

For western Nebraska, an estimate is made (1889-'90) of 50,000 acres "unditch," and 6,000 under cultivation.

The Senate committee report as follows, as a summary:

Total area under ditch and irrigated.

States and Territories.	Under ditch.	Cultivated by irrigation.
	Acres.	*Acres.*
Arizona	455,000	225,000
California	4,000,000	3,300,000
Colorado	3,000,000	1,600,000
Idaho	715,000	500,000
Kansas	300,000	75,000
Montana	986,000	350,000
Nebraska	50,000	5,000
Nevada	142,000	70,000
New Mexico	800,000	625,000
Oregon	191,000	150,000
South Dakota (Black Hills)	100,000	15,000
Texas	200,000	125,000
Utah	700,000	413,000
Washington	75,000	50,000
Wyoming	1,947,000	75,000
Total	13,661,000	7,578,000

The table presented on the authority of the Geological Survey makes a total estimate of 8,307,000 acres, as "irrigated and under ditch;" certainly an aggregate below the fact. At date of this publication (June, 1890) the area "under ditch" west of the ninety-eighth meridian of west longitude will not be less than 10,000,000 acres in extent; under cultivation it will reach at least 9,000,000, and is probably a million more. If the area "under ditch" is as reported in the forgoing, the value for taxation purposes will not be less than $10 per acre, or a total valuation of $136,610,000, while that actually cultivated may be placed by a low valuation at $15 per acre, or a total of $125,270,000. And these being considered as assessor's figures may fairly be doubled. The cost of reclamation will certainly not exceed, all told, more than $7 per acre, or a total of $95,627,000. Indeed it is more probable that $50,000,000 will cover the actual cost of reclaiming the area at present irrigated.

The Senate committee made the following argument on the utility of irrigation.

> The amount of land that may be brought under cultivation in the arid region by irrigation is variously estimated at from 75,000,000 to 150,000,000 acres. It is safe to predict that at least 100,000,000 acres will be ultimately brought under cultivation by irrigation, and that, too, by the water in sight which, when properly utilized, will readily reclaim at least 10 per cent. of the whole arid area. It is worthy of remark that land cultivated by irrigation is much more productive than land where the rainfall is sufficient to produce crops. The certainty of crops every year in an irrigated country where the water supply is sufficient is a most important consideration. Besides, in nearly every part of the arid region more than one crop can be produced each year from the same land, and a good crop is always certain with a constant water supply. Irrigation requires unremitting attention and high cultivation and with such attention and cultivation it is calculated that in any given period of ten years irrigated land will produce from three to five times as much as land cultivated by rainfall.
>
> The question for consideration is: What action should be taken by the Government to enable the people to reclaim these desert lands? The reclamation must be initiated and executed by the people, and not by their Government. In India, and, in fact, in all countries under monarchial or despotic rule, the work of irrigation has been carried on under Government control and largely with Government money. The Government of British India has already expended several hundred millions of dollars in constructing irrigation works, and is continuing such expenditures on a most magnificent scale. The reports show that the investment has been profitable to the Government and of the greatest possible advantage to the people.
>
> But there is no necessity for the United States to engage in such expenditures. If the opportunity is furnished to the people of this country they will reclaim these desert lands so far as reclamation is necessary. The use of industrial co-operation in developing the mineral resources of the far West demonstrates the capacity of the people for great undertakings, which in other countries require vast expenditures of accumulated capital.

LEGAL CONDITIONS OF IRRIGATION.

THE CONSTITUTIONAL PROVISIONS AND LAWS OF THE SEVERAL STATES AND TERRITORIES WITHIN THE ARID REGION IN RELATION TO WATER RIGHTS, PUBLIC CONTROL, AND BENEFICIAL USES, WITH A LIST OF CASES AND DECISIONS.

PART V.

Those who desire to understand the progress of irrigation will do well to carefully examine the constitutional provisions adopted by the several States which are in whole or in part within the area of aridity. Until within a few years past very little attention has been paid to safeguards over natural property, such as water, and through the public control of which, for beneficial uses, can the security of industry alone be achieved.

California, Nevada, and Oregon, the three States first formed west of the eastern lines of industrial moisture, have made no constitutional provision affecting the public character of this use. In their statutes and before their courts the isues involved have constantly been acted upon. There has grown up or evolved out of the necessities of the people and the exigencies of the communities interested a great body of law, custom, regulation, and judicial interpretation. These start in general from the principle of prior appropriation as wrought out by the earlier miners, and embodied in Federal law, and then by the States and Territories, being steadily sustained by the courts, with a few exceptions, as the common law of an arid region such as ours. The development of the beneficial use of water has of course modified the practice of prior appropriations to a first or prior pro rata share of the natural waters, when taken from bed or source for industrial purposes.

The people of Colorado were the first to perceive both the just theory and the exacting conditions embodied in the public nature of water. Its constitution, therefore, becomes a starting point, as framed and adopted in 1875-'76. The sections relating to water rights and obligations are as follows:

CONSTITUTION OF CALIFORNIA.

WATER AND WATER RIGHTS.

SECTION 1. The use of all water now appropriated, or that may hereafter be appropriated, for sale, rental, or distribution, is hereby declared to be a public use, and subject to the regulation and control of the State, in the manner to be prescribed by law: *Provided*, That the rates or compensation to be collected by any person, company, or corporation in this State for the use of water supplied to any city and county, or city or town, or the inhabitants thereof, shall be fixed annually by the board of supervisors, or city or town, by ordinance or otherwise, in the manner that other ordinances or legislative acts or resolutions are passed by such body, and shall continue in force for one year and no longer. Such ordinances or resolutions shall be passed in the month of February of each year, and take effect on the first day of July thereafter. Any board or body failing to pass the necessary ordinances or resolutions fixing water rates, where necessary, within such time, shall be subject to peremptory process to compel action at the suit of any party interested, and shall be liable to such further processes and penalties as the legislature may prescribe. Any person, company, or corporation collecting water rates, in any city and county, or city or town in this State, otherwise than as so established, shall forfeit the franchises and water-works of such person, company, or corporation, to the city and county, or city or town, where the same are collected for the public use.

SECTION 2. The right to collect rates or compensation for the use of water supplied to any county, city and county, or town, or the inhabitants thereof, is a franchise, and cannot be exercised except by authority of and in the manner prescribed by law.

CONSTITUTION OF COLORADO.

WATER RIGHTS—PRIORITIES AND RIGHTS THEREUNDER.

ARTICLE XVI. SEC. 5. The water of every natural stream not heretofore appropriated, within the State of Colorado, is hereby declared to be the property of the public, and is dedicated to the use of the people of the State, subject to appropriation as hereinafter provided.

SEC. 6. The right to divert unappropriated waters of every natural stream for beneficial uses shall never be denied. Priority of appropriation shall give the better right, as between those using the water for the same purpose; but when the waters of any natural stream are not sufficient for the service of all those desiring the use of the same, those using the water for domestic purposes shall have the preference over those claiming for any other purpose, and those using the water for agricultural purposes shall have the preference over those using the same for manufacturing purposes.

ART. II. SEC. 14. Private property shall not be taken for private use unless by consent of the owner, except for private ways of necessity, and except for reservoirs, drains, flumes, or ditches, on or across the lands of others, for agricultural, mining, milling, domestic, or sanitary purposes.

ART. II. SEC. 15. Private property shall not be taken or damaged for public or private use without just compensation. Such compensation shall be ascertained by a board of commissioners of not less than three freeholders, or by a jury when required by the owner of the property, in such manner as may be prescribed by law, and until the same shall be paid to the owner, or into court for the owner, the property shall not be needlessly disturbed, or the proprietary rights of the owner therein invested [divested]; and whenever an attempt is made to take private property for a use alleged to be public, the question whether the contemplated use be really public shall be a judicial question, and determined as such without regard to any legislative assertion that the use is public.

ART. XVI. SEC. 7. All persons and corporations shall have the right of way across public, private, and corporate lands for the construction of ditches, canals, and flumes, for the purpose of conveying water for domestic purposes, for the irrigation of agricultural lands, and for mining and manufacturing purposes, and for drainage, upon payment of just compensation.

ART. XVI. SEC. 8. The general assembly shall provide by law that the board of county commissioners in their respective counties shall have power, when application is made to them by either party interested, to establish reasonable maximum rates to be charged for use of water whether furnished by individuals or corporations.

ART. X. SEC. 3. Ditches, canals, and flumes owned and used by individuals or corporations for irrigating lands owned by such individuals or corporations, or the individual members thereof, shall not be separately taxed so long as they shall be owned and used exclusively for such purposes.

CONSTITUTION OF IDAHO.*

BILL OF RIGHTS.

ARTICLE I. SEC. 14. The necessary use of lands for the construction of reservoirs, or storage basins, for the purposes of irrigation, or for rights of way for the construction of canals, ditches, flumes, or pipes, to convey water to the place of use, for any useful, beneficial, or necessary purpose, or for drainage, or for the drainage of mines, or the working thereof, by means of roads, railroads, tramways, cuts, tunnels, shafts, hoisting works, dumps, or other necessary means to their complete development, or any other use necessary to the complete development of the material resources of the State, or the preservation of the health of its inhabitants, is hereby declared to be a public use, and subject to the regulation and control of the State.

Private property may be taken for a public use, but not until a just compensation, to be ascertained in a manner prescribed by law, shall be paid therefor.

WATER RIGHTS.

ART. XV. SEC. 1. The use of all waters now appropriated, or that may hereafter be appropriated for sale, rental, or distribution; also of all water originally approproated for private use, but which after such appropriation has heretofore been, or may hereafter be sold, rented, or distributed, is hereby declared to be a public use, and subject to the regulation and control of the State in the manner prescribed by law.

---

* These provisions and those of Montana, North Dakota, Washington and Wyoming, were all adopted in 1889.

SEC. 2. The right to collect rates or compensation for the use of water supplied to any county, city, or town, or water district, or the inhabitants thereof, is a franchise, and can not be exercised except by authority of and in the manner prescribed by law.

SEC. 3. The right to divert and appropriate the unappropriated waters of any natural stream to beneficial uses shall never be denied. Priority of appropriation shall give the better right as between those using the water; but when the waters of any natural stream are not sufficient for the service of all those desiring the use of the same, those using the water for domestic purposes shall (subject to such limitations as may be prescribed by law) have the preference over those claiming for any other purpose; and those using the water for agricultural purposes shall have preference over those using the same for manufacturing purposes. And in any organized mining district those using the water for mining purposes or milling purposes connected with mining, shall have preference over those using the same for manufacturing or agricultural purposes. But the usage by such subsequent appropriators shall be subject to such provisions of law regulating the taking of private property for public and private use, as referred to in section fourteen of Article I, of this constitution.

SEC. 4. Whenever any waters have been, or shall be, appropriated or used for agricultural purposes, under a sale, rental, or distribution thereof, such sale, rental, or distribution shall be deemed an exclusive dedication to such use; and whenever such waters so dedicated shall have once been sold, rented, or distributed to any person who has settled upon or improved land for agricultural purposes with the view of receiving the benefit of such water under such dedication, such person, his heirs, executors, administrators, successors, or assigns, shall not thereafter, without his consent, be deprived of the annual use of the same, when needed for domestic purposes, or to irrigate the land so settled upon or improved, upon payment therefor, and compliance with such equitable terms and conditions as to the quantity used and times of use, as may be prescribed by law.

SEC. 5. Whenever more than one person has settled upon or improved land with the view of receiving water for agricultural purposes under a sale, rental, or distribution thereof, as in the last preceding section of this article provided, as among such persons priority in time shall give superiority of right to the use of such water in the numerical order of such settlements or improvements; but whenever the supply of such water shall not be sufficient to meet the demands of all those desiring to use the same, such priority of right shall be subject to such reasonable limitations as to the quantity of water used and times of use as the legislature, having due regard both to such priority of right and the necessities of those subsequent in time of settlement or improvement, may by law prescribe.

SEC. 6. The legislature shall provide by law the manner in which reasonable maximum rates may be established to be charged for the use of water sold, rented, or distributed for any useful or beneficial purpose.

CONSTITUTION OF MONTANA.

WATER RIGHTS.

SECTION 1. The use of all waters now appropriated, or that may hereafter be appriated, for sale, rental, or distribution; also, of all water originally appropriated for private use, but which, after such appropriation has heretofore been, or may hereafter be, sold, rented, or distributed, is hereby declared to be a public use, and subject to the regulation and control of the State in the manner prescribed by law.

SEC. 2. The right to collect rates or compensation for the use of water supplied to any county, city, or town, or water district, or the inhabitants thereof, is a franchise, and can not be exercised except by authority of and in the manner prescribed by law.

SEC. 3. The right to divert and appropriate the unappropriated waters of any natural stream to beneficial uses shall never be denied. Priority of appropriation shall give the better right as between those using the water for the same purpose; but when the waters of any natural stream are not sufficient for the service of all those desiring the use of the same those using the water for domestic purposes shall (subject to such limitations as may be prescribed by law) have the preference over those claiming for any other purpose, and those using the water for agricultural purposes shall have preference over those using the same for manufacturing purposes.

SEC. 4. All persons and corporations shall have the right of way across public, private, and corporate lands for the construction and maintenance of canals, ditches, flumes, or pipes for the purpose of conveying water to the place of use, for any useful or beneficial purpose, and for drainage upon paying therefore a just compensation in the manner prescribed by law.

SEC. 5. Whenever any waters have been, or shall be, appropriated or used for agricultural purposes under a sale, rental, or distribution thereof, such sale, rental, or distribution shall be deemed an exclusive dedication to such use; and whenever such waters so dedicated shall have ever been sold, rented, or distributed to any person who has settled upon or improved land for agricultural purposes with a view of receiving the benefit of such water under such dedication, such person, his heirs, executors, administrators, successors, or assigns shall not thereafter without his consent be deprived of the annual use of the same when needed for domestic purposes, or to irrigate the land so settled upon or improved, upon payment therefor and compliance with such equitable terms and conditions as to the quantity used and times of use as may be prescribed by law.

SEC. 6. Whenever more than one person has settled upon or improved land with the view of receiving water for agricultural purposes under a sale, rental, or distribution thereof, as in the last preceding section of this article provided, as among such persons priority in time shall give superiority of right to the use of such water in the numerical order of such settlements or improvements; but whenever the supply of such water shall not be sufficient to meet the demands of all those desiring to use the same, such priority of right shall be subject to such reasonable limitations as to the quantity of water used and times of use as the legislative assembly, having due regard both to such priority of right and the necessities of those subsequent in time of settlement or improvement, may by law prescribe.

SEC. 7. The legislative assembly shall provide by law the manner in which reasonable maximum rates may be established to be charged for the use of water sold, rented, or distributed for any useful or beneficial purpose.

CONSTITUTION OF NEW MEXICO.

[Proposed article.]

MINING AND WATER RIGHTS.

ART. XIV. SEC. 5. Whenever by priority of possession rights to the use of water for mining, agriculture, manufacturing, or other purposes have vested and accrued the possessors and owners of such vested rights shall be maintained and protected in the same, and the right of way for the construction of ditches and canals for the purposes herein specified is acknowledged and confirmed subject to the restrictions of this constitution as to taking property for public or private use.

CONSTITUTION OF NORTH DAKOTA.

ART. XVII. SEC. 210. All flowing streams and natural water-courses shall forever remain the property of the State for mining, irrigating, and manufacturing purposes.

CONSTITUTION OF WASHINGTON.

WATER AND WATER RIGHTS.

ART. XXI. SEC. 1. The use of the waters of this State for irrigation, mining, and manufacturing purposes shall be deemed a public use.

CONSTITUTION OF WYOMING.

[Proposed article.]

DECLARATION OF RIGHTS.

ART. I. SEC. 31. Water being essential to industrial prosperity, of limited amount, and easy of diversion from its natural channels, its control must be in the State, which in providing for its use shall equally guard all the various interests involved.

SEC. 32. Private property shall not be taken for private use unless by consent of the owner, except for private ways of necessity, and for reservoirs, drains, flumes, or ditches on or across the lands of others for agricultural, mining, milling, domestic, or sanitary purposes, nor in any case without due compensation.

IRRIGATION AND WATER RIGHTS.

ART. VIII. SEC. 1. The water of all natural streams, springs, lakes, or other collection of still water, within the boundaries of the State, are hereby declared to be the property of the State.

SEC. 2. There shall be constituted a board of control, to be composed of the State engineer and superintendents of the water divisions, which shall, under such regulations as may be prescribed by law, have the supervision of the waters of the State and of their appropriation, distribution, and diversion, and of the various officers connected therewith, its decisions to be subject to review by the courts of the State.

SEC. 3. Priority of application for beneficial uses shall give the better right. No appropriation shall be denied except when such denial is demanded by the public interests.

SEC. 4. The legislature shall by law divide the State into four water divisions, and provide for the appointment of superintendents thereof.

SEC. 5. There shall be a State engineer, who shall be appointed by the governor of the State and confirmed by the senate; he shall hold his office for the term of six years, or until his successor shall have been appointed and shall have qualified. He shall be president of the board of control, and shall have general supervision of the water of the State and of the officers connected with its distribution. No person shall be appointed to this position who has not such theoretical knowledge and such practical experience and skill as shall fit him for the position.

CORPORATIONS.

ART. X. SEC. 1. The legislature shall provide for the organization of corporations by general law. All laws relating to corporations may be altered, amended, or repealed by the legislature at any time when necessary for the public good and general welfare, and all corporations doing business in this State may as to such business be regulated, limited, or restrained by law not in conflict with the Constitution of the United States.

SEC. 2. All powers and franchises of corporations are derived from the people, and are granted by their agent, the Government, for the public good and general welfare, and the right and duty of the State to control and regulate them for these purposes is hereby declared. The power, rights, and privileges of any and all corporations may be forfeited by willful neglect or abuse thereof. The police power of the State is supreme over all corporations as well as individuals.

SEC. 3. All existing charters, franchises, special or exclusive privileges under which an actual and bona fine organization shall not have taken place for the purpose for which formed and which shall not have been maintained in good faith to the time of he adoption of this constitution, shall thereafter have no validity.

LAWS RELATING TO IRRIGATION, WATER CONSERVATION AND DISTRIBUTION.

ARIZONA IRRIGATION LAWS.

WATERS AND WATER RIGHTS.

CHAPTER 1.—*Riparian rights.*

3198. (Sec. 1.) The common-law doctrine of riparian rights shall not obtain or be of any force or effect in this Territory.

CHAPTER 2.—*Irrigating canals and acequias.*

3199. (Sec. 1.) All rivers, creeks, and streams of running water in the Territory of Arizona are hereby declared public and applicable to the purposes of irrigating and mining, as hereinafter provided.

3200. (Sec. 2.) All rights in acequias, or irrigating canals, heretofore established shall not be disturbed, nor shall the course of such acequias be changed without the consent of the proprietors of such established rights.

3201. (Sec. 3.) All the inhabitants of this Territory who own or possess arable and irrigable lands shall have the right to construct public or private acequias, and obtain the necessary water for the same from any convenient river, creek, or stream of running water.

3202. (Sec. 4.) Whenever such public or private acequias shall necessarily run through the lands of any private individuals not benefited by said acequias, the damages resulting such private individuals, on the application of the party interested, shall be assessed by the probate judge of the proper county in a summary manner.

3203. (Sec. 5.) No inhabitant of this Territory shall have the right to erect any dam, or build a mill, or place any machinery, or open any sluice, or make any dyke, except such as are used for mining purposes or the reduction of metals, as provided for in sections 6 and 7 of this chapter, that may impede or obstruct the irrigation of any lands or fields, as the right to irrigate the fields and arable lands shall be preferable to all others; and the justices of the peace of the respective precincts shall hear and determine the question relative to all such obstructions in a summary manner, and cause the removal of the same by order directed to the constable of the precincts or sheriff of the county, who shall proceed to execute the same without delay.

3204. (Sec. 6.) Where reduction works or other mining apparatus shall be placed upon lands previously held for agricultural purposes, or persons so holding such lands shall be entitled to remuneration from person or persons erecting or owning said reduction works or mining apparatus, the amount of remuneration shall be adjudged by three or five disinterested persons, or by the probate judge, as the parties interested shall agree; and in case such agreement can not be made, then the party injured may bring suit for damages.

3205. (Sec. 7.) When any ditch or acequia shall be taken out for agricultural purposes, the person or persons so taking out such ditch or acequia shall have the exclusive right to the water, or so much thereof as shall be necessary for said purposes; and if at any time the waters so required shall be taken for mining operations, the person or persons owning said water shall be entitled to damages to be assessed in the manner provided in section 6 of this chapter.

3206. (Sec. 8.) All by-paths or footpaths across any cultivated fields are prohibited, under penalty of a fine not to exceed $10 for the public acequia, to be assessed in a summary manner by the justice of the peace of the precinct; and if the person so offending shall not have wherewith to pay the fine, he shall be adjudged and sentenced to ten days on the public acequia.

3207. (Sec. 9.) All owners of arable and irrigable land bordering on, or irrigable by, any public acequia, shall labor on such public acequia, whether such owners or proprietors cultivate the land or not.

3208. (Sec. 10.) All persons interested in a public acequia, whether owners or lessees of land, shall labor thereon in proportion to the amount of land owned or held by them, and which may be irrigated or subject to irrigation.

3209. (Sec. 11.) It being impracticable to properly inclose the fields in this Territory, all animals shall be kept under a shepherd so that no injury may result to the fields; and if any damage should result, it shall be paid by the owners of the animals causing the same, to be assessed by the justice of the peace of the precinct in a summary manner, and paid to the person or persons whose fields may have been damaged.

3210. (Sec. 12.) In case a community of people desire to construct an acequia in any part of this Territory, and the persons desiring to construct the same are the owners or proprietors of the land upon which they design constructing the said acequia, no one shall be bound to pay damages for such land, as all persons interested in the construction of the said acequia are to be benefited thereby.

3211. (Sec. 13.) Immediately after the publication of this chapter, it shall be the duty of the several justices of the peace in this Territory to call together, in their respective precincts, all the owners and proprietors of land, irrigated by any public acequia, for the purpose of electing one or more overseers for said acequia for the corresponding year.

3212. (Sec. 14.) The manner of conducting such elections, and the number of overseers, shall be regulated by the justices of the peace of their respective precincts; and the only persons entitled to vote at said elections shall be the owners and proprietors of lands irrigated by said acequias.

3213. (Sec. 15.) The pay and perquisites of said overseer shall be determined by a majority of the owners and proprietors of the lands irrigated by said acequias, and paid by them.

3214. (Sec. 16.) It shall be the duty of the overseers to superintend the opening, excavations, and repairs of said acequias; to apportion the number of laborers furnished by the owners, and proprietors; to regulate them according to the quantity of land to be irrigated by each one from said acequia, to distribute and apportion the water in proportion to the quantity to which each one is entitled according to the land cultivated by him; and, in making such apportionment, he shall take into consideration the nature of the seed sown or planted, the crops and plants cultivated, and to conduct and carry on such distribution with justice and impartiality.

3215. (Sec. 17.) During years when a scarcity of water shall exist, owners of fields shall have precedence of the water for irrigation, according to the dates of their respective titles or their occupation of the lands, either by themselves or their grantors. The oldest titles shall have precedence always.

3216. (Sec. 18.) It shall be the duty of each of the owners and proprietors to furnish the number of laborers required by the overseer, at the time and place he may designate, for the purposes mentioned in the foregoing section, and for the time he may deem necessary.

3217. (Sec. 19.) If any overseer of any public acequia, after having undertaken to serve as such, shall willfully neglect or refuse to fulfill the duties required of him by this chapter, or conduct himself with impropriety or injustice in his office as overseer; or take any bribe in money, property, or otherwise, as an inducement to act improperly; or neglect the duties of his office, he shall be fined for each of said offenses in a sum not exceeding $100 nor less than $50, to be recovered before any justice of the peace of the county—one-half of which shall be paid to the county and the other half to the person bringing suit for the same—the said suit to be brought in the name of the Territory of Arizona; and said overseer, on being convicted a second time, shall be removed from his office by the justice of the peace of the precinct, and shall take such pay and perquisites as may be due him for services rendered.

3218. (Sec. 20.) Upon such removal, the justice of the peace shall order a new election to fill the vacancy thereby occasioned, which shall be conducted in the manner prescribed in the thirteenth and fourteenth sections of this chapter.

3219. (Sec. 21.) If any owner or proprietor of land irrigated by such acequia shall neglect or refuse to furnish the number of laborers required by the overseer, as required in the eighteenth section of this chapter after having been duly notified by the overseer, he shall be fined for each offense in a sum not exceeding $10 for the benefit of said acequia, which shall be recovered by the overseer before any justice of the peace in the county, and in such cases the overseer shall be a competent witness to prove the offense or any fact that may serve to constitute the same.

3220. (Sec. 22.) If any person shall in any manner interfere with, impede, or obstruct any of said acequias, or use the water from it without the consent of the overseer, except as provided in section 7 of this chapter during the time of cultivation, he shall pay for each offense a sum not exceeding $10, which shall be recoverable in the manner prescribed in the foregoing section for the benefit of said acequia; and he shall further pay all damages that may have accrued to the injured parties, and, if such person have not wherewith to pay said fine and damages, he shall be sentenced to fifteen days' labor on said public acequia.

3221. (Sec. 23.) All fines and forfeitures received for the use and benefit of any public acequia shall be applied by the overseers to the improvements, excavations, and repairs which may be necessary on said acequia, and for the construction of bridges where they may be crossed by any public street or road.

3222. (Sec. 24.) In all cases of conviction under this chapter an appeal shall be allowed to the probate court, which appeal shall be taken and conducted as all other appeals from the decisions of the justices of the peace.

3223. (Sec. 25.) The regulations of acequias which have been worked according to the laws and customs of Sonora and the usages of the people of Arizona shall remain as they were made and used up to this day; and the provisions of this chapter shall be enforced and observed from the day of its publication.

3224. (Sec. 26.) All plants and trees of any description growing on the banks of any acequia shall belong to the owners of the land through which said acequia may run.

3225. (Sec. 27.) Any person owning lands which may include a spring or stream of running water, or owning lands upon a river where there is not population sufficient to form a public acequia, may construct a private acequia for his own use, subject to his own regulations, provided it does not interfere with the rights of others.

3226. (Sec. 28.) All laws conflicting with the provisions of this chapter are hereby repealed.

[NOTE.—The foregoing chapter is compiled and taken from the Compiled Laws, Chapter LV, page 528. There was no legislation upon the subject by the fourteenth legislature (1887), and this chapter remained unchanged.]

CHAPTER 3—*Ditch Crossings.*

3227. (Sec. 1.) Any person, corporation or company, owning or using any ditch or canal constructed for the purpose of conveying water, shall construct and maintain suitable crossings wherever said ditch or canal crosses any public highway, or usually traveled road of this Territory; said crossing shall be maintained as follows:

From the bottom of the ditch in the roadway there shall be a uniform rise of not more than 1 foot in 3 to the top of the embankment; either side the ditch shall be graveled or macadamized with stone to a depth of not less than 10 inches from the top of one embankment to the other, and the macadamized or paved road across any of said ditches shall not be less than 14 feet wide; provided, that any person or persons, corporation or company may at any of said crossings construct and build a good and substantial bridge to be approved of by the road overseers of the district.

3228. (Sec. 2.) The road overseer of each of the districts in the several counties in this Territory shall have supervision of said crossings, and it shall be his duty to see that the several ditch crossings in his district are constructed and maintained as provided in the preceding section.

3229. (Sec. 3.) For neglect or refusal of any person or persons, corporation or company, whose duty it shall be to construct or maintain such crossings as provided for in section 1, for the period of ten days after being notified in writing by the road overseer of the district in which any such crossing needs construction or repair that such construction or repair is required, such person, corporation or company shall be guilty of a misdemeanor, and upon conviction thereof before a justice of the peace of any such precincts, shall be fined not less than $10 or more than $100 for the first offense; and of not less than $25 nor more than $250, and the costs of prosecution, for each subsequent offense; provided, that whenever such highway or road is constructed, after the construction of such ditch or canal, it shall be the duty of the road overseer of the district to construct and maintain such crossing at the expense of the road fund of the district, and if the same be at any time insufficient, the same shall be paid out of the general fund in the county treasury, to be chargeable to and thereafter collected from such road fund.

3230. (Sec. 4.) All funds collected under the provisions of this act shall be paid into the road fund of the district, wherever such crossings are required.

THE IRRIGATION LAWS OF CALIFORNIA.

WRIGHT IRRIGATION BILL AND AMENDMENTS, 1889.

AN ACT to provide for the organization and government of irrigation districts and to provide for the acquisition of water and other property, and for the distribution of water thereby for irrigation purposes.

SECTION 1. Whenever fifty or a majority of freeholders owning lands susceptible of one mode of irrigation from a common source, and by the same system of works, desire to provide for the irrigation of the same, they may propose the organization of an irrigation district under the provisions of this act, and when so organized such district shall have the powers conferred or that may hereafter be conferred by law upon such irrigation district.

SEC. 2. A petition shall first be presented to the board of supervisors of the county in which the lands or the greatest portion thereof is situated, signed by the required number of freeholders of such proposed district, which petition shall set forth and particularly describe the proposed boundaries of such district, and shall pray that the same may be organized under the provisions of this act. The petitioners must accompany the petition with a good and sufficient bond, to be approved by the said board of supervisors, in double the amount of the probable cost of organizing such district, conditioned that the bondsmen will pay all said cost in case said organization shall not be effected. Such petition shall be presented at a regular meeting of the said board, and shall be published for at least two weeks before the time at which the same is to be presented, in some newspaper printed and published in the county where said petition is presented, together with a notice stating the time of the meeting at which the same will be presented. When such petition is presented, the said board of supervisors shall hear the same, and may adjourn such hearing from time to time, not exceeding four weeks in all; and on the final hearing may make such changes in the proposed boundaries as they may find to be proper, and shall establish and define such boundaries: *Provided*, That said board shall not modify said boundaries so as to except from the operation of this act any territory within the boundaries of the district proposed by said petitioners, which is susceptible of irrigation by the same system of works applicable to the other lands in such proposed district, nor shall any lands which will not, in the judgment of the said board, be benefited by irrigation by said system be included within such district: *Provided*, That any person whose lands are susceptible of irrigation from the same source shall, upon application of the owner to said board, be entitled to have such lands included in said district. Said board shall also make an order dividing said district into five divisions, as nearly equal in size as may be practicable, which shall be numbered first, second, third, fourth, and fifth, and one director shall be elected from each district. Said board of supervisors shall then give notice of an election to be held in such proposed district, for the purpose of determining whether or not the same shall be organized under the provisions of this act. Such notice shall describe boundaries so established, and shall designate a name for such proposed district, and said notice shall be published for at least three weeks prior to such election in a newspaper published within said county; and if any portion of such proposed district lie within another county or counties, then said notice shall be published in a newspaper published within each of said counties. Such notice shall require the electors to cast ballots which shall contain the words, "Irrigation district—Yes," or, "Irrigation district—No," or words equivalent thereto; and also the names of persons to be voted for to fill the various elective offices hereinafter prescribed. No person shall be entitled to vote at any election held under the provisions of this act unless he shall possess all the qualifications required of electors under the general election laws of this State.

SEC. 3. Such election shall be conducted in accordance with the general election laws of the State, provided that no particular form of ballot shall be required. The said board of supervisors shall meet on the second Monday next succeeding such election, and proceed to canvass the votes thereof; and if upon such canvass it appear that at least two-thirds of all the votes cast are "Irrigation district—Yes," the said board shall, by an order entered on their minutes, declare such territory duly organized as an irrigation district, under the name and style theretofore designated, and shall declare the persons receiving, respectively, the highest number of votes for such several offices to be duly elected to such offices. Said board shall cause a copy of such order, duly certified, to be immediately filed for record in the office of the county recorder of each county in which any portion of such lands are situated, and must also immediately forward a copy thereof to the clerk of the board of supervisors of each of the counties in which any portion of the district may be; and no board of supervisors of any county, including any portion of such district, shall, after the date of the organization of such district, allow another district to be formed including any of the lands in such district, without the consent of the board of directors thereof; and from and after the date of such filing, the organization of such district shall be complete, and the officers thereof shall be entitled to enter immediately upon the duties of their respective offices, upon qualifying in accordance with law, and shall hold such offices, respectively, until their successors are elected and qualified. For the purposes of the election above provided for, the said board of supervisors must establish a convenient number of election precincts in said proposed district, and define the boundaries thereof, which said precincts may thereafter be changed by the board of directors of such district.

SEC. 4. An election shall be held in such district on the first Wednesday in April, eighteen hundred and eighty-eight, and on the first Wednesday in April in each second year thereafter, at which an assessor, a collector, and a treasurer, and a board of five directors for the district shall be elected. The person receiving the highest number of votes for any office to be filled at such election is elected thereto. Within ten days after receiving their certificates of election, hereinafter provided for, said officers shall take and subscribe the official oath and file the same in the office of the board of directors. The assessors shall execute an official bond in the sum of ten thousand dollars, and the collector an official bond in the sum of twenty thousand dollars, and the district treasurer an official bond in the sum of fifty thousand dollars; each of said bonds to be approved by the board of directors; and each member of said board of directors shall execute an official bond in the sum of twenty-five thousand dollars, which said bonds shall be approved by the judge of the superior court of said county where such organization was effected and shall be recorded in the office of the county recorder thereof, and filed with the secretary of said board. All official bonds herein provided for shall be in form prescribed by law for the official bonds of county officers.

SEC. 5. Fifteen days before any election held under this act, subsequent to the organization of any district, the secretary of the board of directors shall cause notice to be posted in three public places in each election precinct of the time and place of holding the election, and shall also post a general notice of the same in the office of said board, which shall be established and kept at some fixed place to be determined by said board, specifying the polling places of each precinct. Prior to the time for posting the notices, the board must appoint for each precinct, from the electors thereof, one inspector and two judges, who shall constitute a board of election for such precinct. If the board fail to appoint a board of election, or the members appointed do not attend at the opening of the polls on the morning of election, the electors of the precinct present at that hour may appoint the board, or supply the place of an absent member thereof. The board of directors must, in its order appointing the board of election, designate the house or place within the precinct where the election must be held.

SEC. 6. The inspector is chairman of the election board, and may:

First. Administer all oaths required in the progress of an election.

Second. Appoint judges and clerks, if during the progress of the election any judge or clerk cease to act. Any member of the board of election, or any clerk thereof, may administer and certify oaths required to be administered during the progress of an election. The board of election for each precinct must, before opening the polls, appoint two persons to act as clerks of the election. Before opening the polls, each member of the board and each clerk must take and subscribe an oath to faithfully perform the duties imposed upon them by law. Any elector of the precinct may administer and certify such oath. The polls must be opened one hour after sunrise on the morning of the election, and be kept open until sunset, when the same must be closed. The provisions of the Political Code concerning the form of ballots to be used shall not apply to elections held under this act.

SEC. 7. Voting may commence as soon as the polls are opened, and may be continued during all the time the polls remain opened, and shall be conducted as nearly as practicable in accordance with the provisions of chapter nine of title two of part three of the Political Code of this State. As soon as the polls are closed, the judges shall open the ballot-box and commence counting the votes; and in no case shall the ballot-box be removed from the room in which the election is held until all the ballots have been counted. The counting of ballots shall in all cases be public. The ballots shall be taken out, one by one, by the inspector or one of the judges, who shall open them and read aloud the names of each person contained therein, and the office for which every such person is voted for. Each clerk shall write down each office to be filled, and the name of each person voted for for such office, and shall keep the number of votes by tallies as they are read aloud by the inspector or judge. The counting of votes shall be continued without adjournment until all have been counted.

SEC. 8. As soon as all the votes are read off and counted a certificate shall be drawn up on each of the papers containining the poll list and tallies, or attached thereto, stating the number of votes each one voted for has received, and designating the office to fill which he was voted for, which number shall be written in figures and in words at full length. Each certificate shall be signed by the clerk, judge, and the inspector. One of said certificates, with the poll list and tally paper to which it is attached, shall be retained by the inspector, and preserved by him at least six months. The ballots shall be strung upon a cord or thread by the inspector, during the counting thereof, in the order in which they are entered upon the tally list by the clerks; and said ballots, together with the other of said certificates, with the poll list and tally paper to which it is attached, shall be sealed by the inspector in the presence of the judges and clerks, and indorsed "Election returns of (naming the precinct) precinct," and be directed to the secretary of the board of directors, and shall be immediately delivered by the inspector, or by some other safe and responsible carrier designated by said inspector, to said secretary, and the ballots shall be kept unopened for at least six months, and if any person be of the opinion that the vote of any precinct has not been correctly counted, he may appear on the day appointed for the board of directors to open and canvass the returns, and demand a recount of the vote of the precinct that is so claimed to have been incorrectly counted.

SEC. 9. No list, tally paper, or certificate returned from any election shall be set aside or rejected for want of form if it can be satisfactorily understood. The board of directors must meet at its usual place of meeting on the first Monday after each election to canvass the returns. If at the time of meeting the returns from each precinct in the district in which the polls were opened have been received, the board of directors must then and there proceed to canvass the returns; but if all the returns have not been received the canvass must be postponed from day to day until all the returns have been received, or until six postponements have been had. The canvass must be made in public and by opening the returns and estimating the vote of the district for each person voted for and declaring the result thereof.

SEC. 10. The secretary of the board of directors must, as soon as the result is declared, enter in the records of such board a statement of such result, which statement must show:

First. The whole number of votes cast in the district.

Second. The names of the persons voted for.

Third. The office to fill which each person was voted for.

Fourth. The number of votes given in each precinct to each of such persons.

Fifth. The number of votes given in the district to each of such persons.

The board of directors must declare elected the person having the highest number of votes given for each office to be filled by the votes of the district. The secretary must immediately make out and deliver to such person a certificate of election signed by him and authenticated with the seal of the board. In case of a vacancy in the office of assessor, tax collector, or treasurer, the vacancy shall be filled by appointment by the board of directors. In case of a vacancy in the office of member of the board of directors, the vacancy shall be filled by appointment by the board of supervisors of the county where the office of such board is situated. An officer appointed as above provided shall hold his office until the next regular election for said district, and until his successor is elected and qualified.

SEC. 11. On the first Wednesday in May next following their election the board of directors shall meet and organize as a board, elect a president from their number, and appoint a secretary. The board shall have the power, and it shall be their duty, to manage and conduct the business and affairs of the district, make and execute all necessary contracts, employ and appoint such agents, officers, and employés as may be required, and prescribe their duties, establish equitable by-laws, rules, and regulations for the distribution and use of water among the owners of said lands, and generally to perform all such acts as shall be necessary to fully carry out the purposes of this act. The said by-laws, rules, and regulations must be printed in convenient form for distribution in the district. And it is hereby expressly provided that all waters distributed for irrigation purposes shall be apportioned ratably to each land owner upon the basis of the ratio which the last assessment of such owner for district purposes within said district bears to the whole sum assessed upon the district: *Provided*, That any land owner may assign the right to the whole or any portion of the waters so apportioned to him.

SEC. 12. The board of directors shall hold a regular monthly meeting in their office on the first Tuesday in every month, and such special meetings as may be required for the proper transaction of business: *Provided*, That all special meetings must be ordered by a majority of the board; the order must be entered of record, and five days' notice thereof must, by the secretary, be given to each membe not joining in the order. The order must specify the business to be transacted, and none other than that specified must be transacted at such special meeting. All meetings of the board must be public, and three members shall constitute a quorum for the transaction of business, but on all questions requiring a vote there shall be a concurrence of at least three members of said board. All records of the board shall be open to the inspection of any elector during business hours. The board and its agents and employés shall have the right to enter upon any land in the district to make surveys, and may locate the line for any canal or canals, and the necessary branches for the same, on any of said lands which may be deemed best for such location. Said board shall also have the right to acquire, either by purchase or condemnation, all lands and waters and other property necessary for the construction, use, supply, maintenance, repair, and improvement of said canal or canals and works, including canals and works constructed and being constructed by private owners, lands for reservoirs, for the storage of needful waters and all necessary appurtenances. In case of purchase the bonds of the district, hereinafter provided for, may be used at their par value in payment; and in case of condemnation the board shall proceed in the name of the district under the provisions of title seven of part three of the code of civil procedure. Said board may also construct the necessary dams, reservoirs, and works for the collection of water for said district, and do any and every lawful act necessary to be done, that sufficient water may be furnished to each land owner in said district for irrigation purposes. The use of all water required for the irrigation of the lands of any district formed under the provisions of this act, together with rights of way for canals and ditches, sites for reservoirs, and all other property required in fully carrying out the provisions of this act, is hereby declared to be a public use, subject to the regulation and control of the State in the manner prescribed by law.

SEC. 13. The legal title to all property acquired under the provisions of this act shall immediately and by operation of law vest in such irrigation district, and shall be held by such district in trust for and is hereby dedicated and set apart to the uses and purposes set forth in this act. And said board is hereby authorized and empowered to hold, use, acquire, manage, occupy, and possess said property as herein provided.

SEC. 14. The said board is hereby authorized and empowered to take conveyances or other assurances for all property acquired by it under the provisions of this act in the name of such irrigation district, to and for the uses and purposes herein expressed, and to institute and maintain any and all actions and proceedings, suits at law or in equity, necessary or proper in order to fully carry out the provisions of this act, or to enforce, maintain, protect, or preserve any and all rights, privileges, and immunities created by this act or acquired in pursuance thereof. And in all courts, actions, suits, or proceedings the said board may sue, appear, and defend, in person or by attorneys, and in the name of such irrigation district.

SEC. 15. For the purpose of constructing necessary irrigating canals and works and acquiring the necessary property and rights therefor, and otherwise carrying out the provisions of this act, the board of directors of any such district must, as soon after such district has been organized as may be practicable, estimate and determine the amount of money necessary to be raised, and shall immediately thereupon call a special election, at which shall be submitted to the electors of such district possessing the qualifications prescribed by this act the question whether or not the bonds of said district shall be issued in the amount so determined. Notice of such election must be given by posting notices in three public places in each election precinct in said district for at least twenty days, and also by publication of such notice in some newspaper published in the county where the office of the board of directors of such district is required to be kept once a week for at least three successive weeks. Such notices must specify the time of holding the election, the amount of bonds proposed to be issued, and said election must be held and the result thereof determined and declared in all respects as nearly as practicable in conformity with the provisions of this act governing the election of officers: *Provided*, That no informalities in conducting such an election shall invalidate the same if the election shall have been otherwise fairly conducted. At such election the ballots shall contain the words, "Bonds—Yes," or "Bonds—No," or words equivalent thereto. If a majority of the votes cast are "Bonds—Yes," the board of directors shall immediately cause bonds in said amount to be issued; said bonds shall be payable in gold coin of the United States in installments as follows, to wit: At the expiration of eleven years not less than five per cent. of said bonds; at the expiration of twelve years not less than six per cent.; at the expiration of thirteen years not less than seven per cent.; at the expiration of fourteen years not less than eight per cent.; at the expiration of fifteen years not less than nine per cent.; at the expiration of sixteen years not less than ten per cent.; at the expiration of seventeen years not less than eleven per cent.; at the expiration of eighteen years not less than thirteen per cent.; at the expiration of nineteen years not less than fifteen per cent.; and for the twentieth year a percentage sufficient to pay off said bonds; and shall bear interest at the rate of six per cent. per annum, payable semi-annually on the first day of January and July of each year. The principal and interest shall be payable at the office of the treasurer of the district. Said bonds shall be each of the denomination of not less than one hundred dollars, nor more than five hundred dollars, shall be negotiable in form, signed by the president and secretary, and the seal of the board of directors shall be affixed thereto. They shall be numbered consecutively as issued, and bear date at the time of their issue. Coupons for the interest shall be attached to each bond signed by the secretary. Said bonds shall express on their face that they were issued by authority of this act, stating its title and date of approval. The secretary shall keep a record of the bonds sold, their number, the date of sale, the price received, and the name of the purchaser.

SEC. 16 The board may sell said bonds from time to time in such quantities as may be necessary and most advantageous to raise money for the construction of said canals and works, the acquisition of said property and rights, and otherwise to fully carry out the objects and purposes of this act. Before making any sale the board shall, at a meeting, by resolution, declare its intention to sell a specified amount of the bonds and the day and hour and place of such sale, and shall cause such resolution to be entered in the minutes, and notice of the sale to be given by publication thereof at least twenty days in a daily newspaper published in each of the cities of San Francisco, Sacramento, and Los Angeles, and in any other newspaper, at their discretion. The notice shall state that sealed proposals will be received by the board at their office for the purchase of the bonds till the day and hour named in the resolution. At the time appointed the board shall open the proposals and award the purchase of the bonds to the highest responsible bidder, and may reject all bids; but said board shall in no event sell any of the said bonds for less than ninety per cent. of the face value thereof.

SEC. 17. Said bonds, and the interest thereon, shall be paid by revenue derived from an annual assessment upon the real property of the district; and all the real property in the district shall be and remain liable to be assessed for such payments as hereinafter provided.

SEC. 18. The assessor must, between the first Monday in March and the first Monday in June in each year, assess all real property in the district, to the persons who own, claim, have the possession or control thereof, at its full cash value. He must prepare an assessment book with appropriate headings, in which must be listed all such property within the district, in which must be specified in separate columns under the appropriate head:

First. The name of the person to whom the property is assessed. If the name is not known to the assessor, the property shall be assessed to "unknown owners."

Second. Land by township, range, section, or fractional section, and when such land is not a Congressional division or subdivision, by metes and bounds, or other description sufficient to identify it, giving an estimate of the number of acres, locality, and the improvements thereon.

Third. City and town lots, naming the city or town, and the number and block according to the system of numbering in such city or town, and the improvements thereon.

Fourth. The cash value of real estate, other than city or town lots.

Fifth. The cash value of improvements on such real estate.

Sixth. The cash value of city and town lots.

Seventh. The cash value of improvements on city and town lots.

Eighth. The cash value of improvements on real estate assessed to persons other than the owners of the real estate.

Ninth. The total value of all property assessed.

Tenth. The total value of all property after equalization by the board of directors.

Eleventh, Such other things as the board of directors may require.

SEC. 19. The board of directors must allow the assessor as many deputies, to be appointed by him, as will, in the judgment of the board, enable him to complete the assessment within the time herein prescribed. The board must fix the compensation of such deputies, which shall be paid out of the treasury of the district. The compensation must not exceed five dollars per day for each deputy, for the time actually engaged, nor must any allowance be made but for work done between the first Monday in March and the first Monday in August in each year.

SEC. 20. On or before the first Monday in August in each year the assessor must complete his assessment book, and deliver it to the secretary of the board, who must immediately give notice thereof, and of the time the board of directors, acting as a board of equalization, will meet to equalize assessments, by publication in a newspaper published in each of the counties comprising the district. The time fixed for the meeting shall not be less than twenty nor more than thirty days from the first publication of the notice; and in the meantime the assessment book must remain in the office of the secretary for the inspection of all persons interested.

SEC. 21. Upon the day specified in the notice required by the preceding section for the meeting, the board of directors, which is hereby constituted a board of equalization for that purpose, shall meet and continue in session from day to day, as long as may be necessary, not to exceed ten days, exclusive of Sundays, to hear and determine such objections to the valuation and assessment as may come before them; and the board may change the valuation as may be just. The secretary of the board shall be present during its sessions, and note all changes made in the valuation of property, and in the names of the persons whose property is assessed; and within ten days after the close of the session he shall have the total values, as finally equalized by the board, extended into columns and added.

SEC. 22. The board of directors shall then levy an assessment sufficient to raise the annual interest on the outstanding bonds; and at the expiration of ten years after the issuing of bonds by the board, must increase said assessment for the ensuing ten years, in the following percentage of the principal of the whole amount of bonds then outstanding, to wit: For the eleventh year, five per cent.; for the twelfth year, six per cent.; for the thirteenth year, seven per cent.; for the fourteenth year, eight per cent.; for the fifteenth year, nine per cent.; for the sixteenth year, ten per cent.; for the seventeenth year, eleven per cent.; for the eighteenth year, thirteen per cent.; for the nineteenth year, fifteen per cent.; and for the twentieth year, a percentage sufficient to pay off said bonds. The secretary of the board must compute and enter in a separate column of the assessment book the respective sums in dollars and cents to be paid as an assessment on the property therein enumerated. When collected the assessment shall be paid into the district treasury, and shall constitute a special fund, to be called the "bond fund of [naming the district] irrigation district."

SEC. 23. The assessment upon real property is a lien against the property assessed from and after the first Monday in March for any year; and such lien is not removed until the assessments are paid or the property sold for the payment thereof.

SEC. 24. On or before the first day of November the secretary must deliver the assessment book to the collector of the district, who shall, within twenty days, publish a notice in a newspaper published in each of the counties comprising the district, if there be lands situated in more than one county in such district, that said assessments are due and payable and will become delinquent at 6 o'clock p. m. on the last Monday of December next thereafter; and that unless paid prior thereto five per cent. will be added to the amount thereof, and also the time and place at which payment of assessments may be made. The notice shall also specify a time and place within each election precinct of the district when and where the collector will attend to receive payment of assessments, and shall be published for fifteen days, and a printed copy of said notice shall be posted for the same time in some public place in each precinct. The collector must attend at the time and place specified in the notice to receive assessments, which must be paid in gold and silver coin. He must mark the date of payment of any assessment in the assessment book opposite the name of the person paying, and give a receipt to such person, specifying the amount of the assessment and the amount paid, with a description of the property assessed. On the thirty-first day of December of each year all unpaid assessments are delinquent, and thereafter the collector must collect thereon, for the use of the district, an addition of five per cent.

SEC. 25. On or before the first day of February, the collector must publish the delinquent list, which must contain the names of the persons and a description of the property delinquent, and the amount of the assessments and costs due opposite each name and description. He must append to and publish with the delinquent list a notice, that unless the assessments delinquent, together with cost and percentage, are paid, the real property upon which such assessments are a lien will be sold at public auction. The publication must be made once a week for three successive weeks in a newspaper published in each of the counties comprised in the district. The publication must designate the time and place of sale. The time of sale must not be less than twenty-one nor more than twenty-eight days from the first publication, and the place must be at some point designated by the collector.

SEC. 26. The collector must collect, in addition to the assessments due on the delinquent list and five per cent. added, fifty cents on each lot, piece, or tract of land separately assessed, one-half of which must go to the district and the other to the collector for preparing the list. On the day fixed for the sale, or some subsequent day to which he may have postponed it, of which he must give notice, the collector, between the hours of ten o'clock a. m. and three o'clock p. m., must commence the sale of the property advertised, commencing at the head of the list and continuing alphabetically, or in the numerical order of the lots or blocks, until completed. He may postpone the day of commencing the sales, or the sale, from day to day, but the sale must be completed within three weeks from the day first fixed.

SEC. 27. The owner or person in possession of any real estate offered for sale for assessments due thereon may designate in writing to the collector, prior to the sale, what portion of the property he wishes sold, if less than the whole; but if the owner or possessor does not, then the collector may designate it, and the person who will take the least quantity of the land, or in case an undivided interest is assessed, then the smallest portion of the interest, and pay the assessments and costs due, including two dollars to the collector for the duplicate certificate of sale, is the purchaser. If the purchaser does not pay the assessments and costs before ten o'clock a. m. the following day, the property, on next sale day, before the regular sale, must be resold for the assessments and costs. After receiving the amount of assessments and costs, the collector must make out in duplicate a certificate, dated on the day of sale, stating (when known) the name of the person assessed, a description of the land sold, the amount paid therefor, that it was sold for assessments, giving the amount and the year of the assessment, and specifying the time when the purchaser will be entitled to a deed. The certificate must be signed by the collector, and one copy delivered to the purchaser, and the other filed in the office of the county recorder of the county in which the land sold is situated.

SEC. 28. The collector, before delivering any certificate, must in a book enter a description of the land sold, corresponding with the description in the certificate, the date of the sale, purchasers' names, and amount paid, regularly number the description on the margin of the book and put a corresponding number on each certificate. Such book must be open to public inspection, without fee, during office hours, when not in actual use. On filing the certificates with such county recorder the lien of the assessments vests with the purchaser, and is only divested [illegible] the payment to him, or to the collector for his use, of the purchase money and two per cent. per month from the day of sale until redemption.

SEC. 29. A redemption of the property sold may be made by the owner, or any party in interest, within twelve months from the date of purchase. Redemption must be made in gold or silver coin, as provided for the collection of State and county taxes, and when made to the collector he must credit the amount paid to the person named in the certificate, and pay it, on demand, to the person or his assignees. In each report the collector makes to the board of directors he must name the person entitled to redemption money, and the amount due to each. On receiving the certificate of sale, the county recorder must file it and make an entry in a book similar to that required of the collector. On the presentation of the receipt of the person named in the certificate, or of the collector for his use, of the total amount of redemption money, the recorder must mark the word "redeemed," the date, and by whom redeemed, on the certificate and on the margin of the book where the entry of the certificate is made. If the property is not redeemed within twelve months from the sale, the collector or his successor in office must make to the purchaser or his assignee a deed of the property, reciting in the deed substantially the matters contained in the certificate, and that no person redeemed the property during the time allowed by law for its redemption. The collector shall receive from the purchaser, for the use of the district, two dollars for making such deed.

SEC. 30. The matter recited in the certificate of sale must be recited in the deed, and such deed duly acknowledged or proved is prima facie evidence that—

First. The property was assessed as required by law.

Second. The property was equalized as required by law.

Third. That the assessments were levied in accordance with law.

Fourth. The assessments were not paid.

Fifth. At a proper time and place the property was sold as prescribed by law and by the proper officer.

Sixth. The property was not redeemed.

Seventh. The person who executed the deed was the proper officer.

Such deed, duly acknowledged or proved, is (except as against actual fraud) conclusive evidence of the regularity of all the proceedings from the assessment by the assessor, inclusive, up to the execution of the deed. The deed conveys to the grantee the absolute title to the lands described therein, free of all incumbrances, except when the land is owned by the United States or this State, in which case it is prima facie evidence of the right of possession.

SEC. 31. The assessment book or delinquent list, or a copy thereof, certified by the collector, showing unpaid assessments against any person or property, is prima facie evidence of the assessment, the property assessed, the delinquency, the amount of assessments due and unpaid, and that all the forms of the law in relation to the assessment and levy of such assessments have been complied with.

SEC. 32. When land is sold for assessments correctly imposed, as the property of a particular person, no misnomer of the owner, or supposed owner, or other mistake relating to the ownership thereof, affects the sale or renders it void or voidable.

SEC. 33. On the first Monday in each month the collector must settle with the secretary of the board for all moneys collected for assessments, and pay the same over to the treasurer; and within six days thereafter he must deliver to and file in the office of the secretary a statement under oath, showing:

First. An account of all his transactions and receipts since his last settlement.

Second. That all money collected by him as collector has been paid.

The collector shall also file in the office of the secretary on said first Monday in each month the receipt of the treasurer for the money so paid.

SEC. 34. Upon the presentation of the coupons due to the treasurer, he shall pay the same from said bond fund. Whenever, after ten years from the issuance of said bonds, said fund shall amount to the sum of ten thousand dollars, the board of directory may direct the treasurer to pay such an amount of said bonds not due as the money in said fund will redeem, at the lowest value at which they may be offered for liquidation, after advertising for at least four weeks in some daily newspaper in each of the cities hereinbefore named, and in any other newspaper which said board may deem advisable, for sealed proposals for the redemption of said bonds. Said proposals shall be opened by the board in open meeting, at a time to be named in the notice, and the lowest bid for said bonds must be accepted: *Provided*, That no bond shall be redeemed at a rate above par. In case the bids are equal the lowest numbered bond shall have the preference. In case none of the holders of said bonds shall desire to have the same redeemed, as herein provided for, said money shall be invested by the treasurer, under the direction of the board, in United States gold-bearing bonds, or the bonds of the State, which shall be kept in said "bond fund," and may be used to redeem said district bonds whenever the holders thereof may desire.

SEC. 35. After adopting a plan of said canal or canals, storage, reservoirs, and works, the board of directors shall give notice, by publication thereof not less than twenty days in one newspaper published in each of the counties composing the district, provided a newspaper is published therein, and in such other newspapers as they may deem advisable, calling for bids for the construction of said work, or of any portion thereof; if less than the whole work is advertised, then the portion so advertised must be particularly described in such notice; said notice shall set forth that plans and specifications can be seen at the office of the board, and that the board will receive sealed proposals therefor, and that the contract will be let to the lowest responsible bidder, stating the time and place for opening said proposals, which at the time and place appointed shall be opened in public, and as soon as convenient thereafter the board shall let said work, either in portions or as a whole, to the lowest responsible bidder, or they may reject any or all bids and readvertise for proposals, or may proceed to construct the work under their own superintendence with the labor of the residents of the district. Contracts for the purchase of material shall be awarded to the lowest responsible bidder. Any person or persons to whom a contract may be awarded shall enter into a bond, with good and sufficient sureties, to be approved by the board, payable to said district for its use, for double the amount of the contract price, conditional for the faithful performance of said contract. The work shall be done under the direction and to the satisfaction of the engineer, and be approved by the board.

SEC. 36. No claim shall be paid by the treasurer until allowed by the board, and only upon a warrant signed by the president, and countersigned by the secretary: *Provided*, That the board may draw from time to time from the construction fund and deposit in the county treasury of the county where the office of the board is situated, any sum in excess of the sum of twenty-five thousand dollars. The county treasurer of said county is hereby authorized and required to receive and receipt for the same, and place the same to the credit of said district, and he shall be responsible upon his official bond for the safe-keeping and disbursement of the same, as in this act provided. He shall pay out the same, or any portion thereof, to the treasurer of the district only, and only upon the order of the board, signed by the president and attested by the secretary. The said county treasurer shall report in writing on the second Monday in each month the amount of money in the county treasury, the amount of receipts for the month preceding, and the amount or amounts paid out; said report shall be verified and filed with the secretary of the board. The district treasurer shall also report to the board, in writing, on the first Monday in each month, the amount of money in the district treasury, the amount of receipts for the month preceding, and the amount and items of expenditures, and said report shall be verified and filed with the secretary of the board.

SEC. 37. The cost and the expense of purchasing and acquiring property and constructing the works and improvements herein provided for, shall be wholly paid out of the construction fund. For the purpose of defraying the expenses of the organization of the district, and of the care, operation, management, repair, and improvement of such portions of said canal and works as are completed and in use, including salaries of officers and employés, the board may either fix rates of tolls and charges, and collect the same from all persons using said canal for irrigation and other purposes, or they may provide for the payment of said expenditures by a levy of assessments therefor, or by both said tolls and assessments; if by the latter method such levy shall be made of the completion and equalization of the assessment roll, and the board shall have the same powers and functions for the purposes of said levy as are now possessed by boards of supervisors in this State. The procedure for the collection of assessments by such levy shall in all respects conform to the provisions of this act relating to the payment of principal and interest of bonds herein provided for.

SEC. 38. The board of directors shall have power to construct the said works across any stream of water, water-course, street, avenue, highway, railway, canal, ditch, or flume which the route of said canal or canals may intersect or cross, in such manner as to afford security for life and property; but said board shall restore the same, when so crossed or intersected, to its former state as near as may be, or in a sufficient manner not to have impaired unnecessarily its usefulness; and every company whose railroad shall be intersected or crossed by said works shall unite with said board in forming said intersections and crossings, and grant the privileges aforesaid; and if such railroad company and said board, or the owners and controllers of the said property, thing, or franchise so to be crossed, can not agree upon the amount to be paid therefor, or the points or the manner of said crossings or intersections, the same shall be ascertained and determined in all respects as is herein provided in respect to the taking of land. The right of way is hereby given, dedicated, and set apart, to locate, construct, and maintain said works over and through any of the lands which are now, or may be, the property of this State; and also there is given, dedicated, and set apart, for the uses and purposes aforesaid, all waters and water-rights belonging to this State within the district.

SEC. 39. The board of directors shall each receive four dollars per day, and mileage at the rate of twenty cents per mile, in attending meetings, and actual and necessary expenses paid while engaged in official business under the order of the board. The board shall fix the compensation to be paid to the other officers named in the act, to be paid out of the treasury of the district: *Provided*, That said board shall, upon the the petition of at least fifty, or a majority of the freeholders within such district therefor, submit to the electors at any general election a schedule of salaries and fees to be paid hereunder. Such petition must be presented to the board twenty days prior to a general election, and the result of such election shall be determined and declared in all respects as other elections are determined and declared under this act.

SEC. 40. No director or any other officer named in this act shall in any manner be interested, directly or indirectly, in any contract awarded or to be awarded by the board, or in the profits to be derived therefrom; and for any violation of this provision, such officer shall be deemed guilty of a misdemeanor, and such conviction shall work a forfeiture of his office, and he shall be punished by a fine not exceeding five hundred dollars, or by imprisonment in the county jail not exceeding six months, or by both such fine and imprisonment.

SEC. 41. The board of directors may, at any time, when in their judgment it may be advisable, call a special election, and submit to the qualified electors of the district the question whether or not a special assessment shall be levied for the purpose of raising money to be applied to any of the purposes provided in this act. Such election must be called upon the notice prescribed, and the same shall be held, and the result thereof determined and declared in all respects in conformity with the provisions of section fifteen of this act. The notice must specify the amount of money proposed to be raised, and the purpose for which it is intended to be used. At such elections the ballots shall contain the words, "Assessment—yes," or "Assessment—no." If two-thirds or more of the votes cast are "Assessment—yes," the board shall, at the time of the annual levy hereunder, levy an assessment sufficient to raise the amount voted. The rate of assessment shall be ascertained by deducting fifteen per cent. for anticipated delinquencies from the aggregate assessed value of the property in the district as it appears on the assessment roll for the current year, and then dividing the sum voted by the remainder of such aggregate assessed value. The assessment so levied shall be computed and entered on the assessment roll by the secretary of the board, and collected at the same time and in the same manner as other assessments provided for herein; and when collected shall be paid into the district treasury for the purposes specified in the notice of such special election.

SEC. 42. The board of directors, or other officers of the district, shall have no power to incur any debt or liability whatever, either by issuing bonds, or otherwise, in excess of the express provisions of this act, and any debt or liability incurred in excess of such express provisions shall be and remain absolutely void.

SEC. 43. In case the volume of water in any stream or river shall not be sufficient to supply the continual wants of the entire country through which it passes, and susceptible of irrigation therefrom, then it shall be the duty of the water commissioners, constituted as hereinafter provided, to apportion, in a just and equitable proportion, a certain amount of said water upon certain or alternate weekly days to different localities, as they may, in their judgment, think best for the interest of all parties concerned, and with due regard to the legal and equitable rights of all. Said water commissioners shall consist of the chairman of the board of directors of each of the districts affected.

SEC. 44. It shall be the duty of the board of directors to keep the water flowing through the ditches under their control to the full capacity of such ditches in times of high water.

SEC. 45. Navigation shall never in anywise be impaired by the operation of this act, nor shall any vested interest in or to any mining water rights or ditches, or in or to any water or water rights, or reservoirs, or dams now used by the owners or possessors thereof in connection with any mining industry, or by persons purchasing or renting the use thereof, or in or to any other property now used directly or indirectly in carrying on or promoting the mining industry, ever be affected by or taken under its provisions save and except that rights of way may be acquired over the same.

SEC. 46. None of the provisions of this act shall be construed as repealing or in anywise modifying the provisions of any other act relating to the subject of irrigation or water commissioners. Nothing herein contained shall be deemed to authorize any person or persons to divert the waters of any river, creek, stream, canal, or ditch from its channel to the detriment of any person or persons having any interest in such river, creek, stream, canal, or ditch, or the waters therein, unless previous compensation be ascertained and paid therefor under the laws of this State authorizing the taking of private property for public uses.

CHAPTER XIX. AN ACT TO AMEND SECTIONS 10, 22, AND 27 OF FOREGOING ACT.

SECTION 1. Section ten of said act is hereby amended to read as follows:

Section 10. The secretary of the board of directors must, as soon as the result is declared, enter in the records of such board a statement of such result, which statement must show—

First. The whole number of votes cast in the district and in each division of the district.

Second. The names of the persons voted for.

Third. The office to fill which each person was voted for.

Fourth. The number of votes given in each precinct to each of such persons.

Fifth. The number of votes given in each division for the office of director, and the number of votes given in the district for the offices of assessor, collector, and treasurer.

The board of directors must declare elected the persons having the highest number of votes given for each office. The secretary must immediately make out and deliver to such person a certificate of election, signed by him and authenticated with the seal of the board. In case of the vacancy in the office of assessor, collector, or treasurer the vacancy shall be filled by appointment of the board of directors. In case of a vacancy in the office of director the vacancy shall be filled by appointment by the board of supervisors of the county where the office of such board of directors is situated from the division in which the vacancy occurred. An officer appointed as above provided shall hold his office until the next regular election for said district, and until his successor is elected and qualified.

SEC. 2. Section twenty-two of said act is hereby amended to read as follows:

Section 22. The board of directors shall then levy an assessment sufficient to raise the annual interest on the outstanding bonds, and at the expiration of ten years after the issuing of bonds by the board must increase said assessment for the ensuing ten years in the following percentage of the principal of the whole amount of bonds then outstanding, to wit: For the eleventh year, five per cent.; for the twelfth year six per cent.; for the thirteenth year, seven per cent.; for the fourteenth year, eight per cent.; for the fifteenth year, nine per cent.; for the sixteenth year, ten per cent.; for the seventeenth year, eleven per cent.; for the eighteenth year, thirteen per cent.; for the nineteenth year, fifteen per cent.; and for the twentieth year, a percentage sufficient to pay off said bonds. The secretary of the board must compute and enter in a separate column of the assessment book the respective sums in dollars and cents to be paid as an assessment on the property therein enumerated. When collected the assessment shall be paid into the district treasury, and shall constitute a special fund, to be called the "bond fund of ——— irrigation district." In case of the neglect or refusal of the board of directors to cause such assessment and levy to be made as in this act provided, then the assessment of property made by the county assessor and the State board of equalization shall be adopted and shall be the basis of assessments for the district, and the board of supervisors of the county in which the office of the board of directors is situated shall cause an assessment roll for said district to be prepared, and shall make the levy required by this act in the same manner and with like effect as if the same had been made by said board of directors, and all expenses incident thereto shall be borne by such district. In case of the neglect or refusal of the collector or treasurer of the district to perform the duties imposed by law, then the tax collector and treasurer of the county in which the office of the board of directors is situated must, respectively, perform such duties, and shall be accountable therefor upon their official bonds as in other cases.

SEC. 3. Section twenty-seven of said act is hereby amended to read as follows:

Section 27. The owner or person in possession of any real estate offered for sale for assessments due thereon may designate in writing to the collector, prior to the sale, what portion of the property he wishes sold, if less than the whole; but if the owner or possessor does not, then the collector may designate it, and the person who will take the least quantity of the land, or in case an undivided interest is assessed then the smallest portion of the interest, and pay the assessments and costs due, including two dollars to the collector for the duplicate certificate of sale, is the purchaser. If the purchaser does not pay the assessments and costs before ten o'clock a. m. the following day the property on the next sale day must be resold for the assessments and costs. But in case there is no purchaser in good faith for the same on the first day that the property is offered for sale, then, when the property is offered thereafter for sale and there is no purchaser in good faith for the same, the whole amount of the property assessed shall be struck off to the irrigation district within which such lands are situated as the purchaser, and the duplicate certificate delivered to the treasurer of the district and filed by him in his office. No charge shall be made for the duplicate certificate where the district is the purchaser, and, in such case, the collector shall make an entry, "sold to the district," and he shall be credited with the amount thereof in his settlement. An irrigation district, as a purchaser at such sale, shall be entitled to the same rights as a private purchaser, and the title so acquired by the district, subject to the right of redemption herein provided, may be conveyed by deed, executed and acknowledged by the president and secretary of said board: *Provided*, That authority to so convey must be conferred by resolution of the board, entered on its minutes, fixing the price at which such sale may be made, and such conveyance shall not be made for a less sum than the reasonable market value of such property. After receiving the amount of assessments and costs the collector must make out in duplicate a certificate, dated on the day of sale, stating (when known) the names of the person assessed, a description of the land sold, the amount paid therefor, that it was sold for assessments, giving the amount and year of the assessment, and specifying the time when the purchaser will be entitled to a deed. The certificate must be signed by the collector, and one copy delivered to the purchaser and the other filed in the office of the county recorder of the county in which the land is situated.

CHAPTER XX. AN ACT AMENDATORY OF AND SUPPLEMENTAL.

SECTION 1. The boundaries of any irrigation district now or hereafter organized under the provisions of an act, entitled "An act to provide for the organization and government of irrigation districts, and to provide for the acquisition of water and other property, and for the distribution of water thereby for irrigation purposes," approved March 7, 1887, may be changed in the manner herein prescribed; but such change of the boundaries of the district shall not impair or affect its organization, or its rights in or to property, or any of its rights or privileges of whatsoever kind or nature; nor shall it affect, impair, or discharge any contract, obligation, lien, or charge for or upon which it was or might become liable or chargeable had such change of its boundaries not been made.

SEC. 2. The holder or holders of title, or evidence of title, representing one-half or more of any body of lands adjacent to the boundary of an irrigation district, which are contiguous, and which, taken together, constitute one tract of land, may file with the board of directors of said district a petition in writing, praying that the boundaries of said district may be so changed as to include therein said lands. The petition shall describe the boundaries of said parcel or tract of land, and shall also described the boundaries of the several parcels owned by the petitioners, if the petitioners be the owners, respectively, of distinct parcels, but such descriptions need not be more particular than they are required to be when such lands are entered by the county assessor in the assessment book. Such petition must contain the assent of the petitioners to the inclusion within said district of the parcels or tracts of land described in the petition, and of which said petition alleges they are respectively the owners; and it must be acknowledged in the same manner that conveyances of land are required to be acknowledged.

SEC. 3. The secretary of the board of directors shall cause a notice of the filing of such petition to be given and published in the same manner and for the same time that notices of special elections for the issue of bonds are required by said act to be published. The notice shall state the filing of such petition and the names of the petitioners, a description of the lands mentioned in said petition and the prayers of said petition; and it shall notify all persons interested in or that may be affected by such change of the boundaries of the district to appear at the office of said board at a time named in said notice and show cause in writing, if any they have, why the change in the boundaries of said district, as proposed in said petition, should not be made. The time to be specified in the notice at which they shall be required to show cause shall be the regular meeting of the board next after the expiration of the time for the publication of the notice. The petitioners shall advance to the secretary sufficient money to pay the estimated costs of all proceedings under this act.

SEC. 4. The board of directors, at the time and place mentioned in the said notice, or at such other time or times to which the hearing of said petition may be adjourned, shall proceed to hear the petition, and all the objections thereto, presented in writing by any person showing cause as aforesaid why said proposed change of the boundaries of the district should not be made. The failure by any person interested in said district, or in the matter of the proposed change of its boundaries, to show cause, in writing, as aforesaid, shall be deemed and taken as an assent on his part to a change of the boundaries of the district as prayed for in said petition, or to such a change thereof as will include a part of said lands. And the filing of such petition with said board, as aforesaid, shall be deemed and taken as an assent on the part of each and all of such petitioners to such a change of said boundaries that they may include the whole or any portion of the lands described in said petition.

SEC. 5. The board of directors, to whom such petition is presented, may require as a condition precedent to the granting of the same, that the petitioners shall severally pay to such district such respective sums, as nearly as the same can be estimated (the several amounts to be determined by the board), as said petitioners or their grantors would have been required to pay to such district as assessments had such lands been included in such district at the time the same was originally formed.

SEC. 6. The board of directors, if they deem it not for the best interests of the district that a change of its boundaries be so made as to include therein the lands mentioned in the petition, shall order that the petition be rejected. But if they deem it for the best interests of the district that the boundaries of said district be changed, and if no person interested in said district or the proposed change of its boundaries shows cause in writing why the proposed change should not be made, or if, having shown cause, withdraws the same, the board may order that the boundaries of the district be so changed as to include therein the lands mentioned in said petition, or some part thereof. The order shall describe the boundaries as changed, and shall also describe the entire boundaries of the district as they will be after the change thereof as aforesaid is made; and for that purpose the board may cause a survey to be made of such portions of such boundary as is deemed necessary.

SEC. 7. If any person interested in said district, or the proposed change of its boundaries, shall show cause, as aforesaid, why such boundaries should not be changed, and shall not withdraw the same, and if the board of directors deem it for the best interest of the district that the boundaries thereof be so changed as to include therein the lands mentioned in the petition, or some part thereof, the board shall adopt a resolution to that effect. The resolution shall describe the exterior boundaries of the lands which the board are of the opinion should be included within the boundaries of the district when changed.

SEC. 8. Upon the adoption of the resolution mentioned in the last preceding section, the board shall order that an election be held within said district, to determine whether the boundaries of the district shall be changed as mentioned in said resolution; and shall fix the time at which such election shall be held, and cause notice thereof to be given and published. Such notice shall be given and published, and such election shall be held and conducted, the returns thereof shall be made and canvassed, and the result of the election ascertained and declared, and all things pertaining thereto conducted in the manner prescribed by said act in case of a special election to determine whether bonds of an irrigation district shall be issued. The ballots cast at said election shall contain the words "For change of boundary," or "Against change of boundary," or words equivalent thereto. The notice of election shall describe the proposed change of the boundaries in such manner and terms that it can readily be traced.

SEC. 9. If at such election a majority of all the votes cast at said election shall be against such change of the boundaries of the district, the board shall order that said petition be denied, and shall proceed no further in that matter. But if a majority of such votes be in favor of such change of the boundaries of the district, the board shall thereupon order that the boundaries be changed in accordance with said resolution adopted by the board. The said order shall describe the entire boundaries of said district, and for that purpose the board may cause a survey of such portions thereof to be made as the board may deem necessary.

SEC. 10. Upon a change of the boundaries of a district being made, a copy of the order of the board of directors ordering such change, certified by the president and secretary of the board, shall be filed for record in the recorder's office of each county within which are situated any of the lands of the district, and thereupon the district shall be and remain an irrigation district, as fully and to every intent and purpose as if the lands which are included in the district by the change of the boundaries, as aforesaid, had been included therein at the original organization of the district.

SEC. 11. Upon the filing of the copies of the order, as in the last preceding section mentioned, the secretary shall record in the minutes of the board the petition aforesaid; and the said minutes, or a certified copy thereof, shall be admissible in evidence with the same effect as the petition.

SEC. 12. A guardian, an executor, or an administrator of an estate, who is appointed as such under the laws of this State, and who, as such guardian, executor, or administrator, is entitled to the possession of the lands belonging to the estate which he represents, may, on behalf of his ward or the estate which he represents, upon being thereunto authorized by the proper court, sign and acknowledge the petition in this act mentioned, and may show cause, as in this act mentioned, why the boundaries of the district should not be changed.

SEC. 13. In case of the inclusion of any land within any district by proceedings under this act, the board of directors must, at least thirty days prior to the next succeeding general election, make an order re-dividing such district into five divisions, as nearly equal in size as may be practicable, which shall be numbered First, Second, Third, Fourth, and Fifth, and one director shall thereafter be elected by each division. For the purposes of elections the board of directors must establish a convenient number of election precincts in said districts, and define the boundaries thereof, which said precincts may be changed from time to time, as the board may deem necessary.

CHAPTER XXI. AN ACT AMENDATORY OF AND SUPPLEMENTAL.

SECTION 1. The boundaries of any irrigation district, now or hereafter organized under the provisions of an act entitled "An act to provide for the organization and government of irrigation districts, and to provide for the acquisition of water and other property, and for the distribution of water thereby for irrigation purposes," approved March seventh, one thousand eight hundred and eighty-seven, may be changed, and tracts of land which were included within the boundaries of such district, at or after its organization under the provisions of said act, may be excluded therefrom, in the manner herein prescribed; but neither such change of the boundaries of the district, nor such exclusion of lands from the district, shall impair or affect its organization, or its right in or to property, or any of its rights or privileges, of whatever kind or nature; nor shall it affect, impair, or discharge any contract, obligation, lien, or charge for or upon which it was or might become liable or chargeable had such change of its boundaries not been made, or had not any land been excluded from the district.

SEC. 2. The owner or owners in fee of one or more tracts of land which constitute a portion of an irrigation district, may file with the board of directors of the district a petition, praying that such tracts and any other tracts contiguous thereto may be excluded and taken from said district. The petition shall describe the boundaries of the land which the petitioners desire to have excluded from the district, and also the lands of each of such petitioners, which are included within such boundaries; but the description of such lands need not be more particular or certain than is required when the lands are entered in the assessment book by the county assessor. Such petition must be acknowledged in the same manner and form as is required in case of a conveyance of land, and the acknowledgment shall have the same force and effect as evidence as the acknowledgment of such conveyance.

SEC. 3. The secretary of the board of directors shall cause a notice of the filing of such petition to be published for at least two weeks in some newspaper published in the county where the office of the board of directors is situated, and if any portion of such territory to be excluded lie within another county or counties, then said notice shall be so published in a newspaper published within each of said counties; or if no newspaper be published therein, then by posting such notice for the same time in at least three public places in said district, and, in case of the posting of said notices, one of said notices must be so posted on the lands proposed to be excluded. The notice shall state the filing of such petition; the names of the petitioners; a description of the lands mentioned in said petition, and the prayer of said petition; and it shall notify all persons interested in or that may be affected by such change of the boundaries of the district, to appear at the office of said board at a time named in said notice, and show cause in writing, if any they have, why the change of the boundaries of said district, as proposed in said petition, should not be made. The time to be specified in the notice at which they shall be required to show cause shall be the regular meeting of the board next after the expiration of the time for the publication of the notice.

SEC. 4. The board of directors, at the time and place mentioned in the notice, or at the time or times to which the hearing of said petition may be adjourned, shall proceed to hear the petition and all objections thereto presented in writing by any person showing cause as aforesaid why the prayer of said petition should not be granted. The failure of any person interested in said district to show cause in writing why the tract or tracts of land mentioned in said petition should not be excluded from said district, shall be deemed and taken as an assent by him to the exclusion of such tract or tracts of land, or any part thereof, from said district; and the filing of such petition with such board, as aforesaid, shall be deemed and taken as an assent by each and all of such petitioners to the exclusion from such district of the lands mentioned in the petition, or any part thereof.

SEC. 5. The board of directors, if they deem it not for the best interest of the district that the lands mentioned in the petition, or some portion thereof, should be excluded from said district, shall order that said petition be denied; but if they deem it for the best interests of the district that the lands mentioned in the petition, or some portion thereof, be excluded from the district, and if no person interested in the district show cause in writing why the said lands, or some portion thereof, should not be excluded from the district, or if, having shown cause, withdraws the same, and also, if there be no outstanding bonds of the district, then the board may order that the lands mentioned in the petition, or some defined portion thereof, be excluded from the district.

SEC. 6. If there be outstanding bonds of the district, then the board may adopt a resolution to the effect that the board deems it to the best interest of the district that the lands mentioned in the petition, or some portion thereof, should be excluded from the district. The resolution shall describe such lands so that the boundaries thereof can readily be traced. The holders of such outstanding bonds may give their assent in writing to the effect that they severally consent that the board may make an order by which the lands mentioned in the resolution may be excluded from the district. The assent must be acknowledged by the several holders of such bonds in the same manner and form as is required in case of a conveyance of land, and the acknowledgment shall have the same force and effect as evidence as the acknowledgment of such conveyance. The assent shall be filed with the board and must be recorded in the minutes of the board; and said minutes, or a certified copy thereof, shall be admissible in evidence with the same effect as the said assent; but if such assent be not filed, the board shall deny and dismiss said petition.

SEC. 7. If the assent aforesaid of the holders of said bonds be filed and entered of record as aforesaid, and if there be objections presented by any person showing cause as aforesaid, which have not been withdrawn, then the board may order an election to be held in said district to determine whether an order shall be made excluding said land from the district as mentioned in said resolution. The notice of such election shall describe the boundary of all lands which it is proposed to exclude, and such notice shall be published for at least two weeks prior to such election in a newspaper published within the county where the office of the board of directors is situated; and if any portion of such territory to be excluded lie within another county or counties, then said notice shall be so published in a newspaper published within each of such counties. Such notice shall require the electors to cast ballots which shall contain the words "For Exclusion," or "Against Exclusion," or words equivalent thereto. Such election shall be conducted in accordance with the general election laws of the State: *Provided*, That no particular form of ballot shall be required.

SEC. 8. If at such election a majority of all the votes cast shall be against the exclusion of said lands from the district, the board shall deny and dismiss said petition and proceed no further in said matter; but if a majority of such votes be in favor of the exclusion of said lands from the district the board shall thereupon order that the said lands mentioned in said resolution be excluded from the district. The said order shall describe the boundaries of the district should the exclusion of the said lands from said district change the boundaries of the district, and for that purpose the board may cause a survey to be made of such portions of the boundaries as the board may deem necessary.

SEC. 9. Upon the entry in the minutes of the board of any of the orders hereinbefore mentioned, a copy thereof, certified by the president and the secretary of the board, shall be filed for record in the recorder's office of each county within which are situated any of the lands of the district, and thereupon said district shall be and remain an irrigation district as fully, to every intent and purpose, as it would be had no change been made in the boundaries of the district, or had the lands excluded therefrom never constituted a portion of the district.

SEC. 10. If the lands excluded from any district under this act shall embrace the greater portion of any division or divisions of such district, then the office of director for such division or divisions shall become and be vacant at the expiration of ten days from the final order of the board, under section eight of this act excluding said lands, and such vacancies shall be filled by appointment by the board of supervisors of the county where the office of such board is situated from the district at large. A director appointed as above provided shall hold his office until the next regular election for said district, and until his successor is elected and qualified.

SEC. 11. At least thirty days before the next general election of such district the board of directors thereof shall make an order dividing said district into five divisions, as nearly equal in size as may be practicable, which shall be numbered first, second, third, fourth, and fifth, and one director shall be elected by each division. For the purposes of elections in such district the said board of directors must establish a convenient number of election precincts, and define the boundaries thereof, which said precincts may be changed from time to time, as the board of directors may deem necessary.

SEC. 12. A guardian, an executor, or an administrator of an estate, who is appointed as such under the laws of this State, and who, as such guardian, executor, or administrator, is entitled to the possession of the lands belonging to the estate which he represents, may, on behalf of his ward or the estate which he represents, upon being thereto properly authorized by the proper court, sign and acknowledge the petition in this act mentioned, and may show cause, as in this act provided, why the boundaries of the district should not be changed.

SEC. 13. In case of the exclusion of any lands under the provisions of this act, there shall be refunded to any and all persons who have paid any assessment or assessments to such district, or any lands so excluded, any sum or sums so paid. Such payments shall be made in the same manner as other claims against such district, and from such fund or funds as the board of directors may designate.

CHAPTER CLXXVIII. AN ACT SUPPLEMENTAL.

SECTION 1. The board of directors of an irrigation district now or hereafter organized under the provisions of the act entitled "An act to provide for the organization and government of irrigation districts, and to provide for the acquisition of water and other property, and for the distribution of water thereby for irrigation purposes," approved March seventh, eighteen hundred and eighty-seven, may commence a special proceeding, in and by which the proceedings of said board and of said district providing for and authorizing the issue and sale of the bonds of said district, whether said bonds or any of them have or have not then been sold, may be judicially examined, approved, and confirmed.

SEC. 2. The board of directors of the irrigation district shall file in the superior court of the county in which the lands of the district or some portion thereof are situated a petition praying, in effect, that the proceedings aforesaid may be examined, approved, and confirmed by the court. The petition shall state the facts showing the proceedings had for the issue and sale of said bonds, and shall state generally that the irrigation district was duly organized, and that the first board of directors was duly elected; but the petition need not state the facts showing such organization of the district, or the election of said first board of directors.

SEC. 3. The court shall fix the time for the hearing of said petition, and shall order the clerk of the court to give and publish a notice of the filing of said petition. The notice shall be given and published in the same manner and for the same length of time that the notice of a special election provided for by said act to determine whether the bonds of said district shall be issued is required to be given and published. The notice shall state the time and place fixed for the hearing of the petition and the prayer of the petition, and that any person interested in the organization of said district, or in the proceedings for the issue or sale of said bonds, may, on or before the day fixed for the hearing of said petition, demur to or answer said petition. The petition may be referred to and described in said notice as the petition of the board of directors of —— irrigation district (giving its name), praying that the proceedings for the issue and sale of the bonds of said district may be examined, approved, and confirmed by said court.

SEC. 4. Any person interested in said district, or in the issue or sale of said bonds, may demur to or answer said petition. The provisions of the code of civil procedure respecting the demurrer and the answer to a verified complaint shall be applicable to a demurrer and answer to said petition. The persons so demurring to or answering said petition shall be the defendants to said special proceeding, and the board of directors shall be the plaintiff. Every material statement of the petition not specifically controverted by the answer must, for the purpose of said special proceeding, be taken as true, and each person failing to answer the petition shall be deemed to admit as true all the material statements of the petition. The rules of pleading and practice provided by the code of civil procedure which are not inconsistent with the provisions of this act are applicable to the special proceeding herein provided for. A motion for a new trial must be made upon the minutes of the court. The order granting a new trial must specify the issues to be re-examined on such new trial, and the findings of the court upon the other issues shall not be affected by such order granting a new trial.

SEC. 5. Upon the hearing of such special proceeding the court shall have power and jurisdiction to examine and determine the legality and validity of, and approve and confirm, each and all of the proceedings for the organization of said district under the provisions of the said act, from and including the petition for the organization of the district, and all other proceedings which may affect the legality or validity of said bonds, and the order for the sale, and the sale thereof. The court, in inquiring into the regularity, legality, or correctness of said proceedings, must disregard any error, irregularity, or omission which does not affect the substantial rights of the parties to said special proceeding; and it may approve and confirm such proceedings in part, and disapprove and declare illegal or invalid other and subsequent parts of the proceedings. The court shall find and determine whether the notice of the filing of said petition has been duly given and published for the time and in the manner in this act prescribed. The costs of the special proceedings may be allowed and apportioned between all the parties, in the discretion of the court.

SEC. 6. An appeal from an order granting or refusing a new trial, or from the judgment, must be taken by the party aggrieved within ten days after the entry of said order or said judgment.*

COLORADO IRRIGATION LAWS.

All persons who claim, own, or hold a possessory right or title to any land or parcel of land lying within the boundary of the State of Colorado, as defined in the constitution of said State, when those claims are on the bank, margin, or neighborhood of any stream of water, creek, or river, shall be entitled to the use of the water of said stream, creek, or river, for the purpose of irrigation and making said claims available to the full extent of the soil for agricultural purposes. General Statutes, 1711, (1861).

Nothing in this chapter contained shall be so construed as to impair the prior vested rights of any mill or ditch owner or other person to use the water of any such water-course.

Under the provisions of this act [*eminent domain*] private property may be taken for private use, for private ways of necessity, for reservoirs, drains, flumes, or ditches on or across the land of others for agricultural, mining, milling, domestic, or sanitary purposes. (Session Laws of 1885, pp. 201, 202, 1729.)

Every person, association, or corporation hereafter constructing or enlarging any ditch, canal, or feeder for any reservoir, for irrigation, and taking water directly from any natural stream, and of a carrying capacity of one cubic foot per second of time as so constructed or enlarged, shall within ninety days after the commencement of such construction or enlargement file and cause to be recorded in the office of the county clerk of the county in which such ditch, canal, or feeder may be situated, or if such canal, ditch, or feeder be situated in any water district, in the office of the county clerk of such [each] county in which such water district may extend, a sworn statement in writing, showing the name of such ditch, canal, or of the reservoir supplied by such feeder, the point at which the head-gate thereof is situated (if it be a new construction), the size of the ditch, canal, or feeder in width and depth and the carrying capacity thereof in cubic feet per second, the description of the line thereof and the time when the work was commenced, and the name or names of the owner or owners thereof, together with a map showing the route thereof, the legal subdivisions of the land, if on surveyed lands with proper corners and distances, and in case of an enlargement the depth and width also the carrying capacity of the ditch enlarged, with the width and depth of the ditch, canal, or feeder as enlarged, and the increased carrying capacity of the same thereby occasioned, and the time when such enlargement was commenced, and no priority of right for any purpose shall attach to any such construction or enlargement until record is made. (Sec. 2, p. 162, Acts 1881, 1720.)

This act shall apply to and affect only ditches, canals, or feeders used for carrying water for the purposes of irrigation and for no other purposes whatever. (Sec. 3, p. 162, Acts 1881, 1721.)

Any company formed under the provisions of this (corporations) act, for the purpose of constructing any ditch, flume, * * * shall, within ninety days from the date of their certificate, commence work on such ditch, flume * * * line as shall be named in the certificate, and shall prosecute the work with due diligence until the same is completed, and the time of completion of any such ditch * * * line shall not be extended beyond a period of two years from the time work was commenced as aforesaid; and any company failing to commence work within ninety days from the date of the certificate, or failing to complete the same within two years from the time of commencement as aforesaid, shall forfeit all right to the water so claimed, and the same shall be subject to be claimed by any other company; the time for the completion of any flume constructed under the provisions of this act shall not be extended beyond a period of four years: *Provided*, This section shall not apply to any ditch or flume * * * constructed through and upon any grounds owned by the corporation: *And provided further*, That any company formed under the provisions of this act to construct a ditch for domestic, agricultural, irrigating * * * purposes, or any or either thereof, shall have three years from the time of commencing work thereon within which to complete the same, but no longer. (Sec. 296 (106), pp. 179, 80, G. L., 314.)

All persons on the margin, brink, neighborhood, or precinct of any stream of water shall have the right and power to place upon the bank of said stream a wheel or other machine for the purpose of raising water to the level required for the purpose of irrigation. (Sec. 8, pp. 68, 69, Acts 1861; sec. 6, p. 364, R. S.; sec. 1377 (6) p. 516, G. L., 1727.)

All persons who shall have enjoyed the use of the water in any natural stream, for the irrigation of any meadow land, by the natural overflow or operation of the water

---

*** All these acts took effect from and after their passage.**

of such stream, shall, in case the diminishing of the water supplied from such stream from any cause prevents such irrigation therefrom in as ample a manner as formerly, have right to construct a ditch for the irrigation of such meadow and to take water from such stream therefor, and his, her or their right to water through such ditch shall have the same priority as though such ditch had been constructed at the time he, she or they first occupied and used such land as meadow ground. (Sec. 37, p. 106, Acts 1879, 1723.)

In case the channel of any natural stream shall become so cut out, lowered, turned aside or otherwise changed from any cause as to prevent any ditch, canal, or feeder of any reservoir from receiving the proper inflow of water to which it may be entitled from such natural stream, the owner or owners of such ditch, canal or feeder shall have the right to extend the head of such ditch, canal or feeder to such distance up the stream which supplies the same as may be necessary for securing a sufficient flow of water into the same, and for that purpose shall have the same right to maintain proceedings for condemnation of right of way for such extension as in case of constructing a new ditch, and the priority of right to take water from such stream through such ditch, canal or feeder, as to any such ditch, canal, or feeder, shall remain unaffected in any respect by reason of such extension: *Provided, however,* That no such extension shall interfere with the complete use or enjoyment of any other ditch, canal or feeder. (Sec. 1, pp. 161, 162, Acts 1881, 1719.)

For the purpose of hearing, adjudicating, and settling all questions concerning the priority of appropriation of water between ditch companies and other owners of ditches drawing water for irrigation purposes from the same stream or its tributaries within the same water district, and all other questions of law and questions of right growing out of or in any way involved or connected therewith, jurisdiction is hereby vested exclusively in the district court of the proper county; but when any water district shall extend into two or more counties the district court of the county in which the first regular term after the 1st day of December in each year shall soonest occur, according to the law then in force, shall be the proper court in which the proceedings for said purpose, as hereinafter provided for, shall be commenced; but where said proceedings shall be once commenced by the entry of an order appointing a referee in the manner and for the purpose hereinafter in this act provided, such court shall thereafter retain exclusive jurisdiction of the whole subject until final adjudication thereof is had, notwithstanding any law to the contrary now in force. (Sec. 19, pp. 99, 100, Acts 1879, 1762.)

In order that all parties may be protected in their lawful rights to the use of water for irrigation, every person, association, or corporation owning or claiming any interest in any ditch, canal, or reservoir, within any water district, shall, on or before the 1st day of June, A. D. 1881, file with the clerk of the district court having jurisdiction of priority of right to the use of water for irrigation in such water district a statement of claim, under oath, entitled of the proper court, and in the matter of priorities of water rights in district number * * *, as the case may be, which statement shall contain the name or names, together with the post-office address of the claimant or claimants claiming ownership, as aforesaid, of any such ditch, canal, or reservoir, the name thereof (if any), and, if without a name, the owner or owners shall choose and adopt a name, to be therein stated, by which such ditch, canal, or reservoir shall thereafter be known, the description of such ditch, canal, or reservoir, as to location of head-gate, general course of ditch, the name of the natural stream from which such ditch, canal, or reservoir draws its supply of water, the length, width, depth, and grade thereof, as near as may be, the time, fixing a day, month, and year as the date of the appropriation of water by original construction, also by any enlargement or extension, if any such thereof may have been made, and the amount of water claimed by or under such construction, enlargement, or extension, and the present capacity of the ditch, canal, or feeder of reservoir, and also the number of acres of land lying under and being or proposed to be irrigated by water from such ditch, canal, or reservoir. Said statement shall be signed by the proper party or parties. (Sec. 1, pp. 142, 143, Acts 1881, 1763.)

The secretary of state shall, without delay, after the passage of this act, cause a certified copy of the foregoing section, giving the date of the approval of this act, to be published in one of the public newspapers published in such county in which part or portion of any water district is or shall be established by law at the time of such publication; and said section 1 shall be published, as aforesaid, once in each and every week continuously in said paper until said 1st day of June, 1881, and in case in the mean time any one of said papers shall cease to be published, then such publication shall be made in some other paper in same county (if any), and on conclusion of such publication such publisher of such paper shall deliver to the secretary of state his sworn certificate of publication in duplicate, showing that such publication has been made in his paper in compliance with the preceding section hereof, and stating the first and last day of such publication; and he shall thereupon be entitled to receive from the secretary of state a certificate of the amount due him for such publication, on presentation of which to the auditor of state he shall draw his warrant for the amount in favor of the holder on the State treasurer, who shall pay the same according to law. (Sec. 2, pp, 143, 144, Acts 1881, 1764.)

When at any time after the 1st day of June, A. D. 1881, any one or more persons, associations, or corporations, interested as owners of any ditch, canal, or reservoir in any water district shall present to the district court of any county having jurisdiction or priority of rights to the use of water for irrigation in such water district according to the provisions of (sec. 19, G. S., 1762) an act entitled "An act to regulate the use of water for irrigation and providing for settling the priority of rights thereto, and for payment of the expenses thereof, and for payment of all costs and expenses incident to said regulation of use, or to the judge thereof in vacation, a motion, petition, or application in writing, moving or praying said court to proceed to an adjudication of the priorities of rights to use of water for irrigation between the several ditches, canals, and reservoirs in such district, the court, or judge thereof in vacation, shall, without unnecessary delay, in case he shall deem it practicable to proceed in open court, as prayed for, by an order to be entered of record upon such motion, petition or application, appoint a day in some regular or special term of said court for commencing to hear and take evidence in such adjudication, at which time it shall be the duty of the court to proceed to hear all evidence which may be offered by or on behalf of any person, association, or corporation interested in any ditch, canal, or reservoir in such district, either as owner or consumer of water therefrom, in support of or against any claim or claims of priority of appropriation of water made by means of any ditch, canal, or reservoir, or by any enlargement or extension thereof in such district, and consider all such evidence, together with any and all evidence, if any, which may have been heretofore offered and taken in such district in the same matter by any referee heretofore appointed under the provisions of said act above herein mentioned, and also the arguments of parties or their counsel, and shall ascertain and find from such evidence, as near as may be, the date of the commencement of such ditch, canal, or reservoir, together with the original size and carrying capacity thereof as originally constructed, the time of the commencement of each enlargement or extension thereof, if any, with the increased capacity thereby occasioned, the time spent severally in such construction and enlargement, or extension and re-enlargement, if any, the diligence with which the work was in each case prosecuted, the nature of the work as to difficulty of construction, and all such other facts as may tend to show the compliance with the law, in acquiring the priority of right claimed for each such ditch, canal, or reservoir, and determine the matters put in evidence, and make and cause to be entered a decree determining and establishing the several priorities of right, by appropriation of water, of the several ditches, canals, and reservoir [reservoirs] in such water district, concerning which testimony shall have been offered, each according to the time of its said construction and enlargement or enlargements or extensions, with the amount of water which shall be held to have been appropriated by such construction and enlargements or extensions, describing such amount by cubic feet per second of time, if the evidence shall show sufficient data to ascertain such cubic feet, and if not, by width, depth, and grade, and such other description as will most certainly and conveniently show the amount of water intended as the capacity of such ditch, canal, or reservoir, in such decree. Said court shall further order that each and every party interested or claiming any such ditch, canal, or reservoir shall receive from the clerk, on payment of a reasonable fee therefor, to be fixed by the court, a certificate under seal of the court showing the date or dates and amount or amounts of appropriations adjudged in favor of such ditch, canal, or reservoir under and by virtue of the construction, extension, and enlargements thereof severally; also specifying the number of said ditch and of each priority to which the same may be entitled by reason of such construction, extension, and enlargements. (Sec. 4, pp. 144-5-6, Acts 1881.)

The holder of such certificate shall exhibit the same to the water commissioner of the district when he commences the exercise of his duties, and as such water commissioner shall keep a book in which shall be entered a brief statement of the contents of such certificate, and which shall be delivered to his successor, and said certificate, or statement thereof in his book, shall be the warrant of authority to said water commissioner for regulating the flow of water in relation to such ditch, canal, or reservoir. Said certificate shall be recorded, at the same rates of charges as in cases of deeds of conveyance, in the records of each county into which the ditch, canal, or reservoir to which such certificate relates shall extend; and said certificate or said record thereof, or a duly certified copy of such record, shall be prima facie evidence of so much of said decree as shall be recited therein in any suit or proceeding in which the same may be relevant. (Sec. 5, pp. 146—7, Acts 1881, 1767.)

Notice shall be given by the clerk of said court of the time so appointed by publishing the same in one public newspaper in such county into which such water district may extend, which notice shall be so published in such paper once in each week until four successive weekly publications shall have been made, the last of which shall be on a day previous to the day appointed as aforesaid. Said notice shall contain a copy of said order, and shall notify all persons, associations, and corporations interested as owners in any ditch, canal, or reservoir in such water district to appear at said court at the time so appointed and file a statement of claim under oath, in case no statement has been before filed by him, her, or them, showing the ditch, canal, or reservoir, or two or more such, in which he, she, or they claim an interest, together with the names of all the owners thereof, which statement may be made by any one of the owners of such ditch, canal, or reservoir for and in behalf of all; and also that all persons interested as owners or consumers may then and there present his, her, or their proofs for or against any priority of right of water by appropriation sought to be shown by any party by or through any such ditch, canal, or reservoir (either as owner or consumer of water drawn therefrom). Ten printed copies of said notice shall also be posted in ten public places in such water district not less than twenty days before the day so appointed, which copies shall be so posted by the party or parties moving the adjudication. (Sec. 6, p. 147, Acts 1881, 1768.)

Proof of the proper publication of said notice or notices in said public papers shall consist in such case of the sworn certificate of the publisher of such newspaper, showing the publication to have been made in accordance with the provisions of section 3, of this act, which certificate shall be procured by the party or parties moving the adjudication at his or their expense, and on said certificate being filed the clerk shall enter the amount of the printer's fee therefor as costs advanced by the party procuring the same, which sum shall be counted to his, her, or their credit in distribution of cost. Proof of the posting of said printed copies shall be made by the affidavit of some credible person, certified to be such by the clerk or other officer administering the oath, showing when, where, and how said copies were posted. (Sec. 7, pp. 147-8, Acts 1881, 1769.)

The party or parties moving such adjudication shall cause a printed or written copy of the notice aforesaid, published as aforesaid, to be served on every person, association, or corporation shown by the statement of claim on file, as provided in section 1 hereof, which service shall be made within ten days from the time of the first publication by the clerk, by any credible person certified by said clerk or referee to be such, by delivering such copy as aforesaid to the person to be served, if such person by due diligence can be found in the county of his residence. If such person can not be found, as aforesaid, then by leaving such copy at his or her usual place of residence, if he or she have such residence, in charge of some person of the age of fourteen years or over there residing; and on any corporation by delivering the copy to the president, or vice president, or secretary, or treasurer thereof, or the manager or superintendent in charge of their ditch, canal, or reservoir, or authorized agent or attorney, or by leaving such copy at the office or usual place of business of such corporation, and the proof of such service shall be made by affidavit of the person or persons serving said copies, showing when and how such service has been made on such party. In case of parties not served in any manner as aforesaid the clerk shall deposit in the post-office, duly inclosed in an envelope with the proper postage stamp thereon, a copy directed to the address of such party, shown in the statement of claim aforesaid, filed by him or her under section 1 hereof. (Sec. 8, pp. 148-9, Acts 1881, 1770.)

The court, in making such decree, as aforesaid, shall number the several ditches and canals in the water district concerning which adjudication is made in consecutive order, according to priority of appropriation of water thereby made by the original construction thereof, as near as may be, having reference to the date of each decree as rendered, and shall also number the reservoirs in like manner separately from ditches and canals, and shall further number each several appropriation of water consecutively, beginning with the oldest appropriation, without respect to the ditches or reservoirs by means of which such appropriations were made; whether such appropriation shall have been made by means of construction, extension, or enlargement, which number of each ditch, canal, or reservoir, together with the number or numbers of any appropriations of water held to have been made by means of the construction, extension or enlargement thereof, shall be incorporated in said decree and certificate of the clerk, to be issued to the claimants, as provided in section 1 of this act, so as to show the order in priority of such ditch or canal; and of such reservoir, and also of such successive appropriation of water pertaining thereto, for the information of the water commissioner of the district in distributing water, such numbering to be as near as may be having reference to date of decrees as rendered. (Sec. 9, p. 149, Acts 1881, 1771.)

If for any cause the judge of said court shall deem it impracticable or inexpedient to proceed to hear such evidence in open court, he shall, instead of the order mentioned in section 4 of this act, make and cause to be entered of record an order appointing some discreet person, properly qualified, a referee of said court, to whom shall be referred the statement of claim aforesaid on file in said matter, the matter of taking evidence and reporting the same, making an abstract and findings upon the same, and preparing a decree in said adjudication; and also in case of any water district in which a referee has been heretofore appointed, and evidence taken by him under the provisions of the act, the title of which is recited in section 4 of this act; such evidence so already taken, together with the abstract thereof and report of the referee who took the same, shall be also referred to said referee, to be appointed as aforesaid, and he shall proceed with his duties as hereinafter provided, first taking an oath [of] office, such as is required to be taken by referees in other cases under the provisions of the code of civil procedure. (Sec. 10, pp. 149-50, Acts 1881, 1772.)

Said referee shall prepare and publish a notice containing a copy of the order appointing him, in which notice he shall appoint a time or times and place or places suitable and convenient for the claimants in such water districts at which he will attend for the purpose of hearing and taking evidence touching the priority of right of the several ditches, canals, and reservoirs in said district, and notifying all persons, associations, and corporations interested as owners or consumers of waters [water] to attend by themselves, their agents, or attorneys, at the times and places appointed in said notice, and notifying such owners to then and there file a statement of claim in case such statement has not been already filed under the provisions of section 1 hereof, such as mentioned in section 6 hereof, and present their proofs touching any priority of right claimed by them for any ditch, canal, or reservoir in said district, which notice shall be published in same manner and times and in all respects according to the provisions for publication of the newspaper notices mentioned in section 6 of this act, and proof of such publication shall be made in the same manner as is provided in section 7 of this act; and he shall also post ten or more printed copies of such notice in ten or more public places in said district, which copies shall be so posted at least twenty days before the time of commencing to take said evidence. (Sec. 11, p. 150, Acts 1881, 1773.)

Proof of the posting of said copies shall be made by the affidavit of said referee or other person certified by him to be a credible witness, which shall show when, where, and how the said copies were posted, and shall be filed by him with his report. (Sec. 12, p. 151, Acts 1881.)

Said referee shall attend at the times and places mentioned in his said notice, for the purpose therein mentioned; and all persons, associations, choosing to do so, and being interested as owners of or consumers of water from any ditch, canal, or reservoir in said district, and may also attend by themselves, their agents or attorneys, before said referee, at some one or more of said times and places so appointed, and shall have right to offer any and all evidence they may think advisable for their interests in the matter to be adjudicated, as well in districts in which evidence has been heretofore taken as in other districts. All such evidence as has been heretofore taken, if any, in such district, shall be kept present by said referee, subject to inspection by any party desiring to examine the same for purposes of the investigation. (Sec. 13, p. 151, Acts 1881, 1775.)

Said referee shall have power to administer oaths to all witnesses, and to issue subpœnas for witnesses and subpœnas *duces tecum*, which subpœnas may be served by any party, or constable, or sheriff, or deputy sheriff, and may require witnesses to appear at any of the places appointed by said referee for taking evidence. He shall permit all witnesses to be examined by the parties calling them respectively, and to be cross-examined by any party interested, and he shall take all testimony in writing, and note all objections offered to any part of the testimony taken, with the cause assigned for the objection, and shall proceed in all other respects as in case of taking depositions. He shall certify all books and papers offered by any one in his own behalf, and preserve them with the testimony offered concerning the same, and in case of books and papers offered in evidence, which shall not be under the control of the party desiring the evidence for which such books may be offered, said referee shall make a true copy of the parts demanded and certify the same, and preserve the same, together with the evidence offered concerning the same and concerning said books and papers, as part of the evidence in the matter. (Sec. 14, pp. 151-2, Acts 1881, 1776.)

No person, association, or corporation willfully refusing to produce any book or paper, if in his or their power to do so, when rightfully demanded for examination and copying, shall be allowed the benefit of any testimony or proofs in his, her, or their behalf, in making final adjudication, if the court shall be satisfied, from all the evidence shown concerning such refusal, that the same was willful. (Sec. 15, p. 152, Acts 1881, 1777.)

Said referee shall also examine all witnesses to his own satisfaction, touching any point involved in the matter in question, and shall ascertain as far as possible the date of the commencement of each ditch, canal, or reservoir, with the original size and carrying capacity thereof, the time of the commencement of each enlargement thereof, with the increased carrying capacity thereby occasioned, the length of time spent in such construction or enlargement, the diligence with which the work was prosecuted, the nature of the work as to difficulty of construction, and all such other facts as may tend to show compliance with the law in acquiring the priority of right claimed for such ditch, canal, or reservoir; and upon all the facts so obtained shall be determined the relative priorities among the several ditches, canals, and reservoirs, the volume or amount of water lawfully appropriated by each, as well as by means of the construction, as by the enlargements thereof, and the time when each such several appropriations took effect. (Sec. 16, p. 152, Acts 1881, 1778.)

Every person present before said referee at any time when he shall be engaged in hearing testimony, who shall willfully disturb the proceedings; and every person who shall willfully refuse or neglect to obey the subpœna issued by said referee, when his lawful fees shall be tendered him for his attendance before the referee, shall be guilty of contempt of the court appointing such referee, and on complaint, under oath of the referee or other person, before the said district court, or judge thereof in vacation, may be brought before the court or judge and dealt with accordingly. (Sec. 17, pp. 152–3, Acts 1881, 1779.)

Every witness who shall attend before said referee under subpœna, by request of any party, shall be entitled to the same fees and mileage as witnesses before the district court in the county in which he shall so attend, and shall be paid by the party requiring his testimony. (Sec. 18, p. 153, Acts 1881, 1780.)

The said referee shall take all the testimony offered, and for that purpose shall give reasonable opportunity to all parties to be heard, and may at any place, when the time limited thereat shall expire, adjourn the further taking of testimony then proposed or desired to be offered to the next place in order according to his said published appointments, and at the last place may continue until all testimony shall be taken or make further appointments at any former place or places as may seem best and most convenient for all parties, giving reasonable notice thereof. (Sec. 19, p. 153, Acts 1881, 1781.)

Said referee, upon closing the testimony, shall proceed to carefully examine the same, together with all testimony and proofs which may have been heretofore taken by any former referee in the same district, if any such shall have been taken under the provisions of said act, the title of which is recited in section 4 of this act; he shall make an abstract of all the testimony and proofs in his possession concerning each ditch, canal, and reservoir separately, and shall number each ditch and canal in order, and likewise each reservoir, each class consecutively, and also number the several appropriations of water shown by the evidence, all in manner and form as provided in section 9 hereof, and shall make a separate finding of all the facts connected with each ditch, canal, and reservoir, touching which evidence shall have been offered; and he shall prepare a draught of a decree in accordance with his said findings, in substance the same as the decree mentioned in section 4 of this act, and conformable also to the provisions of section 9 hereof, so far as the same are applicable, which decree, so prepared by him, shall be returned with his report to the court, and he shall file his report with said evidence, abstract, and findings, and said decree, with the clerk of the court, and inform the judge of so doing without delay. (Sec. 20, pp. 153–4, Acts 1881, 1782.)

Upon the filing of said report the court, or judge thereof in vacation, shall cause an order to be entered setting some day in a regular or special term of said court as soon as practicable, when the court will proceed to hear and determine the report, at which time any party interested may appear, himself or counsel, and move exceptions to any matter in the findings or decree made by said referee, and after hearing the same the court shall, if the decree reported be approved, cause the same to be entered of record, or otherwise such modifications thereof, or other decree as shall be found just and conformable to the evidence and the true intent of this act, and to so much of any and all former laws of the State as shall be adjudged consistent herewith. (Sec. 21, p. 154, Acts 1881, 1783.)

No claim of priority of any person, association, or corporation, on account of any ditch, canal, or reservoir, as to which he, or she, or they, shall have failed or refused to offer evidence under any adjudication herein provided for, or heretofore provided by this act, the title of which is recited in section 4 hereof, shall be regarded by any water commissioner in distributing water in times of scarcity thereof, until such time as such party shall have by application to the court having jurisdiction obtained leave and made proof of the priority of right to which such ditch, canal, or reservoir shall be justly entitled, which leave shall be granted in all cases upon terms as to notice to other parties interested, and on payment of all costs, and upon affidavits or petition sworn to, showing the rights claimed, and the ditches, canals, and reservoirs, with the names of the owners thereof against which such priority is claimed, nor until a decree adjudging such priority to such ditch, canal, or reservoir has been entered, and certificate, such as mentioned in section 4 hereof, shall have been issued to claimant and presented to the water commissioner. (Sec. 22, pp. 154–5, Acts 1881, 1784.)

Every party interested shall have the right to complain to the court of any act of willful neglect or oppression on the part of the said referee in exercising his powers under this act, whereby such party shall have been aggrieved, either by refusal of said referee to hear or take evidence offered, or by preventing reasonable opportunity to offer such evidence; and the court may order such proceedings in the premises as will give redress of the grievance, at the cost of said referee, if he appear willfully in fault; otherwise, in case of accident or mistake, costs shall be awarded as to the court shall seem just. (Sec. 23, p. 155, Acts 1881, 1785.)

The district court, or judge thereof in vacation, shall have power to make all orders and rules consistent with this act which may be found necessary and expedient, from time to time during the progress of this case, for carrying out the intent of this act, and of all parts consistent therewith of the said act, the title of which is recited in section 4 hereof; as well as touching the proceedings in court, as of the acts and doings of said referee, for the purpose of securing to any party aggrieved by the acts of said referee or any proceeding of the court, opportunity for redress; and this act shall be construed liberally in all courts, in favor of securing to all persons interested the just determination and protection of their rights. (Sec. 24, p. 155, Acts 1881, 1786.)

No persons, associations, or corporation representing any ditch, canal, or reservoir, shall be permitted to give or offer any evidence before said referee until he, she, or they shall have filed a statement of claim in substance the same in all respects as is required to be filed under the provisions of section 1 hereof. (Sec. 25, p. 155, Acts 1881, 1787.)

The district court, or judge thereof in vacation, shall have power to order, for good cause shown, and upon terms just to all parties, and in such a manner as may seem meet, a re-argument or review, with or without additional evidence, of any decree made under the provisions of this act, whenever said court or judge shall find from the cause shown for that purpose by any party or parties feeling aggrieved, that the ends of justice will be thereby promoted; but no such review or re-argument shall be ordered unless applied for by petition or otherwise within two years from the time of entering the decree complained of. (Sec. 26, p. 156, Acts 1881, 1788.)

Any party or parties representing any ditch, canal or reservoir, or any number of parties representing two or more ditches, canals, or reservoirs, which are affected in common with each other by any portion of such decree, by which he or she or they may feel aggrieved, may have an appeal from said district court to the supreme court, and in such case the party or parties joining, desiring an appeal, shall be the appellants, and the parties representing any one or more ditches, canals, or reservoirs affected in common adversely to the interests of appellants shall be the appellees. The party or parties joining in such appeal shall file a statement in writing, verified by affidavit properly entitled in such cause in the district court, which statement shall show that the appellants claim a valuable interest in the ditch, canal, or reservoir, or two or more of such, which are affected in common with each other by some portion of said decree; also stating the name or names, or otherwise the description of the same, and the name or names, or otherwise the description of any one or more other ditches, canals [or] reservoirs, which by said decree derive undue advantage in respect of priority as against that or those represented by appellants; and also setting forth the name or names, of the party or parties claiming such other one or more ditches, canals or reservoirs, affected in common by said decree adversely to the interest of appellant or appellants, and praying that an appeal be allowed against such other parties as appellees. If the court or judge in vacation, on examination, find such statement in accordance with the statements of claim filed by the parties named as appellees, mentioned in section 1 of this act, he shall approve the same and make an order to be prepared and presented by the appellants allowing the appeal and showing the name or names of the appellants and appellees, with the name or names or description of the one or more ditches, canals, or reservoirs claimed by the party or parties appellant and appellee, as shown by their several statements of claim filed as aforesaid, before the taking of testimony, and fix the amount of the appeal bond, which bond shall be executed by one or more of appellants, as principal or principals, and by sufficient securities, and approved by the court or judge in vacation, and shall be conditioned for the payment of all costs which may be awarded against the appellants or any of them in the supreme court. (Sec. 27, pp. 156–157, Acts 1881, 1789.)

The order last aforesaid shall be entered of record, and the appellant or appellants shall cause a certified copy thereof to be served on each of the appellees, by delivering the same to him or her, if he or she may be found, or otherwise serving the same in manner the same as may be at the time provided for serving summons from the district court by the laws then in force, and shall also cause the said order to be published in the same manner as the notices required to be published by the referee mentioned in section 11 of this act, and proof of the publication in any newspaper shall be the same as in case of said referee's notice, and proof of the posting of the ten printed copies in the district shall be by affidavit of the parties posting the same, with the certificate of the clerk of the district court appealed from, that the affiant is a known and credible person. (Sec. 28, p. 157, Acts 1881, 1790.)

The appellant or appellants shall file the transcript of record of the district court with the clerk of the supreme court at any time within six months after the appeal shall be allowed as aforesaid. Only so much of the decree appealed from, and so much of the evidence as shall affect the appropriations of water claimed by means of the construction or enlargement or re-enlargement of the several ditches, canals, and reservoirs mentioned in the order allowing the appeal, need be copied into the bill of exceptions. (Sec. 29, pp. 157-158, Acts 1881, 1791.)

The supreme court, on dismissal of such appeal, or on affirming or reversing the parts of the decree appealed from, in whole or in part, shall award costs, as in its discretion shall be found and held to be equitable. (Sec. 30, p. 158, Acts 1881, 1792.)

The supreme court, in all cases in which judgment is rendered, and any part of the decree appealed from is reversed, and in which it may be practicable, shall make such decree in the matters involved in the appeal as should have been made by the district court, or direct in what manner the decree of that court should be amended. (Sec. 31, p. 158, Acts 1881, 1793.)

The said proof of the service and publication of said order allowing the appeal shall be filed with the clerk of the supreme court within sixty days after the making of said order, and if not so filed the supreme court shall, on motion of the appellee or any of the appellees, at any time after such default in filing said proof, and before the said proof shall be filed, dismiss such appeal, and if the transcript of record be not filed within the time limited by section 29 of this act, such appeal shall, on motion, be dismissed. After the filing of the record and proof of service aforesaid the cause on appeal shall be proceeded with as the rules of the supreme court, or such special rules as said court may make in such cases, and their order from time to time thereunder may require. Said court shall have power to make any and all such rules concerning such appeals as may be necessary and expedient in furtherance of this act, as well as to preparation of the case for submission as to supplying deficiencies of record, if any, and for avoiding unnecessary costs and delay. (Sec. 32, p. 158, Acts 1881, 1794.)

The district court, or judge thereof in vacation, in case of the death, resignation, illness, absence, or other disability of the referee hereby provided for, or for any misconduct in him, or other good cause to such judge appearing, shall appoint such other properly qualified person in his stead as he shall deem proper, who shall proceed without delay to perform all the duties of his office, as herein pointed out, which shall remain unperformed by his predecessor in office. (Sec. 33, p. 159, Acts 1881, 1795.)

Nothing in this act or in any decree rendered under the provisions thereof, shall prevent any person, association or corporation from bringing and maintaining any suit or action whatsoever hitherto allowed in any court having jurisdiction to determine any claim of priority of right to water, by appropriation thereof, for irrigation or other purposes, at any time within four years after the rendering of a final decree under this act in the water district in which such rights may be claimed, save that no writ of injunction shall issue in any case restraining the use of water for irrigation in any water district wherein such final decree shall have been rendered, which shall effect [affect] the distribution or use of water in any manner adversely to the rights determined and established by and under such decree, but injunctions may issue to restrain the use of any water in such district not affected by such decree, and restrain violations of any right thereby established, and the water commissioner of every district where such decree shall have been rendered shall continue to distribute water according to the rights of priority determined by such decree, notwithstanding any suits concerning water rights in such district, until in any suit between parties the priorities between them may be otherwise determined, and such water commissioner have official notice by order of the court or judge determining such priorities, which notice shall be in such form and so given as the said judge shall order. (Sec. 34, p. 159, Acts 1881, 1796.)

After the lapse of four years from the time of rendering a final decree in any water district, all parties whose interests are thereby affected shall be deemed and held to have acquiesced in the same, except in case of suits before then brought, and thereafter all persons shall be forever barred from setting up any claim to priority of rights to water for irrigation in such water district adverse or contrary to the effect of such decree. (Sec. 35, p. 160, Acts 1881, 1797.)

The referee appointed [as provided] in this act shall be paid the sum of $6 per day while engaged in discharging his duties as herein provided, and also his reasonable and necessary expenses and mileage at the rate of 10 cents for each mile actually and necessarily traveled by him in going and coming in the discharge of his duties as such referee, which said per diem allowance, expenses, and mileage shall be paid out of the treasury of the county in which such water district shall lie, if it be contained in one county, and if such water district shall extend into two or more counties, then in equal parts thereof, shall be paid out of the treasury of such county into which such district shall extend. He shall keep a just and true account of his services, expenses, and mileage, and present the same from time to time to the district court, or judge in vacation, verifying the same by oath, and the judge, if he finds the same correct and just, shall certify his approval thereof thereon, and the same shall thereupon be allowed by the board of county commissioners of the county in which said water district shall lie, but if said [water district] extend into two or more counties, he shall receive from the clerk of the district court separate certificates under seal of the court, showing the amount due him from each county, upon which certificate the board of county commissioners of the respective counties shall allow the same on presentation thereof. (Sec. 36, p. 160, Acts 1881, 1798.

All laws and parts of laws heretofore in existence inconsistent with the provisions of this act, shall be and the same are hereby appealed. (Sec. 37, p. 160, Acts 1881, 1799.

Nothing herein contained shall be construed to authorize any sheriff to serve any writ outside the limits of his own county, or give effect to any record by way of notice or otherwise, in any county other than that in which it belongs. (Sec. 35, p. 106, Acts 1889, 1800.)

The fees of the clerk of the district court for a service rendered under this act shall be paid by the counties interested in the same manner as the fees of the water commissioners, upon the said clerk rendering his account, certified by the district judge, to the board or boards of county commissioners of said county or counties embracing the water district in case of which the services shall have been rendered. (Sec. 43, p. 108, Acts 1879, 1801.)

Whenever testimony shall or may be taken in any district created by this act for the purpose of procuring a decree as to appropriation of water and priorities thereof, under the statutes of this State, any testimony theretofore taken before any former referee may be introduced, and shall be received as evidence. (Sec. 28, p. 259.)

Any ditch company formed under the provisions of this (corporations) act shall have the right of way over the line named in the certificate. (Sec. 275 (85), p. 171, G. L., 309.)

When any person owning claims in such locality (on the bank, margin, or neighborhood of any stream) has not sufficient length of area exposed to said stream to obtain a sufficient fall of water to irrigate his land, or that his farm or land used by him for agricultural purposes is too far removed from said stream, and that he has [illegible] water facilities on those lands, he shall be entitled to a right of way through the farms or tracts of lands which lie between him and said stream, or the farms or tracts of lands which lie above or below him on said stream, for the purposes hereinbefore stated. (Sec. 2, p. 67, acts 1861. Sec. 2, p. 362, R. S. Sec. 1373 (2), p, 515, G. L., 1712.)

Such right of way shall extend only to a ditch, dike, or cutting sufficient for the purpose required. (Sec. 3, p. 67, acts 1861. Sec. 3, p. 363, R. S. Sec. 1734 (3), p. 115, G. L., 1713.)

Upon the refusal of the owners of tracts of land or lands through which said ditch is proposed to run to allow of its passage through their property the person or persons desiring to open such ditch may proceed to condemn and take the right of way therefor (under the provisions of the "eminent domain act"). (Sec. 1376 (5), p. 516, G. L., 1715.)

No tract or parcel of improved or occupied land in this State shall, without the written consent of the owner thereof, be subjected to the burden of two or more irrigating ditches constructed for the purpose of conveying water through said property to lands adjoining or beyond the same when the same object can feasibly and practicably be attained by uniting and conveying all the water necessary to be conveyed through such property in one ditch. (Sec. 1, p. 164, acts 1881, 1716.)

Whenever any person or persons find it necessary to convey water for the purpose of irrigation through the improved or occupied lands of another, he or they shall select for the line of such ditch through such property the shortest and most direct route practicable upon which said ditch can be constructed with uniform or nearly uniform grade and discharge the water at a point where it can be conveyed to and used upon the land or lands of the person or persons constructing such ditch. (Sec. 2, p. 164, acts 1881, 1717.)

No person or persons having constructed a private ditch for the purposes and in the manner hereinafter provided shall prohibit or prevent any other person or persons from enlarging or using any ditch by him or them constructed in common with him or them upon payment to him or them of a reasonable proportion of the costs of construction of said ditch. (Sec. 3, p. 164, acts 1881, eminent domain, 1718.)

The right of way shall not be refused by the owner of any tract of land upon which it is required (by those who wish to place wheels upon the bank of a stream), subject, of course, to the like regulations as required for ditches, and laid down in sections hereinbefore enumerated. (Sec. 8, pp. 68-9, acts 1861. Sec. 6, p. 364, R. S. Sec. 1377 (6), p. 516, G. L., 1727.)

If any corporation formed under this (corporations) act for the purpose of constructing a * * * ditch * * * shall be unable to agree with the owner for the purchase of any real estate required for the purposes of any such corporation or company, or the transaction of the business of the same, or for right of way, or any other lawful purpose connected with or necessary to the operations of such company, such corporations may acquire such title in the manner provided by law. (Sec. 304 (114), p. 182, G. L., 338.)

Any company formed under the provisions of this act for the purpose of constructing a * * * ditch * * * may cause such examination and survey as may be necessary to the selection of the most advantageous route, and for such purpose, by its officers, agents, or servants, may enter upon the lands of any person or corporation, but subject to liability for all actual damages which shall be occasioned thereby. (Sec. 305 (115), p. 183, G. L., 339.)

Persons desirous to construct and maintain reservoirs for the purpose of storing water shall have the right to take from any of the natural streams of the State and store away any unappropriated water not needed for immediate use for domestic or irrigating purposes; to construct and maintain ditches for carrying such water to and from such reservoir, and to condemn lands for such reservoirs and ditches in the same manner provided by law for the condemnation of lands for right of way for ditches: *Provided*, No reservoir with embankments or a dam exceeding ten feet in height shall be made without first submitting the plans thereof to the county commissioners of the county in which it is situated and obtaining their approval of such plans. (Sec. 38, pp. 106–7, acts 1879, 1724.)

The owners of any reservoir may conduct the water therefrom into and along any of the natural streams of the State, but not so as to raise the waters thereof above ordinary high-water mark, and may take the same out again at any point desired without regard to the prior rights of others to water from said stream; but due allowance shall be made for evaporation and seepage, the amount to be determined by the commissioners of irrigation of the district; or, if there are no such commissioners, then by the county commissioners of the county in which the water shall be taken out for use. (Sec. 39, p. 107, acts 1879, 1725.)

The owners of the reservoirs shall be liable for all damages arising from leakage or overflow of the waters therefrom, or by floods caused by breaking of the embankments of such reservoirs. (Sec. 40, p. 107, acts 1879, 1726.)

Every ditch company organized under the provisions of this (corporations) act shall be required to keep their ditch in good condition, so that the water shall not be allowed to escape from the same to the injury of any mining claim, road, ditch, or other property; and whenever it is necessary to convey and ditch over, across, or above any lode or mining claims or to keep the water so conveyed therefrom, the company shall, if necessary to keep the water of said ditch out or from any claim, flume the ditch so far as necessary to protect such claim or property from the water of said ditch. (Sec. 278 (88), pp. 172–3, G. L., 312.)

The owners of reservoirs shall be liable for all damages arising from leakage or overflow of the waters therefrom, or by floods caused by the breaking of the embankments of such reservoirs. (Sec. 40, p. 107, acts 1879, 1726.)

The owner or owners of any ditch for irrigation or other purposes shall carefully maintain the embankments thereof, so that the waters of such ditch may not flood or damage the premises of others, and shall make a tail ditch so as to return the water in such ditch with as little waste as possible into the stream from which it was taken. (Sec. 7, p. 36, R. S., with first clause, amendment, 1872, p. 144, sec. 1, second clause, sup. by sec. 2, p. 78, acts 1876, 1728.)

Any ditch company constructing a ditch, or any individual having ditches for irrigation, or for other purposes, wherever the same may be taken across any public highway or public traveled road, shall put a good substantial bridge, not less than 14 feet in breadth, over such water-course where it crosses said road. (Sec. 10, p. 364, R. S. Sec. 1381 (10), p. 516, G. L., 1730.)

When any such ditch or water-course shall be constructed across any public traveled road, and not bridged within three days thereafter, it shall be the duty of the supervisor of the road district to put a bridge over said ditch or water-course, of the dimensions specified in section 10 of this chapter, and call on the owner or owners of the ditch to pay the expenses of constructing such bridge. (Sec. 11, p. 364, R. S. Sec. 1382 (21), p. 517, G. L., 1731.)

If the owner or owners of such ditch refuse to pay the bill of expenses so presented, the supervisor may go before any justice of the peace in the township or precinct and make oath to the correctness of the bill, and that the owner or owners of the ditch refuse payment; and thereupon such justice of the peace shall issue a summons against such owner or owners, requiring him or them to appear and answer to the complaint of such supervisor in an action of debt for the amount sworn to be due, such summons to be made returnable and served, and proceedings to be had thereon as in other cases; and in case judgment shall be given against such owner or owners the justice shall assess, in addition to the amount sworn to be due as aforesaid, the sum of $10 as damages arising from the delay of such owner or owners, such judgment to be collected as in other cases, and to be a fund in the hands of the supervisor of roads for the repairs of roads in such precinct or district. (Sec. 12, p. 365, R. S. Sec. 1383 (12), p. 517, G. L., 1732.)

No person or persons, or corporation * * * shall cause waste water, or the water from any ditch, road, drain, or flume or other place, to flow in or upon any road or highway so as to damage the same, and any such person or persons or corporation so offending or violating any of the provisions of this section or any of the sections of this act, for which there is no specific penalty provided, shall pay a fine of not less than $10 nor more than $300 for each offense, and a like fine of $10 for each day that such obstruction shall be suffered to remain in said highway, and shall also be liable to any person or persons or corporation in a civil action for any damages resulting therefrom; and it shall be the duty of the road overseer in the district in which such violation shall occur to prosecute any person, persons, corporation, or corporations violating the provisions of this act. (As amended, p. 326, Session Laws, 1885, 2988.)

Any person or persons, corporation or company, owning or constructing any ditch, race, drain, or flume, in, upon, or across any highway, shall keep the highway open for safe and convenient travel by constructing bridges over such ditch, race, drain, or flume; and within five days after any ditch is constructed across, in, or upon any highway at any point thereof so as to interfere with or obstruct such highway, the person or persons owning or constructing such ditch shall erect a good and substantial bridge of not less than 20 feet in width across the same, which shall thereafter be maintained by the county: *Provided*, That all such bridges which shall be of greater length than 20 feet, shall be constructed as herein provided, and thereafter maintained in proper condition for safe travel by the owner or owners of said ditch. Any person or persons, corporation or company, constructing any ditch, race, drain, or flume, in, upon or across any highway, and failing to keep the highway open for safe and convenient travel, as in this act provided, shall forfeit the sum of $25 to the county for each and every day of failure to keep the same open for safe and convenient travel as aforesaid. And any person or persons, corporation or company, who shall fail to erect a good and substantial bridge across any ditch, race, drain, or flume, within five days after the same is constructed in, upon, or across any highway, and keep the same in proper condition and repair, as herein provided, shall forfeit the sum of $25 to the county for each and every day of failure to erect such bridge and keep the same in repair, as aforesaid, together with the cost of constructing there a good and substantial bridge, or making necessary repairs, which the road overseers of the district shall at once proceed to build or repair, and such party or parties so neglecting shall also be liable in damages to any person or persons damaged by such neglect. (As amended, session laws, 1885, p. 324, 2990.)

The owner of any irrigating or mill ditch shall carefully maintain and keep the embankments thereof in good repair, and prevent the water from wasting. (Sec. 1, p. 78, acts 1876. Sec. 1385 (1), p. 518, G. L., 1733.)

During the summer season it shall not be lawful for any person or persons to run through his or their irrigating ditch any greater quantity of water than is absolutely necessary for irrigating his or their said land, and for domestic and stock purposes; it being the intent and meaning of this section to prevent the wasting and useless discharge and running away of water. (Sec. 2, p. 78, Acts 1876. Sec. 1386 (2), p. 518, G. L., 1734.)

Any person who shall willfully violate any of the provisions of this act, shall, on conviction thereof before any court having competent jurisdiction, be fined in a sum of not less than $100. Suits for penalties under this act shall be brought in the name of the people of the State of Colorado. (Sec. 3, p. 78, Acts 1876. Sec. 1387 (3), p. 518, G. L., 1735.)

That the owner or owners of every irrigating ditch, flume or canal, in this State shall be required to erect and keep in good repair a head-gate at the head of their ditch, flume, or canal. Such head-gate, together with the necessary embankments, shall be of sufficient height and strength to control the water at all ordinary stages.

The frame-work of such head-gate shall be constructed of timber not less than 4 inches square, and the bottom, sides, and gate, or gates, shall be of plank not less than 2 inches in thickness. (Sec. 1, p. 165, Acts 1881, 1736.)

Owners of all ditches shall be liable for all damages resulting from their neglect or refusal to comply with the provisions of section 1 (G. S. 1736) of this act. (Sec. 2, p. 165, Acts 1881, 1737.)

Ditch owners are also required to construct and maintain a weir, or measuring device at the heads of their ditches. (Ch. XIV.)

Every person who shall willfully open, close, change, or interfere with any head-gate or water-box, without authority, shall be guilty of a misdemeanor, and on conviction thereof shall be fined not less than $50, nor more than $300, and may be imprisoned not exceeding sixty days. (Sec. 44, p. 108 Acts 1879, 1755.)

Any person or persons who shall knowingly and willfully cut, dig, break down, or open any gate, bank, embankment, or side of any ditch, canal, flume, feeder, or reservoir in which such person or persons may be joint owner, or the property of another, or in the lawful possession of another or others, and used for the purpose of irrigation, manufacturing, mining, or domestic purposes with intent maliciously to injure any person, association, or corporation, or for his or her own gain, unlawfully, with intent of stealing, taking or causing to run or pour out of such ditch, canal, reservoir, feeder, or flume, any water for his or her own profit, benefit, or advantage, to the injury of any other person, persons, associations, or corporation, lawfully in the use of such water or of such ditch, canal, reservoir, feeder, or flume, he, she or they so offending shall be deemed guilty of a misdemeanor, and on conviction thereof shall be fined in any sum not less than $5 nor more than $300, and may be imprisoned in the county jail not exceeding ninety days. (Sec. 1, p. 163, Acts 1881, 1759.)

Justices of the peace shall have jurisdiction of all offenses under the provisions of this act (G. S. 1759), saving to any party defendant the right to be tried by a jury, as in other criminal cases before such justices now provided for by law; and also the right to appeal, in manner and form as by law now, or hereafter to be provided for by law, in criminal cases before such justices. (Sec. 2, p. 163, Acts 1881, 1760.)

Every person who shall willfully commit any trespass by entering upon the improved or inclosed land of another, without the permission of the owner thereof, with intent to cut, injure, or destroy any dam, dike, or embankment kept or maintained for the purpose of storing water in any lake, creek, or reservoir, shall, upon conviction therefor, be punished by imprisonment in the county jail not less than ten days nor more than one year, or by a fine of not less than $50 and not more than $1,000, or by both such fine and imprisonment. (P. 165.)

If any person shall unlawfully, wantonly, willfully, or maliciously, cut down, break down, level, demolish, or otherwise destroy or damage any bridge, embankment, milldam, or ditch, being the property of another * * * where the value of the personal property destroyed or injured shall exceed $20, shall, on conviction, be punished by imprisonment in the State penitentiary not more than five years, or by a fine not exceeding $1,000; or, where the value of the personal property destroyed or injured shall be $20 or under, shall, on conviction, be punished by a fine not exceeding $100, or imprisonment in the county jail not more than three months, or both such fine and imprisonment in the discretion of the court. (As amended Session Laws 1885, p. 167, 903.)

Any person who shall willfully or maliciouly damage or interfere with any * * * ditch, flume, * * * or any of the fixtures, tools, implements, appurtenances, or any property of any company which may be organized under the provisions of this act, upon conviction thereof before any court of competent jurisdiction in the county where the offense shall have been committed, shall be deemed guilty of a misdemeanor, and shall be punished by fine or imprisonment, or both, at the discretion of the court, said imprisonment not to exceed one year, and said fine not to exceed $500, which fine shall be paid into the county treasury for the use of the common schools, and said offender shall also pay all damages that any such corporation may sustain, together with costs of suit. (Sec. 297 (107), p. 180, G. L., 315.)

If any person or persons shall hereafter throw or discharge into any stream of running water, or into any ditch or flume in this State, any obnoxious substance, such as refuse matter from slaughter-house or privy, or slops from eating-houses or saloons, or any other fleshy or vegetable matter which is subject to decay in the water, such person or persons shall, upon conviction thereof, be punished by a fine not less than $100 nor more than $500 for each and every offense so committed. (Sec. 1, Acts 1874, p. 99. Sec. 165, p. 307, G. L. In force Feb. 13, 1874, 882.)

That it shall be lawful for any person or persons to float any and all kinds of timber, such as saw-logs, ties, fencing poles or posts, and fire-wood down any of the streams of this State: *Provided*, That any person or persons desiring to float any such timber down said streams shall first execute a bond running to the people of each county through which such timber is floated, in a sum sufficient to cover all damages that may be done to any bridges, dams, or irrigating ditches that are now or may hereafter be constructed in or across any streams of this State, such bond to be approved by the board of county commissioners of the county or counties through which such timber is to be floated. (Sec. 1856 (1), p. 643, G. L., 3259.)

Water sold by the inch by any individual or corporation shall be measured as follows, to wit: Every inch shall be considered equal to an inch square orifice under a 5-inch pressure, and a 5-inch pressure shall be from the top of the orifice of the box put into the banks of the ditch to the surface of the water; said boxes, or any slot or aperture through which such water shall be measured, shall in all cases be 6 inches perpendicular, inside measurement, except boxes delivering less than 12 inches, which may be square, with or without slides. All slides for the same shall move horizontally, and not otherwise; and said box put into the banks of ditch shall have a descending grade from the water in ditch of not less than one-eighth of an inch to the foot. (Sec. 2779 (3), pp. 926-7, G. L. Sec. 6, p. 638, R. S. Amd. Sec. 1, pp. 308-9, Acts 1874 and 1877, 3472.)

All persons for the purpose of weighing or measuring goods, wares, merchandise, water, or other articles actually sold by him, not in accordance with this chapter, shall be deemed guilty of a misdemeanor, and upon conviction thereof may be imprisoned not exceeding one year, or fined not exceeding $1,000, at the discretion of the court in which the conviction shall be obtained. (Sec. 2785 (9), p. 928, G. L. Sec. 9, p. 309, Acts 1874, 3478.)

Any company constructing a ditch under the provisions of this act shall furnish water to the class of persons using the water in the way named in the certificate, in the way the water is designated to be used, whether miners, mill men, farmers, or for domestic use, whenever they shall have water in their ditch unsold, and shall at all times give the preference to the use of water in said ditch to the class named in the certificate; the rates at which water shall be furnished to be fixed by the county commissioners as soon as such ditch shall be completed and prepared to furnish water. (Sec. 277 (87), p. 172, G. L., 211.)

The county commissioners of each county shall, at their regular January session in each year, hear and consider any and all applications which may be made to them by any party or parties interested in procuring water for irrigation by purchase from any ditch or reservoir furnishing and selling water, or proposing to furnish water for sale, the whole or upper part of which shall lie in such county, which application shall be supported by such affidavit or affidavits as the applicant may see proper to present, showing reasonable cause for such board to proceed to fix the price of water to be hereafter sold from such ditch or reservoir, and [if] such board of commissioners shall, upon examination of such affidavit or affidavits, or from the oaths of witnesses in addition thereto, find that the facts sworn to show the application to be in good faith, and that there is reasonable grounds to believe that unjust prices are, or are likely to be, charged for water from such ditch or reservoir, they shall enter an order fixing a day, not sooner than forty days thereafter nor later than the third day of the [next] regular session of their board, when they will hear all parties directly or indirectly interested in said ditch or reservoir, or in procuring water therefrom for irrigation, who may appear, as well as all the testimony by witnesses, or depositions taken on notices as hereinafter provided, touching the said ditch or reservoir, and the cost of furnishing water therefrom, at which time all persons or corporations interested in said ditch or reservoir, as well as all interested in obtaining water therefrom, or in lands which may be irrigated therefrom, may appear by themselves, their agents, or attorneys, and said commissioners shall then proceed to take action in the matter of fixing such price of water; provided the applicant shall, within ten days from the time of entering such order, cause a copy thereof, duly certified, to be delivered to the owner of such ditch or reservoir, if it be owned by one person, or each of the owners if it be owned by several persons, or to the president, secretary, or treasurer of the company if it belongs to a corporation or association having such officers, or if such owner can not be found he shall cause such copy to be left at his usual place of residence, with some person or member of his family residing there, and over fourteen years of age, and if such ditch officer can not be found, he shall cause such copy to be left at the office or place of business of the company of which he is such officer, or at his residence if such company have no place of business, and if such ditch is owned by several owners, not an incorporated company, it shall be sufficient to serve such notice by delivering one such copy each to a majority of them, and such applicant shall make affidavit of the manner in which such copy or copies have been served. Depositions mentioned in section 1 hereof, to be used before said commissioners, shall be taken before any officer in the State authorized by law to take depositions, upon reasonable notice being given to the opposite party of the time and place of taking such depositions. (Sec. 1, pp. 94-5-6, Acts 1879, 1738.)

Said board shall hear and examine all legal testimony or proofs offered by any of the parties interested, as before mentioned, as well concerning the value of the construction of such ditch and reservoir as the cost and expense of maintaining and operating the same, and all matters which may affect the just price and value of water to be furnished therefrom; and they shall have power to issue subpœnas to witnesses and compel their attendance, which subpœnas shall be served by the sheriff of the proper county when required; and also to compel the production of books and papers required for evidence in as full and ample a manner as the district court now has. They may adjourn the hearing from time to time to further the ends of justice or suit the general convenience of parties. Upon hearing an [and] considering all the matters and facts involved in the case, the board of commissioners shall enter an order naming and describing the ditch or reservoir with sufficient certainty, and fixing a just price upon all water to be thereafter sold, which price shall not be thereafter changed oftener than once in two years: *Provided*, That no price so fixed shall effect [affect] the rights of parties, or their lawful assignees or grantees, who may have contracts with the company, association, or person owning such ditch or reservoir, or their lessees, grantees, or successors, nor the rights of such owners, lessees, or grantees under such contract, nor shall it in any way affect or hinder the making of such contract. (Sec. 2, p. 96, Acts 1879, 1739.)

Any person or persons, acting jointly or severally, who shall have purchased and used water for irrigation for lands occupied by him, her, or them, from any ditch or reservoir, and shall not have ceased to do so, for the purpose or with the intent to procure water from some other source of supply, shall have a right to continue to purchase water to the same amount for his, her, or their lands, on paying or tendering the price thereof fixed by the county commissioners as above provided; or, if no price shall have been fixed by them, the price at which the owners of such ditch or reservoir may be then selling water or did sell water during the then last preceeding year. This section shall not apply to the case of those who may have taken water as stockholders or share-holders after they shall have sold or forfeited their shares or stock, unless they shall have retained a right to procure such water by contract, agreement, or understanding, and use between themselves and the owners of such ditch, and not then to the injury of other purchasers of water from or shareholders in [the] same ditch. (Sec. 3, pp. 96, 97, Acts 1879, 1740.)

The lands now irrigated, or which may be hereafter irrigated, from ditches now taking water from the following-described rivers or natural streams of the State of Colorado, are hereby declared to constitute irrigation districts. (Sec. 5, p. 97, Acts 1879, 1741.)

Other irrigation districts may be formed from time to time by the governor on petition of parties interested. Several districts were formed under this power and commissioners appointed, and these new districts were incorporated into the new act. (Act 1879, creating districts.)

For the better regulation of the distribution of water for irrigation among the several ditches, canals, and reservoirs into which such water may be lawfully taken in times of scarcity thereof, the water districts now or to be hereafter established by law shall be constituted into water divisions, as follows: (Ditto), 1802.

There shall be one water commissioner for each of the above-named districts, and for each district hereafter formed, who shall be appointed by the governor, to be selected by him from persons recommended to him by the several boards of county commissioners of the counties into which water districts may extend, and the water commissioner so appointed shall hold his office until his successor is appointed and qualified. The governor shall, by like selection and appointment, fill all vacancies which may be occasioned by death, resignation, or continued absence from the district, removal or otherwise. Said county commissioners may, from time to time, recommend persons to be appointed as above provided, and the governor may at any time remove any water commissioner in his discretion. Sec. 16, pp. 98, 99, Acts 1879, 1752.)

That within ten days after his appointment, and before entering upon the duties of his office, such water commissioner shall take and subscribe the oath of office prescribed by the constitution of this State. (Sec. 17, p. 99, Acts 1879, 1753.)

It shall be the duty of said water commissioners to divide the water in the natural stream or streams of their district among the several ditches taking water from the same, according to their prior rights of each respectively; in whole or in part to shut and fasten, or cause to be shut and fastened, by order given to any sworn assistant, sheriff, or constable of the county in which the head of such ditch is situated, the head-gate of any ditch or ditches heading in any of the natural streams of the district which in a time of a scarcity of water shall not be entitled to water by reason of the priority of the rights of others below them on the same stream. (Sec. 18, p. 99, Acts 1879, 1754.)

The water commissioners herein provided shall be each entitled to pay at the rate of $5 per day for each day he shall be actually employed in the duties of his office, not to exceed eighty days in any one year, to be paid by the county or counties in which his irrigation district may lie. Each water commissioner shall keep a just and true account of the time spent by him in the duties of his office, and shall present a true copy thereof, verified by oath, to the board of commissioners of the county in which his district may lie, and said board of commissioners shall allow the same; and if said irrigation district shall extend into two or more counties, then such water commissioner shall present his account for his said services, verified as aforesaid, to the board of county commissioners of each county into which such district extends, and each board of county commissioners shall allow an equal part thereof. (P. 254, Acts 1885, 1756.)

Said water commissioner shall have power, in case of emergency, to employ a suitable assistant to aid him in the discharge of his duties. Such assistant shall take the same oath as the water commissioner, and shall obey his instructions, and shall be entitled to $3 per day for every day he is so employed, not to exceed twenty-five days, to be paid upon the certificate of the water commissioner, in the same manner as provided for paying water commissioners. (Sec. 41, p. 107, Acts 1879, 1757.)

Said water commissioners shall not begin their work until they shall be called on by two or more owners or managers, or persons controlling ditches in their several districts, by application in writing, stating that there is necessity for their action; and they shall not continue performing services after the necessity therefor shall cease, 1758.

If at any time any ditch or reservoir from which water is or shall be drawn for irrigation shall not be entitled to a full supply of water from the natural stream which supplies the same, the water actually received into and carried by such ditch, or held in such reservoir, shall be divided among all the consumers of water from such ditch or reservoir, as well as the owners, share-holders or stockholders thereof as the parties purchasing water therefrom; and parties taking water partly under and by virtue of holding shares, and partly by purchasing the same, to each his share pro rata, according to the amount he, she, or they (in cases in which several consume water jointly) shall be then entitled, so that all owners and purchasers shall suffer from the deficiency arising from the cause aforesaid each in proportion to the amount of water which he, she, or they should have received in case no such deficiency of water had occurred. (Sec. 4, p. 97, Acts 1879, 1722.)

The governor shall appoint a State hydraulic engineer, who shall hold his office for the term of two years, or until his successor may be appointed and qualified. The governor may at any time, upon good cause shown, remove said State engineer. Said State engineer shall have general supervision over the water companies [commissioners] of the different water districts in the State. He shall have his office at the State capitol, in an office to be provided for him by the secretary of state, and be subject to his direction and control; who shall also furnish him with suitable furniture, postage, and such proper and necessary books and instruments as will best enable him to discharge the duties of his office. He shall be paid a salary of $2,000 per annum, payable quarterly, by the State treasurer, on warrants drawn by the State auditor. No person shall be appointed as such hydraulic engineer who is not known to have such theoretical knowledge and practical skill and experience as shall fit him for the position. (Sec. 6, pp. 119-20, Acts 1881, 1807.)

Said State engineer shall make, or cause to be made, careful measurements and calculations of the maximum and minimum flow in cubic feet per second of water in each stream from which water shall be drawn for irrigation, as may be best for affording information for irrigating purpose, commencing with those streams most used for irrigation; also, to collect facts and make report as to a system of reservoirs for the storage of water, their location, capacity and cost; and he shall keep proper and full records of his work, observations and calculations. (Sec. 7, p. 120, Acts 1881, 1808.)

Said State engineer shall, before entering on the discharge of his duties, take and subscribe an oath before some officer authorized by law to administer oaths, to faithfully perform the duties of his office, and file with the secretary of state said oath and his official bond, in the penal sum of $2,000, with sureties to be approved by the secretary of state, and conditioned for the faithful discharge of the duties of his office, and for delivering to his successor, or other officer authorized to receive the same, all moneys, implements, books and other property belonging to the State then in his hands or under his control, or with which he may be legally chargeable as such officer. (Sec. 8, pp. 120-1, Acts 1881, 1809.)

Said State engineer will have power to employ assistants at an expense not to exceed $1,500 in any one year, who shall be paid out of any moneys appropriated for that purpose, on certificate of said State engineer, showing the services rendered and the amount therefor [thereof], and on presentation of such certificate to the State auditor by the person entitled thereto, he shall issue his warrant on the State treasurer for the amount thereof, to be paid out of any appropriation as aforesaid, and not otherwise. (Sec. 9, p. 277, acts 1883, 1801.)

Said State engineer shall prepare and render to the government [governor] yearly, and oftener if required, full and true reports of his work, touching all the matters and duties devolving upon him by virtue of his office, which report shall be delivered at the time when the reports of other State officers are required by law to be made, in order that they may be laid before the general assembly at each regular session thereof. (Sec. 10, p. 121, Acts 1881, 1811.)

Said State engineer shall, on request of any party interested, on payment of his per diem, charges, and reasonable expenses, measure and ascertain the carrying capacity of any ditch, canal, or feeder, or any reservoir, hereafter constructed or enlarged, and give to the party or parties requiring his services an official certificate of the size and carrying capacity of such ditch, canal, or feeder, in cubic feet per second, as he shall find it to be at the time of measuring the same. (Sec. 11, p. 121, Acts 1881, 1812.)

For the more accurate and convenient measurement of any water appropriated pursuant to any judgment or decree rendered by any court establishing the claims of priority of any ditch, canal, or reservoir, the owners thereof shall construct and maintain, under the supervision of the State engineer, a measuring weir or other device for measuring the flow, in cubic feet per second, the water at the head of such ditch, canal, or reservoir, or as near thereto as practicable. The State engineer shall compute and arrange in tabular form the amount of water that will pass such weir or measuring device in cubic feet per second, at the different stages thereof, and he shall furnish a copy of a statement thereof to any water commissioners having control of such ditch, canal, or reservoir. (Sec. 12, pp. 121–2, Acts 1881, 1813.)

Whenever any three or more persons associate under the provisions of this act to form a company for the purpose of constructing a ditch for the purpose of conveying water to any mines, mills, or lands, to be used for mining, milling, or irrigating of lands, they shall, in their certificate, in addition to the matters required in section 2 of this (corporation) act, specify as follows: The stream or streams from which the water is to be taken out; the point or place on said stream, at or near which the water is to be taken out; the line of said ditch, as near as may be, and the use to which the said water is to be applied. (Sec. 274 (84), p. 171, G. L., 308.)

Any ditch company formed under the provisions of this act shall have the right of way over the line named in the certificate, and shall also have the right to run the water of the stream or streams named in the certificate through their ditch: *Provided*, That the line proposed shall not interfere with any other ditch whose rights are prior to those acquired under this act and by virtue of said certificate, except the right to cross by flume; nor shall the water of any stream be diverted from its original channel to the detriment of any person or persons who may have priority of right. (Sec. 275 (85), p. 171, G. L., 309.)

Any corporation owning any ditch or canal for conveying, or reservoirs for storing, water for irrigation purposes, and the capital stock being fully subscribed and paid up, and when such corporation shall have no income sufficient to keep its ditch, canal or reservoir in good repair, such corporation shall have power to levy an assessment upon the capital stock thereof, to be levied pro rata on all the shares of stock, payable in money or labor, or both, for the purpose of keeping the property of such corporation in good repair, and for the payment of any claim against said corporation not otherwise provided for. But no such assessment shall be made unless the question of making such assessment shall first be submitted to the stockholders of such corporation at an annual meeting, or at a special meeting called for that purpose, and a majority of the stockholders, either in person or by proxy, voting thereon shall vote in favor of making such assessments; and an action may be maintained to recover any assessment against any delinquent share-holder, as provided in section 2 of this act. (Sec. 276 (86), p. 172, G. L., 810.)

Companies organized under the laws of this State, holding ditches or canals by virtue of their organization, which derive their supply of water for their respective ditches or canals from the same head gate or gates, or the same source or sources of supply, may consolidate their interests and unite their respective companies under one name and management, by filing a certificate of that fact in the office of the secretary of this State, and a counterpart thereof in the office of the recorder of the county or counties in which such ditches or canals are situated, which certificates shall be signed by the presidents of the companies so uniting, with the common seals of the companies affixed thereto, and shall set forth the facts of such union of interests, and give the name of the new company thus formed. (Sec. 1, Acts 1876, p. 68—omitted in G. L., 313.)

All ditches used for the purpose of irrigation, and that only when the water is not sold for the purpose of deriving a revenue therefrom, be, and the same are hereby, declared free from all taxation, whether for State, county, or municipal purposes. (Sec. 1, p. 143, Acts 1872. Sec. 1384 (1), p. 517, G. L., 1761.)

Water sold by the inch by any individual or corporation shall be measured as follows, to wit: Every inch shall be considered equal to an inch square orifice under a 5-inch pressure, and a 5-inch pressure shall be from the top of the orifice of the box put into the banks of the ditch to the surface of the water; said boxes or any slot or aperture through which such water shall be measured shall in all cases be 6 inches perpendicular, inside measurement, except boxes delivering less than 12 inches, which may be square, with or without slides; all slides for the same shall move horizontally and not otherwise; and said box put into the banks of ditch shall have a descending grade from the water in ditch of not less than one-eighth of an inch to the foot. (347.)

For the purpose of encouraging cultivation and the making of irrigation ditches the State board of land commissioners are hereby authorized to sell at public sale, at not less than the appraised value, not more than one-half of any tract of arid land belonging to the State, except the school land, in alternate quarter sections as nearly as may be, to any responsible person or corporation, on condition that said person or corporation dig an irrigation ditch in such location, and of sufficient capacity to furnish water for the entire tract. All contracts for the sale of State lands under the provisions of this section shall be drawn by the attorney-general, and signed by the governor and the secretary of the board, in behalf of the State, and by the other parties in interest; and in no case shall the titles to any of said lands pass from the State until such ditch is completed in a manner satisfactory to the State board, and the purchasers have given, in addition to such price as may be fixed by the State board, a suitable contract or agreement, secured by a sufficient bond, that they will furnish water for the remaining portion of the tract of land, as aforesaid, at not to succeed [exceed] such rates as the State board may agree. Upon the fulfillment of the above conditions patent may issue for not more than one-half of said tract, and the remaining portion of said tract may be subsequently disposed of in the same manner as other State lands. (Sec. 8, p. 226, Acts 1881, 2724.)

The State board of land commissioners may sell in parcels of not more than 5,000 acres, at public sale, at not less than its appraised value, any of the lands granted to the State for public improvements, under the act approved September 4, 1841, conditioned upon the location of colonies thereon, or the construction of extensive lines of ditches covering such lands: *Provided*, That not more than one-half of any one section of land shall be sold, in alternate half sections: *And provided further*, That every alternate one-half section unsold shall not be sold for three years thereafter. (Sec. 2196 (22), p. 728, G. L., 2744.)

When any company shall organize under the provisions of this act to form a company for the purpose of constructing a flume, their certificate, in addition to the matters required in the second section of this act (G. S., 238), shall specify as follows: The place of beginning, the terminus, and the route, as near as may be, and the purpose for which such flume is intended, and when organized, according to the provisions of this act, said company shall have the right of way over the line proposed in such certificate for such flume, provided it does not conflict with the rights of any former fluming, ditching, or other company. (Sec. 279, 80, p. 173, G. L., 316).

Act to Regulate Rates, etc., 1887.

Section 1. The county commissioners of each county shall, at their regular sessions in each year, and at such other sessions as they, in their discretion, may deem proper, in view of the irrigation and harvesting season and the convenience of all parties interested, hear and consider all applications which may be made to them by any party or parties interested either in furnishing and delivering for compensation in any manner, or in procuring for such compensation water for irrigation, mining, milling, manufacturing, or domestic purposes from any ditch, canal, conduit, or reservoir, the whole or any part of which shall lie in such county; which application shall be supported by such affidavits as the applicant or applicants may present, showing reasonable cause for such board of county commissioners to proceed to fix the rate of compensation for water to be thereafter delivered from such ditch, canal, conduit, or reservoir within such county.

Sec. 2. Every such board of commissioners shall, upon examination of such affidavit or affidavits, or from the oaths of witnesses in addition thereto, if they find that the facts sworn to show the application to be in good faith and that there are reasonable grounds to believe that unjust rates of compensation are, or are likely to be, charged or demanded for water from such ditch, canal, conduit, or reservoir, shall enter an order fixing a day not sooner than twenty days thereafter, nor later than the third day of the next regular session of their board, when they will hear all parties interested in such ditch or water works as aforesaid, or in procuring water therefrom for any of the said uses, as well as all documentary or oral evidence or depositions, taken according to law, touching the said ditch or other work as aforesaid, and the cost of furnishing water therefrom.

Sec. 3. At the time so fixed all persons interested as aforesaid on either side of the controversy, or in lands which may be irrigated from such ditch or other work aforesaid, may appear by themselves, their agents, or attorneys, and said commissioners shall then proceed to take action in the matter of fixing such rates of compensation for the delivery of water: *Provided*, The applicant or applicants—if the application be made by a party or parties as aforesaid, desirous of procuring water—shall, within ten days from the time of entering the said order fixing the hearing, cause a copy of such order, duly certified, to be delivered to the owner or owners of such ditch, canal, conduit, or reservoir, or to the president, secretary, or treasurer of the company, if it be owned by a corporation or association having such officers. If any such owner can not be found, a copy shall be left at his usual place of abode, with some person residing there, over twelve years of age, and if such officer of any corporation or association can not be found, such copy shall be left at the usual place of business of the company of which he is such officer, or at his residence, if such company have no place of business, and if such ditch or other work aforesaid shall be owned by several owners, not being an incorporated company, it shall be sufficient to serve such notice by delivering one copy each to a majority of them. If the applicant be the owner or party controlling such ditch, canal, conduit, or reservoir, such notice shall be given by causing printed copies of such order, in hand-bill form, in conspicuous type, to be posted securely in ten or more public places throughout the district watered from such ditch or other work aforesaid—if the water be used for irrigation—and one copy shall be posted for every mile in length of such ditch; but if such ditch or other work be for the supply of water for milling or mining, it shall be sufficient to serve such copy on the parties then taking water therefrom. The person or persons making such service or posting such printed copies shall make affidavit of the manner in which the same has been done, which affidavit shall be filed with the said board of county commissioners. Depositions mentioned in section 2 hereof, to be used before said commissioners, shall be taken before any officer in the State authorized by law to take depositions, upon reasonable notice being given to the opposite party of the time and place of taking the same.

SEC. 4. Said board of commissioners may adjourn or postpone any hearing from time to time, as may be found necessary, or for the convenience of parties, or of public business; and they shall hear and examine all legal testimony or proofs offered by any party interested as aforesaid, as well concerning the original cost and present value of works and structure of such ditch, canal, conduit, or reservoir, as the cost and expense of maintaining and operating the same, and all matters which may affect the establishing of a reasonable maximum rate of compensation for water to be furnished and delivered therefrom; and they may issue subpœnas for witnesses, which subpœnas shall be served by the sheriff of the county, who shall receive the lawful fees for all such service; and said board may also issue a subpœna for the production of all books and papers required for evidence before them. Upon hearing and considering all the evidence and facts and matters involved in the case said board of commissioners shall enter an order describing the ditch, canal, conduit, reservoir, or other work in question with sufficient certainty, and fixing a just and reasonable rate of compensation for water to be thereafter delivered from such ditch or other work as last aforesaid within the county in which such commissioners act; and such rate shall not be changed within two years from the time when they shall be so fixed, unless upon good cause shown. The district court of the proper county, or the judge thereof in vacation, may, in case of refusal to obey the subpœna of the board of county commissioners, compel obedience thereto, or punish for refusal to obey, after hearing, as in cases of attachment for contempt of such district court.

SEC. 5. Every person who shall swear or affirm falsely in any matter or testify falsely after being duly sworn or having affirmed as a witness in any proceeding provided for in this act shall be deemed guilty of perjury, and on conviction shall be punished accordingly.

SEC. 6. All acts and parts of acts inconsistent with this act are hereby repealed; but such repeal shall not work any interference with any proceeding by any board of county commissioners now pending, saving that any such proceeding may, at the request of either party, be carried on to completion under the provisions hereof.

ACT TO PREVENT EXTORTION, ETC., 1887.

SEC. 1. It shall not be lawful for any person owning or controlling, or claiming to own or control, any ditch, canal, or reservoir carrying or storing, or designed for the carrying or storing, of any water taken from any natural stream or lake within this State to be furnished or delivered for compensation for irrigation, mining, milling, or domestic purposes to persons not interested in such ownership or control to demand, bargain for, accept, or receive from any person, who may apply for water for any of the aforesaid purposes, any money or other valuable thing whatever, or any promise or agreement therefor, directly or indirectly, as royalty, bonus, or premium, prerequisite or condition precedent to the right or privilege of applying or bargaining for or procuring such water; but such water shall be furnished, carried, and delivered upon the payment or tender of the charges fixed by the county commissioners of the proper county, as is or may be provided by law. Any and all moneys, and every valuable thing or consideration of whatsoever kind which shall be so as aforesaid demanded, charged, bargained for, accepted, received, or retained contrary to the provisions of this section shall be deemed and held an additional and corrupt rate, charge, or consideration for the water intended to be furnished and delivered therefor, or because thereof, and wholly extortionate and illegal, and when paid or delivered, or surrendered may be recovered back by the party or parties paying, delivering, or surrendering the same from the party to whom or for whose use the same shall have been paid, delivered, or surrendered, together with all costs of suit, including reasonable fees of attorneys of plaintiff, by proper action in any court having jurisdiction.

SEC. 2. Every person owning or controlling, or claiming to own or control, any ditch, canal, or reservoir, as is mentioned in the first section of this act, who shall, after demand in writing made upon him for the supply or delivery of water for irrigation, mining, milling, or domestic purposes, to be delivered from the ditch, canal, or reservoir owned, possessed, or controlled by him, and after tender of the lawful rate of compensation therefor in lawful money, demand, require, bargain for, accept, receive, or retain from the party making such application any money or other thing of value, or any promise or contract or any valuable consideration whatever, as such royalty, bonus, premium, prerequisite, or condition precedent, as is by the provisions of the said first section of this act prohibited, shall be deemed guilty of a misdemeanor, and on conviction thereof shall be punished by fine of not less than one hundred dollars nor more than five thousand dollars, or imprisonment for a term of not less than three months nor more than one year, or both such fine and imprisonment, in the discretion of the court.

SEC. 3. Every person owning or controlling, or claiming to own or control, any ditch, canal, or reservoir such as is mentioned in the first section of this act, who shall, after demand in writing made upon him for the supply or delivery of water for irrigation, mining, milling, or domestic purposes, to be delivered from the ditch, canal, or reservoir owned, possessed, or controlled by him, and after tender of the lawful rate of compensation therefor in lawful money, refuse to furnish or carry and deliver from such ditch, canal, or reservoir, any water so applied for, which water can or may be by use of reasonable diligence in that behalf and within the carrying or storage capacity of such ditch, canal, or reservoir, be lawfully furnished and delivered, without infringement of prior rights, shall be deemed guilty of a misdemeanor, and upon conviction thereof shall be punished by fine of not less than one hundred dollars nor more than five thousand dollars, or imprisonment for a term of not less than three months nor more than one year, or both such fine and imprisonment, in the discretion of the court.

SEC. 4. When any corporation, in defiance or by attempted evasion of the provisions of this act, shall, after tender of the compensation hereinbefore provided for, refuse to deliver water such as is mentioned in the third section of this act to any person lawfully entitled to apply therefor, it shall be the duty of the attorney-general, upon request of the county commissioners of the proper county, or upon his otherwise receiving due notice thereof, to institute and prosecute to judgment and final determination proceedings in *quo warranto* for the forfeiture of the corporate rights, privileges, and franchises of any such corporation so offending, or by *mandamus* or other proper proceedings to compel it to its duty in that behalf.

SEC. 5. The word person as used in this act shall include corporations and associations and the plural as well as the singular number; and every officer of a corporation or member of an association or co-ownership, and every agent violating any of the provisions of this act, shall be liable to restore the unlawful consideration extorted, and be punishable under the penal provisions of this act, the same as if the thing done in disobedience to its provisions were done for his own sole benefit and advantage.

ACT TO REGULATE WATER COMMISSIONER'S BOND, ETC., 1887.

SEC. 1. That section 42 of chapter 57 of the general statutes of the State of Colorado, entitled "Irrigation," the same being general section 1752 thereof, be, and the same is hereby, amended so as to read as follows:

SEC. 42. There shall be one water commissioner for each of the above-named districts, and for each district hereafter formed, who shall be appointed by the governor, to be selected by him from persons recommended to him by the several boards of county commissioners of the counties into which water districts may extend, and the water commissioner so appointed shall, before entering upon his duties, give a good and sufficient bond for the faithful discharge of his duties, with not less than three sureties, in a sum not less than one thousand dollars nor more than five thousand dollars; the amount of said bond to be fixed by the county commissioners and approved by the governor and State engineer. The commissioner so appointed shall hold his office until his successor is appointed and qualified: *Provided, however*, That if such water district shall be embraced in more than one county, and the several counties in which such water district is situated disagree as to the amount of the bond as herein required of water commissioners, then and in that event the governor shall fix the amount thereof, with the same effect as though fixed by the county commissioners.

SEC. 2. The governor shall, by like selection and appointment, fill all vacancies which may be occasioned by death, resignation, or continued absence from the district, removal or otherwise. Said county commissioners may, from time to time, recommend persons to be appointed as above provided, and the governor may at any time remove any water commissioner, in his discretion.

ACT REGULATING DISTRIBUTION OF WATER, ETC., 1887.

SEC. 1. Every person or company owning or controlling any canal or ditch used for the purposes of irrigation shall, during the time from April 15 to November 1 in each year, keep a flow of water therein, so far as may be reasonably practicable for the purpose of irrigation, sufficient to meet the requirements of all such persons as are properly entitled to the use of water therefrom to the extent, if necessary, to which such persons may be entitled to water, and no more: *Provided, however*, That whenever the rivers or public streams or sources from which the water is obtained are not sufficiently free of ice, or the volume of water therein is too low and inadequate for that purpose, then such canal or ditch shall be kept with as full a flow of water therein as may be practicable, subject, however, to the rights of priorities from the streams or other sources, as provided by law, and the necessity of cleaning, repairing, and maintaining the same in good condition.

Sec. 2. The owners or persons in control of any canal or ditch used for irrigating purposes shall maintain the same in good order and repair, ready to receive water by April 15 in each year, so far as can be accomplished by the exercise of reasonable care and diligence, and shall construct the necessary outlets in the banks of the canal or ditch for a proper delivery of the water to persons having paid-up shares or who have purchased rights to the use of the water: *Provided, however,* That a multiplicity of outlets in the canal or ditch shall at all times be avoided, so far as the same shall be reasonably practicable, and the location of the same shall be under the control of and shall be at the most convenient and practicable points consistent with the protection and safety of the ditch for the distribution of water among the various claimants thereof, and such location shall be under the control of a superintendent.

Sec. 3. It shall be the duty of those owning or controlling such canals or ditches to appoint a superintendent, whose duty it shall be to measure the water from such canal or ditch through the outlets to those entitled thereto, according to his or her pro rata share.

Sec. 4. Any superintendent or any person having charge of the said ditch who shall willfully neglect or refuse to deliver water as in this act provided, or any person or persons who shall prevent or interfere with the proper delivery of water to the person or persons having the right thereto, shall be guilty of a misdemeanor, and upon conviction thereof shall be subject to a fine of not less than ten nor more than one hundred dollars for each offense, or imprisonment not exceeding one month, or by both such fine and imprisonment, and the money thus collected shall be paid into the general fund of the county in which the misdemeanor has been committed, and the owner or owners of such ditches shall be liable in damages to the person or persons deprived of the use of the water to which they were entitled, as in this act provided.

Sec. 5. Any water commissioner, or his deputy or assistant, who shall willfully neglect or refuse, after being called upon in accordance with section 1758 of the general statutes of the State, to promptly measure water from the stream or other source of supply into the irrigating canals or ditches in his district, according to their respective priorities, to the extent to which water may be actually necessary for the irrigation of lands under such canals or ditches, shall be deemed guilty of a misdemeanor, and shall be subject to the same penalty as provided in section four of this act.

Sec. 6. In all cases declared misdemeanors by this act, any justice of the peace of the county in which the offense was committed, may, upon complaint being made as is now required by law, issue a warrant directed to any proper officer of the county, for the arrest of any person so charged with any such misdemeanor; and upon the arrest of such person or persons, the justice of the peace before whom such person or persons may be brought for trial shall hear and determine the cause, and if he find the accused guilty, shall assess the fine, and if imprisonment be a portion of the sentence, then to fix the term of imprisonment, or both, as provided in section 4 of this act: *Provided,* The accused may have a trial by jury, which shall be summoned as in cases before justices of the peace for assault and battery.

An Act for Appointment of Water Division Superintendents, 1887.

Sec. 1. That the governor shall appoint a superintendent of irrigation for each of the water divisions now existing within the State, or which may hereafter be created. Such superintendents of irrigation to hold office for a period of two years from the date of their respective appointments, or until their successors may be appointed and qualified. The governor may at any time in his discretion remove said superintendents of irrigation, or any of them and appoint others in their stead for the remainder of said term of two years: *Provided,* That the governor shall not appoint a superintendent of irrigation in any district [division] until the board of county commissioners of some one or more of the counties whose territory or any part of whose territory is included in such water district [division] shall have, at a meeting regularly called and held, adopted a resolution requesting such appointment to be made, and have had the same certified to the governor.

Sec. 2. Said superintendent of irrigation shall have general control over the water commissioners of the several districts within his division. He shall, under the general supervision of the State engineer, execute the laws relative to the distribution of water in accordance with the rights of priority of appropriation as established by judicial decree, and perform such other functions as may be assigned to him by the State engineer.

Sec. 3. Said superintendent of irrigation shall, in the distribution of water, be governed by the regulations of this act and acts that are now in force, but, for the better discharge of his duties, he shall have the authority to make such other regulations to secure the equal and fair distribution of water, in accordance with the rights of priority of appropriation as may in his judgment be needed in his division: *Provided*, Such regulations shall not be in violation of any part of this act, or other laws of the State, but shall be merely supplementary to and necessary to enforce the provisions of the general laws and amendments thereto.

SEC. 4. Any person, ditch company, or ditch owner who may deem himself injured or discriminated against by any such order or regulation of such superintendent of irrigation, shall have the right to appeal from the same to the State engineer, by filing with the State engineer a copy of the order or regulation complained of, and a statement of the manner in which the same injuriously affects the petitioner's interest. The State engineer shall, after due notice, hear whatever testimony may be brought forward by the petitioner, either orally or by way of affidavits, and through the superintendent of irrigation shall have power to suspend, amend, or confirm the order complained of.

SEC. 5. Said superintendent of irrigation shall commence the discharge of his duties in his division as soon as the first water commissioner in any district within his division shall be called out, and shall continue to discharge his duties until the last water commissioner in any district of his division ceases to be needed. Each water commissioner shall report immediately to the superintendent of irrigation of his division when he is called out and when he ceases to be needed, and shall, during the continuance of his duties, be under the control of the superintendent of irrigation of his division. The superintendent of irrigation shall receive as compensation five dollars per day for every day during which he is employed in the discharge of his duties.

SEC. 6. Within thirty days after the appointment of said superintendent of irrigation, it shall be his duty to give bond to the amount of ten thousand dollars for the faithful discharge of his duty, said bond to be approved by the board of county commissioners of the county wherein said superintendent of irrigation may reside, and to be filed in the office of the county clerk and recorder of such county.

SEC. 7. Within thirty days after his appointment said superintendent of irrigation shall send to the clerk of the district court, within his division, of such counties as have had rendered by the district court of such county, judicial decrees fixing the priorities of appropriation of water for irrigation purposes for any water district, a notification of his appointment to such office, and shall request of the said clerk a certified copy of every decree of the district court establishing priorities of appropriation of water used for irrigation purposes within that district. Thereupon it shall be the duty of the clerk within ten days after the receipt of such request from said superintendent of irrigation, to prepare a certified copy of all decrees of such district court establishing priorities of water rights made within that district, under the provisions of the general statutes of the State of Colorado, and transmit the same to the superintendent of irrigation requesting it. Said superintendent of irrigation shall then cause to be prepared a book to be entitled "The register of priorities of appropriations of water rights for water division No. ——, State of Colorado," within which he shall enter and preserve such certified copies of decree. Said superintendent of irrigation shall then, from such certified copies of decree, make out a list of all the ditches, canals, and reservoirs entitled to appropriations of water within his division, arranging and numbering the same in consecutive order according to the dates of their respective appropriations within his division, and without regard to the number such ditches, canals, and reservoirs may bear within their respective water districts. Such superintendent of irrigation shall then enter from his register a tabulated statement of all the ditches, canals, and reservoirs in his division, whose priorities have been decreed, which statement shall contain the following information concerning each ditch, canal, and reservoir, arranged in separate columns: The name of the ditch, canal, or reservoir, its number in his division, the district in which it is situated, the number of it in its proper district, and the number of cubic feet of water per second to which it is entitled, and such other and further information as he may deem useful to the proper discharge of his duty. In case any decrees of court establishing priorities of appropriation of water for irrigation purposes are made after the transmittal of the copy of previous decrees to the superintendent of irrigation, it shall be the duty of the clerk of the court wherein such decree is rendered to transmit to the superintendent of irrigation of the division within which such county is situated, within ten days after it is rendered, a copy of such decree, and the superintendent of irrigation shall enter the same in his register. Such register to be filed and kept in the office of the State engineer.

SEC. 8. Said superintendent of irrigation shall have the right to call out any water commissioner of any water district within his division at any time he may deem it necessary, and he shall have the power to perform the regular duties of water commissioner in all the districts within his division.

SEC. 9. All water commissioners shall make reports to the superintendent of irrigation of their division as often as may be deemed necessary by said superintendent.

Said reports shall contain the following information: The amount of water necessary to supply all the ditches, canals, and reservoirs of that district; the amount of water actually coming into the district to supply such ditches, canals, and reservoirs; whether such supply is on the increase or decrease; what ditches, canals, and reservoirs are at that time without their proper supply; the probability as to what the supply will be during the period before the next report will be required; and such other and further information as the superintendent of irrigation of that division may suggest. Said superintendent of irrigation shall carefully file and preserve such reports, and shall from them ascertain what ditches, canals, and reservoirs are, and what are not, receiving their proper supply of water, and if it shall appear that in any district in that division any ditch, canal, or reservoir is receiving water whose priority post-dates that of the ditch, canal, or reservoir in another district, as ascertained from his register, he shall at once order such post-dated ditch, canal, or reservoir shut down and the water given to the elder ditch, canal, or reservoir. His orders being directed at all times to the enforcement of priority of appropriation, according to his tabulated statement of priorities, to the whole division, and without regard to the district within which the ditches, canals, and reservoirs may be located. The reports of water commissioners, by the superintendent of irrigation, shall be filed and kept in the office of the State engineer.

Sec. 10. In case any ditch, canal or reservoir, in any district within such superintendent of irrigation's division, shall fail to receive its regular supply of water, the owner of such ditch, canal or reservoir may report such fact to the water commissioner of that district, who shall immediately apportion the water in his district, and send forthwith, by telegram if necessary, a report of such fact to the superintendent of irrigation of his division; and thereupon it shall be the duty of the superintendent to compare such report with his register, and if any ditch, canal or reservoir of any other district of his division is receiving water to which any ditch, canal or reservoir of any other district is entitled, he shall at once order the shutting down of the post-dated ditches, canals or reservoirs, and the water given to the ditches, canals or reservoirs having the priority of appropriation: *Provided, however*, That nothing in this act shall be construed as interfering with the priority of water for domestic use.

Sec. 11. Such superintendent of irrigation shall, in the discharge of his duties, be clothed with the powers of justice of the peace, and any person violating his orders relative to the opening or shutting down of head-gates, or the using of water for irrigation purposes, shall be deemed guilty of contempt, and summary punishment may be inflicted, not exceeding ninety days' imprisonment, or three hundred dollars fine, or both.

Sec. 12. The expenses and salary of the superintendents of irrigation shall be paid *pro rata* by the counties interested, in the same manner as the fees of water commissioners are paid; and the fees of the clerks of the district courts, for services rendered under the provisions of this act, shall also be paid by the counties interested, upon the said clerk rendering his account, certified by the district judge, to the boards of county commissioners of the counties embraced in the water divisions, in case of which the services have been rendered.

Act to Protect Water Rights, etc., 1887.

Sec. 1. That it shall be the duty of every person who is entitled to take water for irrigation purposes from any ditch, canal, or reservoir to see that he receives no more water from such ditch, canal, or reservoir through his head-gate or by any ways or means whatsoever than he is entitled to, and that he shall at all times take every precaution to prevent more water than he is entitled to coming from such ditch, canal, or reservoir upon his land.

Sec. 2. That it shall be the duty of every such person taking water from any ditch, canal, or reservoir to be used for irrigation purposes, on finding that he is receiving more water from such ditch, canal, or reservoir either through his head-gate or by means of leaks or by any means whatsoever, immediately to take steps to prevent his further receiving more water from such ditch, canal, or reservoir than he is entitled to, and if knowingly he permits such extra water to come upon his land from such ditch, canal, or reservoir and does not immediately notify the owner or owners of such ditch, or take steps to prevent its further flowing upon his land, he shall be liable in damages to any person, company, or corporation who may be injured by such extra appropriation of water for the actual damage sustained by the party aggrieved, which damages shall be adjudged to be paid together with the costs of suit and a reasonable attorney's fee to be fixed by the court and taxed with the costs.

ACT TO SECURE RIGHT OF WAY, ETC., 1887.

Be it enacted by the general assembly of the State of Colorado:

SEC. 1. That section two (2) of said act (approved February 11, 1881, being general section No. 1720 of the general statutes of the State of Colorado, which is section 10 of chapter 57 of said general statutes, entitled "Irrigation," be, and the same is hereby, amended so as to read as follows:

SEC. 2. Every person, association, or corporation hereafter constructing or enlarging any ditch, canal, or feeder for any ditch or reservoir for irrigation, and taking water directly from any natural stream, and of a carrying capacity of more than one cubic foot of water per second of time, as so constructed or enlarged, shall, within ninety (90) days after the commencement of such construction or enlargement, file in the office of the county clerk and recorder of the county in which the head-gate of such ditch or feeder may be situated, and also in the office of the State hydraulic engineer, a map showing the point of location of such head-gate, the route of such ditch or canal, or the high-water line of such reservoir or reservoirs, and the route of the feeder to and ditches or canals from such reservoir or reservoirs; the legal subdivisions of the lands upon which such structures are built or to be built, if on surveyed lands; the names of the owners of such lands as far as the same are of record in the office of the county clerk of the county in which they are situated; such courses, distances, and corners, by reference to legal subdivisions, if on surveyed lands, or to natural objects if on unsurveyed lands, as will clearly designate the location of such structures. Upon or attached to such map shall be a statement showing:

First. The point of location of the head-gate above mentioned.

Second. The depth, width, and grade of such ditch, canal, or feeder.

Third. The carrying capacity of such ditch, canal, or feeder, in cubic feet per second of time, and the capacity of such reservoir or reservoirs in cubic feet when filled to the high-water mark.

Fourth. The time of commencement of work on such structures, which time may be dated from the commencement of the surveys therefor. In case of an enlargement, such statement shall also show the matters required in items second, third, and fourth above, as to the enlargement, and state the increased capacity arising from such enlargement. If such statement be filed within the time above limited priority of right of way and water accordingly shall date from the day named as the day of commencing work; otherwise only from the date of the filing of the same: *Provided*, That nothing herein contained shall be taken to dispense with the necessity of due diligence in the prosecution of such structures on the part of the projectors of the same. Such statement shall be signed by the person, association, or corporation on whose behalf it is made, and the truth of the matters shown in such map and statement shall be sworn to by some person in whose personal knowledge the truth of the same shall lie.

DAKOTA IRRIGATION LAWS.

[The Territorial laws have been adopted in both North and South Dakota.]

WATER RIGHTS.

SEC. 2029. Any person or persons, corporation or company, who may have or hold a title or possessory right or title to any mineral or agricultural lands within the limits of this Territory shall be entitled to the usual enjoyment of the waters of the streams or creeks in said Territory for mining, milling, agricultural, or domestic purposes: *Provided*, That the right to such use shall not interfere with any prior right or claim to such waters when the law has been complied with in doing the necessary work.

SEC. 2030. When any persons, corporation, or company owning or holding land, as provided in section 2029, shall have no available water facilities upon the same, or whenever such lands are too far removed from any stream or creek to so use the waters thereof as aforesaid, such person or persons, corporation or company shall have the right of way through and over any tract or piece of land for the purpose of conducting and conveying said water by means of ditches, dikes, flumes, or canals, for the purpose aforesaid.

SEC. 2031. Such right to dig and construct such ditches, dikes, flumes, and canals over and across the lands of another shall only extend to so much digging, cutting, or excavation as may be necessary for the purposes required.

SEC. 2032. In all controversies respecting rights to water under the provisions of this act the same shall be determined by the date of appropriation as respectively made by the parties, whether for mining, milling, agricultural, or domestic purposes.

SEC. 2033. The waters of the streams or creeks of the Territory may be made available to the full extent of the capacity thereof for mining, milling, agricultural, or domestic purposes, without regard to deterioration in quality or diminution in quantity, so that the same do not materially affect or impair the rights of the prior appropriator.

SEC. 2034. Any person or persons, corporation or company, damaging or injuring the lands or possessions of another by reason of cutting or digging ditches or canals or erecting flumes as provided by section 2030, the party so committing such injury or damage shall be liable to the party so injured for the actual damage occasioned thereby.

SEC. 2035. This act shall not be so construed as to impair or in any way or manner interfere with the rights of parties to the use of the waters of such streams or creeks acquired before the passage of this act: *Provided*, That all water rights or ditches that have not been used or worked upon for one year next prior to the passage of this act shall be deemed abandoned and forfeited and subject to appropriation anew. Any person or persons, corporation or company who may dig any ditch or canal, dike, or flume over or across any public road, trail, or highway, or who use the waters of such ditch, dike, flume, or canal shall be required to bridge the same and keep the same in good repair at such crossing or other places where the water from any such ditch, dikes, flumes, or canals may flow over or in anywise injure any road, trail, or highway, either by bridges or otherwise.

SEC. 2036. Any person or persons, corporation or company offending against section 2035, on conviction thereof shall forfeit and pay for every such offense a penalty of not less than twenty-five dollars nor more than one hundred dollars, to be recovered with costs of suit in civil action in the name of the Territory of Dakota, before any court having jurisdiction. One-half of the fine so collected shall be paid into the county treasury of the county in which the offense was committed, and the other half shall be paid to the person or persons informing the nearest magistrate that such offense has been committed. All such fines and costs shall be collected without stay of execution, and such defendant or defendants may by order of the court be confined in the county jail until such fine and costs have been paid.

SEC. 2037. Any person or persons, corporation or company appropriating the waters of any streams or creeks in this Territory shall turn the water from the channel of such creek or stream, and construct at least twenty feet of ditch or flume, within thirty days from the date of appropriation, and turn the water therein; and construct at least twenty rods of said ditch or flume, if needed, within six months from the date of such appropriation, and turn the water therein; and within twenty days from the date of location, the locator or locators of such water right shall file a location certificate thereof with the register of deeds in the proper county within which such water right is situated; a copy of such certificate shall be posted at or near the head of such ditch, flume, or canal, and shall contain the name or names of the locators, the date of location, number of inches of water claimed or appropriated, and the purpose of the appropriation; and in no case shall the number of inches of water claimed exceed the conveying capacity of the first twenty feet of the flume or ditch, nor shall said ditch or flume be enlarged to the prejudice or injury of a subsequent appropriator before such enlargement.

SEC. 2038. On failure to commence the construction of such ditch or flume for sixty days after location, and prosecute such ditch, canal, or flume to final completion without unnecessary delay, such appropriation shall be deemed abandoned.

SERVITUDES.

SEC. 2760. The following land burdens or servitudes upon land may be attached to other land as incidents or appurtenances, and are then called easements:

* * * * * * *

4. The right of way.
5. The right of taking water, etc.

* * * * * * *

9. The right of receiving water from or discharging the same upon land.
10. The right of flooding land.
11. The right of having water flow without diminution or disturbance of any kind.

RIGHTS AND OBLIGATION OF OWNERS.

SEC. 2771. The owner of land owns water standing thereon or flowing over or under its surface, but not forming a definite stream. Water running in a definite stream, formed by nature over or under the surface, may be used by him as long as it remains there; but he may not prevent the natural flow of the stream, or of the natural spring from which it commences its course, nor pursue nor pollute the same.

ARTESIAN WELLS.

SECTION 1. [*Commissioner created.*] That for the purpose of carrying into effect the provisions of this act, the judge of probate of each county shall be *ex officio* county artesian well commissioner, which office is hereby created.

SEC. 2. [*Application by ten resident freeholders.*] Before the artesian well commissioner shall take any action toward creating or establishing any artesian well, there shall be filed with him an application, signed by not less than ten resident freeholders of any township or townships in which such artesian well and the lands to be benefited thereby and to be assessed therefor may be situated, giving a description of the place where said well is proposed to be located, and also a definite description of the beginning, the route, and the terminus of the water-way through which it is proposed that the water from such well shall flow when the same is completed and in operation, and offering the right of way for said well and such water-way through their said land, and who shall be subject to direct assessment therefor.

SEC. 3. [*Appointment of viewers—duties.*] At the expiration of twenty days after the filing of such application the said commissioners shall appoint three disinterested persons as viewers who shall without unnecessary delay proceed to personally examine the place where said well is to be located and the course, route, and terminus of said proposed water-way, and shall ascertain whether said location of such well and establishment of said water-way is practicable and necessary and beneficial to the public welfare of the district in which the same is proposed to be located, and shall report the result of such investigations in writing to said well commissioner, having first been duly sworn to faithfully and impartially discharge their duties as such viewers. If any person upon whose land the proposed well is located, or through whose land any water-way therefrom may pass, shall have filed any protest against the location of said proposed well and water-way, prior to the appointment of said viewers, they shall assess the damages, if any, which such person may sustain from the location of such well or said water-ways through his land, and shall report said damages with the report of their proceedings made as heretofore provided.

SEC. 4. [*Report when damages assessed.*] If a majority of the viewers assess and report damages in favor of any person protesting against the location of such well or its water-ways, their report shall be presented to the board of county commissioners of said county, and if said board shall consider the proposed well of sufficient importance to the public they shall order the costs and damages to be paid out of the county treasury; but if a majority report against the claims for damages of such person he shall be liable for the costs of such appraisement.

SEC. 5. [*Power of county commissioners.*] If it shall be made to appear to the board of county commissioners that the damages assessed are unreasonable they may set aside such assessment, and in such case the artesian-well commissioner may order another appraisement by different persons, under the same regulations as provided in the first appraisement.

SEC. 6. [*Appeal to district court.*] Any person aggrieved by any decision of any board of commissioners had under this chapter may appeal therefrom to the district court, the same as provided relating to highways, bridges, and ferries. (Section 29, chapter 29, Political Code, 1217 General Laws.)

SEC. 7. [*Fee of viewers.*] The viewers appointed under the provisions of section 3 of this act shall receive the sum of two dollars per day for their services as desribed in said section, to be paid by the persons who signed the application for said well, who shall be severally liable to pay the same.

SEC. 8. [*Survey after favorable report—plat filed.*] If the viewers make and file a written report with said commissioners recommending said location and route as practicable, necessary, and beneficial the commissioners shall cause a survey and measurement of the location of said well and the line of the proposed water-way to be made by the county surveyor, and a plat thereof shall be filed in the office of the register of deeds of said county, and be subject to public inspection, and shall show the location of the well and the lines and route of the water-way therefrom.

SEC. 9. [*Order of location by commissioner—damages.*] Upon the filing of the plat and the minutes of said survey as provided in said section 5, the said commissioner shall make an order in writing in which he shall declare said well and water-ways therefrom to be located in accordance with said plat and survey: *Provided*, That in cases where damages have been appraised and assessed, the same shall first be paid to the person entitled thereto, or paid into the county treasury for their use, before such lands shall be actually taken.

SEC. 10. [*Railway's contribution to water-way—penalty—collection.*] Whenever it is necessary to construct a water-way from any artesian well across the right of way or road-bed of any railroad company it shall be the duty of the railroad, when notified by the commissioners to do so, to make and maintain the necessary opening through said road-bed, and to build and maintain a suitable culvert. Notice in writing to make such opening and to construct such culvert may be served on such company as provided in the service of summons, at least thirty days before such railroad company shall become liable.

In case such railroad company shall refuse or neglect to comply with the provisions of this section, it shall be liable to a penalty of ten dollars for each day's refusal or neglect to make such opening and construct such culvert. The district attorney of the county in which such railroad company shall have refused or neglected to comply with the provisions of this section, shall upon complaint being made by the artesian-well commissioner bring suit to collect such penalty or fines, and it shall be his duty to prosecute the same to a final determinatin in any court having competent jurisdiction.

SEC. 11. [*Duty of road overseers, etc.*] All that part of such artesian well or artesian-well water-course, which is laid and constructed within the limits of or across any public highway shall be under the jurisdiction of the overseer of public highways or road supervisors, and it shall be his duty to keep the same open and free from all obstructions, and when any highway is subsequently constructed along or across such artesian-well water-way then so much thereof as shall come within the limits of such highway shall also be kept open and free from obstructions as above provided.

SEC. 12. [*Name of well.*] In his order locating any well under the provisions of this act the artesian-well commissioner shall give the same a name by which it shall be known and recorded.

SEC. 13. [*Advertise for bids for construction—contract—security.*] After making said order locating said well and the water-ways thereof, the artesian-well commissioner shall proceed to advertise for bids for contracts for sinking or making such well, and constructing said water-ways. He shall give not less than sixty days' notice of the time and place where such bids may be offered and opened, by causing a notice thereof to be published, not less than eight weekly insertions, in the official paper of said county, such bids shall be filed with the county clerk of said county by the parties making the same, and shall be taken subject to the approval of the board of county commissioners of said county. No contract made by the artesian well commissioner shall be valid unless approved by the board of county commissioners of such county, and their approval indorsed thereon by the chairman of said board.

The artesian well commissioner shall contract with the lowest responsible bidder giving adequate security for the performance of the work.

Such security shall cover the completion of the job in the manner and within the time fixed in the contract, and the amount thereof shall be fixed by said artesian-well commissioner. Said commissioner shall reserve the right to reject any and all bids, and may adjourn the time for receiving such bids from time to time by publishing a notice of such adjournment, but not in all more than sixty days from and after the time named in the first advertisement for receiving such bids. The contract for sinking the well may be separate from the contract for constructing the water-ways, and may be let to different persons. Whenever any such artesian well shall have been fully completed and final report thereof made by the well commissioner to the board of county commissioners, the said board shall turn over the control and management of said well and appurtenances to the board of supervisors of the township wherein said well is situated.

SEC. 14. [*Board of assessment—meetings.*]—Immediately after making his order locating said well, the artesian-well commissioner shall notify the chairman of the board of county commissioners and the county treasurer of said county, who shall, together with said well commissioner, constitute a board of assessment herein. The county clerk of said county shall be the clerk of said board of assessment. The members of said board shall meet within twenty days after receiving said notice, and may adjourn from day to day until their duties are performed as hereinafter set forth.

SEC. 15. [*Mode of assessment and apportionment—tax collection.*]—The said board of assessment shall make an estimate of the costs of constructing said artesian well and the said water-ways, for the purpose of raising the funds necessary for the construction of said well. They shall have power to apportion the costs thereof as follows:

(1) They shall create a county fund to be known as the artesian well fund, and may levy an assessment upon all taxable property in said county, not exceeding two mills on the dollar, and the basis of value upon which the annual levy of the current or preceding year was made: *Provided*, That not more than one-tenth of the cost of any artesian well, or water-ways therefrom, shall be paid out of said fund, and the amount so paid shall be applied to the payment of the expenses and per diem of the well commissioners, the viewers, surveyors, members of the board of assessment, damages for right of way, and other like incidental expenses.

(2) They shall determine what portion of the costs of said well and its water-ways shall be paid by each of the townships in which said well or said water-courses therefrom are situated: *Provided*, That in no case shall the amount apportioned to any one township exceed one-fourth of the estimated cost of such well and water-ways,

and the county clerk shall present a statement of such amount to the respective clerks of such townships if organized; and said board of assessment shall establish and determine the rate of assessment necessary in such townships to raise the amount so apportioned to such townships. It shall then be the duty of the officers of such townships, who have similar duties to perform in other matters of township revenue, to levy, and they are hereby empowered to levy, an assessment upon the taxable property of said township, not exceeding the rate fixed by the board of assessment for such township, which shall be placed upon the tax list under the head of "General township tax for artesian well purposes," and collected as other township taxes are collected, and shall be held by the county treasurer when collected as a distinct fund to be disbursed, as hereinafter provided, to pay for constructing such well.

(3) In addition to the foregoing general township and county assessments, the said board of assessment shall also make a special assessment against each piece and parcel of land directly benefited by said well and said water-courses, carefully adjusting the per cent. and amount of such assessments with reference to the relative distance of such lands from the well itself and the water-courses, and the amounts so apportioned shall be levied as a special tax upon said land, and shall be placed upon the tax list by the county clerk or auditor under the head of "Direct tax for artesian well," and shall be paid into the county treasury as other taxes, and kept by said treasurer in a special fund to pay for the cost of constructing said well and said waterways; said assessment shall be for a sufficient amount with the general county and township tax aforesaid to pay for said well and water-ways.

SEC. 16. [*Annual installments.*]—Said board of assessment may provide that the entire amount necessary to pay for the construction of said well and water-courses be levied and collected as above in one year, or they may divide the same into two, three, four, or five equal installments, one of which shall be collected the first year, and one installment each year following, provided that the portion designated as county and township tax shall all be collected the first year.

SEC. 17. [*Review of assessment—appeal.*]—The owner of any lands directly assessed for the construction of any artesian well under the provisions of this act, who may feel aggrieved by such assessment, may at any time before such tax becomes delinquent appear before the board of county commissioners of the county in which such assessment was made, and ask to have said assessment as to his property reviewed, and said board shall have the right to raise or lower his assessment, so as to make it just and reasonable, and an appeal may be taken from the action of said board as in other cases.

SEC. 18. [*Disqualifications by interest—vacancy—how filled.*] No member of any county board, and no county officer, whose lands have been directly assessed under this act, shall act on the board of assessment. In case any member of such board is so disqualified, his place shall be filled by calling in the sheriff of said county, or, if said sheriff is so disqualified, the county coroner may act on said board.

SEC. 19. [*Benefits—principle of assessment.*] All assessments of benefits under the provisions of this act shall be upon the principle of benefits derived. All descriptions of land under the provisions of this act shall be made by giving the legal subdivision thereof whenever practicable, and when the tract of land which is to be benefited or affected by such well is less than such legal subdivision it may be described by designation of the lot or other boundaries, or in some way by which it may be known.

SEC. 20. [*Additional assessment.*] Whenever the amount assessed for the construction of any well shall not be sufficient to complete the same, and to pay all the costs and incidental expenses, a further assessment shall be made to meet the deficit or additional expense. Such further assessment shall be apportioned, assessed, levied, and collected as provided in the first instance, and on the same percentage, and shall be collected in one year.

SEC. 21. [*Enrollment of tax by clerk.*] It shall be the duty of the county clerk to spread on his roll the total amount of all the well taxes determined upon by the board of assessment, to be assessed upon any township at large, as a part of the township tax for the year, and he shall also spread upon said roll separately, and immediately following the other descriptions, all tracts or parcels of land specially assessed for benefits, and shall place opposite each description the amount of taxes apportioned thereon for such benefits. All wells shall be entered separately, naming each well.

SEC. 22. [*Collection—mode of.*] All taxes assessed under the provisions of this act shall be collected in the same manner as Territorial and other general taxes are collected, and collecting officers are hereby vested with the same power and authority in the collection of such taxes as are or may be conferred by law for collecting general taxes. All taxes levied under the provisions of this act, with all lawful costs, interests, and charges, shall be and remain a perpetual lien upon the lands upon which they are assessed, and a personal claim against the owner or owners of such lands until they are paid.

SEC. 23. [*Sale for delinquency.*] If the taxes levied for the construction of any well are not paid to the county treasurer as provided herein, he shall proceed to sell the said lands for such taxes, at the same time and in the same manner in every respect, as in the case of any other tax and with like effect.

SEC. 24. [*Compensation of officers.*] The artesian-well commissioner and the members of the board of assessment herein provided for shall receive for their services a sum not to exceed three dollars per day for each day actually and necessarily spent by them in the discharge of their respective duties as hereinbefore described. All expenses, except on contract for constructing said well or such water-courses, shall be paid out of the general fund of the county on the order of the board of county commissioners, as other claims against the county are paid; said fund to be reimbursed out of the first money collected under the provisions of subdivision 1 of section 15 of this act.

SEC. 25. [*Blanks drawn by attorney-general.*] It shall be the duty of the attorney-general to draught a complete set of all the blank forms that may be required under this act, and county clerks are authorized, and it shall be their duty, to procure at the expense of their respective counties the necessary books and blanks to carry out the provisions of this act.

SEC. 26. [*Mode of payment to contractor.*] No payment shall be made to any person contracting to construct or sink an artesian well or any water-course therefrom under the provisions of this act except as follows: One-third of the amount to be paid for the entire performance of the contract may be paid when one-third of said work is done; one-third of said amount may be paid when two-thirds of said work is completed; but the balance of said amount shall not be paid until said contract has been fully completed and the work accepted and approved by the artesian-well commissioner. The said payments shall be made in the following manner: The contractor shall make a statement of the amount claimed by him to be due under his contract, and if the same is correct it shall be approved by the artesian-well commissioner, whose duty it shall be to carefully examine the work done under said contract; said claim so approved shall be presented to the board of county commissioners, and if correct, they shall issue county orders or warrants upon the well funds of each particular well, naming it: *Provided*, That if the assessment of taxes for such well has been divided into installments, as provided in this act, said board shall not issue orders payable in any one year for a larger amount than the said installment for that year, but shall draw as near as may be to the exact amount of such installment. When such orders or warrants are presented to the county treasurer for payment, if he has not yet received sufficient funds to pay the same, then such orders may be indorsed and registered as other county warrants under the general law, and shall bear the same rate of interest as other warrants.

SEC. 27. [*Description of assessed lands filed with register—lien.*] The clerk of the board of assessment provided for in this act shall make a statement of the direct assessment for benefits made against the several pieces and parcels of lands, giving a description of such lands, the amount of the direct assessment against each piece or parcel, the name of the well for which the assessment was made, and shall file the same with the register of deeds of said county, and the same shall thereafter be a lien upon said lands to secure the payment of any orders or warrants issued as herein provided; which lien may be foreclosed by the holder of such warrants or orders, and shall be prior to all other liens except for taxes.

SEC. 28. [*Water-course unobstructed, duty of overseer of highways.*] It is hereby made the duty of every person through whose land any water-course constructed under this act may pass to keep the same open and unobstructed. On failure so to do, any person aggrieved may complain to the overseer of highways in the district where such water-course is situated, and such overseer shall have the authority, and it is hereby made his duty, to call out the persons residing in said district who are liable for road tax, and open said water-way, and the expense thereof shall be entered by the county clerk as a tax against said land.

SEC. 29. [*Repeal.*] All laws heretofore enacted on the subject of artesian wells are hereby repealed: *Provided*, That all proceedings heretofore had and all contracts made under the provisions of existing laws on the subject of artesian wells are hereby declared to be valid and may be continued and completed under the provisions of this act.

SEC. 30. [*Effect when.*] This act shall take effect on the 1st day of July, 1889.

Approved March 8, 1889.

IDAHO IRRIGATION LAWS.

The general laws of Idaho, 1881, in an act regulating rights to the use of water for mining, agricultural, manufacturing, and other purposes, contain the following provisions, and which have been adopted as part of the State laws:

SECTION 1. The right to the use of water flowing in a river, creek, cañon, ravine, or other stream may be acquired by appropriation, and as between appropriations priority in time shall secure the priority of right.

SEC. 2. The appropriation must be in good faith, for some useful and beneficial purpose, and when once perfected, may be converted or changed to any other beneficial use than that originally designated or for which it may have been employed.

SEC. 3 The appropriator, or his or their successors in interest, may change the place of diversion, if the rights acquired by others are not interfered with, and no injury to others results therefrom, and may also extend any ditch, canal, flume, pipe, or other conduit to points or places beyond such as may have accrued prior to such extension.

SEC. 4. A person, company, or corporation desiring to appropriate water must post a notice in writing in a conspicuous place, at the point of intended diversion, stating—

First, the quantity of water intended to be claimed and diverted, giving the number of inches, measured under a 4-inch pressure, and accurately describing the point of its diversion.

Second, the purpose for which the same is claimed or intended to be used, and the point or place of such intended use.

Third, the means which are designed to be employed for diverting and conducting the waters, and the size or dimensions of the ditch, canal, pipe, flume, or other conduit. A copy of the notice, within the time allowed for a mining claim, must be furnished to the county officer for record.

SEC. 5. Within sixty days after the notice is posted the claimant or his or their successors in interest must commence the making, digging, or constructing of the ditch, canal, flume, or other conduit, the work for the complete diversion and conducting of the water shall be prosecuted diligently and without unnecessary interruption: *Provided*, That when the work can not be carried on by reason of unavoidable natural causes, such as the state of the weather or action of the elements, this section shall not be applicable.

SEC. 6. By "complete diversion" is meant the conducting of the water claimed to the place of intended use, or to such other place as may have been adopted, and an actual beneficial use made.

SEC. 7. By compliance with the above conditions and requirements the appropriation is perfected, and the right to the use of the waters claimed, which the ditch, canal, flume, or other conduit is capable of conducting, is declared to relate back to the time of the posting of notice of claim: *Provided*, That nothing contained in this section shall be so construed as to render any person or party liable to damages or to make compensation to any appropriator for any waters used prior to the time of a "complete diversion."

SEC. 8. All ditches, canals, and other works heretofore made, constructed, or provided, and by the means of which the waters of any stream have been diverted and applied to any beneficial use, shall be taken to have secured the right to the waters claimed to the extent of the quantity which the works are capable of conducting, and not exceeding the quantity claimed, without regard to or in compliance with the requirements of this act.

SEC. 9. In case where any person, company, or corporation have heretofore made claim to divert the waters of any stream and the same has not been forfeited or abandoned, and have not cut, excavated, made, or constructed the necessary ditch, canal, flume, or other conduit to carry such waters and apply the same to a beneficial use, such claimant must, within four months from and after the date of the approval of this act, commence work in pursuance with the requirements, and carry the same to completion, or at the expiration of the time or upon failure to prosecute the work in the manner required, the claim shall cease to be of any validity as to the foundation of a right to the waters of any stream.

SEC. 10. All persons, companies, and corporations owning or claiming any lands situated on the banks or in the vicinity of any stream shall be entitled to the use of the waters for the purpose of irrigating the land so held or claimed.

SEC. 11. Whenever any such owner or claimant to land has not sufficient length of frontage on a stream to afford the requisite fall for a ditch, canal, or other conduit in his own premises, or where the land proposed to be irrigated is back from the banks of the stream and convenient facilities for watering the land can not be had, the owner or claimant shall be entitled to the right of way through the lands of others for the purposes of irrigation: *Provided*, That in making, constructing, keeping up, and maintenance of the ditch, canal, or conduit through the lands of others, the person, company, or corporation and those succeeding to the interest of the same shall keep the ditch, canal, or other conduit in good repair, and shall also be liable to the owners or claimants of the lands crossed for all damages which may be occasioned by an overflow or result from any neglect or accident (unless the same be unavoidable).

SEC. 12. In case of the refusal of the owners or claimants of any lands through which such ditch, canal, or other works are proposed to be made or constructed, to allow a passage, the persons, company, or corporation desiring the right of way may present a petition to the county commissioners describing the lands to be crossed, the size of the ditch, canal, or works, the quantity of land required, giving the names of the owners or parties interested, and asking for appointment of three appraisers to ascertain the compensation to be made. When the petition is filed the county commissioners shall give notice, either by newspaper publication or notices in three public places, one the county seat, that the appraisers will be appointed, unless good cause be shown by the parties adversely interested why the petition should be denied. The notice must be published or posted not less than thirty days prior to the hearing, and the expense defrayed by the petitioners.

SEC. 13. The appraisers shall impartially hear the proofs and allegations offered by the respective parties, and, after viewing the lands and premises, shall ascertain and certify the compensation proper to be paid for the right of way to the parties owning or interested in the lands to be crossed and the damages, if any, after making allowance for real or direct benefits which the owner or party interested may desire from the making of a ditch, canal, or other works. They, or a majority of them, shall subscribe the certificate, and it shall be recorded in the county recorder's office, and upon the payment or tender of the compensation and damages, if any, or the deposit of such amount in the county treasury to the credit of the party or parties interested, the persons, companies, or corporations shall have the right of way for the proposed ditch, canal, or other works.

SEC. 14. All persons, companies, or corporations owning or having the possessory title or right to lands adjacent to any stream, shall have the right to place in the channel of or upon the banks or margin of the same, rams or other machines for the purpose of raising the water to a level above the banks of such heights as may be requisite for its flow to and upon the lands, and the right of way over and across the lands of others for conducting the water may be acquired in the manner heretofore mentioned.

SEC. 15. Where the owners of any spring or the appropriators of any stream may desire to conduct the waters to any lands for irrigation, or to any city or town for the use of the inhabitants, or to any factory, or to any distant place, with the intent to apply the same to a beneficial use, and where to accomplish the object it may be necessary to cross with ditches, flumes, or other conduit the lands owned and occupied by others than the owners or appropriators of the spring or stream, the right of way over and across the lands of others may be acquired in the manner prescribed in the preceding section.

SEC. 16. The owners or constructors of ditches, canals, works, or others aqueducts, and their successors in interest, using and employing the same to convey the waters of any stream or spring, whether the ditches, canals, works, or aqueducts be upon the lands owned or claimed by them or upon other lands, shall keep and maintain the same, and the embankments, flumes, or other conduit by which the waters are or may be conducted, in good repair and condition, so as not to damage or in any way injure the property or premises of others.

SEC. 17. Nothing in this act shall be so construed as to interfere with or impair the rights to water appropriated and acquired prior to the passage of this act, but this reservation in behalf of existing rights shall not exempt such appropriatiors from liability as heretofore provided.

SEC. 18. In case the volume of water in any stream shall not be sufficient to supply continually the wants for irrigating purposes of the owners or proprietors of land in any district or neighborhood in which customs exist for distributing the waters amongst such owners or proprietors, the water diverted shall, in such case, be held to be a common right in those accustomed to a participation in the use and enjoyment of the distribution, and such custom shall be upheld in all courts as conferring the common right in the same: *Provided*, That this section shall not be construed to affect any prior vested right.

SEC. 19. In case any person, company, or corporation shall have constructed a ditch for the purpose of directing the water of any river, creek, cañon, ravine, or spring, for the purpose of selling the water for irrigating purposes, the owners or cultivators of land along the line of, and covered by, the ditch or canal shall be entitled to, and have the right to, the use of water for the purpose of irrigating in the following order: First, all persons through whose land the ditch or canal runs shall be entitled to the use of the water in the order of their location; second, after those through whose land the ditch or canal runs, those upon either side of the line of the ditch or canal shall be entitled to the use of the water; those equally distant from the line shall be entitled to priority in the order of their location along the line: *Provided always*, That the owners or cultivators of such lands shall pay the usual and customary rates for the use of the water, and whenever any ditch or canal has been constructed for the purpose of conveying water and selling the same for irrigating purposes it shall be unlawful for the owner or owners to change the line so as to prevent or interfere with the use of water by any one who, prior to the proposed change, had used water for irrigating purposes. And it is the duty of the owner or owners to keep the same in good repair, and to cause the water to flow through to the extent of its capacity, provided so much may be needed during the entire time that water may be necessary for irrigating purposes: *And provided further*, That the river, creek, cañon, ravine, or spring from which the water is taken furnishes an amount of water sufficient for such purpose, subject to the appropriation of the owner or owners of the ditch or canal. For a failure to cause the water to flow, the owner or owners or lessees of any such ditch shall be personally liable to any one for any danger resulting from the failure; and in addition to personal liability the damages shall be a lien upon the ditch or canal, which shall continue in force until the damages are paid. No person entitled to the use of water from any such ditch or canal shall, under any circumstances, use more water than good husbandry shall require for the crop or crops that he shall cultivate; and any person using an excess of water shall be liable to the owner or owners for the value of the excess, and, in addition, shall be liable to all damages sustained by any other person who would have been entitled to the use of the excess of water.

The General Laws of 1881, in an act regulating the distribution of water for purposes of irrigation, in substance is as follows:

SECTION 1. The inhabitants of any vicinity or neighborhood who use the waters of any ditch, stream, or spring for the purpose of irrigation, or have or claim a common right to the same for such purposes, shall constitute a water district, and a majority of the inhabitants having the common right may annually, on the fourth Monday of March, elect a water-master, whose duties shall be to superintend the distribution of the waters among those having the common right. The water-master shall file a bond, faithfully to perform his duties, in the sum of $500, with two sufficient sureties in the county recorder's office of the county wherein the district is situated, and he shall employ one or more deputies, as authorized by the inhabitants of his district, and they shall receive such compensation as the inhabitants agree upon.

SEC. 2. The owner or owners of any ditch for the distribution and sale of water for the purposes of irrigation shall employ a water-master for the distribution of the water of the ditch to the persons purchasing the same for such purposes, and no account or demand for the use of the water during any time the water-master is not so employed shall be valid or collectible.

SEC. 3. The water-master and his deputies shall regulate the distribution of water among the several ditches of his district and among the several inhabitants entitled and accustomed to the use according to their respective rights and necessities, and when the quantity of water is not sufficient to afford a supply to those entitled to it, the water-master and his deputies shall regulate the quantity to be used by each person and the time at and during which each person may use the same: *Provided*, That nothing in this act shall be so construed as to interfere with the individual right of companies or corporations, or in any manner interfere with the rights of individuals, companies, or corporations, to the use and control of water which is or may be their private property.

SEC. 4. Where a ditch is common property, or there is a common right to the use of the water of a ditch without payment, and any labor or materials are necessary for the repair or cleaning of the ditch, or any gate or flume on or belonging to it, the water-master may make a fair pro rata assessment of labor or materials against the inhabitants of the district claiming the use of such water according to the benefits received by each, and if any person so assessed shall neglect or refuse, for the period of ten days after notice, to furnish his just proportion of labor or materials, he shall forfeit all rights to the use of the water from the ditch for the year in which he shall make such defaults.

SEC. 5. The water-master shall see that there are provided the necessary and proper head-gates and dams, and that the water is turned and runs into the ditches of his district at the proper season of the year; and he may require all persons receiving water to construct proper gates at the points at which they take water from any ditch, dam, or reservoir; and he shall have such control of the location of ditches and gates as may be necessary to secure the most equitable distribution of the water among those entitled to its use.

SEC. 6. Any person who shall, without the consent of the water-master of the district, divert any water from the ditch or channel where it was placed or caused or left to run by the water-master and his deputies, or who shall shut or open any ditch, gate, or dam with intent so to divert any water, and thereby deprive any person of the use of the same during any part of the time he is entitled to it, or who shall cut any ditch or the banks thereof, or break or destroy any gate or flume, shall be fined not less than five nor more than twenty dollars, and shall be liable to any person injured in three times the actual damage sustained.

IN KANSAS.

Irrigation companies have the right of way through any lands or lots, and, with the consent of the municipal authorities, through any street, alley, or public ground of any city of the second or third class, and may use as much water as is necessary for the purpose for which they were organized, but no injury shall result to milling or other improvements already constructed. Any such company may sell or lease any portion of its water, transmit power by shafting, etc., borrow money necessary for completing and operating its works, issue bonds therefor, and mortgage the company property as security, enter upon any property for the purpose of making surveys, hold voluntary grants made in aid of the construction and maintenance of the works, construct a canal not more than 50 feet wide, and furnish water at such rates as its by-laws may prescribe.

Any person or company furnishing water to irrigate any land shall have a lien for payment upon the crops grown thereon.

Any person wilfully injuring any irrigating canal, the right of way having been secured, is guilty of a misdemeanor and may be punished by fine or imprisonment.

MONTANA IRRIGATION LAWS.*

Revised Statutes, 1879, in the fifth division of general laws, Chapter XV, on corporations for industrial or productive purposes, Article I, contains provisions in substance as follows:

SEC. 271. Whenever any three or four persons form a company for constructing a ditch for the purpose of conveying water to mines, mills, or lands, for the use of mining, milling, or irrigation of lands, they shall in their certificate specify as follows: The stream or streams from which the water is taken; the point or place on said stream at or near which the water is to be taken out; the line of said ditch, as near as may be, and the use to which the water is intended to be applied. For other details of certification see section 244.

SEC. 272. Any ditch company shall have the right of way over the line named in the certificate, and the right to run the water of the stream or streams through their ditch: *Provided*, That the proposed line shall not interfere with any other ditch whose rights are prior; the water of any stream shall not be diverted from its original channel to the detriment of any miners or mill-men or others along the line of the stream who have priorority of right.

SEC. 273. Any company constructing a ditch shall furnish water in the way and manner named in the certificate designated to be used, whether miners, mill-men, or farmers, whenever they shall have water in their ditch unsold. They shall give the preference at all times to this class of persons, the rates for furnishing water to be fixed by county commissioners or the tribunal transacting county business as soon as the ditch is completed and prepared to furnish water.

SEC. 274. Every ditch company organized shall keep the banks of their ditch in good condition, so that the water will not escape and injure any mining claim, road, ditch, or other property; and whenever it is necessary to convey any ditch over, across, or above any lode or mining claim the company shall flume the ditch, if necessary, to keep the water out or from any claim, so far as it is necessary to protect the claim or property from the water of the ditch.

SEC. 275. When any company shall organize to form a company to construct a flume, their certificate shall, in addition to details required by previous sections, specify as follows: The place of beginning, termini, and route, as near as may be, and the purpose for which the flume is intended; and when organized, the company shall have the right of way over the line proposed for the flume, provided it does not conflict with the right of any former fluming, ditching, or other company.

* * * * * * *

SEC. 279. Any company formed for the purpose of constructing any ditch or flume shall commence work within sixty days from the date of their certificate, and shall prosecute the work with due diligence until the same is completed; the time of completion shall not extend beyond three years from the time the work was commenced; and the company failing to commence work within sixty days of the date of certificate, and failing to complete it within three years of commencement, shall forfeit all right to the route claimed, and it shall be subject to be claimed by any other company.

SEC. 280. Every corporation formed has power, first, to have succession by its corporate name for the period limited in its certificate of charter; second, to sue and be sued, complain and defend in any court of law or equity; third, to make and use a common seal and alter the same at pleasure; fourth, to hold, purchase, and convey such real and personal estate as the purposes of the corporation may require; fifth, to appoint such subordinate officers and agents as the business of the corporation shall require, and to allow them a suitable compensation; sixth, to make by-laws, not inconsistent with any existing law, for the management of its property, the regulation of its affairs, and for the transfer of stock: *Provided*, That no corporation formed shall own or hold possession of more than six hundred and forty acres of land.

---

* Territorial laws adopted by the State.

SEC. 281. The powers enumerated in the preceding sections shall vest in any corporation that shall hereafter be created, although they may not be specified in the certificate; but no corporation shall possess or exercise any corporate powers, except such as shall be necessary to the exercise of the powers so enumerated.

SEC. 282. Willful or malicious damages, or interference with property of any kind belonging to any company organized, upon conviction before the county court where the offense is committed, shall be fined not exceeding five hundred dollars, or imprisoned not exceeding one year, or both, and the offender shall pay all damages the corporation may sustain, together with costs of suit.

* * * * * * *

SEC. 285. Whenever any organized company shall not have acquired, by gift or purchase, the right of way required for the construction or maintenance of any road, ditch, telegraph, or flume, or may be affected by the operations of the same, they may present a petition to the probate judge of the county, describing the lands required, giving the name and residence of each owner, and praying for the appointment of appraisers. The judge, having evidence that the owners have been notified ten days previously by publication or notices in some public place in the county, shall appoint three impartial appraisers, who shall take an oath to perform their duties faithfully. Two of them shall review the premises, ascertain and certify the proper compensation to be made, as well as all damages accruing to the owners, after making a just allowance for the real benefits or advantages which the owners may derive from the construction of the road, ditch, telegraph, or flume. They shall file a certificate of their ascertainment and assessment in the county clerk's office. The probate judge upon such certificate and proof that compensation has been paid to the parties entitled to the same, or deposited to their credit, shall have a certified copy of the description of the lands and payment or deposit of compensation recorded in the recorder's office of the proper county. The corporation shall have the exclusive right of all such lands, during the continuance of the corporation, and may take possession of, hold, and use the same for the purpose of the road, ditch, telegraph, or flume, and shall be discharged from all claims for any damage. If at any time after an actual ascertainment of compensation the title acquired or the assessment should be deemed defective, the corporation shall proceed and perfect the title by procuring the assessment of the proper compensation to be made to any person who has an interest in or lien upon the lands. The probate judge may authorize the corporation, if already in possession, to make payment in the manner hereinafter provided; if not in possession to take possession of and use the premises until the final conclusion of the proceedings, and may stay all actions against the corporation on account thereof: *Provided*, That the corporation shall pay a sufficient sum into court, or give approved security to pay the compensation. When possession shall be so authorized it shall be lawful for the owners to conduct the proceedings to a conclusion if the same shall be delayed by the company.

The substance of Article I, Chapter XXXIII, on rights of persons and corporations is as follows:

SEC. 731. Any person or persons, corporation or company, who may have or hold a title or possessory right or title to any agricultural lands as defined by the organic act shall be entitled to the use and enjoyment of the waters of the streams or creeks for the purposes of irrigation, and making the land available for agricultural purposes to the full extent of the soil: *Provided*, That in all cases where, by virtue of prior appropriation, any person may have diverted all the water of any stream, or to such an extent that there shall not be an amount sufficient left for those having a subsequent right for such purpose of irrigation, and there shall at any time be a surplus so diverted, over and above what is actually used for such purpose by prior appropriation, such person shall be required to turn and cause to flow back the surplus water, and upon failure to do so, within five days after demand being made upon him in writing by any person having a right to the use of the surplus water, the person diverting the same shall be liable to the person aggrieved in the sum of twenty-five dollars for each and every day the water shall be withheld after the notice, to be recovered by civic action by any person having a right to the use of the surplus water.

SEC. 732. When any person or persons, corporation or company, owning or holding land shall have no available water facilities, and when it is necessary to raise the waters of the stream or creek to a sufficient height to irrigate the land, or whenever the lands are too far removed from the stream or creek to use the waters, the person or persons, corporation or company, shall have the right of way through and over any tract or piece of land for the purpose of conducting and conveying the water by means of ditches, dikes, flumes, or canals.

SEC. 733. The right to dig and construct ditches, dikes, flumes, and canals over and across the lands of another shall only extend to so much digging, cutting, or excavations as may be necessary for the purposes required.

SEC. 734. In all controversies respecting the rights to water the same shall be determined by the date of the appropriation as respectively made by the parties.

SEC. 735. The waters of the streams or creeks may be made available to the full extent of the capacity for irrigating purposes without regard to deterioration in quality or diminution of quantity, so that the same does not materially affect or impair the rights of the prior appropriator; but in no case shall the same be diverted or turned from the ditches or canals of the appropriator so as to render the same unavailable.

SEC. 736. Any person or persons, corporation or company, damaging or injuring the lands or possessions of another by reason of cutting or digging ditches or canals, or erecting flumes, shall be liable to the party so injured.

SEC. 737. This article shall not be so construed as to impair, or in any way or manner interfere with, the rights of parties to such use of the water of streams or creeks as may have been acquired before its passage.

SEC. 738. This article shall not be so construed as to prevent or exclude the appropriation of the waters of the streams or creeks for mining, manufacturing, or other beneficial purposes, and the right also to appropriate the same is hereby equally recognized and declared.

SEC. 739. Any person or persons, corporation or company, who may dig and construct ditches, dikes, flumes, or canals over or across any public roads or highways, or who may use the waters of the same, shall be required to keep the same in good repair at such crossings or other places where the water may flow over or in any wise injure any roads or highways, either by bridging or otherwise.

SEC. 740. Any person or persons offending against the preceding section on conviction shall pay for every offense not less than $25 nor more than $100, with costs of suits in civil action; one-half the fine shall be paid for the benefit of the common schools of the county, the other half to the person or persons giving the information. The defendant or defendants may be confined in the county jail until the fine and the costs are paid.

SEC. 741. In all controversies respecting the rights to water, whether for mining, manufacturing, agricultural, or other useful purposes, the rights of the parties shall be determined by the dates of appropriation respectively, with the modifications heretofore existing under the local laws, rules, or customs, and decisions of the Supreme Court.

Article II deals with the regulations for the sale of water, and in substance is as follows:

SEC. 742. Any person or persons, corporation or company, having the right to use, sell, or dispose of water, and engaged in using, selling, or disposing of the same, who shall have a surplus not used or sold; or any person or persons, corporation or company having a surplus of water, and the right to sell and dispose of the same, shall, and they or it are hereby required, upon the payment or tender to the person or persons entitled thereto of an amount equal to the usual and customary rates per inch, to convey and deliver to the person or persons, company or corporation, such surplus of unsold water, or so much for which the payment or tender shall have been made, and shall continue so to convey and to deliver the same weekly, so long as the surplus of unused or unsold water shall exist and the payment or tender be made.

SEC. 743. Any person or persons, corporation or company, shall, at their own cost and expense, construct or dig the necessary flumes or ditches to receive and convey the surplus water so desired by it or them, and shall pay or tender to those having a right to the use, sale, or disposal thereof, an amount equal to the necessary costs and expense of tapping any gulch, stream, reservoir, ditch, flume, or aqueduct, and putting in gates, gauges, or other proper and necessary appliances, usual and customary in such cases, and until the same shall be so done the delivery of the surplus water shall not be required.

SEC. 744. Any person or persons, company or corporation, constructing the necessary ditches, aqueducts, or flumes, and making the payments or tenders, shall be entitled to the use of so much of the surplus water as the ditches, aqueducts, or flumes shall have the capacity to carry, and for which payment or tender shall have been made, with all the rights and privileges incidental thereto, so long as the unsold or surplus water exists and the payment or tender shall be or have been made, and may institute and maintain appropriate action, at law or in equity, for the enforcement of such right or recovery of damages arising from a failure to deliver, or wrongful diversion of the same.

SEC. 745. Nothing in this article shall be so construed as to give the person or persons, corporation or company, acquiring the right to the use of water, as hereinbefore provided, the right to sell or dispose of the same after being so used by it or them, or prevent the original owner or proprietor from retaking, selling, and disposing of the same in the usual and customary manner after it is so used.

Chapter XLV, on rights of way for the development of mines, Article IV, in substance is as follows:

SEC. 886. The proprietor, owner, or owners of mining claims, whether patented under the laws of the United States or held under the local laws and customs, shall have a right of way for ingress and egress, for the necessary purposes, over and across the lands or mining claims (patented or otherwise) of others, as hereinafter prescribed.

SEC. 887. Whenever any mine or mining claim shall be so situated that it can not be conveniently worked without a road thereto, or a ditch to convey the water thereto, or a ditch or a cut to convey the water therefrom, or without a flume to carry water and tailings therefrom, or without a shaft or tunnel thereto, which road, ditch, cut, flume, shaft, or tunnel shall necessarily pass over, under, through, or across any lands or mining claim owned or occupied by others, either under a patent from the United States or otherwise, then shall the first-mentioned owner or owners be entitled to the right of way for the road, ditch, cut, flume, shaft, or tunnel over, under, through, and across the other lands or mining claims.

SEC. 888. Whenever the owner or owners of any mine or mining claim desire to work the same successfully, he or they shall have the right of way for the purposes heretofore mentioned, and if it shall not have been acquired by agreement between all parties, it shall be lawful for him or them to present a petition to the judge of the district court of the county, praying that the right of way be awarded to him or them. The petition shall be verified and contain a description of the character and extent of the right sought, the mine or claim of the petitioner, and the claim or claims, and the lands to be affected by the right, with the names of the occupants or owners. It may also set forth any tender or offer hereinafter mentioned, and shall demand the relief sought.

SEC. 889. Upon the receipt and filing of the petition with the clerk of the court, the judge shall direct a citation to issue under the seal of the court, to the owners, named in the petition, of the mining claims and lands to be affected by the proceedings, requiring each of them to appear before the judge on a day therein named, which shall not be less than ten days from the service thereof, and show cause why the right of way should not be allowed. The citation shall be served on each of the parties in the manner prescribed by law.

SEC. 890. Upon the return day of the citation, or upon any day to which the hearing shall be adjourned, the judge shall hear the allegations and proofs of the respective parties, and if he is satisfied that the claims of the petitioner can only be conveniently worked by means of the privilege prayed for, he shall make an order adjudging and awarding the right of way, and shall appoint three commissioners, disinterested parties, and residents of the county, to assess the damages resulting to the lands or claims affected by the order.

SEC. 891. The commissioners shall faithfully and impartially proceed to examine the premises and shall assess the damages and report the amount to the judge, and if the right of way shall affect the property of more than one person or company, the report shall contain an assessment of damages to each company or person.

SEC. 892. For good cause shown, the judge may set aside the report of such commissioners and appoint three others, whose duties shall be the same as above mentioned.

SEC. 893. Upon the payment of the sum assessed as damages to the persons to whom it shall be awarded, or a tender thereof to them, then the person or persons petitioning shall be entitled to the right of way, and may immediately proceed to occupy the same, and to erect such works and structures and make such excavations as may be necessary to the use and enjoyment of the right.

SEC. 894. Appeals from the assessment of damages may be made and prosecuted in the proper district court by any party interested, at any time within ten days after the filing of the report, and a written notice of the appeal shall be served upon the appellee. The appellant shall file with the clerk of the court a bond, with sureties to be approved by the clerk, in the amount of the assessment appealed from in favor of the appellee, conditioned that the appellant shall pay any costs that may be awarded to the appellee and abide by any judgmentt hat may be rendered in the cause.

SEC. 895. Appeals shall bring before the appellate court only the propriety of the amount of damages and may be tried by the court or before a jury.

SEC. 896. The prosecution of any appeal shall not hinder, delay, or prevent the appellee from exercising all the rights and privileges heretofore mentioned: *Provided*, That the appellee shall file with the clerk of the court in which the appeal is pending a bond with sufficient sureties, to be approved by the clerk, in double the amount of the assessment appealed from, conditioned that the appellee shall pay to the appellant whatever amount he may recover in the action.

SEC. 897. If the appellant recover $50 more damages than the commissioners shall have awarded, or the appellee shall offer to allow judgment against him to be taken, the appellee shall pay the costs of appeal, otherwise the appellant shall pay such costs.

SEC. 898. The costs and expenses of proceedings, except as herein otherwise provided, shall be paid by the party making the application: *Provided, however*, That if the applicant shall, before the commencement of such proceedings, have tendered to the parties owning or occupying the lands or mining claims a sum equal to or more than the amount of damages recovered by the defendant or defendants, then all of the costs and expenses shall be paid by the party or parties owning the lands or mining claims affected by the right of way and who appealed and resisted the claim of the applicants.

The substance of Article I, section 1081 (Chapter LIV, on roads and highways), is as follows: County roads running parallel shall not be nearer than one mile, and upon the presentation of a petition signed by at least five freeholders of any neighborhood praying for passage to the various water-courses for stock purposes, the commissioners may at their discretion establish such passage-way. This section shall also apply to the opening and establishment of neighborhood roads running to timber.

(For other details of roads, see section 1064.)

The general laws for 1883 contain an act to punish persons for unlawfully diverting water; in substance it is as follows:

SECTION. 1. Any person who shall divert from any water-course or ditch any water flowing therein, and by such diversion shall deprive another of the use of water to which he is entitled by law, and who shall refuse immediately to relinquish the water so diverted, upon demand being made by the person, or the agent of the person, to whom the water rightfully belongs, shall, on conviction, be fined in any sum not to exceed $100 or imprisoned in the county jail not exceeding three months, or by both.

SEC. 2. If any person, by force, threats, intimidation, or putting in fear with arms, or otherwise, near or upon any water-course or ditch, shall prevent or seek to prevent any person from possessing or obtaining any water which he desires for some useful purpose, or by these means shall prevent any person lawfully entitled to the use thereof from diverting the water, when and where he may desire, the person so offending shall be deemed guilty of felony, and on conviction, be imprisoned in the Territorial prison not less than one year, nor more than five years.

The general laws of 1885 contain an act relative to water-rights, in substance as follows:

SECTION 1. The right to the use of running water flowing in the rivers, streams, cañons, and ravines may be acquired by appropriation.

SEC. 2. The appropriation must be for some useful or beneficial purpose, and when the appropriator or his successor in interest abandons and ceases to use the water for such purposes the right ceases; but questions of abandonment shall be questions of fact, and shall be determined as other questions of fact.

SEC. 3. The person entitled to the use of water may change the place of diversion, if others are not thereby injured, and may extend the ditch, flume, pipe, or aqueduct, by which the diversion is made, to any place other than where the first use was made, and may use the water for other purposes than that for which it was originally appropriated.

SEC. 4. The water appropriated may be turned into the channel of another stream and mingled with its waters, and then [be] reclaimed; but in reclaiming it water already appropriated by another must not be diminished in quantity or deteriorated in quality.

SEC. 5. As between appropriators, the one first in time is first in right.

SEC. 6. Any person hereafter desiring to appropriate water must post a notice in writing in a conspicuous place at the point of intended diversion, stating first, the number of inches claimed, measured as hereinafter provided; second, the purpose for which it is claimed, and place of intended use; third, the means of diversion, with size of flume, ditch, pipe, or aqueduct, in which he intends to divert it; fourth, the date of appropriation; fifth, the name of the appropriator. The appropriator shall file with the recorder of the county, within twenty days after date of appropriation, a notice, which, in addition to the facts required to be stated in the posted notice, shall contain the name of the stream from which the diversion is made, if it has a name, and if not, such a description of it as will identify it; also an accurate description of the point of diversion and reference to some natural object or permanent monument.

The recorded notice shall be verified by the affidavit of the appropriator, or some one in his behalf, which must state that the matter and things contained in the notice are true.

SEC. 7. Within forty days after posting the notice the appropriator must proceed to prosecute the excavation or construction of the work by which the water appropriated is to be diverted, and must prosecute the same with reasonable diligence to completion. If the ditch or flume, when constructed, is inadequate to convey the amount of water claimed, the excess claimed above the capacity of the ditch or flume shall be subject to appropriation by any other person.

SEC. 8. A failure to comply with the provisions of this act deprives the appropriator of the right to the use of water as against a subsequent claimant who complies therewith, but by complying the right to the use of the water shall relate back to the date of posting notice.

SEC. 9. Persons who have heretofore acquired rights to the use of water shall, within six months after the publication of this act, file in the recorder's office of the county wherein the water-right is situated a declaration in writing, except notice be given of record setting forth the same facts required in the notice provided for in section 6 of this act. The declaration shall be verified as before required in cases of notice of appropriation of water: *Provided*, That a failure to comply with the requirements of this section may in no wise work a forfeiture of such heretofore acquired rights, nor prevent any such claimant from establishing such rights in the courts.

SEC. 10. The record provided for in the preceding sections, when duly made, shall be taken and received in all the courts as prima facie evidence of the statements therein obtained.

SEC. 11. In any suit hereafter commenced for the protection of rights acquired to water, the plaintiff may make any or all persons who have diverted water from the same stream or source parties to such action, and the court may in one decree settle the relative priorities and rights of the parties to such suit. When damages are claimed for the wrongful diversion of water, the same may be assessed and apportioned by the jury in their verdicts, and judgment may be entered for or against one or more of several defendants, and may determine the ultimate rights of parties between themselves.

SEC. 12. In any action concerning joint water-right, or joint rights in water-ditches, unless partition of the same is asked by parties to the action, the court shall hear and determine such controversy as if the same were several as well as joint.

SEC. 13. The recorder of each county must keep a well-bound book, in which he must record the notices and declarations provided for in this act, and he shall be entitled to have and receive the same fees as are now or hereafter may be allowed by law for recording instruments entitled to be recorded.

SEC. 14. The measurement of water appropriated shall be conducted in the following manner: A box or flume shall be constructed, with a head-gate placed so as to leave an opening of 6 inches between the bottom of the box or flume and lower edge of the head-gate, with a slide to enter at one side of and of sufficient width to close the opening left by the head-gate, by means of which the dimensions of the opening are to be adjusted. The box or flume shall be placed level, and so arranged that the stream in passing through the aperture is not obstructed by backwater or an eddy below the gate; but before entering the opening to be measured the stream shall be brought to an eddy, and shall stand three inches on the head-gate and above the top of the opening. The number of square inches contained in the opening shall be the measure of inches of water.

NEBRASKA LAW.

Irrigation companies may be incorporated under general laws, and are declared to be works of internal improvement, and, as such, towns may vote gratuities to them to the extent of 10 per cent. of the assessed value of such towns, and by a two-thirds vote to the extent of 15 per cent., and may issue bonds for the same purpose to the amount of 10 per cent. of the assessed value.

NEVADA IRRIGATION LAWS.

An Act to Regulate the Use of Water for Irrigation and for other Purposes, etc.

SECTION 1. That the lands now irrigated, or which may hereafter be irrigated in the State of Nevada, are hereby divided into the following irrigation districts: District No. 1 shall consist of all the lands irrigated from the Truckee River and its tributaries. District No. 2 shall consist of all the lands irrigated from the Carson River and its tributaries. District No. 3 shall consist of all the lands irrigated from the East and West Walker Rivers and their tributaries. District No. 4 shall consist of all the lands irrigated from the Humboldt River and its tributaries. District No. 5 shall consist of all the lands irrigated from the Owyhee River and its tributaries. District No. 6 shall consist of all the lands irrigated from the Rees River and its tributaries. District No. 7 shall consist of all the lands irrigated from the White River and its tributaries. District No. 8 shall consist of all the lands irrigated from the Muddy River and its tributaries. Other irrigation districts may be formed from time to time by the governor, on petition of the parties interested, comprising territory not within any of the above-established irrigation districts.

SEC. 2. There shall be one water commissioner for each of the above-named districts and for each district hereafter formed, who shall be appointed by the governor whenever his service may be required, to be selected by him from the persons recommended to him by the several boards of county commissioners of the counties in which the water districts may extend, and the water commissioners so appointed shall hold office for the period of two years, or until their successor is appointed and qualified. The governor, by like selection and appointment, shall fill all vacancies which may be caused by death, resignation, or continued absence from the district, removal or otherwise, and the governor may at any time remove any water commissioner for failure to perform his duties or for any other cause.

SEC. 3. That within twenty days after his appointment, and before entering upon the duties of his office, such water commissioner shall take and subscribe to an oath to faithfully and impartially perform the duties of his office, which oath shall be deposited with the clerk of the court having jurisdiction over his district.

SEC. 4. It shall be the duty of said water commissioners to divide the water in the natural lakes or streams of their districts among the several ditches taking water from the same according to the prior rights of each, respectively, in whole or in part, and to shut and fasten, or cause to be shut and fastened, the head-gates of any ditch or ditches heading in any of the natural streams or lakes of the district, which in time of a scarcity of water makes it necessary by reason of the priority of the rights of others above or below them on the stream.

SEC. 5. Every person who shall willfully open, close, change, or interfere with any head-gate or water-box without authority shall be guilty of a misdemeanor, and on conviction thereof shall be fined in any sum not exceeding five hundred dollars, or imprisoned in the county jail for a term not exceeding six months, or both such fine and imprisonment. The water commissioners, or their assistants, within their districts, shall have authority to arrest any person or persons offending, and take them before the nearest justice of peace in the county, to be dealt with as in other cases.

SEC. 6. The water commissioner herein provided shall be entitled to pay at the rate of five dollars per day for each day he shall be actually employed in the duties of his office, not to exceed ninety days in any one year, to be paid by the county in which his irrigation district may lie. Each water commissioner shall keep a just and true account of the time spent by him in the duties of his office, and shall present a true copy thereof, verified by oath, to the board of county commissioners of the county in which his district may be, and said board of county commissioners shall allow and pay the same out of the county treasury, and where irrigation districts shall extend into two or more counties then said water commissioner shall be paid for his services as follows: In District No. 2, Douglas County shall pay ——, Ormsy County shall pay ——, Lyon County shall pay ——, Churchill County shall pay ——. In District No. 3, Esmeralda County shall pay ——, Lyon County shall pay ——, Douglas County shall pay ——. In District No. 4, Humboldt County shall pay three-sevenths ——, Lander County shall pay one-quarter ——, Eureka County shall pay one-quarter ——, Echo County shall pay three-sevenths ——. District No. 6, Lander County shall pay ——, Nye County shall pay ——. Said water commissioner shall have power, in case of emergency, to employ suitable assistants to aid him in the discharge of his duties; such assistants shall take the same oath as the water commissioner and shall obey his instructions, and each shall be entitled to four dollars per day for every day he is actually employed, not to exceed thirty-five days in any one year, to be paid upon the certificate of the water commissioner in the same manner as is provided for payment of water commissioners.

SEC. 7. Said water commissioners shall not begin their work until they shall be called by three or more owners or managers or persons controlling ditches in their several districts by application in writing, stating that there is a necessity for their action, and they shall not continue performing services after the necessity therefor shall cease.

SEC. 8. For the purpose of hearing, adjudicating, and settling all questions concerning the propriety of the appropriation of water between ditch companies and other owners of ditches drawing water for beneficial purposes from the same stream or its tributaries or lakes, within the same irrigation district, and all other questions of law and questions of right growing out of or in any way involved or connected therewith, jurisdiction is hereby vested exclusively in the several district courts as follows: For district No. 1, in the district court of the State of Nevada, Washoe County; for district No. 2, in the district court of the State of Nevada, Ormsby County; for district No. 3, in the district court of the State of Nevada; for district No. 4, in the district court of the State of Nevada, for either Humbolt or Elko Counties; for district No. 5, in the district court of the State of Nevada; for district No. 6, in the district court of the State of Nevada, Lander County; for district No. 7, in the district court of the State of Nevada; for district No. 8, in the district court of the State of Nevada. All lakes, streams, and reservoirs not herein enumerated shall be for all purposes attached to and belong to the irrigation district in which the greater portion of its waters is, it being the intention and meaning hereof to add to each irrigation district all waters not hereinbefore enumerated, the majority of which lie within their respective areas, for the purpose of acquiring rights to the appropriation and use thereof and adjudicating the same.

SEC. 9. In order that all parties may be protected in their lawful rights to the use of water for beneficial purposes, every person, association, or corporation owning or claiming any interest in any ditch, canal, or reservoir within any water district shall, on or before the first day of September, eighteen hundred and eighty-nine, file with the county recorder of the county a statement of their claim under oath, entitled of the proper county, which statement shall contain the name or names, together with the post-office address, of the claimant or claimants claiming ownership as aforesaid of any such ditch, canal, or reservoir, the name thereof (if any), and if without a name the owner or owners shall choose and adopt a name to be therein stated by which such ditch, canal, or reservoir shall thereafter be known; the description of such ditch, canal, or reservoir as to location of head-gate, general course of ditch, the name of the natural stream or lake from which such ditch, canal, or reservoir draws its supply of water; the length, breadth, depth, and grade thereof as near as may be; the time, fixing a day, month, and year as the date of appropriation of water by original construction, also by the enlargement or extension, if any such thereof have been made, and the amount of water claimed by or under such construction, enlargement, or extension, and the present capacity of the ditch, canal, or feeder of reservoir, and also the number of acres of land lying under and being, or proposed to be, irrigated by water from such ditch, canal, or reservoir; or if such waters have been appropriated for other beneficial purposes than irrigation, a statement of such purposes. Said statement shall be signed by the proper party or parties and filed with the recorder of the county wherein the right claimed is situated, which shall be recorded by him in a book kept for that purpose.

SEC. 10. Upon the filing of such statement the recorder shall indorse upon the back thereof the date of filing, and shall prepare an index of the same in a book to be provided for that purpose by the county commissioners, which said index shall contain the date of filing, the name of the party, association, or corporation, the name of the ditch, the stream from which the water is taken by such ditch, canal, or reservoir, the location of the head-gate, the date of the appropriation of the water by construction, enlargement or extension. Said index shall be prepared alphabetically by reference to the name of the ditch, canal, or reservoir.

SEC. 11. For filing and indexing such statement the recorder shall receive the same fees as for recording deeds, to be paid by the party or parties filing the same.

SEC. 12. That hereafter every person, company, or corporation constructing, enlarging, or extending any ditch, canal, or reservoir for beneficial purposes, and intending to use or appropriate any water from any natural stream or lake within any water district for such beneficial purposes, shall file with the county recorder of the proper county before the commencement of the construction, enlargement, or extension of such ditch, canal, or reservoir, a statement showing the stream or streams from which the water is to be taken; the point or place on said stream at or near which the water is to be taken out; the line or commencement of said ditch or ditches as near as may be; the use or uses to which said water is to be applied; the dimensions of said ditch or ditches, and each thereof, giving width on bottom and top, slope of banks, and grade of ditch, and likewise of any and all enlargements thereof, which statement shall be filed and indexed as is provided in section 9 of this act; and from the time of filing any such statement water sufficient to fill such ditch or ditches and subserve the use or uses aforesaid, if a lawful and just use, shall be deemed and adjudged appropriated: *Provided*, That nothing herein contained shall be permitted to interfere with a prior right to said water or to any thereof: *And provided further*, That such person or persons or corporation shall, within sixty days next ensuing the filing of such statement, begin the actual construction of said ditch or ditches, and shall prosecute the work of the construction thereof diligently and continuously to its completion: *And provided further*, That the beginning of all necessary survey of such ditch or ditches shall be construed as the beginning of said work of construction.

SEC. 13. The water of every natural stream not heretofore appropriated within this State is hereby declared to be the property of the public, and the same is dedicated to the use of the people, subject to appropriation as herein provided. The provisions of this act shall apply to all cases where the water of natural streams or lakes is appropriated for beneficial purposes, whether the water be conducted through ditches, canals, flumes, or tunnels, and shall apply also to cases where for irrigating purposes the water is stored in reservoirs, and the owner or owners of any ditch, canal, flume, or tunnel through which water is conducted for irrigating purposes, and also the owners of reservoirs, may conduct the water therefrom into and along any of the natural streams of the State, but not so as to raise the waters thereof above high-water mark, and may take the same out again at any point desired; but due allowance shall be made for evaporation and seepage, the amount to be determined by the water commissioner of the proper district, subject to review and determination by the court having jurisdiction over priorities in such districts.

SEC. 14. Whenever any person or persons, association or corporation, interested as owners of any ditch, canal, or reservoir in any district, shall desire a determination of the priorities of rights to the use of water from any stream or streams from which they draw the water for their ditch or ditches, canals, or reservoirs, they shall present to the district court having jurisdiction over the rights in such water district, or to the judge thereof, a petition or application in writing, moving or praying said court to proceed to an adjudication of the priorities of rights to use of the water for irrigation, between the several ditches, canals, or reservoirs, in such district, on the stream or streams named in such motion, petition, or application. The said motion, petition, or application shall state the names of the ditches, canals, or reservoirs claiming water from said stream or streams as appears from the final statements in the recorder's office, together with the names of the persons, associations, or corporations interested therein, taken from such statements, and shall set forth the nature of the claim or claims of the applicant or applicants, and such motion, petition, or application shall be entitled "In the matter of an application for an adjudication of the priorities of rights to use water for beneficial purposes in water districts. District No. ——, on ——" (stating the stream or streams). Upon the filing and docketing of such application the court or judge thereof shall, without unnecessary delay, by an order to be entered of record upon such petition or application, appoint a day for commencing to hear and take evidence in such adjudication, at which time it shall be the duty of the court or judge thereof to proceed and hear all evidence that may be offered by or in behalf of any person, association, or corporation interested in stream or streams in such district, in any ditch, canal, or reservoir, either as owner or consumer of water therefrom, in support of or against any claims of priority of appropriation of water made by means of any ditch, canal, or reservoir, or by any enlargement or extension thereof in such district, or on such stream or streams, and consider all such evidence, also the arguments of the parties or their counsel, and shall ascertain and find from such evidence, as near as may be, the date of the commencement of such ditch, canal, or reservoir, together with the original size and carrying capacity thereof as originally constructed; the time of the commencement of each enlargement or extension thereof, if any, with the increased capacity thereby occasioned; the time spent severally in such construction, enlargement, or extension, and re-enlargement, if any; the diligence with which the work was in each case prosecuted; the nature of the work as to the difficulty of construction, and all such other facts as may tend to show the compliance with the law in acquiring the priority of right claimed for each such ditch, canal, or reservoir, and determine the matters put in evidence, and make and cause to be entered a decree determining and establishing the several priorities of right, by appropriation of water of the several ditches, canals, and reservoirs in such water district in such stream or streams, concerning which testimony shall have been offered, each according to the time of its said construction and enlargements and extensions, with the amount of water which shall be held to have been appropriated by such construction and enlargement or extensions, describing such amount by cubic feet per second of time (which shall also be the measurement for the sale of water), if the evidence shall show sufficient data to ascertain such cubic feet, and if not, by width, depth, and grade, and such other description as will most certainly and conveniently show the amount of water intended as the capacity of such ditch, canal, or reservoir. In such decree such court or judge thereof shall receive from the clerk, on payment therefor, a certificate, under seal of the court, showing date or dates and amount or amounts of appropriations adjudged in favor of such ditch, canal, or reservoir, under and by virtue of the construction, extension, and enlargement thereof severally, also specifying the number of said ditch, as determined by said court, with reference to priority and of each priority to which the same may be entitled by reason of said construction, extension, and enlargements; provided, that any party or parties claiming any right to the use of water for beneficial purposes in such district and on such stream or streams by reason of being owner of or interested in any ditch, canal, or reservoir, who is not mentioned in the petition or application, and shall become parties to such proceedings and shall have their rights adjudicated therein. The court, or judge thereof, may, instead of taking testimony orally or in open court, refer the matter to a referee, with such powers as in other cases. The testimony may be taken at any place ordered by the court, or judge thereof, or by the referee.

SEC. 15. The holder of the certificate provided for in section fourteen shall exhibit the same to the water commissioner of the district when he commences the exercise of his duties, and such water commissioner shall keep a book in which he shall enter a brief statement of the contents of such certificate and which shall be delivered to his successor, and said certificate, or statement thereof in his book, shall be the warrant of authority to said commissioner for regulating the flow of water in relation to such ditch, canal, or reservoir; said certificate shall be recorded at the same rates of charges as in case of deeds of conveyance in the records of each county into which the ditch, canal, or reservoir, to which such certificate relates, shall extend; and said certificate, or said record thereof, or a duly certified copy of such record, shall be prima facie evidence of so much of the decree as shall be recited therein in any suit or proceeding in which the same may be relevant.

SEC. 16. Upon the order of the court fixing the time of such hearing being made, the clerk shall make a certified copy of such order, which order shall contain the names of all parties alleged in the application to be interested in the matter, which shall be thereupon served upon each of the parties therein named, in the same manner as summons. It shall be the duty of the clerk also to give public notice of such application in a newspaper, if any printed and in circulation, in each county wherein such water district is situated, which shall be published at least twenty days, and which said notice shall contain the date of the filing of said petition or application, the name or names of the parties filing the same, a copy of the order made by the court of hearing, and shall notify all parties interested as owners in any ditch, canal, or reservoir, on such stream or streams, in such water district, as well as the persons named in the petition or application, to appear at said court, or before the judge thereof, at the time appointed and stated in the order; and all persons interested as owners or consumers may then and there present his or her or their proofs for or against any priority of right of water by appropriation sought to be shown by any party, by or through any ditch, canal, or reservoir (either as owner or consumer of water therefrom), and in case any party mentioned in the petition or application can not be personally served in any county embraced in such water district, the published notices above provided shall be deemed sufficient service of notice: *Provided further*, That in addition to such publication the clerk shall mail such published notice to each party mentioned in the petition or application, directing the same to the address of the parties, as stated in the sworn statement on file. Proof of the proper publication shall consist in the sworn certificate of the publisher of the paper in which notice is published, to which shall be attached a printed copy taken from such paper.

SEC. 17. Any person or persons who shall willfully cut, dig, or break down or open any gate, bank, or embankment or side of any ditch, canal, or reservoir, flume, pipe, tunnel, or feeder in which such person or persons may be joint owners or which is the property of another or in the lawful possession of another or others and used for the purpose of irrigation, milling, manufacturing, mining, or domestic purposes, with intent maliciously to injure any person, association, or corporation, or for his or her own gain or with the intention of stealing, taking, or causing to run or pour out of such canal or reservoir, feeder, pipe, or flume any water for his or her own profit, benefit, or advantage, or to the injury of any other person, persons, association, or corporation lawfully in the use of such water or of such ditch, canal, tunnel, feeder, pipe, or flume, he, she, it, or they so offending shall be deemed guilty of a misdemeanor and on conviction thereof shall be fined in any sum not exceeding $500, and may be imprisoned in the county jail not exceeding six months, or both, at the discretion of the court.

SEC. 18. Any party or parties representing any ditch, canal, or reservoir, or any number of parties representing two or more ditches, canals, or reservoirs, which are affected, in common with each other, by any portion of the decree rendered by the district court, by which he, she, it, or they may feel aggrieved, may have an appeal from said district court to the supreme court, and in such case the party or parties joining desiring an appeal shall be the appellants, and the parties representing any one or more ditches, canals, or reservoirs affected in common adversely to the interest of appellants shall be appellees. The party or parties in such appeal shall, within sixty days after the date of the decree is entered under this act, file a notice of appeal in writing stating that such party or parties appeal to the supreme court of the State from the decree rendered in the case or any part thereof. When only a part of the decree is appealed from, the notice of the appeal shall so state and shall also in that case specify the portion or part of the decree appealed from. Upon filing of such notice of appeal the cause shall be deemed to be appealed to the supreme court of the State: *Provided, however*, That the party or parties appealing as aforesaid shall, within sixty days as aforesaid, enter into an understanding to be approved by the district court, or judge thereof, and to be given to all parties in said suit or proceedings other than the parties appealing, and to be in such an amount as the court or said judge shall order, conditioned that the parties giving the said undertaking shall prosecute their appeal to effect and without unnecessary delay, and will pay all costs and damages which the parties to whom the undertaking is given, or either or any of them, may sustain in consequence of such appeal.

SEC. 19. The notice last aforesaid shall be entered of record, and the appellant or appellants shall cause a certified copy thereof to be served on each of the parties or their attorneys, if they have one, as in other cases.

SEC. 20. The appellant or appellants shall, within six months after the appeal be allowed as aforesaid, file in the office of the clerk of the supreme court of the State a certified transcript of the proceedings had in the case in the district court, containing the pleadings and the statements of the parties filed therein and all evidence of record offered on the hearing of the cause, or so much thereof as shall affect the appropriation of water claimed by the means of construction, enlargement, or re-enlargement of the several ditches, canals, and reservoirs mentioned in the order allowing the appeal; such statement to be served, filed, and settled in the same manner as statements on motion for new trials.

SEC. 21. The supreme court in all cases heard before it under this act shall, when it can properly be done, render such decree as the court or judge below should have rendered. It may either reverse or modify the decree of the court below. If reversed in whole or in part it may direct the court below as to its further proceedings therein.

SEC. 22. No claim of priority of any person, association, or corporation, on account of any ditch, canal, or reservoir, as to which he, she, it, or they have filed or refuse to offer evidence under any adjudication herein provided for, shall be regarded by any water commissioner in distributing water in times of scarcity thereof, until such time as such party shall have, by application to the court having jurisdiction, obtained leave therefor and made proof of the priority of right to which such ditch, canal, or reservoir shall be justly entitled, which shall only be granted upon terms as to notice to other parties interested, and upon payment of all costs, and upon affidavit or petition, sworn to, showing the rights claimed, and the ditches, canals, and reservoirs, with the names of the owners thereof, against which such priority is claimed, nor until a decree adjudging such ditch, canal, or reservoir has been entered, and certificate, such as mentioned in section fifteen thereof, shall have been issued to claimant and presented to the water commissioner.

SEC. 23. No person, association, or corporation representing any ditch, canal, or reservoir shall be permitted to give or offer any evidence before said court until he, she, it, or they shall have filed a statement of a claim, in substance the same in all respects as is required to be filed under the provisions thereof.

SEC. 24. The district court or judge thereof shall have power to order, for good cause shown, upon terms just to all parties, and in such manner as may seem meet, a re-argument or review, with or without additional evidence, of any decree made under the provisions of this act, whenever said court or judge shall find from the cause shown for that purpose by any party or parties feeling aggrieved that the ends of justice will thereby be promoted, but no such review or re-argument shall be ordered unless applied for by petition or otherwise within one year of the time of entering the decree complained of.

SEC. 25. Persons desiring to construct and maintain reservoirs for the purpose of toring water shall have the right to take from any of the natural streams of the State and store away any unappropriated water not needed for immediate use, for domestic irrigation, or other needful purposes; to construct and maintain ditches, canals, flumes, and tunnels in the same manner provided by law for the condemnation of lands for right of way for ditches, provided no reservoir with embankment or a dam exceeding 10 feet in height shall be made without submitting the plans thereof to the county commissioners of the county in which it is situated and obtain their approval of said plans.

SEC. 26. The owners of reservoirs shall be liable for all damages arising from leakage or overflow of the waters therefrom, or by floods caused by the breaking of the embankment of such reservoir.

SEC. 27. Every witness who shall attend before the court or judge thereof, or before the person appointed to take testimony, in the causes provided for in this act, under subpœna by request of any party, shall be entitled to the same fees and mileage as witnesses in civil cases in the district court, and shall be paid by the party requiring his testimony. All other costs of the proceeding shall be paid by the parties claiming water, as may be adjudged by the court or judge.

SEC. 28. Whenever, in actions for proceedings, for the determination of water rights, it may become necessary to divide the water of any stream or ditch between the different claimants, it shall be divided, as far as possible, by periods of time, instead of fractional parts of the water.

SEC. 29. Said water commissioners shall so divide, regulate, and control the use of the water of all streams within their respective districts in such manner, as near as may be, as will prevent unnecessary waste of water; and to that end such commissioners shall so shut and fasten the head-gate or gates of all ditches so that no more water will flow into said ditch than is actually required and will be used for the purpose or purposes for which such water was appropriated; and any person may resort to any court of competent jurisdiction for such relief as he may be entitled to.

SEC. 30. Whenever testimony shall or may be taken in any district created by this act for the purpose of procuring decree as to appropriation of water and priorities thereof, any testimony theretofore taken upon the hearing of any former application or petition under this act may be introduced and shall be received as evidence.

SEC. 31. This act shall in nowise be construed as impairing or abridging any rights already vested in any person or persons, company or corporation, by virtue of the law heretofore.

SEC. 32. All acts and parts of acts inconsistent with this act are hereby repealed.

SEC. 33. This act shall take effect and be in force from and after its passage.

UNLAWFUL DIVERSION AND WASTE OF WATER.

SECTION 1. Any person or persons who shall, during the irrigating season, divert and conduct the water, or portion thereof, of any river, creek, or stream into a slough or sloughs, dam or dams, pond or ponds, and retain, or cause the same to be held or retained therein without making any other use of such water, or who shall, during the irrigating season, divert and conduct the water, or portion thereof, away from any such river, creek, or stream, and run, or cause or allow the same to run to waste on sage-brush or greasewood land, such diversion shall be deemed an unlawful use and waste of water.

SEC. 2. Any person or persons, company, corporation, or association who shall, during the irrigating season, divert and conduct, or any person or persons aiding, abetting, or assisting any such person or persons, company, corporation, or association in diverting and conducting, during the irrigating season, the water, or portion thereof, of any river, creek, or stream into any slough or sloughs, dam or dams, or pond or ponds, and retain, or cause the same to be retained therein without making any other use of such water, or who shall, during the irrigating season, divert and conduct the water, or portion thereof, away from any river, creek, or stream, and run, or cause or allow the same to run to waste, contrary to and in violation of the provisions of this act, shall be guilty of a misdemeanor, and upon conviction thereof, in any court of competent jurisdiction in this State, shall be punished by a fine not exceeding five hundred dollars or by imprisonment in the county jail of the county not exceeding six months, or by both such fine and imprisonment.

Approved February 28, 1889.

RECLAMATION COMMISSION.

Whereas the State of Nevada has received from the General Government a grant of two million acres of land in lieu of the sixteenth and thirty-sixth sections, previously granted to the State of Nevada, the proceeds from the sale of which are to be placed to the credit of the school fund of the State; and

Whereas under an act of Congress approved September 4, 1841, and an act approved March 21, 1864, a grant of 500,000 acres of land was made to the State of Nevada for internal improvements; and

Whereas the selections of said lands are not confined to any particular section of unappropriated land; and

Whereas the greater portion of unappropriated lands in the State of Nevada is known to be desert, waste, and actually valueless and without sale, unless water, for the purpose of irrigation, can be brought upon them, and the land properly and systematically irrigated, crops of all kinds can not be successfully raised; and

Whereas the permanent settlement, growth, wealth, and independence of the State and people, as well as the sale of school lands, depend upon the reclamation of these desert lands: Now, therefore,

The people of the State of Nevada, represented in senate and assembly, do enact as follows:

SECTION 1. A board of reclamation commissioners is hereby created, to consist of four members, to be known as the "board of reclamation and internal improvements," for the storage of water and reclamation of arable desert lands in this State. Said board to consist of J. F. Clark, of Humboldt County, Evan Williams, of Ormsby County; J. R. Bradley, of Elko County, and Herman Springmeyer, of Douglas County. The said J. F. Clark, of Humboldt County, and Evan Williams of Ormsby County, to hold the position for the term of four years, or until the election of their successors, and the said J. R. Bradley, of Elko County, and Herman Springmeyer, of Douglas County, to hold the position for the term of two years, or until the election of their successors. The State of Nevada is hereby divided into seven internal improvement and reclamation districts, of which Douglas, Ormsby, Esmeralda, Lyon, and Storey, shall constitute the first district, Washoe County, the second district, Churchill County, the third district, Humboldt County, the fourth district, Elko County, the fifth district, Lander, Eureka, and White Pine Counties, the sixth district, and Nye and Lincoln Counties the seventh district. At the general election in eighteen hundred and ninety, and at each general election thereafter, there shall be elected from the State at large two reclamation commissioners, one who shall serve for the term of two years, and one for the term of four years, from and after the first Monday in January next succeeding such election.

The office of said board shall be in the State capitol building, at the seat of government. The board shall adopt rules and regulations for the transaction of its business.

SEC. 2. The board of reclamation shall invite, receive, and procure information and statistics in regard to all public lands within this State, and the waters running therein, which are or may become possible of reclamation, by means of conducting upon them the unappropriated waters running through natural or artificial channels within this State, and shall report the same, together with an approximate estimate of costs and result of such proposed reclamation, at each biennial session of the legislature.

SEC. 3. The board of reclamation shall also invite, receive, procure, and publish facts and statistics regarding the natural water-courses of this State and several districts, including source, supply, water-power, and other matters relating to the value of said waters, or the most practical methods of utilizing the same, either for milling, mining, manufacturing, or agricultural purposes, in order that said information may be offered for the attraction of dormant capital and the encouragement of individual enterprise.

SEC. 4. It shall be the duty of the surveyor-general, *ex officio*, to furnish the board of reclamation, within a reasonable time, maps, profiles, and estimates to determine the cheapest and most economical and valuable routes for canals, reservoirs, and other improvements for irrigation and milling purposes; and also to furnish maps, plans, and estimates for the purpose of building reservoirs, dams, etc., connected with the storing and preserving of waste water.

SEC. 5. The board of reclamation shall have the power to divide the State into districts, and to appoint a superintendent for each reclamation district within the State, which they may establish and refine, whose duty it shall be to superintend the building, constructing, and maintenance of the canals, dams, and other like works within his district as so defined.

SEC. 6. The work of building and constructing any and all canals, dams, and other improvements shall be done by contract, if done by private parties the contracts to be let to the lowest responsible bidder. The work done by contract shall be let in lots of one or more sections, said sections not being more than one mile in length, as indicated by the maps, profiles, plans, and specifications prepared by the surveyor-general and adopted by said board.

SEC. 7. The board of reclamation commissioners, of the State are hereby authorized and directed to employ a competent civil engineer to ascertain and report the number of irrigating ditches in each reclamation district, the capacity of the same in inches, and amount heretofore appropriated and used through said ditches.

SEC. 8. Any irrigating ditch now constructed and hereafter carrying more water than reported by said civil engineer, the owner or owners thereof of said ditch shall pay to the reclamation fund of the State, for such additional water, such sums or rates as the board of reclamation commissioners shall designate; which sum so paid shall constitute a part of the reclamation fund, and shall be available for demands against said fund.

SEC. 9. Whenever the board of reclamation commissioners deem the reorganization or division of any district advisable for internal improvements contemplated by this act, they shall have power to make such changes and establish such additional rules for the government thereof as will not conflict with prior rights as now recognized by law.

SEC. 10. The board shall have power to purchase or rent such lands for reservoirs, sites, or ditches, as they may deem best, whether within or without the boundaries of this State.

SEC. 11. The board of reclamation commissioners, on petition of ten or more persons interested in irrigation ditches in any district in this State petitioning for the issuance of bonds of said district for reclamation purposes, said board shall, at the next general election, submit the question, together with amount of bonds to be issued, to the voters of said district; and, if carried at said election, the said board shall issue and dispose of said bonds under such rules and regulations as they may adopt, the proceeds thereof to be placed in the reclamation fund of the district, and made available for reclamation purposes.

SEC. 12. The board shall advertise for and receive bids upon the work to be done as soon as the surveyor-general can have surveys, maps, plans, specifications, and estimates of the same in readiness for adoption by the board and inspection by bidders, and shall fix a time when they will open bids and award contracts, which shall not be done on less than four weeks' notice thereof, which said notice shall be given for said time by publication in one newspaper in the reclamation district where the work is to be done, or by posting notices.

SEC. 13. The terms of contracting may be to pay monthly, as the work progresses, on the estimate of the surveyor-general or engineer of the amount of work done, seventy per centum of its contract value, reserving to the district or State thirty per centum of the value thereof to insure its faithful completion according to contract, when full payment shall be made, including the retained per centum.

SEC. 14. The board shall fix a definite day for the final completion of any canal, dam, or other improvement, and require all contracts to be done and completed on or before that day, and shall in any agreement reserve the right of forfeiture to the State or district of any retained per centum, and to award the contract of any person or persons who, in the opinion of the surveyor-general, confirmed by the board, fails to make such monthly progress as will insure the completion of any such work so undertaken or contracted for on the day named.

SEC. 15. The board of reclamation shall, upon organization as herein provided, be authorized, empowered, and directed to construct a canal, ditch, or other proper work at, from, or upon the most desirable and practical point on any river or water-way in the State, or that can be procured—the said point to be hereafter selected by said board—to connect with, and to be connected with, for the purpose of milling or irrigating the arable lands situate, lying, and being in the accessible vicinity of such selected river or water-way; and the said canal, ditch, or other work shall be built or established upon a grade or plan in accordance with the configuration and necessities of the shortest and most feasible route and safe carriage of the requisite volume of water required to irrigate the lands within the scope of said ditch or work.

SEC. 16. The total cost of said canal, ditch, or work shall not exceed one hundred thousand dollars, and the cost thereof is hereby limited to that sum.

SEC. 17. The board of reclamation shall audit and certify to the State board of examiners the several amounts that may become due from time to time for work and labor done, services or material furnished in and about the location and building of canals and other works of reclamation that may be carried on, built, and completed under the board, and when approved by the State board of examiners, the controller shall audit the same and draw his warrant upon the State treasurer for the several amounts of such claims, to be paid out of the reclamation fund of the State or district.

SEC. 18. The elective members of the board shall be paid their necessary traveling expenses, and they shall receive no other compensation for their personal services.

SEC. 19. It shall be unlawful for any State officer, or any member of the board of reclamation, to be interested, directly or indirectly, or to take or have any interest or profit, in any manner, in any work of constructing any canal or other improvement for reclamation under this act, and upon conviction shall be fined in any sum not less than one thousand dollars nor more than ten thousand dollars, or imprisonment in the State prison not less than one year nor more than five years, or both such fine and imprisonment.

SEC. 20. The annual rent for water within the scope of any canal, ditch, or work created and built by the board of reclamation shall be one dollar per acre per year. Said rental of water shall be held as a lien against said lands.

SEC. 21. The annual rent of water shall be collected in the same manner and by the same officers as taxes are now collected, and paid into the State or district treasury without fee or abatement and accounted for as the water rent, and placed to the credit of the reclamation and internal improvement fund; and it is hereby enacted that all lands sold by the State under the provisions of this act shall be supplied with the necessary water for reclamation whenever in the judgment of the board it is practicable to do so, and the right of way for the secondary ditches is hereby reserved by the State, and shall be reserved and excepted by the surveyor-general and State land register, from every patent issued by the State, to take up, convey, and deliver all waste water over and across any lands sold and conveyed by the State to any person or persons.

SEC. 22. One hundred thousand dollars is hereby appropriated for the construction and building of any canal, ditch, dam, or other work or works mentioned in this act, and in no case shall a contract or contracts be entered into that shall in the aggregate exceed the sum of one hundred thousand dollars for the construction and building of said canal or work.

SEC. 23. The money herein appropriated shall be taken from the State school fund and placed to the credit of the reclamation fund, herein credited, and in its place shall be deposited one hundred bonds of one thousand dollars each, bearing interest at the rate of four per cent. per annum. Said bonds shall run for twenty years, but shall be redeemable by the State at its pleasure after two years. Said bonds shall be signed by the governor and State controller, and countersigned by the State treasurer, and authenticated with the great seal of the State, and shall state in substance that the State of Nevada owes to its school fund one thousand dollars, the interest on which sum, at four per cent. per annum, it agrees to pay until said bond is redeemed for the benefit of the common schools of the State. Said bonds shall be lithographed, as is usual in such cases, and deposited with the treasurer of the State. The interest on said bonds shall be paid semi-annually, on the first day of January and July, on the written order of the State board of education to the State controller, directing him to draw his warrant for the amount of such semi-annual interest on the reclamation interest and sinking fund herein created. All sums derived from the interest on said bonds shall go into the general school fund for the support of the common schools of the State, and for the regular and prompt payment of which the faith and credit of the State is hereby pledged.

SEC. 24. There shall be levied and collected for the fiscal year commencing January first, A. D. eighteen hundred and ninety-one, and annually thereafter, an ad valorem tax of two cents on each one hundred dollars of all the taxable property in the State, and all sums derived from this tax shall go into the reclamation interest and sinking fund for the payment of the interest and redemption of bonds herein authorized by this act.

SEC. 25. The reclamation fund is hereby made a permanent fund, into which all revenue arising from the last-mentioned section, and from the water rent aforesaid, in section fifteen, and from any other source provided by law, shall be paid and shall be devoted as follows: First, to the payment of interest on bonds; second, to the redemption of the principal sum of the bonds at or before maturity; third, to the reclamation of new districts that may be hereafter created; fourth, to be transferred to the general fund of the State.

Approved March 3, 1889.

ARTESIAN WELLS.

SECTION 1. Section one of said act is hereby amended so as to read as follows:

Section one. Every person, firm, company, corporation, or association, that shall, after the passage of this act, commence the sinking of artesian wells, for stock or agricultural purposes, shall be entitled for sinking such artesian well, where flowing water is obtained, the following specified sums: For the first two hundred feet, one dollar and twenty-five cents per foot; for the third one hundred feet, one dollar and fifty cents per foot; for the fourth one hundred feet, two dollars per foot; for the fifth one hundred feet, two dollars and twenty-five cents per foot; for the sixth one hundred feet, two dollars and fifty cents per foot; for the seventh one hundred feet, three dollars per foot; for the eighth one hundred feet, three dollars and fifty cents per foot; for the ninth one hundred feet, four dollars per foot; for the tenth one hundred feet, four dollars and fifty cents per foot; for all depths exceeding one thousand feet, five dollars per foot for each and every foot below the said one thousand feet. And an additional bounty of one thousand dollars for every well sunk to the depth of one thousand feet or more: *Provided*, That such well shall furnish twenty thousand gallons of water each twenty-four hours, flowing continuously for thirty days, said sums to be paid in the manner provided for in sections four and five of this act: *Provided*, That no bounty shall be paid on any well which does not furnish seven thousand gallons of water in each twenty-four hours, flowing continuously for thirty days: *And provided further*, That no two wells shall receive a bounty if located within the same county. Where two or more wells within the prescribed limit apply for a bounty, the well which first furnished the amount of water required by this act shall be entitled to the bounty allowed by this act.

SEC. 2. Section six of said act is hereby amended so as to read as follows:

Section six. The sum of ten thousand dollars is hereby appropriated out of any money in the general fund of this State for the payment of bounties herein provided for.

OREGON IRRIGATION LAWS.

SEC. 4057. A right of way over any State lands belonging to the State of Oregon, school or University lands, tide or swamp, and overflowed lands, is hereby granted to any railroad corporation who may construct railroad over such lands, on each side of said road to the width of fifty feet.

SEC. 4058. A right of way for the construction of a water-ditch to be used for irrigation, manufacturing, or mining purposes, ditches or water-pipes for conveying water to cities and towns for domestic purposes or for the extinguishment of fires, is hereby granted to any individuals or corporations who may construct such water-ditches of water-pipes over any of the State lands belonging to the State of Oregon—tide, swamp, and overflowed lands, and school lands—for a distance on each side of said ditches or water-pipes of twenty-five feet.

SEC. 4059. It shall be the duty of said railroad corporation or water company or individuals constructing said railroads, water-ditches, or water-pipes to file a copy of the field-notes of the survey of such railroads, ditches, or water-pipes with the secretary of state of the State of Oregon, showing the location of said railroad, water-ditch, or water-pipe.

SEC. 4060. All patents hereafter granted by the State of Oregon for any of the class of lands heretofore mentioned shall be made subject to any vested rights of the owners of such railroads, water-ditches or water-pipes as may have been acquired under the preceding sections.

NEW MEXICO IRRIGATION LAWS.

The treaty of peace between the United States and Mexico in 1848 contains the following provisions in Articles VIII and IX:

"ART. VIII. Mexicans now established in territories previously belonging to Mexico, and which remain for the future within the limits of the United States as defined by the present treaty, shall be free to continue where they now reside, or to remove at any time to the Mexican Republic, retaining the property which they possess in the said territories, or disposing thereof and removing the proceeds wherever they please, without being subjected on this account to any contribution, tax, or charge whatever.

"Those who shall prefer to remain in the said territories may either retain the title and rights of Mexican citizens, or acquire those of citizens of the United States; but they shall be under the obligations to make their election within one year from the date of the exchange of ratifications of this treaty, and those who shall remain in the said territories after the expiration of that year without having declared their intentions to retain the character of Mexicans shall be considered to have elected to become citizens of the United States. In the said territories property of every kind now belonging to Mexicans not established there shall be inviolably respected. The present owners, the heirs of these, and all Mexicans who may hereafter acquire said property by contract shall enjoy with respect to it guarantees equally ample as if the same belonged to citizens of the United States.

"ART. IX. Mexicans who in the territories aforesaid shall not preserve the character of citizens of the Mexican Republic conformably with what is stipulated in the preceding article shall be incorporated into the union of the United States and be admitted at the proper time (to be judged of by the Congress of the United States) to the enjoyment of all the rights of citizens of the United States according to the principles of the Constitution, and in the mean time shall be maintained and protected in the free enjoyment of their liberty and property, and secured in the free exercise of their religion, without restriction."

The Gadsden treaty between the United States and Mexico in 1853 contains the following provisions in Article V:

"All the provisions of the eighth and ninth, sixteenth and seventeenth articles of the treaty of Guadalupe Hidalgo shall apply to the territory ceded by the Mexican Republic in the first article of the present treaty, and to all the rights of persons and property, both civil and ecclesiastical, within the same, as fully and as effectually as if the said articles were herein again recited and set forth."

The Kearney code of laws, 1846, contains in section 1 the following provisions relative to water-courses, stock-marks, etc.:

"The laws heretofore in force concerning water-courses, stock-marks and brands, horses, inclosures, commons, and arbitration shall continue in force, except so much of said laws as require the ayuntamientos of the different villages to regulate these subjects. The duties and powers of such ayuntamientos are transferred to and enjoined upon alcaldes and prefects of the several countries."

IRRIGATION LAWS.

SECTION 1. No inhabitant shall have the right to construct any building to the impediment of the irrigation of lands or fields, such as mills or any other property, that may obstruct the course of the water, as the irrigation of the fields should be paramount to all other uses of the water.

SEC. 2. All by-paths or foot-paths are prohibited across the fields under penalty of fine or imprisonment.

SEC. 3. It being impracticable or absolutely impossible for the fields to be fenced in, all animals shall be kept under a shepherd, so that no injury may result to the fields, and in case any damage should result it shall be paid by the persons causing it.

SEC. 4. In case a community of people desire to construct a ditch or acequia, and the constructors are the owners of all the land upon which the ditch or acequia is constructed, no one shall be bound to pay for the land, as all persons interested in the construction are to be benefited by it.

SEC. 5. The course of ditches or acequias already established shall not be disturbed.

SEC. 6. All rivers and streams of water heretofore known as public ditches or acequias are hereby established and declared to be public ditches or acequias.

SEC. 7. From and after the publication of this act it shall be the duty of the several justices of the peace to call together in their respective precincts, whenever it may be deemed convenient, all the owners of ditches or acequias, as well as the proprietors of lands irrigated by any public ditch or acequia, for the purpose of electing one or more overseers for the ditches or acequias for the same year.

SEC. 8. All fines and forfeitures recovered for the use and benefit of any public ditch or acequia shall be applied by the overseer to the improvements, excavation and to bridges for the same, wherever it is crossed by any public road and bridges may be necessary.

SEC. 9. In all cases of conviction under this act an appeal may be granted to the district court, which appeal shall be taken and conducted as all other appeals from the decisions of justices of the peace.

SEC. 10. The regulations of ditches or acequias which have been worked shall remain as they were made, and have remained up to this day.

SEC. 11. All plants of any description growing on the banks of the ditches or acequias shall belong to the owners of the land through which the ditches or acequias run.

SEC. 12. If any person or persons intentionally make lagoons of water, whether on their own or other land, after the gathering of the crops, from which lagoons damage results to houses, common or private grounds or public roads, the person so offending shall, on conviction, be fined in any sum not less than five nor more than ten dollars.

SEC. 13. Any person convicted of having committed injuries heretofore mentioned shall pay to the party injured the damages assessed by three persons appointed for that purpose by the justice.

SEC. 14. All fines arising from the provisions of this act shall be applied to the repairs herein mentioned, and in case of not being so expended, they shall go into the treasury of the county wherein they were collected.

SEC. 15. All acequias, public or private, when completed, shall be the property of the persons who may have completed them, and no person or persons who may desire the use of the waters of them shall be allowed to do so without the consent of a majority of the owners, and upon payment of a share proportionate to the primary cost of the acequia or ditch to the amount of the land proposed to be irrigated, or the quantity of water proposed to be used: *Provided*, That the provisions of this section shall not apply to any acequias or ditches, public or private, that may pass from the limits of any one county to within the lines of any other.

SEC. 16. Where any acequia or ditch, public or private, passes from within the limits of any one county to within the lines of any other, such acequia or ditch within the proper precincts of the respective counties shall be under the exclusive control and management of the officers of such precincts and counties.

SEC. 17. All the inhabitants shall have the right to construct either private or common acequias, and to take the water for them from wherever they can, with the distinct understanding to pay the owner through whose lands the acequias have to pass a just compensation for the land used.

SEC. 18. If the owner or owners of lands where a new ditch for an acequia is to be made should ask an exorbitant price as a compensation, which shall not be satisfactory to the owner or owners of the acequia, the probate judge of the county shall appoint three honest, skillful men to make an appraisement and fix the compensation, which once done shall be executed and without appeal.

SEC. 19. When any public ditch or part thereof shall be destroyed by rain, or in any other manner, and it shall be absolutely impossible to reconstruct it where it ran before it was destroyed, the major-domo of the ditch, with the consent, should they deem it necessary, of a majority of those having a common interest therein, may cut through the lands of any person or persons by first obtaining their consent, the community interested in the ditch offering to pay a compensation to be agreed upon between them and the owner or owners of the lands through which the ditch is to be opened.

SEC. 20. If the owner or owners who shall be solicited to permit the opening of a new ditch through their lands should refuse or decline to accept the compensation offered, or should ask a compensation which the interested parties consider exorbitant, the major-domo shall lay the case before the justice of the peace of the precinct, and he shall appoint three men, experts, to establish a just compensation to be paid to the owner or owners through whose lands the ditch is to pass.

SEC. 21. Whenever three experts shall be appointed as appraisers, they shall file in the office of the justice of the peace an oath impartially to discharge their duties, and shall proceed to the place where the land or lands are situated, and before appraising shall ascertain whether or not the ditch is destroyed, and whether the labor or cost required to rebuild it would be so great as to render its reconstruction impossible; and if they think the injury done may be repaired they will so report to the justice of the peace, and the land solicited for the purpose of opening the new ditch shall in no manner be touched; but if they should think a part of the ditch irreparably destroyed, they shall then examine the land or lands over which the new ditch should be opened and the place where it should properly run.

SEC. 22. Whenever any land or lands of any person or persons are appraised the appraisers shall file a report in the office of the justice of the peace who appointed them, giving the name of the person whose land was appraised and the sum to be paid him by the parties interested in the public ditch for which the right of way through the land is solicited; they shall also state, in the most distinct manner, the place and point where the opening for the ditch is to be made, and the direction which the ditch is to take through such land.

SEC. 23. The parties interested shall possess the right of property in the land or lands assigned to them, and in case of legal resistance being made they may in an action of forcible entry and detainer, as provided by law, compel the person or persons who interpose such resistance to desist therefrom; but the parties interested shall first pay the appraised value of the land or lands: *Provided*, That the appraisers shall be impartial persons.

SEC. 24. In each precinct where public necessity requires it an election shall, on the third Monday of February, 1880, be held, as hereinafter provided, for directors of such of the acequias as irrigate different places.

SEC. 25. The manner of conducting the election, and the number of overseers, shall be regulated by the justice of the peace, and the only persons entitled to vot[illegible]t the elections shall be the owners or renters of lands irrigated by the ditches or ac[illegible]ias.

SEC. 26. The overseers shall superintend the repairs and excavations on the ditches or acequias; apportion the number of laborers furnished by the proprietors; regulate them according to the quantity of land to be irrigated by each one; distribute and apportion the water in the proportion to which each one is entitled according to the land cultivated by him, taking into consideration the nature of the seed, crops, and plants cultivated.

SEC. 27. If any overseer of any public ditch or acequia shall willfully neglect or refuse to fulfill his duties, or conduct himself with impropriety or injustice, or take any bribe in money, property, or otherwise, he shall be fined for each of such offenses in a sum not exceeding $90, to be recovered before any justice of the peace in the county, one-half the sum to be paid to the county and the other half to the person bringing suit; and on a second conviction may be removed from his office on petition of two-thirds of the proprietors of the land irrigated.

SEC. 28. In all cases of removal the justice of the peace shall order a new election to fill the vacancy occasioned by it.

SEC. 29. The pay and other perquisites of the overseers shall be determined by a majority of the owners of the land irrigated by the ditch or acequia.

SEC. 30. In acequias of extended irrigation, and where the lands which they irrigate are unequal, and some persons have at once several sections and parts in other sections, there shall be elected a chief major-domo, an assistant major-domo, and three acequia commissioners. The duties of the commissioners shall be to regulate the number of laborers for the respective acequias for which they have been elected, that shall be furnished by each owner or tenant of irrigable lands to be irrigated. Should it be necessary, or should any three persons, owners, or tenants require it, the commissioners shall measure the lands in order to better apportion the number of laborers that each owner or tenant shall supply for the cleaning up of the acequias, and for any subsequent work which public necessity may demand during the year, the care of which is charged to the major-domos and assistant major-domos, the chief major-domo being always the superior officer; and he, with his assistant, shall take care that the acequias shall be kept running in all their vigor from the time the water is first let in after cleaning until the crops no longer require it.

SEC. 31. Whenever a list has been made by the acequia commissioners, as provided in the foregoing section, at any of the acequias, or by any major-domo and his assistant, where commissioners are not elected, another list shall be made and delivered to the justice of the peace, who shall record it for the reference of all interested parties and in order that the work may be so ordered.

SEC. 32. The chief majors-domo of all the acequias shall be the receivers and disbursers of all the fines resulting from their respective acequias, and on the tenth of October in each year they shall give an account to the justices of the peace of their precincts of the fines received and the manner in which they have disbursed any part of them.

SEC. 33. Should the commissioners be charged with the duty of measuring the lands, they shall be paid at the rate of two dollars per diem during the time they may be so occupied, which sum shall be paid from the respective funds belonging to the acequias.

SEC. 34. In the elections every owner or tenant of irrigable lands irrigated by any of the acequias shall be entitled to vote and be voted for. The persons receiving the greatest number of votes shall be declared elected to their respective offices, and shall receive a certificate of the same from their respective justices of the peace. All such elections shall be held from and after the year eighteen hundred and eighty-one, on the first Monday of January in each year.

SEC. 35. All persons interested in a common ditch or acequia, be they owners or lessees, shall labor thereon in proportion to their land.

Sec. 36. All owners of tillable lands shall labor on public ditches or acequias, whether they cultivate the land or not.

Sec. 37. Each proprietor shall furnish the number of laborers required by the overseer, at the time and place he may designate and for the time he may deem necessary.

Sec. 38. If a proprietor of land irrigated by any such ditch or acequia shall neglect or refuse to furnish the number of laborers required by the overseer after having been legally notified, he shall be fined for each offense in a sum not exceeding ten dollars for the benefit of the ditch or acequia, and the overseer shall be a competent witness to prove the offense.

Sec. 39. If any person shall in any manner obstruct, interfere with, or disturb any of the ditches or acequias, or use the water therefrom without the consent of the overseer during the time of cultivation, he shall pay for each offense a sum not exceeding ten dollars and all damages that may have accrued to the injured parties, and if the person or persons are unable to pay the fine and damages they shall be sentenced to fifteen days' labor on public works.

Sec. 40. All overseers of ditches shall see that the water currents run so that no injury may result to the proprietors of lands or tenements or to the public convenience; and in case danger is anywhere threatened by the ditches, either from increase of water or by inundation, from which damage might result, the overseers are required, if the damage might result to but one precinct, to report the danger to the justice of the peace, and if to two or more, to the probate judge of the county.

Sec. 41. The probate judge, or the justice of the peace, shall appoint three suitable persons to make an examination, and if they shall sustain the report made by the overseer the probate judge or the justice of the peace shall order all persons owning real estate within the limits considered in danger to meet together, and, under direction of the overseer or some other person appointed, set about the prevention of damages by the construction of breakwaters, barriers, or any other work deemed advisable as a means of a averting the threatened injury: *Provided*, That the labor shall be performed in proportion to the property of each person interested in the same.

Sec. 42. In all cases where it becomes necessary to take any of the steps mentioned, the person in charge shall direct the labor, notify the parties interested of the number of laborers to be furnished and the part of the work assigned to such parties respectively, and informing them of the place where work shall commence and the day appointed for commencing it: *Provided*, That if after receiving the notice any person or persons shall fail to comply, the person in charge may report to the judge or justice by whom he was appointed who shall cause the delinquent to appear, and fine him in any sum not less than five dollars.

Sec. 43. Every person being a tiller of irrigated lands, who shall have commenced the performance of his part in the common labor on any public acequia, is and shall be obligated to continue on that work until the completion of the cleansing of the acequia.

Sec. 44. If any owners or lessees of lands shall attempt to abandon their co-laborers without complying with sections forty-five and forty-six, they shall each pay a fine of not less than five dollars, nor more than ten dollars.

Sec. 45. If any person having his fields on the upper portion of an acequia, having reached such fields, shall propose for any cause or causes, reason or pretext, to abandon his co-laborers, or to withdraw his quota of laborers, he shall not be permitted so to do until the completion of the cleansing of the acequia: *Provided*, That touching the repairs and excavations to be made, the proper proportion of labor shall be furnished by the owners, and the majors-domo shall superintend the work as heretofore provided. If in any acequias already constructed there shall be included any dikes and dams which may have been destroyed, and the parties interested in such dikes and dams shall have agreed or contracted to work on the acequia, they shall remain and fulfill their engagements.

Sec. 46. As in the excavation of such acequias, and in the first cleansing of some of them, the work sometimes continues for thirty days, more or less, the different majors-domo shall take into consideration the small amount of land tilled by some, and shall not compel these to furnish as much labor as is required of those having larger interests.

Sec. 47. Every owner or tenant of irrigable lands, irrigated by any of the acequias, shall be compelled to hold at all times during the operations of any acequia to which they belong, the number of laborers to them assigned, at the disposal and order of the major-domo of such acequia, or his assistant, and it shall not be legal for any owner or tenant of irrigable lands, to absent himself for a time exceeding three days without informing the chief major-domo in regard to the persons remaining in his stead, and he shall present them, so that in his presence they may assume the responsibilities during the time of his absence. All the responsibilities of the absentees shall fall on the substitutes, and no other persons shall be admitted as substitutes. And if any owner or tenant of irrigable lands shall absent himself from the precinct during the time the acequias are in operation, without complying with the duty imposed upon him, he shall besides paying the penalty fixed by the major-domo, be responsible for an amount equal to the value of the labor due at a just and common estimate per diem for the time he was absent and for the number of laborers that may have been assigned to him. Nor shall any proprietor, on account of having rented his lands reserving a part for himself, be exempted from working on the acequia at any time of the work.

Sec. 48. This section relates to the penalties for failure to perform work due on an acequia, the disbursement of the sums collected as fines, etc.

Sec. 49. All currents and sources of water, such as springs, rivers, ditches flowing from natural sources, shall be and they are by this act declared free, in order that all persons traveling shall have the right to take water therefrom for their own use and that of the animals under their charge; but the word traveler shall not in any manner extend to persons who travel with a large number of animals; such persons shall not use the water of any spring belonging to any individual, without having first obtained the consent of the owner. And if any person in transit or traveling, at the time of using any of the water mentioned, shall cause any injury to the fields, to lands under crop, or to other property of any person, he shall pay to the injured party all damages that may have been done: *Provided, further*, That this act shall in no manner apply to wells: *Provided, further*, That this act shall not be applicable to ponds or reservoirs of water that persons may construct for their own proper use and benefit, and no person under pretext of title to the sources, springs, rivers, or ditches, shall have the right to embarrass or hinder, or molest any transient person or traveler in or at the time of taking the water for his proper use and giving water to his animals.

Sec. 50. Hereafter, if any person or persons shall embarrass, hinder, and molest any person or persons at the time they may wish to take water for their animals, and shall claim or demand any compensation for the use of the same, the person or persons so offending shall be fined not less than twenty-five dollars, nor more than fifty dollars, and shall be liable to pay all the damages caused to the person hindered.

Sec. 51. Every person who shall foul the water of any stream, or throw into any ditch, river, or spring of flowing water any dead or pestiferous animal or other filth, dirty vessels, or other impurities that might injure the general health of the inhabitants of any town or settlement, shall be fined not less than one dollar nor more than ten dollars.

Sec. 52. The major-domos of the ditches, and the commissioners of the same, shall prosecute all persons violating the provisions of this act.

Sec. 53. All the salt lakes, with the salt which has accumulated or may accumulate on their shores, are and shall be free to the citizens; and each one shall have power to collect salt on any occasion free from molestation or disturbance. If any person or persons shall prevent, or attempt to prevent, any other person or persons from gathering salt, or going for or returning with it, or if any persons shall arm or embody themselves for any or either of the above purposes, or shall molest, disturb hinder, or annoy any person or persons while gathering salt, or going to or returning from any salt lake, or shall interfere with the salt gathered, or the animals, carts, or wagons, or any other convenience used in its carriage, shall be guilty of felony, and shall be punished by confinement in the county jail or Territorial prison not less than two nor more than seven years, nor be fined not less than one thousand dollars.

Sec. 1305. The different communities or Pueblos of Indians residing within our settlements shall be subject to render their services in working the acequias and highways in which they have the common use of the water of said acequias with the immediate citizens to their Pueblos, and enjoy at the same time the benefit and commercial traffic: *Provided*, That in such service they shall be entirely subject to the laws now in force on both branches of roads and acequias.

In addition to the foregoing there prevails among the Pueblo Indians of New Mexico the custom of annually electing a major-domo by all interested. He has control over the distribution of the water and calls out the help required for repairs, etc., much in the same manner as practiced among the Mexicans.

TEXAS IRRIGATION LAW.

CHAP. 88.—[S. H. B. No. 298.] An act to encourage irrigation, and to provide for the acquisition of the right to the use of water, and for the construction and maintenance of canals, ditches, flumes, reservoirs, and wells for irrigation, and for mining, milling, and stockraising in the arid districts of Texas.

Section 1. That the unappropriated waters of every river or natural stream within the arid portions of the State of Texas, in which, by reason of the insufficient rainfall, irrigation is necessary for agricultural purposes, may be diverted from its natural channel for irrigation, domestic, and other beneficial uses: *Provided*, That said water shall not be diverted so as to deprive any person who claims, owns, or holds a possessory right or title to any land lying along the bank or margin of any river or natural stream of the use of the water thereof for his own domestic use.

Sec. 2. That the unappropriated waters of every river or natural stream within the arid portions of the State, as described in the preceding section of this act, are hereby declared to be the property of the public, and may be acquired by appropriation for the uses and purposes as hereinafter provided.

Sec. 3. The appropriation must be for the purpose named in this act, and when the appropriator, or his successor in interest, ceases to use it for such purposes the right ceases.

Sec. 4. As between appropriators, the one first in time is the one first in right to such quantity of the water only as is reasonably sufficient and necessary to irrigate the land susceptible of irrigation on either side of ditch or canal.

Sec. 5. Every person, corporation, or association of persons which have constructed or may hereafter construct any ditch, canal, or reservoir, for the purposes named in this act, and taking water from any natural stream, shall, within ninety days after this act goes into effect, or within ninety days after the commencement of such construction, file and cause to be recorded in the office of the county clerk of the county where the head gate of such ditch or canal may be situated, or to which said county may be attached for judicial purposes, in a well-bound book to be kept by said clerk for that purpose, a sworn statement in writing, showing the name of such ditch or canal, the point at which the head gate thereof is situated, the size of the ditch or canal in width and depth, and the carrying capacity thereof in cubic feet per second of time, the name of said stream from which said water is taken, the time when the work was commenced, and the name of the owners or owner thereof, together with a map showing the route of said ditch or canal.

Sec. 6. Within ninety days next after the filing of said statement, the party claiming the right to appropriate the water shall begin the actual construction of the proposed ditch, canal, or reservoir, and shall prosecute the work thereon diligently and continuously to completion.

Sec. 7. "Completion," as used in the preceding section, is hereby defined to be the conducting of the water in the main canal to the place of intended use.

Sec. 8. By compliance with the preceding provisions of this act the claimant's right to the use of the water relates back to the time when the work of excavation or construction was commenced on said proposed ditch, canal, or reservoir: *Provided*, That a failure to file said statement shall in no wise work a forfeiture of such heretofore acquired rights, nor prevent such claimants of such heretofore acquired rights from establishing such rights in the courts.

Sec. 9. When any person, corporation, or association of persons, by compliance with the preceding provisions of this act, shall become entitled to the use of the waters in any river or stream, it shall thereafter be unlawful for any other person, corporation, or association of persons, except for domestic use by any one entitled thereto, to so divert the flow of water in said river or stream in such manner and to the extent of depriving said person, corporation, or association of persons in priority of the use of the water to which they may be so entitled.

Sec. 10. Corporations may be formed and chartered under the provisions of this act and of the general incorporation laws of the State of Texas, for the purpose of constructing, maintaining, and operating canals, ditches, flumes, feeders, laterals, reservoirs, and wells, and of conducting, transferring, and furnishing water to all persons entitled to the same, for irrigation and domestic uses, and for the purpose of building storage reservoirs for the collection and storage of water for the uses before mentioned, and for mining, milling, and stock-raising. All persons who own or hold a possessory right or title to land adjoining or contiguous to any canal, ditch, flume, or lateral, constructed and maintained under the provisions of this act, and who shall have secured a right to the use of water in said canal, ditch, flume, or lateral, shall be entitled to be supplied from such canal, ditch, flume, or lateral with water for irrigation of such land and domestic uses: *Provided*, The party so entitled shall first make available his said land for agricultural or grazing purposes, and shall provide cisterns, wells, or storage reservoirs for water for domestic purposes.

Sec. 11. All corporations and associations formed for the purposes of irrigation as provided in this act, are hereby granted the right of way, not to exceed one hundred feet in width, over all public, university, school, and asylum lands of the State, with the use of the rock, gravel, and timber on the right of way, for construction purposes, and may obtain the right of way over private lands by contract. Any such corporation may also obtain the right of way over private lands by condemnation by causing the damages for any private property appropriated by such corporations or associations to be assessed and paid for as provided in cases of railroads.

Sec. 12. All surplus water not used or disposed of, as provided for in the preceding sections of this act, shall be conducted back to the stream from which it was taken. And all water sold or disposed of may be measured in inches, feet, or fractional portion of the whole supply, or distributed by the hour or acre system. But any person, corporation, or association of persons shall furnish water in the way and manner named in the contract or certificate issued to the purchasers of said water, so long as water remains unsold in the ditch: *Provided*, That the commissioner of agriculture, insurance, statistics, and history shall make a report to the legislature at its next regular session, and at each regular session thereafter, as to the cost and expense attending the construction and maintenance of canals, ditches, flumes, feeders, and wells for irrigation in various parts of the State, and accompany the same with a statement of the charges made for the uses of water by canal, ditch, and well companies, and the legislature shall, at such times as it deems proper, either by direct legislation or by the creation of a commissioner or water inspector or inspectors, with full delegated power, control and regulate the quantity of water which may be diverted by any water company or individual, when and in the manner in which it may be diverted, and may establish and enforce all such reasonable rules and regulations necessary and proper governing and controlling such corporations and water construction companies and persons operating under the provisions of this act, and may also control, regulate, change, and fix the charges for the use of water made by such ditch, canal, and well companies.

SEC. 13. All said persons, corporations, and associations shall have the right to run along or across all roads and highways necessary in the construction of their work, and shall at all such crossings construct and maintain necessary bridges for the accommodation of the public, and shall not affect or impair the usefulness or condition of said road or highway.

SEC. 14. Any person who shall willfully or through gross negligence injure any irrigating canal or its appurtenances, wells, or reservoirs, or who shall waste the water thereof, or shall take the water therefrom without authority shall be deemed guilty of a misdemeanor, and for each offense shall be liable to a fine not exceeding five hundred dollars.

SEC. 15. Any corporation created and organized under the provisions of the general laws of this State or the provisions of this act for the purpose of irrigation shall have the power to acquire lands by voluntary donation or purchase or in payment of stock or water rights, and to hold and dispose of all such lands and other property, and to borrow money for the construction, maintenance, and operation of its canals, ditches, flumes, feeders, reservoirs, and wells, and may issue bonds and mortgage its corporate property and franchises to secure the payment of any debt contracted for the same: *Provided*, All lands acquired by said corporation, except such as are used for the construction, maintenance, and operation of said canals, ditches, laterals, feeders, reservoirs, and wells shall be alienated within twenty years from the date of acquiring said lands or be subject to judicial forfeiture.

SEC. 16. All laws and parts of laws in conflict with the provisions of this act are hereby repealed.

SEC. 17. Whereas it is necessary that irrigating canals should be built at once to afford water for irrigational purposes for the present year; therefore an emergency exists, and an imperative public necessity demands the suspension of the constitutional rule which requires a bill to be read on three several days, and that this act take effect and be in force from and after its passage.

CHAPTER REGULATING THE MODE OF IRRIGATION.

ART. 2982. The commissioners' court are authorized to order, regulate, and control the time, mode, and manner of erecting, repairing, cleaning, guarding, and protecting the dams, ditches, roads, and bridges belonging to any irrigation farms and property and the fences or other like protection in and around such farms: *Provided*, That such farms, dams, ditches, and fences be owned conjointly by two or more different persons: *And provided further*, That the same be situated outside of a corporation having jurisdiction thereof.

ART. 2983. Said courts shall have power to establish all needful police regulations for the government and control of irrigation farms and property, and said courts may assess and collect fines for breaches of any regulations established by them or by the joint owners of such farms and property, or recognized by said court as consistent with ancient usage and the law of the State; said courts may order meetings of joint owners for the election of commissioners and other officers, and for the consideration of any of their other interests, or the said court may proceed and elect said officers, and may regulate the right of way, the stoppage and passage of the water, and the right distribution of the shares of said water; they may forbid the running of stock at large on the common farm; they may fine for taking water out of turn and for carelessness and wantonness in overflowing roads and neighboring lands, and generally they may do or cause to be done what they consider just and needful or beneficial to the jointowners.

ART. 2984. If any owner of a *suerte* or subdivision lot in said farm shall fail or refuse to do or pay his proportion of labor and expense in and on any dam, ditches, fences, bridges, or other needful appurtenances to such irrigation farms, the commissioners' court may lease said *suerte: Provided,* That such leasing shall be at public outcry, after ten or more days of due public notice; and to the person bidding the shortest term, not to exceed four years, who shall give good security to discharge faithfully all such charge and work.

ART. 2985. Upon the application of the owners of any suitable lands and water and the assurance and the proper security given the county, if required by said court, that no injury will result to the public health, the commissioners' courts are authorized by decree to license and permit any such owners to proceed and dam the water and to ditch, fence, and irrigate their lands: *Provided,* That joint owners of all irrigation farms shall be liable for damages done to the public or to any person by reason of the overflow of such irrigation water; suit to be brought against the person occasioning the injury or in such other way as may be sanctioned by said court.

ART. 2986. If, in the establishment of any new project of irrigation or the extension thereof, the commissioners' court deem it of sufficient importance to order a dam or ditch to be made on the lands of any person refusing to consent thereto, the said court, after giving such person actual notice in writing and full hearing and consideration of his objections, may decree the making of the same and shall depute two or more discreet and disinterested freeholders of the vicinage to arbitrate and fix the amount of damage permanently sustained by such person, which shall, by that or another such commission, be levied upon and paid forthwith by the applicants for such irrigation project in the ratio of the interest and several shares of the said applicants and joint owners, and the said courts may, after like personal notice to parties interested, order the multiplication or extension of any ditches for irrigation, and of irrigation, and of irrigation farms at and below, or at the sides of other such property, when it shall be the duty of such court to proceed and assess all just fines and equitable damages, and to fix and direct the rate and amount and kind of work, labor, and tax to be paid by any of such applicants and others, according to their interest.

ART. 2987. Where the health of the public may be injured by irrigation or the damming up of water for any purpose it shall be the duty of the commissioners' courts, after due mature hearing and consideration, to decree the discontinuance, and they shall proceed and break up and discontinue all such dams, ditches, and irrigation, whether the same have been heretofore ever so long in existence or may hereafter be started.

ART. 2996. All corporations for irrigation or navigation are hereby granted the right of way, not to exceed one hundred feet in width, over all public, university, school, and asylum lands, with use of necessary rock, gravel, and timber for construction purposes, and may attain the right of way over private lands by contract, or the damages for any private appropriated by such corporations shall be assessed and paid for as provided for in cases of railroads.

ART. 3000. Whenever any canal or ditch for irrigation shall be constructed under the provisions of this chapter, all persons owning lands adjacent to and irrigable from said canal or ditch, shall have the right to use the water of said canal or ditch, under such regulations as may be prescribed by law or by the commissioners' court of the county where such lands are situated.

UTAH IRRIGATION LAWS.

WATER RIGHTS.

SEC. 422. Whenever, by priority of possession, rights to the use of water for mining, agriculture, manufacturing, or other purposes, have vested and accrued, and the same are recognized and acknowledged by the local customs, laws, and the decisions of courts, the possessors and owners of such vested rights shall be maintained and protected in the same; and the right of way for the construction of ditches and canals for the purposes herein specified is acknowledged and confirmed; but whenever any person, in the construction of any ditch or canal, injures or damages the possession of any settler on the public domain, the party committing such injury or damage shall be liable to the party injured for such injury or damage.

SEC. 423. All patents granted, or pre-emption or homesteads allowed, shall be subject to any vested and accrued water right, or rights to ditches and reservoirs used in connection with such water rights, as may have been acquired under or recognized by the preceding section.

SEC. 424. The right to the use of water for the reclamation of desert lands, in accordance with the provisions of an act approved March third, eighteen hundred and seventy-seven, shall depend upon bona fide prior appropriation; and such right shall not exceed the amount of water actually appropriated, and necessarily used for the purpose of irrigation and reclamation; and all surplus water over and above such actual appropriation and use, together with the water of lakes, rivers, and other sources of water supply upon the public lands and not navigable, shall remain and be held free for the appropriation and use of the public for irrigation, mining, and manufacturing purposes, subject to existing rights.

SEC. 425. All navigable rivers, within the Territory occupied by the public lands, shall remain and be deemed public highways; and in all cases where the opposite banks of any streams not navigable belong to different persons, the stream and the bed thereof shall become common to both.

SEC. 2775. s 1. The selectmen of the several counties of this Territory are hereby created ex officio water commissioners for their respective counties, whose powers and duties shall be to make, or cause to be made and recorded, such observations, from time to time, as they may deem necessary, of the quantity and flow of water in the natural sources of supply, and to determine, as near as may be, the average flow thereof at any season of the year, and to receive, hear, and determine all claims to the use of water, and on the receipt of satisfactory proof of any right to the use of water having vested, to issue to the person owning such right a certificate therefor for recording, and to generally oversee, in person, or by agents appointed by them, the distribution of water within their respective counties, from natural sources of supply, to all the corporations or persons having joint rights in and to any natural source of supply, and to fairly distribute, according to the nature and extent of recorded rights, and according to law, to each of said corporations or persons their several portions of such water; and in case of dispute between any of such persons or corporations as to the nature or extent of their rights to the use of water or right of way, or damages therefor, of any one or more of such persons or corporations, to hear and decide upon all such disputed rights, and to file a copy of their findings and decisions as to such rights with the county recorder, and to distribute the water according to such findings or decision, unless otherwise ordered by a court of competent jurisdiction.

SEC. 2776. s 2. In cases where persons, or corporations, use water in different counties from the same natural source of supply, the water commissioners of each of said counties shall unite in appointing, either from among their number or otherwise, as they may determine, a board of reference of not less than three competent persons, to hear and decide all disputes in regard to water rights in and to such natural source of supply, and they shall file a copy of their decision with the county recorders of each of said counties; said water commissioners and members of the board of reference shall each, respectively, have power to administer oaths, and if any person who may be duly sworn in any matter in relation to the nature, extent, or exercise of any right or duty under any of the provisions of this act, shall falsely swear, such person shall be deemed guilty of perjury.

SEC. 2777. s 3. The certificate of the water commissioners shall state generally the nature and extent of the right to use water of the person, or corporation, to whom it is issued, and must be filed with the county recorder for recording.

SEC. 2778. s 4. It shall be the duty of the county recorder of each county, upon any certificate of water commissioners being filed in his office, as prescribed by this act, and upon any findings or decisions of any commissioners, or board of reference, as to the extent of any such rights, and upon payment of the fees allowed by law for such service, to record, in a book, or books, to be kept by him for such purposes, all such certificates, findings, and decisions, which said record shall be deemed to impart notice to all persons whomsoever of the contents thereof, and shall be prima facie evidence of the existence and verity of the facts therein recited.

SEC. 2779. s 5. No person, or corporation, shall maintain any suit, at law or in equity, for the determination of the existence or extent of any right, or rights, to the use of water in this Territory, until after the decision of the proper county commissioners, or of the proper board of reference, as the case may be, unless said commissioners, or board, shall fail and neglect to hear and decide such person's claim of right to use of water for more than three months after such person may have presented, in writing, his claim, or claims, and evidence in support thereof, for adjudication: *Provided*, This section shall not be construed to affect or impair the authority or jurisdiction of any court in the issuance of a temporary injunction or restraining order in such cases, or to abridge the right of any person aggrieved by any such decision to maintain any lawful suit, or appeal, after such decision may have been made.

SEC. 3780. s 6. A right to the use of water for any useful purposes, such as for domestic purposes, irrigating lands, propelling machinery, washing and sluicing ores, and other like purposes, is hereby recognized and acknowledged to have vested and accrued, as a primary right, to the extent of, and reasonable necessity for such use thereof, under any of the following circumstances:

1. Whenever any person or persons shall have taken, diverted, and used any of the unappropriated water of any natural stream, water-course, lake, or spring, or other natural source of supply.

2. Whenever any person or persons shall have had the open, peaceable, uninterrupted, and continuous use of water for a period of seven years.

Sec. 2781. s 7. A secondary right to the use of water for any of said purposes is hereby recognized and acknowledged to have vested and accrued (subject to the perfect and complete use of all preliminary rights) to the extent of and reasonable necessity for such use thereof, under any of the following circumstances:

1. Whenever the whole of the waters of any natural stream, water-course, lake, spring, or other natural source of supply has been taken, diverted, and used by prior appropriators for a part, or parts, of each year only; and other persons have subsequently appropriated any part, or the whole, of such water during any other part of such year, such person shall be deemed to have a secondary right.

2. Whenever, at the time of an unusual increase of water exceeding seven years average flow of such water, at the same season of each year, all the water of such average flow then being used by prior appropriators, and other persons appropriate and use such increase of water, such persons shall be deemed to have acquired a secondary right.

Sec. 2782. s 8. A right to the use of water may be measured by fractional parts of the whole source of supply, or by such fractional parts, with a limitation as to periods of time when used, or intended to be used; or it may be measured by cubic inches with a limitation as to periods of time when used or intended to be used; or it may be measured by cubic inches with a limitation specifying the depth, width, and declination of the water at point of measurement, and, if necessary, with a further limitation as to periods of time when used, or intended to be used, and such right may be appurtenant to the land upon which such water is used, or it may be personal property, at the option of the rightful owner of such right, and a change of the place of use of water shall in no manner affect the validity of any person's right to use water, but no person shall change the place of use of water, to the damage of his coowners in such right, without just compensation.

Sec. 2783. s 9. A continuous neglect to keep in repair any means of diverting or conveying water, or a continuous failure to use any right to water, for a period of seven years at any time after the passage of this act, shall be held to be abandonment and forfeiture of such right, and whenever hereafter a conveyance of any parcel of land is executed, and a right to the use of water has been continuously exercised from the time of its first appropriation, in irrigating such land, such right shall pass to the grantee of such conveyance; and in cases where such right has been exercised in irrigating different parcels of land at different times, such right shall pass to the grantee of any parcel of land on which such right was exercised next preceding the time of the execution of any conveyance thereof; subject, however, in all cases to payment by the grantee of any such conveyance, of all amounts unpaid on any assessment then due upon any such right: *Provided,* That in any of the cases mentioned in this section, any such right to the use of water, or any part thereof, may be reserved by the grantor of any such conveyance, by making such reservation in express terms inserted in such conveyance.

Sec. 2784. s 10. All rights to the use of water, and means of diverting water, shall be exempt from taxation, except for the purpose of regulating the use of the exercise of such right in all cases where the land or other property upon which the pertaining to such rights is assessable for taxation, but in making the assessment the assessor shall estimate the increased value of such land or other property, caused by the use of such water.

Sec. 2785. s 11. It shall be the duty of all persons using water from any natural source of supply to provide suitable ditches for conveying surplus water again into the natural channel, or other places of use, to the satisfaction or approval of the water commissioners; and if, through neglect so to provide such ditches, water is allowed to form pools or marshes, or otherwise run to waste, and if any person shall turn or use any water in a manner that damages the property of another, except when such turning or using in the prudent, careful exercise of such person's lawful right to so turn or use, such person or persons so offending shall be liable for damages to any aggrieved person entitled to the use of water from the same source of supply, and the water commissioners may, on application, or of their own motion, cause the water supply to be diverted from such offending party until such waste ditches are provided.

Sec. 2786. s 12. Whenever the terms mentioned in this section are employed in this act, they are employed in the sense hereinafter affixed to them, except when a different sense plainly appears:

1. The term "person," when applicable, includes "firm," "partnership," "joint stock company," "association," and "corporation."

2. Words in the singular number may include the plural, and words in the masculine may include the feminine.

3. The term "continuous use" includes use for that part of each year necessary for the purpose used for.

Sec. 2787. s 14. Whenever the waters of any natural source of supply are not sufficient for the service of all those having primary rights to the use of the same, such water shall be distributed to each owner of such right in proportion to its extent, but those using the water for domestic purposes shall have the preference over those claiming for any other purpose, and those using the water for irrigating lands shall have preference over those using the same for any other purpose, except domestic purposes: *Provided*, Such preference shall not be exercised to the injury of any vested right, without just compensation for such injury.

SEC. 2788. s 15. All persons shall have the right of way across and upon public, private, and corporate lands, or other right of way, for the construction and repair of all necessary reservoirs, dams, water-gates, canals, ditches, or flumes, other means of securing and conveying water for any necessary public use, or for drainage, upon payment of just compensation therefor, but such right of way shall in all cases be exercised in a manner not to unnecessarily impair the practical use of any other right of way, highway, or public or private road, nor to unnecessarily injure any public or private property.

SEC. 2789. s 16. Whenever a majority of individuals owning several rights to the use of water, and a joint interest in the means of diverting or conveying such water, or who may desire to divert and use any unappropriated water, desire to organize themselves into an association for the purposes of regulating the diversion and distribution of such water, they may organize into a corporation in the manner provided in "An act providing for incorporating associations for mining, manufacturing, commercial, and other industrial pursuits," approved February 18, 1870, and all amendments thereto, with power to levy and collect all necessary assessments, and the distribution of water to each stockholder may be regarded as the payment of dividends, and such corporation shall have perpetual succession, unless dissolved by three years' non-use of its rights, or by a two-thirds majority vote of its members, at a meeting called for that purpose; in all cases of dissolution, the property held by the corporation shall revert to the members in proportion to their rights therein, or they may organize into an irrigation district, under "An act to incorporate irrigation companies," approved January 20, 1856, as they may elect.

AN ACT COMPILING THE LAWS RELATING TO THE INCORPORATION OF IRRIGATION COMPANIES.

SEC. 2403. s 1. *Be it enacted, etc.*, That upon the majority of the citizens of any county or part thereof, representing to the county court that more water is necessary, and that there are streams or parts of streams unclaimed or unused, which, if brought out of their natural channels and thrown upon tracts of land under cultivation, or to be put under cultivation, can be of value to the interests of agriculture, the county court having jurisdiction may proceed to organize the county, or part thereof, into an irrigation district; and thereafter the land-holders of such district shall be equally entitled to the use of the water in or to be brought into such district, according to their acknowledged rights: *Provided*, Such land-holders pay their proportion of the expense incurred in the construction and keeping in repair of the necessary canals, flumes, dams, or ditches.

SEC. 2404. s 2. The citizens of an irrigation district, when so organized for the purposes provided in the preceding section, may, in mass-meeting, proceed to the formation of a company, by electing, *viva voce*, not less than three nor more than thirteen trustees, a secretary, and a treasurer. Notice of the time, place, and object of said mass-meeting shall be given by the clerk of the county court at least ten days previous by advertising three times in some newspaper having general circulation in the county, and by posting up notices in three public places in the district.

SEC. 2405. s 3. It shall be the duty of the trustees so elected to locate the proposed canal or ditch, determine the amount and quality of the land to be benefited thereby, to estimate the cost, including dams, flumes, locks, waste-weirs, and all the appurtenances belonging thereto, the amount per acre of the percentage on taxable property which will be necessary to construct the same.

SEC. 2406. s 4. It shall then be the duty of the trustees to make a report to the county court of the location and estimate provided for in section 3 of this act; also to call a meeting of the holders of the lands to be benefited by the proposed canal or ditch, at which a copy of said report shall be presented, and the said land-holders shall vote "yes" or "no" upon the following questions:

1. Do you mutually agree to pay —— per acre, land tax, to construct the proposed canal or ditch?

2. Do you approve the action of the mass-meeting in the election of officers?

Notice shall be given by the trustees at least ten days previous to the time appointed for such meeting, by advertising at least three times in some newspaper having general circulation in the county, and by posting up notices in three public places in the district. Said advertisement and notice shall state distinctly the time and place and object of such meeting, and be signed by a majority of the trustees and the secretary. The voting at said meeting shall be by ballot, and the chairman and secretary of said meeting shall be the judge and clerk of the election. A ballot-box shall be provided by the trustees, and each voter shall present his ballot to the judge of election, who shall deposit it in the box, and the clerk shall write the name of the voter in a poll-list or book, which shall also be provided by the trustees. No person shall be entitled to vote at said meeting or election unless he is a land-holder in the district. Immediately after the close of the election the ballots shall be openly counted by the judge and clerk, assisted by two persons chosen by the voters present. A certificate of the results of the election, signed by the persons who counted the votes, shall be forwarded at once to the clerk of the county court by the judge of said election.

SEC. 2407. s 5. If upon counting the votes it shall appear that two-thirds of the votes polled have been answered in the affirmative, then the tax so agreed upon shall be a law in the said irrigation district; and the tax when collected shall be paid over to the treasurer of said company on his order: *Provided*, That not exceeding one-half of the tax so agreed upon shall be collected at one time, and the residue to be collected as the work progresses: *Provided further*, That if the first estimate prove insufficient for the construction of the canal or ditch with its appurtenances, then additional taxes may be assessed in the same manner as hereinbefore provided until the said canal or ditch is completed.

SEC. 2408. s 6. If less than two-thirds of the votes polled are answered in the affirmative, then all proceedings under this act shall be null and of no effect: *Provided*, That if there are objections to the officers so elected by the mass-meetings, the electors may write other names on their tickets; the persons having the most votes to be declared elected, and it shall be the duty of the county clerk to notify such officers forthwith of their election.

SEC. 2409. s 7. Within twenty days after receiving such notice, the officers so elected shall file bonds in the office of the clerk of the county court, conditioned for the faithful performance of their several duties; the amount of such bonds to be declared by the county court having jurisdiction.

SEC. 2410. s 8. The term of office of the first trustees, secretary, and treasurer shall be till the next general election, and thereafter for two years, and until their successors are elected and file bonds.

SEC. 2411. s 9. All subsequent elections for determining the rate of tax shall be held annually on the first Monday in December, and for the election of company officers, biennially, on the same day, at such time and place within the district as shall be designated by the trustees, at which time the number of trustees may be changed by a two-thirds vote to not less than three nor more than thirteen. Notice of said election shall be given and the election conducted and certificates thereof returned, as provided in section 4 of this act, and the officers elected shall give bonds as provided in section 7 of this act. The rate of tax determined at said election by a majority vote shall be a law in said irrigation district, and shall constitute a permanent lien on the interest of the tax-payer in said canal or ditch and his right to the use of the water therein flowing from the day of assessment: *Provided*, That no tax created or payable by this act shall be or create a lien upon the land.

SEC. 2412. s 10. The trustees at their first meeting shall elect one of their number president, and it shall be their duty and they shall have power to fill any vacancy which may occur in the board by death, change of residence, or otherwise; and the persons chosen for this purpose shall hold office until the next annual election. The trustees shall also have power to meet at such times and places as they may deem expedient to make by-laws, rules, and regulations necessary to carry into effect the objects of the people; to appoint agents, subordinates, and officers, and employ such workmen as may be requisite; to appoint assessors and collectors, or make agreement with the county assessors to assess and collect the tax, and notify collectors when additional installments of the tax will be needed; to construct and complete said canals or ditches, with all necessary appurtenances thereto; to cause to be kept an account of all receipts and disbursements, and to complete said canals and ditches, and settle all accounts of the same. Said trustees shall make an annual report of their proceedings under this act to the county court on or before the first day of February, and shall file with the clerk of the county court a map of said irrigation district, showing the location and subdivision of land therein, and of the company's canals and ditches.

SEC. 2413. s 11. The trustees shall have power to sue and be sued, plead and be impleaded, to have and to hold all such real estate and personal property as may be necessary to construct the contemplated ditch or canal, including all appurtenances belonging thereto.

SEC. 2414. s 12. If any part of the lands to be benefited by the proposed ditch or canal are not legally claimed, then such lands may be appraised by the trustees and shall be held and the possession of them sold by the trustees, as opportunity may offer, and the estimated amount of the funds necessary to complete such canal or ditch shall be decreased by the estimated value of such lands, previous to the levy and assessment of any tax.

SEC. 2415. s 13. Where the streams to be taken out for irrigation purposes come from counties other than the one in which the district is situated, but where there are no existing claims to the water and where no individual or settlement will be injured thereby, then the power of said irrigation district is hereby extended to said other county, insomuch as said extension may be necessary for the construction of dams to turn the waters, and ditches or canals with all necessary appurtenances as may be necessary to convey the same to where it is to be used.

SEC. 2416. s 14. Where lakes or ponds in natural basins have outlets, or where such can be made by dams across hollows, such lakes or ponds may be used as reservoirs, to store water for lands lying on lower levels; and the people of any irrigation district may, under the provisions of this act, construct such artificial or use such natural basins for irrigation purposes: *Provided*, The waters of such lakes or ponds are in no case to be raised, by dams or otherwise, so as to interfere with or damage settlers upon the margin thereof.

SEC. 2417. s 15. Upon the construction or partial construction of any canal, ditch, or reservoir contemplated in this act, they shall become the property of the irrigation district; and thereafter all funds necessary for repairs upon said canal, ditch, or reservoir, and for keeping the same in order, or for altering or enlarging the same, may be levied by a tax upon the lands benefited, the landholders in the district to vote upon the same in the manner heretofore provided for in this act. And in case of any sudden emergency, caused by inundation or otherwise, said trustees are hereby authorized and empowered to make such repairs, or take such measures as they may deem necessary to preserve the canals, or ditches or other works of said company or district, and for payment of the expenses so increased the trustees are hereby authorized and empowered to levy a tax for the necessary amount upon all the lands of said district benefited by such canals or ditches, and said tax may be collected in the same manner and at the same time, if necessary, as provided for the collection of other taxes in said district.

SEC. 2418. s 16. All property or money belonging to any irrigation district, in the hands of the trustees to be expended by them under the provisions of this act, is hereby exempted from all city, county, and Territorial taxes.

SEC. 2419. s 17. After any canal or ditch shall have been laid out under this act, or under any special charter where other provision has not been made, the trustees or company may agree with the owners of land through which it will pass for the purchase of so much thereof as may be necessary for the making of the canal or ditch and the appurtenances thereto belonging.

SEC. 2420. s 18. In every case where the owner of the land so required shall absent himself from the country, or shall not, from any cause, be capable in law so to agree, or shall refuse to agree, or ask an exorbitant price, the value of such land and the damages to the owner thereof shall be ascertained in the following manner:

1. The owner of or claimant to such land and the trustees may each select a referee, and in case of disagreement the two may select a third, and these referees shall proceed to determine the value of the land under controversy, and assess the amount of damages, if any, which each owner of lands or improvements has sustained, or will sustain, in consequence of the canal or ditch.

2. The appraisal, with a description of the land so appraised, shall be acknowledged by the referees signing it, before the clerk of the county court of the county in which the lands are situated, and when so acknowledged it shall be filed in the said clerk's office within ten days after it shall have been made. In case the occupant or claimant shall refuse or neglect to select a referee as herein provided, the trustee may petition the district court of the district in which the land is situated for the appointment of three or more commissioners to condemn the land and fix and determine the damages; said commissioners to be appointed upon such notice to the complainant or occupant as said court shall direct. Said commissioners shall report to said court their award and determination for approval or disapproval. The motion for approval of said award shall be heard on such notice as the court shall direct.

SEC. 2421. s 19. The trustees, upon payment to the rightful claimant of the several sums assessed in the appraisal so made, or upon making a tender thereof when the same shall be refused, shall be entitled to enter upon the lands described in the appraisal, and have and hold the same for the use and benefit of such irrigation district forever.

SEC. 2422. s 20. If on any parcel of the lands so described there shall be no person then living authorized to receive payment for the damages assessed for such parcel, and such damages shall not have been lawfully demanded within ten days after the filing of such appraisal, the board of trustees may enter thereon without payment or tender of such damages, but subject to such payment whenever the same shall be thereafter lawfully required.

SEC. 2423. s 21. Any person who, in violation of any right of any other person, or of said corporation, willfully turns or uses the water, or any portion thereof, of said canal, ditch, or reservoir, except at a time or times when the use of such water has been duly distributed to such person, or willfully uses any greater quantity of such water than has been duly distributed to him, or in any way changes the flow of water when lawfully distributed for irrigation or other useful purposes, except when duly authorized to make such change, or willfully or maliciously breaks or injures any dam, canal, water-gate, ditch, or other means of diverting or conveying water for irrigation or other useful purpose, is guilty of a misdemeanor.

SEC. 2424. s 22. All companies or districts organized under the provisions of this act shall be liable for any damage which may occur by the breakage of any canal or ditch. When any land in an irrigation district is benefited or damaged by the company's canals or ditches, from soakage or other incidental cause, and the owner of said land and the company can not agree as to the amount of the benefit or damage, the matter in dispute, as well as the question of damage through breakage, may be referred and decided as provided in the preceding section of this act. No irrigation company organized under the laws of this Territory shall be entitled to divert the waters of any stream to the injury of any irrigation company or person holding a prior right to the use of said waters, and all cases of dispute arising from such unlawful diversion may also be referred and decided as provided in section 18 of this act.

SEC. 2425. s 23. Nothing in this act shall be so construed as to interfere with the right of the legislative assembly to repeal, alter, or amend the same at pleasure.

SEC. 2426. s 24. That persons who have constructed canals, ditches, or dams, and taken out water for irrigation purposes before the passage of this act to which this act is amendatory, are hereby authorized to organize under the provisions of said act, and to enjoy all the rights, powers, and privileges guarantied therein: *Provided*, They shall proceed in the same manner as is provided for the organization of new companies.

SEC. 2427. s 25. Nothing in this act shall be so construed as to prevent any association of persons incorporating under the laws of this Territory relating to private corporations for general purposes.

WYOMING IRRIGATION LAWS.

RIGHTS TO USE OF WATER AND RIGHT OF WAY FOR DITCHES.

SEC. 1317. All persons who claim, own, or hold a possessory right or title to any land or parcel of land within the boundary of Wyoming Territory, when those claims are on the bank, margin, or neighborhood of any stream of water, creek, or river, shall be entitled to the use of the water of said stream, creek, or river for the purposes of irrigation and making said claim available to the full extent of the soil for agricultural purposes. [C. L. 1876, ch. 65, § 1.]

SEC. 1318. When any person owning claims in such locality has not sufficient length of area exposed to said streams to obtain a sufficient fall of water to irrigate his land or his farm, or land used by him for agricultural purposes is too far removed from said stream, and he has no water facilities on those lands he shall be entitled to a right of way through the farms or tracts of land which lie between him and said stream, or the farms or tracts of land which lie above and below him, on said stream, for the purposes hereinbefore stated: *Provided*, That, in the construction, keeping up, and using any ditch through the lands of another person, the person or persons constructing or using said ditch, or whose duty it shall be to keep the same in repair, shall be liable to the person owning or claiming such land for all damages accruing to such person by reason of said construction, keeping up, and using such ditch. [C. L. 1876, ch. 65, § 2.]

SEC. 1319. Such right of way shall extend only to a ditch, dike, or cutting sufficient for the purposes required. [C. L. 1876, ch. 65, § 3.]

SEC. 1320. Upon the refusal of the owners of tracts of land, or lands through which said ditch is proposed to run, to allow of its passage through their property, the persons desiring to open such ditch may present to the county commissioners of the county in which said lands are located, a petition, signed by the person or persons describing with convenient accuracy the lands so required to be taken as aforesaid, setting forth the name or names of the owner or other person interested, and praying the appointment of three appraisers to ascertain the compensation to be made to such owner or persons interested. Upon the receipt of said petition, the said county commissioners shall give notice, at least thirty days prior to the appointment of said appraisers, by public notice in a newspaper, when published in the county, or by posting three or more notices in three different places in said county, stating that such appraisers will be appointed on the —— day of ——. [C. L. 1876, ch. 65, § 5.]

SEC. 1321. The said appraisers, before entering upon the duties of their office, shall take an oath to faithfully and impartially discharge their duties as said appraisers. They shall hear the proofs and allegations of the parties, and any two of them, after reviewing the premises, shall, without fear, favor, or partiality, ascertain and certify the compensation proper to be made to said owner or persons interested, for the lands to be taken or affected, as well as all damages accruing to the owner or person interested, in consequence of the condemnation of the same, taken or injuriously affected as aforesaid, making such deduction or allowance for real benefits or advantages which such owner or parties interested may derive from the construction of said ditch or flume. They, or a majority of them, shall subscribe a certificate of their said ascertainment and assessment, which shall be recorded in the county clerk's office of the county in which said lands are situated, and upon the payment of the compensation (if any) the said person or persons shall have the right of way to construct said ditch or flume. [C. L. 1876, ch. 65, § 6.]

SEC. 1322. All persons on the margin, bank, neighborhood, or precinct of any stream of water shall have the right and power to place upon the bank of said stream a wheel or other machine for the purpose of raising water to the level required for the purpose of irrigation, and the right of way shall not be refused by the owner of any tract of land upon which it is required, subject, of course, to the like regulations as required for ditches and laid down in the last preceding section. [C. L. 1876, ch. 65, § 7.]

SEC. 1323. The owner or owners of any ditch for irrigation or other purposes shall carefully maintain the embankments thereof, so that the waters of such ditch may not flood or damage the premises of others. [C. L. 1876, ch. 65, § 8.]

SEC. 1324. Nothing in this chapter contained shall be so construed as to impair the prior vested rights of any mill or ditch owner, or other person, to use the waters of any such water course. [C. L. 1876, ch. 65, § 9.]

SEC. 1325. Any ditch company constructing a ditch, or any individual having ditches for irrigation or for other purposes, whenever the same be taken across any publichighway or public traveled road, shall put a good substantial bridge (not less than fourteen feet in breadth) over such water course where it crosses said road. [C. L. 1876, ch. 65, § 11.]

SEC. 1326. When any such ditch or water-course shall be constructed across any public traveled road, and not bridged within three days thereafter, it shall be the duty of the county commissioners of the county in which said ditch and road are located to put a bridge over said ditch or water-course, of the dimensions specified in the foregoing section, and call upon the owner or owners of the said ditch or water-course to pay the expenses of constructing said bridge, and if payment therefor be refused, a civil action may be maintained for the recovery of the same, together with all accruing costs. [C. L. 1876, ch. 65, § 12.]

SEC. 1327. Upon the refusal of the owner or owners of land or lands through which any person or persons are desirous of constructing any irrigation ditch or ditches, then it shall be lawful for the parties interested to settle the matter by the appointment of a board of arbitration consisting of three men as hereinafter provided. [S. L. 1882, ch. 57, § 1.]

SEC. 1328. The creation of the board of arbitration shall be as follows: The person or persons desiring the construction of such ditch or ditches and the owner or owners of the land or lands through which the construction of such ditch or ditches is contemplated shall each choose one disinterested resident property holder of the county in which the land or lands mentioned above are situated, and the two so chosen shall designate a third person with like qualifications as themselves, and it shall be lawful for these persons to immediately proceed to hear the proof and allegations of the parties concerned. It shall be lawful for any two of such board of arbitration to make such assessment of damages as may in their judgment be deemed just and right, taking into consideration the benefits, if any, that may accrue to the owner or owners of the land or lands through which the construction of such ditch or ditches is contemplated. [S. L. 1882, ch. 57, § 2.]

SEC. 1329. Should the verdict or assessment of such board of arbitration be unsatisfactory to either or both of the parties interested, then recourse may be had by an appeal made in writing within ten days from the rendering of such verdict by such board of arbitration, addressed to the board of county commissioners of the county in which the contestants reside, in which case the party taking the appeal shall give bonds for all the costs; then the case shall stand as though no action had been taken in the matter and the parties may then proceed under this chapter in the same manner as though the proceedings to ascertain the compensation to be given had been taken before the county commissioners in the first instance. [S. L. 1882, ch. 57, § 3.] (For proceedings before commissioners see §§ 1320 and 1321.)

SEC. 1330. In case no appeal be taken as above provided by either of the parties interested, then the finding of such board of arbitration shall be binding and final: *Provided*, The sum of money agreed upon by the board of arbitration has been tendered or paid, or a deed for such right of way executed and delivered or tendered by the party or parties over whose land the right of way is sought. [S. L. 1882, ch. 57, § 4.]

APPROPRIATION OF WATER AND PROCEDURE.

SEC. 1331. The lands now irrigated, or which may be hereafter irrigated, from ditches taking water from the following described rivers and natural streams of the Territory of Wyoming, are hereby declared to constitute irrigation districts:

District number one shall consist of all lands irrigated from ditches from the North Platte River and its tributaries, except the Laramie River, between its intersection with the boundary line between Nebraska and Wyoming and its intersection with the western boundary line of Laramie County, Crow Creek, Lone Tree Creek, Pole Creek, Horse Creek, Chugwater Creek, Cheyenne River, Niobrara or Running Water River, and their tributaries.

District number two shall consist of all lands irrigated from ditches taking water from the Laramie River and tributaries, except Chugwater Creek, North Platte River and its tributaries, between its intersection with the western boundary line of Laramie County and the mouth of the Sweetwater, Sabille Creek and North Laramie Creek; and also the following-named streams, situate in whole or in part in the county of Albany, namely: Douglass Creek, Lake Creek, the three Beaver Creeks, Four-Mile Creek, Dutton Creek, Cooper Creek, Rock Creek and tributaries, Sabille, Sheep Creek, Deer Creek and tributaries, Antelope Creek, Fish Creek and its tributaries, Dale Creek and its tributaries, and also the following-named lakes, to wit: Cooper Lake, James Lake, Ione Lake, Sportsman's Lake, Lake Hutton, Lake Creighton, Lake George, Steamboat Lake, Horse Creek Lake, Lake Hattie, and Lake Owen.

District number three shall consist of all lands irrigated from ditches taking water from the North Platte River and its tributaries to the line of Carbon County, and all streams or continuations of streams lying within Carbon County.

District number four shall consist of all lands irrigated from ditches taking water from the Green River and its tributaries.

District number five shall consist of all lands irrigated from ditches taking water from the Powder, Tongue, and Big Horn Rivers and their tributaries, except Wind River.

District number six shall consist of all lands irrigated from ditches taking water from the little Powder River, Little Missouri River, and the Belle Fourche and their tributaries.

District number seven shall consist of all lands irrigated from ditches taking water from that portion of Green River lying within Uinta County and Bear River.

District number eight shall consist of all lands irrigated from ditches taking water from Wind River to Johnson County line.

Other irrigation districts may be formed from time to time by the governor, on petition of the parties interested, comprising territory not within any of the above-established irrigation districts. [S. L. 1886, ch. 61, § 1.]

SEC. 1332. There shall be one water commissioner for each of the above-named districts, and for each district hereafter formed, who shall be appointed by the governor, to be selected by him from persons recommended to him by the several boards of county commissioners of the counties into which water districts may extend, and the water commissioners so appointed shall hold their office for two years, or until their successor is appointed and qualified. The governor, by like selection and appointment, shall fill all vacancies which may be occasioned by death, resignation, or continued absence form the district, removal or otherwise, and the governor may at any time remove any water commissioner for failure to perform his duties, or for any other cause. [S. L. 1886, ch. 61, § 2.]

SEC. 1333. Within twenty days after his appointment, and before entering upon the duties of his office, such water commissioner shall take and subscribe an oath to faithfully and impartially perform the duties of his office, which oath shall be deposited with the clerk of the court having jurisdiction over the priority of rights to use of water in his district. [S. L. 1886, ch. 61, § 3.]

SEC. 1334. It shall be the duty of the said water commissioners to divide the water in the natural stream or streams of their districts among the several ditches taking water from the same, according to the prior rights of each, respectively, in whole or in part, and to shut and fasten, or cause to be shut and fastened, the head-gates of any ditch or ditches heading in any of the natural streams of the district, which in time of a scarcity of water, makes it necessary, by reason of the priority of the rights of others above or below them on the stream. [S. L. 1886, ch. 61, § 4.]

SEC. 1335. Every person who shall willfully open, close, change, or interfere with any head-gate or water-box without authority shall be guilty of a misdemeanor, and on conviction thereof shall be fined in any sum not exceeding one hundred dollars, or imprisoned in the county jail for a term not exceeding six months, or both fine and imprisonment. The water commissioners or their assistants, within their districts, shall have authority to arrest any person or persons offending and turn them over to the sheriff of the proper county. [S. L. 1886, ch. 61, § 5.]

SEC. 1336. The water commissioners herein provided shall be entitled to pay at the rate of five dollars per day for each day he shall be actually employed in the duties of his office, not to exceed fifty days in any one year, to be paid by the county in which his irrigation district may lie. Each water commissioner shall keep a just and true account of the time spent by him in the duties of his office, and shall present a true copy thereof, verified by oath, to the board of county commissioners of the county in which his district may be, and said board of county commissioners shall allow the same, and if said irrigation district shall extend into two or more counties then said water commissioner shall present his account for his said services, verified as aforesaid, to the board of county commissioners of the county in which sits the district court having jurisdiction over the priorities of the rights to use of water for the purposes for which it was appropriated in such districts. [S. L. 1886, ch. 61 § 6.]

SEC. 1337. Said water commissioners shall have power, in case of emergency, to employ suitable assistants to aid him in the discharge of his duty; such assistants shall take the same oath as the water commissioner and shall obey his instructions, and each shall be entitled to four dollars per day for every day he is employed, not to exceed thirty-five days in any one year, to be paid upon the certificate of the water commissioner in the same manner as is provided for payment of water commissioners. [S. L. 1886, ch. 61, § 7.]

SEC. 1338. Said water commissioners shall not begin their work until they shall be called on by two or more owners or managers, or persons controlling ditches in the several districts, by application in writing, stating that there is a necessity for their action, and they shall not continue performing services after the necessity therefor shall cease. [S. L. 1886, ch. 61, § 8.]

SEC. 1339. For the purpose of hearing, adjudicating, and settling all questions concerning the priority of appropriation of water, between ditch companies and other owners of ditches, drawing water for beneficial purposes, from the same stream, or its tributaries, within the same irrigation district, and all other questions of law and questions of right growing out of or in any way involved or connected therewith, jurisdiction is hereby vested, exclusively in the several district courts, as follows: For district number one, in the district court of Laramie County; for district number two, in the district court of Albany County; for district number three, in the district court of Carbon County; for district number four, in the district court of Sweetwater County; for district number five, in the district court of Johnson County; for district number six, in the district court of Crook County; for district number seven, in the district court of Uinta County; for district number eight, in the district court of Fremont County. All streams, lakes, and reservoirs not herein enumerated shall be, for all purposes, attached to and belong to the irrigation district in which the greater portion of its water is, it being the intent and meaning hereof to add to each irrigation district all waters not hereinbefore enumerated the majority of which lie in their respective areas, for the purposes of acquiring rights to the appropriation and use thereof and adjudicating the same. [S. L. 1886, ch. 61, § 9.]

SEC. 1340. In order that all parties may be protected in their lawful rights to the use of water for beneficial purposes, every person, association, or corporation, owning or claiming any interest in any ditch, canal, or reservoir, within any water district shall, on or before the first day of September, eighteen hundred and eighty-six, if such statements are not already matters of record at the time this act is approved, file with the clerk of the district court having jurisdiction of priority of rights to the use of water for irrigation, in such water district, a statement of claim under oath, entitled of the proper court, which statement shall contain the name or names, together with the post-office address of the claimant or claimants claiming ownership, as aforesaid, of any such ditch, canal, or reservoir, the name thereof (if any), and if without a name, the owner or owners shall choose and adopt a name, to be therein stated, by which such ditch, canal, or reservoir, shall thereafter be known. The description of such ditch, canal, or reservoir as to location of head-gate, general course of ditch, the name of the natural stream from which such ditch, canal, or reservoir draws its supply of water, the length, width, depth, and grade thereof, as near as may be, the time, fixing a day, month, and year, as the date of appropriation of water by original construction, also by any enlargement or extension, if any such thereof have been made, and the amount of water claimed by or under such construction, enlargement, or extension, and the present capacity of the ditch, canal, or feeder, or reservoir, and also the number of acres of land lying under and being, or proposed to be, irrigated by water from such ditch, canal, or reservoir; or if such waters have been appropriated for other beneficial purposes than irrigation, a statement of such purpose; such statement shall be signed by the proper party or parties; and shall file with the county clerk and *ex-officio* register of deeds a like statement, which shall be recorded by him in a book kept for that purpose. [S. L. 1886, ch. 61, § 10.

SEC. 1341. Upon the filing of such statement, the clerk of the court shall indorse upon the back thereof the date of filing, and shall prepare an index of the same, in a book to be provided for that purpose by the county commissioners, which said index shall contain the date of filing, the name of the party, association, or corporation, the name of the ditch, the stream from which the water is taken by such ditch, canal, or reservoir, in general terms, the location of the head-gate, the date of the appropriation of the water, by construction, enlargement or extension; said index shall be prepared alphabetically, by reference to the name of the ditch, canal, or reservoir. [S. L. 1886, ch. 61, § 11.]

SEC. 1342. For filing and indexing such statement, the clerk of the court shall receive a fee of one dollar, to be paid by the party or parties filing the same. [S. L. 1886, ch. 61, § 12.]

SEC. 1343. Hereafter every person, company, or corporation, constructing, enlarging, or extending any ditch, canal, or reservoir, for beneficial purposes, and intending to use or appropriate any water from any natural stream within a water district, for such beneficial purposes, shall file with the county clerk and *ex officio* register of deeds and the clerk of the district court, of the proper county, before the commencement of the construction, enlargement, or extension of such ditch, canal, or reservoir, a statement showing the stream or streams from which the water is to be taken; the point or place on said stream at or near which the water is to be taken out; the line of said ditch or ditches as near as may be; the use or uses to which said water is intended to be applied; the dimensions of such ditch or ditches, and each thereof, giving width on bottom and top, slope of banks, and grade of ditch; and likewise of any and all enlargements thereof; which statement shall be filed and indexed as is provided in section thirteen hundred and forty, and from the time of filing any such statement water sufficient to fill such ditch or ditches, and to subserve the use or uses aforesaid, if a lawful and just use, shall be deemed and adjudged to be appropriated: *Provided*, That nothing herein contained shall be permitted to interfere with a prior right to said water, or to any thereof; *And provided further*, That such person or persons, or corporation, shall, within sixty days next ensuing the filing of such statement, begin the actual construction of said ditch or ditches, and shall prosecute the work of the construction thereof diligently and continuously to its completion; *And provided further*, That the beginning of all necessary surveys of such ditch shall be construed as the beginning of said work of construction. [S. L. 1886, ch. 61, § 13.]

SEC. 1344. The water of every natural stream not heretofore appropriated within this Territory is hereby declared to be the property of the public and the same is dedicated to the use of the people, subject to appropriation as herein provided. The provisions of this chapter shall apply to all cases where water of natural streams is appropriated for beneficial purposes, whether the water be conducted through ditches, canals, flumes, or tunnels, and shall apply also to cases where for irrigation purposes the water is stored in reservoirs, and the owner or owners of any ditch, canal, flume, or tunnel through which water is conducted for irrigation purposes, and also the owners of reservoirs, may conduct the water therefrom into and along any of the natural streams of the Territory, but not so as to raise the waters thereof above high-water mark, and may take the same out again at any point desired, but due allowance shall be made for evaporation and seepage, the amount to be determined by the water commissioner of the proper district, subject to review and determination by the court having jurisdiction over priorities in such district. [S. L. 1886, ch. 61, § 14.]

SEC. 1345. Whenever any person or persons, association or corporation, interested as owners of any ditch, canal, or reservoir, in any district, shall desire a determination of the priorities of rights to the use of water from stream or streams from which they draw the water for their ditch or ditches, canals or reservoirs, they shall present to the district court having jurisdiction over the rights in such water district, or to the judge thereof in vacation, a motion, petition, or application in writing, moving or praying said court to proceed to an adjudication of the priorities of rights to the use of water for irrigation between the several ditches, canals, or reservoirs in such district on the stream or streams named in the motion, petition, or application. The said motion, petition, or application shall state the names of the ditches, canals, or reservoirs claiming water from said stream or streams, as appears by the final statements in the clerk's office, together with the names of the persons, associations, or corporations interested therein, taken from said statements, and shall set forth the nature of the claim or claims of the applicant or applicants, and such motion, petition, or application shall be entitled "In the matter of an application for an adjudication of the priorities of rights to use water for beneficial purposes in water district number ——, on ———" (stating the stream or streams). Upon the filing and docketing of such application the court, or judge thereof in vacation, shall without unnecessary delay, by an order to be entered of record, upon such motion, petition, or application, appoint a day, in some regular term of said court, or in vacation thereof, for commencing to hear and take evidence in such adjudication, at which time it shall be the duty of the court, or judge thereof in vacation, to proceed and hear all evidence that may be offered by or in behalf of any person, association, or corporation interested in such stream or streams in such district in any ditch, canal, or reservoir, either as owner or consumer of water therefrom, in support of or against any claims of priority of appropriation of water made by means of any ditch, canal, or reservoir, or by an enlargement or extension thereof in such district, or on such stream or streams, and consider all such evidence, also the arguments of the parties or their counsel, and shall ascertain and find from such evidence, as near as may be, the date of the commencement of such ditch, canal, or reservoir, together with the original size and carrying capacity thereof, as originally constructed, the time of the commencement of each enlargement or extension thereof, if any, with the increased capacity thereby occasioned, the time spent severally in such construction, enlargement, or extension and re-enlargement, if any, the diligence with which the work was in each case prosecuted, the nature of the work as to the difficulty of construction, and all such other facts as may tend to show the compliance with the law in acquiring the priority of right claimed for each such ditch, canal, or reservoir, and determine the matters put in evidence, and make and cause to be entered a decree determining and establishing the several priorities of right by appropriation of water of the several ditches, canals, and reservoirs in such water district in such stream or streams concerning which testimony shall have been offered, each according to the time of its said construction and enlargement or enlargements and extensions, with the amount of water which shall be held to have been appropriated by such construction and enlargement or extensions, describing such amount by cubic feet per second of time (which shall also be the method of measurement for the sale of water), if the evidence shall show sufficient data to ascertain such cubic feet, and if not, by width, depth, and grade, and such other description as will most certainly and conveniently show the amount of water intended as the capacity of such ditch, canal, or reservoir in such decree. Such court, or judge thereof in vacation, shall further order that each and every person interested or claiming any such ditch, canal, or reservoir shall receive from the clerk, on payment of a reasonable fee therefor, to be fixed by the court, or judge in vacation, a certificate, under seal of the court, showing date or dates, and amount or amounts, of appropriations adjudged in favor of such ditch, canal, or reservoir, under and by virtue of the construction, extension, and enlargement thereof severally, also specifying the number of said ditch as determined by the court with reference to priority, and of each priority to which the same may be entitled by reason of said construction, extension, and enlargement: *Provided*, That any party or parties claiming any right to the use of water for beneficial purposes in such district, and on such stream or streams, by reason of being owner of or interested in any ditch, canal, or reservoir, who is not mentioned in the motion, petition, or application filed and presented to the court, shall be notified by the clerk of such application, and shall become parties to such proceedings, and shall have their rights adjudicated therein. The court or judge thereof, in vacation, may, instead of taking the testimony orally or in open court, refer the matter to some person to take and reduce to writing the testimony to the court, or judge thereof in vacation, and the person to whom such cause shall be referred for that purpose shall have the same power and duties concerning the taking of testimony and compelling the attendance of witnesses as masters in chancery. [S. L. 1886, ch. 61, § 15.]

SEC. 1346. Upon the order of the court fixing the time of hearing being made, the clerk shall place a certified copy of such order, which order shall contain the names of all the parties alleged in application to be interested in the matter in the possession of the sheriff of the proper county, which shall be thereupon served upon each of the parties therein named in the same manner as a summons, and a return of the service shall be made and filed with the clerk within fourteen days after the delivery of said order to the sheriff, or if served by any other person, in cases where a summons could be served, then return shall be made within fourteen days after date of order. It shall be the duty of the clerk also to give public notice of such application and order, by publication in a newspaper, if any be printed and in circulation, in some county wherein such water district is situated, which notice shall be published at least once each week for two consecutive weeks, and which said notice shall contain the date of the filing of said motion, petition, or application, the name or names of the parties filing the same, a copy of the order made by the court for hearing, and shall notify all parties interested as owners in any ditch, canal, or reservoir on such stream or streams in such water district, as well as the persons named in the motion, petition, or application, to appear at said court, or before the judge thereof in vacation, at the time appointed and stated in the order, and that all persons interested as owners or consumers may then and there present his, her, or their proofs for or against any priority of right of water by appropriation sought to be shown by any party by or through any ditch, canal, or reservoir (either as owner or consumer of water drawn therefrom), and in case any party mentioned in the motion, petition, or application can not be personally served in any county embraced in such water district, the published notice above provided shall be deemed sufficient service of notice: *Provided further*, That in addition to such publication the clerk shall mail such published notice to each party mentioned in the motion, petition, or application, directing the same to the address of such parties as stated in the sworn statement on file. Proof of the proper publication shall consist in the sworn certificate of the publisher of the paper in which notice is published, to which shall be attached a printed copy taken from such paper. [S. L. 1886, ch. 61, § 16.]

SEC. 1347. Any person or persons who shall knowingly and willfully cut, dig, or break down, or open any gate bank, embankment, or side of any ditch, canal, or reservoir, flume, tunnel, or feeder in which such person or persons may be joint owners, or on the property of another, or in the lawful possession of another or others, and used for the purpose of irrigation, milling, manufacturing, mining, or domestic purposes, with intent maliciously to injure any person, association, or corporation, or for his or her own gain, unlawfully, with the intention of stealing, taking, or causing to run, or pour out of such canal, or reservoir feeder, or flume, any water for his or her own profit, benefit, or advantage, to the injury of any other person, persons, association, or corporation lawfully in the use of such water, or of such ditch, canal, tunnel, feeder, or flume, he, she, it, or they, so offending, shall be deemed guilty of a misdemeanor, and, on conviction thereof, shall be fined in any sum not exceeding one hundred dollars, and may be imprisoned in the county jail not exceeding six months, or both, at the discretion of the court. [S. L. 1886, ch. 61, § 17.]

SEC. 1348. Any party or parties, representing any ditch, canal, or reservoir, or any number of parties, representing two or more ditches, canals, or reservoirs, which are affected, in common with each other, by any portion of the decree rendered by the district court, by which he, she, it, or they may feel aggrieved, may have an appeal from said district court to the supreme court, and in such case the party or parties joining, desiring an appeal, shall be the appellants, and the parties representing any one or more ditches, canals, or reservoirs affected in common, adversely to the interests of appellants, shall be appellees. The party or parties in such appeal shall, within sixty days after the date of the decree, file in the district court wherein any decree is entered under this chapter a notice of appeal in writing, stating that such party or parties appeals to the supreme court of the Territory from the decree rendered in the case, or any part thereof. When only a part of the decree is appealed from the notice of the appeal should so state, and shall also in that case specify the portion or part of the decree appealed from. Upon filing of such notice of appeal the cause shall be deemed to be appealed to the supreme court of the Territory: *Provided, however,* That the party or parties appealing as aforesaid, shall, within sixty days aforesaid, enter into an undertaking, to be approved by the district court, or judge thereof, and to be given to all parties in said suit or proceeding, other than the parties appealing, and to be in such an amount as the court or said judge shall fix, conditioned that the parties giving their said undertaking shall prosecute their appeal to effect, and without unnecessary delay, and will pay all costs and damages which the parties to whom the undertaking is given, or either or any of them, may sustain in consequence of such appeal. [S. L. 1886, ch. 61, § 18.]

SEC. 1349. The order last aforesaid shall be entered of record, and the appellant or appellants shall cause a certified copy thereof to be served on each of the appellees, by delivering the same to him or her, if he or she may be found, or otherwise serving the same, in manner the same, as may be provided for serving summons from the district court by the laws then in force. [S. L. 1886, ch. 61, § 19.]

SEC. 1350. The appellant or appellants shall within six months after the appeal be allowed as aforesaid, file in the office of the clerk of the supreme court of this Territory a certified transcript of the proceedings had in the case in the district court, containing the pleadings and the statements of the parties filed herein and all evidence of record offered on the hearing of the cause, or so much thereof as shall effect the appropriation of water claimed by the means of construction, enlargement, or re-enlargement of the several ditches, canals, and reservoirs mentioned in the order allowing the appeal. When the evidence has been taken in the open court, or before the judge, in vacation, such evidence, or the substance thereof, reduced to writing and signed by the judge, or in case notes of said testimony have been taken by the official stenographer, a transcription of the same, signed by the stenographer and attested by his official seal, filed with the clerk of the court, shall be deemed a record of the evidence taken in said court. [S. L. 1886, ch. 61, § 20.]

SEC. 1351. The supreme court, in all cases heard before it under this chapter, shall, where it can properly be done, render such decree as the court, or the judge below, should have rendered. It may either reverse or modify the decree of the court or judge below, and in cases where the decree of the court below is reversed, in whole or in part, it may direct the court below as to its further proceedings therein. [S. L. 1886, ch. 61, § 21.]

SEC. 1352. No claim of priority of any person, association, or corporation on account of any ditch, canal, or reservoir, as to which he, she, it, or they have failed or refuse to offer evidence, under any adjudication herein provided for, shall be regarded by any water commissioner in distributing water in times of scarcity thereof, until such time as such party shall have by application to the court having jurisdiction obtained leave and made proof of the priority of right to which such ditch, canal, or reservoir shall be justly entitled, which leave shall be granted in all cases upon terms as to notice to other parties interested, and upon payment of all costs, and upon affidavit or petition sworn to, showing the rights claimed, and the ditches, canals, and reservoirs, with the names of the owners thereof, against which such priority is claimed, nor until a decree adjudging such priority to such ditch, canal, or reservoir has been entered, and certificate such as mentioned in section thirteen hundred and forty-six shall have been issued to claimant and presented to the water commissioner. [S. L. 1886, ch. 61, § 22.]

SEC. 1353. No person, association, or corporation representing any ditch, canal, or reservoir shall be permitted to give or offer any evidence before said court until he, she, it, or they shall have filed a statement of claim in substance the same in all respects as is required to be filed under the provisions hereof. [S. L. 1886, ch. 61, § 23.]

SEC. 1354. The district court, or judge thereof in vacation, shall have power to order for good cause shown, upon terms just to all parties, and in such manner as may seem meet, a re-argument or review, with or without additional evidence, of any decree made under the provisions of this chapter, whenever said court or judge shall find from the cause shown for that purpose by any party or parties feeling aggrieved, that the ends of justice will be thereby promoted, but no such review or re-argument shall be ordered unless applied for by petition or otherwise within two years of the time of entering the decree complained of. [S. L. 1886, ch. 61, § 24.]

SEC. 1355. Persons desiring to construct and maintain reservoirs for the purpose of storing water shall have the right to take from any of the natural streams of the Territory and store away any unappropriated water not needed for immediate use, for domestic or irrigation or other beneficial purposes, to construct and maintain ditches, canals, flumes, or tunnels, for carrying such water to and from such reservoirs, ditches, canals, tunnels, and flumes, in the same manner provided by law for the condemnation of lands for right of way for ditches: *Provided*, No reservoir with embankments or a dam exceeding ten feet in height shall be made without first submitting the plans thereof to the county commissioners of the county in which it is situated, and obtaining their approval of said plans: *And provided further*, That no such reservoir shall be constructed or made in or across the channel of any natural and running stream. [S. L. 1886, ch. 61, § 25.]

SEC. 1356. The owners of reservoirs shall be liable for all damage arising from leakage or overflow of the waters therefrom, or by floods caused by breaking of the embankments of such reservoir. [S. L. 1886, ch. 61, § 26.]

SEC. 1357. Every witness who shall attend before the court, or the judge thereof in vacation, or before the person appointed to take testimony, in the causes provided for in this chapter, under subpœna, by request of any party, shall be entitled to the same fees and mileage as witnesses in civil cases in the district court, and shall be paid by the party requiring his testimony. [S. L. 1886, ch. 61, § 27.]

SEC. 1358. It shall not be necessary for any corporation heretofore organized and now existing, or for any corporation hereafter organized, under the laws of this Territory, which has heretofore, or shall have hereafter constructed, operated, or maintained any ditches, canals, flumes, tunnels, or reservoirs, or other appropriations of water, for the purpose of irrigation, mining, manufacturing, domestic uses, or for any beneficial purpose whatever, to incorporate as a ditch company, or companies, if the objects or purposes for which such corporation shall have been formed or incorporated, imply, permit, or make necessary, or advantageous, such use or uses of water; and such corporation for all the purposes of this chapter shall have all the rights of a natural person as defined herein, and shall have its rights determined in the same manner: *Provided*, No priority of water right shall take from any city or town the water required for the use of the residents thereof. [S. L. 1886, ch. 61, § 28.]

SEC. 1359. Said water commissioners shall so divide, regulate, and control the use of the water of all streams within their respective districts in such manner, as near as may be, as will prevent unnecessary waste of water, and to that end such commissioners shall so shut and fasten the head-gate or gates of all ditches so that no more water will flow into said ditch than is actually required and will be used for the uses or purposes for which such water was appropriated, and any person who may be injured by the action of any water commissioner or by his failure to act pursuant to this chapter, may resort to any court of competent jurisdiction for such relief as he may be entitled to. [S. L. 1886, ch. 61, § 29.]

SEC. 1360. It shall be the duty of every person, corporation, or company, who shall construct, maintain, or operate any ditch or canal under the provisions of this chapter to construct and maintain, at the point and place where the water is diverted from its natural channel, some fit and proper obstruction whereby all fish will be prevented from entering said ditch or canal. Any person, company, or corporation violating the provisions of this section shall be adjudged guilty of a misdemeanor, and on conviction thereof shall be punished by a fine of not more than one hundred dollars or by imprisonment in the county jail not less than ten nor more than sixty days, or by both such fine and imprisonment. [S. L. 1886, ch. 61, § 30.]

SEC. 1361. This chapter shall in no wise be construed as impairing or abridging any rights already vested in any person or persons, company or corporation, by virtue of the law heretofore in force. [S. L. 1886, ch. 61, § 31.]

IRRIGATION—APPROPRIATION OF WATER—TERRITORIAL ENGINEER.

SECTION 1. There shall be a Territorial engineer, who shall be appointed by the governor, by and with the consent of the legislative council; he shall hold his office for the term of two years, commencing on the first day of April, A. D. eighteen hundred and eighty-eight, and until his successor shall be appointed and shall have qualified.

The governor may at any time, upon good cause being shown, remove the Territorial engineer, and fill the vacancy occasioned by such removal from office.

The Territorial engineer shall receive a salary of two thousand and five hundred dollars per annum, payable in monthly installments by the Territorial treasurer, upon warrants drawn by the Territorial auditor.

The Territorial engineer shall keep his office at the Territorial capitol, in a room in the capitol building, to be set aside for his use by the governor.

Before entering upon the duties of his office he shall take and subscribe an oath before some officer authorized by the laws of this Territory to administer oaths, to faithfully perform the duties of his office, and file with the secretary of the Territory said oath and his official bond, in the penal sum of five thousand dollars, with not less than two sureties to be approved by the governor of the Territory, and conditioned for the faithful discharge of the duties of his office, and for delivering to his successor, or other officer appointed by the governor to receive the same, all moneys, books, and other property belonging to the Territory then in his hands, or under his control, or with which he may be legally chargeable, as such officer. No person shall be appointed as such Territorial engineer who is not known to have such theoretical knowledge and practical skill and experience as shall fit him for the position.

SEC. 2. The Territorial engineer shall have general supervision of the diversion and division of the water of the various natural streams in the Territory, and shall have supervision of the work of the water commissioners of the different water districts of the Territory, and shall do and perform any and all work for the Territory which comes within the nature of his profession as an engineer, when called upon by the governor to do so.

SEC. 3. The Territorial engineer shall make, or cause to be made, careful measurements and calculations of the maximum, minimum, and ordinary flow, in cubic feet per second of time, of the waters flowing in each stream from which water shall be drawn for irrigation purposes, commencing such work upon those streams most used for irrigation; he shall collect facts and make a report as to a system of reservoirs for the storage of waters in those portions of the Territory where such a system is practicable, stating in such report the location, capacity, and cost of such reservoirs; he shall become conversant with the water-ways of the Territory, and needs of the Territory as to irrigation matters, and in his report to the governor he shall make such suggestions as to the amendment of existing laws, or the enactment of new laws, as his information and experience may suggest; and he shall keep full and proper records of his works, observations, and calculations, all of which shall be the property of the Territory.

SEC. 4. The Territorial engineer shall, on request of any party interested, measure and ascertain the carrying capacity of any ditch used for irrigation or other beneficial purposes, which may be now or which may hereafter be constructed or enlarged, and give to the party or parties requiring such services an official certificate of the size and carrying capacity of such ditch, expressed in cubic feet per second of time, as he shall find it at the time of measuring the same. For such services he shall be entitled to receive from the party or parties requiring the same his per diem charges, not exceeding ten dollars per day, and his reasonable traveling expenses: *Provided*, That all per diem charges for such services received by the Territorial engineer shall be delivered by him to the Territorial treasurer, who shall credit the same to the general fund. If the applicant or applicants for such engineer's certificate shall state in writing to the engineer that the ditch to be measured is so remote from the office of the engineer as to render the expense of the engineer's personal examination too great, or if in the engineer's judgment such ditch is too far distant to prevent him, consistently with his public duties, to make such personal examination, it shall in such cases be his duty to appoint some competent civil engineer residing in the vicinity of such ditch to make a sworn statement, setting forth the width on top and bottom, depth, grade, and slope of the bank of such ditch or its enlargement, and all such other data concerning such ditch so to be measured as the Territorial engineer shall direct. Such civil engineer shall receive for his services such sum as may be agreed upon between himself and the party requiring his services, but in the absence of any agreement in writing such compensation shall not exceed ten dollars per day and his reasonable traveling expenses. The Territorial engineer shall furnish the person so appointed with blank certificates upon which to enter the necessary data concerning the ditch or its enlargement so to be measured, which blank shall be properly filled out and verified by the oath of the party making such measurements and returned to the Territorial engineer, who shall make his own calculations of the carrying capacity of such ditch or enlargement, expressed in cubic feet per second of time, and certify to the same. The certificates provided for in this section shall set forth the time of making the measurement, the location of the headgate of the ditch measured, the name of the natural stream of water from which such ditch draws its supply of water, the width of such ditch both on top and on bottom, its depth and grade, and its carrying capacity expressed in cubic feet per second of time, and also the name of the ditch and of the owner or owners thereof, if known. All such certificates shall be recorded at length in the office of the said Territorial engineer, and copies of such record, duly certified to by the said engineer, shall be received in all the courts of this Territory as prima facie evidence of the fact therein set forth as hereby required.

SEC. 5. The Territorial engineer, with the consent of the governor, shall have power to employ assistants at an expense not to exceed one thousand dollars in any one year, who shall be paid out of any moneys appropriated for that purpose, on the certificate of said Territorial engineer, approved by the governor, showing the reason for such employment, the services rendered, and the amount thereof, and on presentation of such certificate to the Territorial auditor, by the person entitled thereto, he shall issue his warrant on the Territorial treasurer for the amount thereof to be paid out of any appropriations, as aforesaid, and not otherwise.

SEC. 6. When the Territorial engineer is called away from his office in the discharge of his public duties he shall be entitled to his actual traveling expenses, which shall be paid out of any money appropriated for that purpose, on the certificate of the said engineer; such certificate shall be presented by the said engineer to the Territorial auditor, who shall thereupon draw his warrant upon the Territorial treasurer for the amount thereof, to be paid out of such appropriation: *Provided*, That this section shall not be so construed as to authorize the payment of traveling expenses to said engineer when called away from his office to perform any of the work mentioned in section four of this act.

SEC. 7. The appropriator of any of the public waters in this Territory shall construct and maintain, under the direction of the Territorial engineer, a flume or other measuring device, at or as near the head of his ditch as is practicable, for the purpose of assisting the water commissioners in determining the amount of water that may be turned into the ditch or the amount that may be by his ditch diverted from the stream. In case any owner or appropriator of public waters that have been adjudicated upon neglect or refuse to put in such measuring device, after thirty days' notice to do so by the Territorial engineer, the said engineer may direct the water commissioner, of the district in which the ditch may be situate to put in such flume or measuring device, which being done by the water commissioner, he, the said commissioner, shall present the bill of the cost of such flume or measuring device to the owner or owners of the ditch, and if such owner or owners shall refuse or neglect, for three days after presentation of such bill, to pay the same, the said water commissioner may maintain a civil action in his own name, in any court of the Territory, for the recovery of the same, with all accruing costs. Said suit shall be prosecuted by the county and prosecuting attorney for the county wherein such suit may be brought, free of any charge against said commissioner.

SEC. 8. The Territorial engineer shall prepare and render to the governor yearly, and oftener if required, full and true reports of his work, touching all the matters and duties devolving upon him by virtue of his office, which report shall be delivered to the governor on or before the thirtieth day of November in each year, in order that the same may be laid before the legislative assembly at its regular sessions.

SEC. 9. In all cases in which the priorities to the right to the use of the waters of any of the streams of this Territory have been adjudicated by any of the district courts of this Territory under the provisions of chapter two of title nineteen of the Revised Statutes of Wyoming, it shall be the duty of the clerk of the district court wherein said adjudication may have been made to forward a certified copy of such decree to the Territorial engineer immediately after the rendering of a decree in the matter of such adjudication, and for such copy there shall be paid to the said clerk, out of the treasury of the county wherein such decree was rendered, compensation at the rate of ten cents for each one hundred words contained in such decree. On receipt of such copy of such decree it shall be the duty of the Territorial engineer to cause the same to be recorded at length in a suitable book, to be provided for that purpose, and as soon thereafter as practicable to forward to the water commissioner of the water district wherein the stream adjudicated upon is situated a statement showing the title of the court in which such decree was rendered, the date of the decree, the name of each ditch the priority of which has been by such decree determined, its capacity, showing the width, depth, and grade of the said ditch and the quantity of water per second of time to which said ditch is declared by such decree to be entitled, to be expressed in cubic feet per second of time, and thereafter, in the supervision of the distribution of the waters of such streams by said ditches so adjudicated upon, it shall be the duty of the said water commissioner to be guided by such statement. It shall be the duty of the Territorial engineer to procure and cause to be recorded in his office a description of the flume or other measuring device at the head of each ditch so adjudicated upon, showing the width, depth, and grade of each flume or other measuring device, and to calculate and determine the quantity of water, expressed in cubic feet per second of time, which will flow through such flume or other measuring device at various depths, and furnish the proper water commissioner with a statement of the same.

SEC. 10. The water of every natural stream not heretofore appropriated, within the Territory of Wyoming, is hereby declared to be the property of the public, and the same is hereby dedicated to the use of the people of said Territory, subject to appropriation as hereinafter provided.

SEC. 11. Every person, company, or corporation hereafter constructing, enlarging, or extending any ditch, canal, or reservoir for irrigation or other beneficial purposes, and intending to use or appropriate any water from any natural stream within a water district for such purposes, shall, within ninety days after the commencement of the construction, enlargement, or extension of such ditch, canal, or reservoir, file and cause to be recorded in the office of the county clerk and *ex-officio* register of deeds of the county in which is situated the district court having jurisdiction of all questions concerning the priority of rights to the use of water in such water district, a statement of claim under oath, setting forth the name or names, together with the post-office address of the owner or owners of any such ditch, canal, or reservoir; the name thereof, if any, and if without a name, the owner or owners shall adopt a name to be therein stated by which such ditch, canal, or reservoir shall thereafter be known; the number of the water district in which the same is situated; a description of such ditch, canal, or reservoir, as to location of head-gate and the general course of such ditch; the name of the natural stream from which such ditch, canal, or reservoir draws its supply of water; the length, width at top and bottom, depth, grade, and carrying capacity thereof, expressed in cubic feet per second of time, as near as may be; the time, giving the day, month, and year when work was commenced thereon by original construction, enlargement, or extension, as the case may be, and likewise the date when water was actually appropriated therefrom for irrigation and other beneficial purposes; the number of acres lying under and being, or proposed to be, irrigated by water therefrom, and a map or plat on a scale of not less than one inch to the mile, showing the location of route of such ditch, canal, or reservoir, and the natural stream from which it draws its supply of water, and also the legal subdivisions of land through which they flow: *Provided*, That in case the said statement gives the direction or route of such ditch by courses and distances, according to the field-notes of the survey thereof, it shall not be necessary to include in any such statement the map or plat above referred to. Such statement shall be signed by the person owning such ditch, canal, or reservoir, or, in case of a copartnership, by any member thereof, for and in behalf of such copartnership, or in case of a corporation, by the president or secretary thereof, and such statement shall be recorded as aforesaid in a book to be kept for that purpose.

SEC. 12. If the owner or owners of any such ditch, canal, or reservoir shall prosecute the work of construction thereon diligently and continuously until completed, and shall otherwise comply with the provisions of law, such owner or owners shall, as regards the owner or owners of all other ditches subsequently constructed and drawing their supply of water from the same stream, have a priority of right to the use of such water from and after the date of the commencement of the construction thereof, but not otherwise. The beginning of all necessary surveys of such ditch shall be considered as the commencement of such work of construction.

SEC. 13. When the waters of any natural stream are not sufficient for the service of all those desiring the use of the same, those using the water for domestic purpose shall have preference over those claiming water for any other purpose, and those using the water for agricultural purposes shall have the preference over those using the same for manufacturing purposes.

SEC. 14. The priority of right to the use of such water shall be limited and restricted to so much thereof as may be necessarily used and appropriated for irrigation or other beneficial purposes as aforesaid, irrespective of the carrying capacity of the ditch, and all the balance of the water not so appropriated shall be allowed to run in the natural stream from which such ditch draws its supply of water, and shall not be considered as having been appropriated thereby; and in case the owner or owners of any such ditch, canal, or reservoir shall fail to use the water therefrom for irrigation or other beneficial purposes, or shall refuse to furnish any surplus water to the owner or owners of lands lying under such ditch as hereinafter provided, during any two successive years, they shall be considered as having abandoned the same, and shall forfeit all water rights, easements, and privileges appurtenant thereto, and the waters formerly appropriated by them may be again appropriated for irrigation and other beneficial purposes the same as if such ditch, canal, or reservoir had never been constructed; neither shall the owner or owners of any such ditch, canal, or reservoir have any right to receive from others any royalty for the use of the water carried thereby, but every such owner or owners having a surplus supply of water and furnishing the same to others from any ditch, canal, or reservoir as hereinafter provided, shall be considered common carriers and shall be subject to the same laws that govern common carriers.

SEC. 15. The owner or owners of any such ditch which carries a greater quantity of water than the owner or owners thereof necessarily use for irrigation and other beneficial purposes in connection with their own lands shall, when application is made to them for that purpose, furnish such surplus water at reasonable rates to the owners of lands lying under any such ditch for the purpose of reclaiming such lands and rendering the same productive, and in case of refusal so to do the owner or owners of any such ditch may be compelled by injunction suit to furnish such water on such terms as to the court may seem meet and proper: *Provided*, That the board of county commissioners in their respective counties shall have power, when application is made to them by either party interested, to establish reasonable maximum rates to be charged for the use of water, whether furnished by individuals or corporations.

SEC. 16. The cubic foot of water per second of time shall be the legal standard for the measurement of water in this Territory, both for determining the flow of water in natural streams and ditches and also for the purpose of distributing water therefrom.

SEC. 17. Nothing in this act contained shall in any wise interfere with any prior right to the use of said water; neither shall the owner or owners of any such ditch, canal, or reservoir who have heretofore complied with the laws relating thereto enacted by the ninth legislative assembly of Wyoming be required to file any additional statement of claim under the provisions of this act.

IRRIGATION, ANCIENT AND MODERN.

ITS PHYSICAL FEATURES AND CHARACTERISTICS.

POSSIBLE EVIL EFFECTS—PRINCIPLES OF LEGISLATION IN ANCIENT TIMES—ITALY—SPAIN—FRANCE—MEXICO—AUSTRALIAN LEGISLATION—DEAKINS' REPORT—EGYPT.

PART VI.

Irrigation of land is an art that existed for many centuries previous to any authentic written history. The traditions of the Chinese people are very ancient, and irrigation is mentioned in their earliest history as extensively practiced. In Egypt, Syria, and the ancient kingdoms of Eastern Asia agriculture depended almost wholly upon irrigation, and still so depends in those countries where the people have survived the political changes of thousands of years. The irrigation of gardens, vineyards, and fields is frequently mentioned in the Scriptures; one of the earliest books speaks of it, and one of the prophets refers to "furrows of the plantation." The systems adopted in California, Texas, New Mexico, and Colorado are of ancient origin, and are copied from ancient models. They are not the best, but they are cheap and easy of construction. The settlement of the drier regions of our territory adds another instance to those of past history. The actual history of irrigation in the United States begins with the construction of the Pacific railroads.

The enormous sums expended by the British Government in India in irrigating works, and the profit derived from them will serve to sustain the arguments put forth by Mr. Cole and others, that while Great Britain is engaged in India not only in the construction of reservoirs for the storage of the waters and streams, but for gathering in the rains and dews for the purposes of irrigation, spending millions annually in such works, and in keeping them in repair, our own country, possessing vaster domains than any nation of the world, and of incomparable value, has only to enter upon her own possessions and, by trenching her mountain sides, beget reservoirs as enduring as the foundations of the earth.

USES, ABUSES, AND REMEDIES.

The late Hon. George P. Marsh, for many years United States minister to Italy, in an exhaustive article on "IRRIGATION, ITS EVILS, THE REMEDIES, AND THE COMPENSATIONS," treats on all the phases of this important subject. In this article Mr. Marsh refers to the customs and laws governing the use of water in every country of Europe. The methods of accumulating and distributing the water of precipitation, and of flooding springs and streams for agricultural purposes, are readily accessible, and in the practical employment of the system our engineers and the ingenuity of our people will, he says, no doubt overcome any special difficulties arising from the peculiar geographical and meteorological features of our territory. The social, legal, sanitary, and financial aspect of the subject in its application to extensive tracts of cultivated land are not familiar to the American public. He says, cautions of a not altogether obvious nature are more needed than instruction on points of practical method, or of adaptability to particular branches of agriculture. He points out the evils and difficulties of the practice of irrigation, and suggests precautions against the occurrence of these evils and the means of palliating them where they are to some extent inevitable. In the introduction of new systems of industrial or rural occupation in a scale large enough to affect the rights and interests of whole classes of the population, equal regard should be paid to the good of every class, and on all such occasions the moral, social, and sanitary consequences of great changes in the habits and employments of large bodies of the people is of more consequence than the merely financial results. In this, as in most questions of political economy, is encountered the great enigma of the right relation between capital and labor, and there are not many instances where these relations are more unsatisfactory than in the employment of irrigation on the great scale in which it is practiced in many parts of Europe. Mr. Marsh says the tendency of irrigation in the Old World as a regular agricultural method is to promote the accumulation of large tracts of land in the hands of single proprietors, and consequently to dispossess the smaller land-holders. Where a district derives its supply of water for irrigation from a single stream or lake not practicably inexhaustible, the interests of production require that the husbandry of the entire district be administered in a uniform or harmonious system, and consequently that the control of the source of water-supply be vested in a single head; for it is obvious that each land-holder can not be allowed to draw off at his pleasure and appropriate to his own use the whole current or such parts of it as may suit his convenience. The cause, capacity, and channels of division and of final discharge must be determined by some common principle, and adapted to the branches of husbandry best suited to the soil and climate. The agricultural economy of each farmer must remain substantially fixed and invariable, and even so simple a thing as the rotation of crops would be almost impracticable, because it would be impossible to change the whole system of supply. The canals of diversion and distribution once established, the net-work must remain immutable, "as the arteries and veins of the human system." The measurement of flowing water and its diversion between different occupants are matters of extreme complexity, and jealousies and dissensions often arise between neighboring claimants in regard to the ascertainment of the quantity rightfully belonging to each and the amount actually withdrawn by each from the common source of supply. The consequence of these interminable vexations is that the poorer or more peaceably disposed land-holder is obliged to sell his possessions to a richer proprietor, and the whole district gradually passes into the hands of a single holder, family, or corporation. In the large irrigated plain lands of Europe real estate is accumulated in vast tracts of single ownership, and farming is conducted on a scale hardly surpassed in England or even on the almost boundless regions of our own West. In illustration of this Mr. Marsh states that ten years ago a single proprietor exhibited at an agricultural fair at Modena one hundred yoke of oxen from his own estate. There are doubtless, he says, considerable economical advantages in the system. The unity of administration tends to increase production as well as to diminish the cost, but the evils more than counterbalance this advantage. Pliny, the elder, complained eighteen hundred years ago that great farms had been the ruin of Italy. Next in importance to the moral and social aspects of the system comes the question of the effects of irrigation on the health of the population employing it in certain branches of agriculture where water is largely used. The fact is established that the miasmatic exhalations are highly deleterious. The rice grounds of Lombardy are almost as destructive to health as those of Georgia and other Southern States. All irrigation, Mr. Marsh says, except where the configuration of the surface and the character of the soil are such as to promote the rapid draining of the water, or where special precautions are provided against its influence, is prejudicial to health. The increased dampness of the atmosphere is injurious to the respiratory system in some localities, and in others the exhalations from the watered soil and moistened manure tend to develop malarious influences, and aggravate, if not occasion, febrile diseases. Mr. Marsh says, in a foot-note:

> There is no doubt the insalubrity of Rome is greatly aggravated by the abundantly irrigated gardens within the walls of that city, and the increased prevalence of malarious fevers in the neighborhood of New York and other American cities is due to increased extent of market gardens, and consequently of irrigated lands in their vicinity.

INFILTRATION OF THE SOIL.

Mr. Marsh notices the purely physical evils which he regards as in many cases inseparable from this system of husbandry, and says the first and most obvious effect of withdrawing water from its narrow natural channels and distributing it over the surface of the earth is a great increase in the humidity of the soil watered, a like increase in the evaporation from it, and a corresponding reduction of the atmospheric temperature, as in other cases of evaporation. The water imbibed by the earth is generally estimated at about one-seventh of the quantity applied. This may not be sufficient to affect the consistence of the soil to a serious degree, but of the remaining six-sevenths the portion not carried off by evaporation, employed to irrigate lands at a lower level, or discharged into running streams or lakes, frequently produces a very prejudicial effect on the soil of adjacent lands over which the water flows or into which it percolates. Thus, he says, the infiltration of the superfluous water from the rice grounds of Lombardy sometimes renders the lower fields adjacent unfit for any other husbandry to a distance of miles from the land flowed for watering the rice. The division of brooks and rivers and the final discharge of the current by remote outlets tends to deprive the district originally watered by it of their proper supply, and while on the one side considerable tracts of land are sometimes drenched with superfluous moisture, on the other water-courses large enough to drive mills and other machinery may be laid dry and their fish destroyed, and even the subterranean conduits from their beds which fed the springs and wells at lower levels may cease to flow.

Irrigation always compacts and hardens the soil, and frequently to a very inconvenient degree. This, of course, increases the labor both of plowing and the subsequent tillage with hoe or cultivator, and farmers are tempted to rely too much on the fertilizing power of irrigation, and consequently to use little manure, a liberal application of which renders land less liable to become hard and tenacious by watering. A general opinion prevails that water employed for irrigation dissolves some of the fertilizing ingredients of the soil, and carries them with it in its flow or percolation through the adjacent fields into which it escapes. This opinion was controverted by Liebig, who taught that none of the material constituents of vegetation were thus abstracted by water, and that view has been confirmed by other observers. But later experiments appear to show that the doctrines of Liebig and his followers are not strictly true, for mineral and vegetable substances, which enter more or less into the food of plants, have been detected in the field, drains, and other currents from cultivated soils. There is, however, no satisfactory evidence that land is impoverished by irrigation, though the consistence of the soil may be sometimes affected injuriously. The increase of the natural humidity of the soil provokes the growth of aquatic weeds, and in all freely irrigated lands the borders of the channels of distribution are fringed with water-plants, in spite of all efforts to destroy them. In many localities irrigation can not be carried on upon a great scale without the construction of large reservoirs. The objections to these arise from the fact that it is almost impossible to make the retaining dams or walls sufficiently secure to prevent the waters from ultimately bursting their barriers and overwhelming the country below with ruinous desolation. Works of hydraulics are full of examples of such calamities.

THE NEED OF CARE AND CAUTION.

The quality of the grain roots and other vegetables cultivated by irrigation is a point of importance, and Mr. Marsh says he has not found the meal of Indian corn or other cereals produced by irrigation less sweet or less nutritious than that produced on unwatered fields. There are, he says, economical obstacles to irrigation, as it is seldom practicable without considerable outlay. Dams, dikes, artesian boring machines, pumping-machines, reservoirs, aqueducts, and canals are some of them indispensable where irrigation is employed at all extensively. The ground must be prepared to permit either a flow over it or its gradual absorption and infiltration, and a good deal of labor is required in the way of grading before irrigation can be practiced with advantage. On the Alps irrigation is practiced almost up to the limit of perpetual frost. The water of the melting snows at its low temperature is conducted immediately over the grass. There is danger, too, of entering into the system without previous careful inquiry as to the sufficiency of supply, and this involves experiments varied and long continued to determine. There is another suggestion to make in estimating the economical value of irrigation—namely, that in some parts of our own country production is now overabundant, and needs repression rather than enlargement. Mr. Marsh says: "From all this it will be obvious that considerable evils attend the practice of field irrigation, and they would be sensibly felt in its introduction in a country which stands in no special need of such a resource for increasing its agricultural production." The object of Mr. Marsh in pointing out these evils has been to inculcate the necessity of caution in attempting a revolution in our agricultural methods, but by no means to discourage careful study of the subject, or judicious experiment in appropriate localities.

He points out the necessity of taking especial care that water shall not be allowed to stagnate and poison the air. Hilly and winding slopes admit of a simple and efficient mode of irrigation, or a substitute which is not available on level soil. This method has been practiced with success in many parts of the United States, where it is known by the name of "circling." It consists in horizontally terracing the slopes, or furrowing them with the hill-side plow, and leaving the surface permanently in this condition.

The duties of the general and local governments of the United States in this branch of rural economy are by no means confined to the simple protection of nature's waters from private encroachment. Governments ought to take steps for collecting and diffusing all knowledge on the subject, and by encouraging and aiding experiments and by special inquiry into the physical conditions and capabilities, the wants and the means of all our territory. Much of the practical information needed may be gathered from European experience and by the study of the methods employed in those exceptional parts of our territory where irrigation has been long practiced.

Mr. Marsh, speaking of the stupendous net-work of canals lately constructed by the British Government in India, says:

> There are serious objections to the assumption of such burdens and responsibilities by republican government, but there are insuperable objections to any other system.
>
> The literature of European legislation, customary law, and judicial action on this subject is voluminous enough to form a library of itself, and of late years much has been done to lighten the labors of research on water questions, and to facilitate the application of law by codification and completion of digests and compends by private jurists.

Mr. Marsh says he is thoroughly convinced, after much observation and inquiry, that irrigation may be immensely extended among us with great commercial advantage, and that by reasonable prudence, and, above all, by a sufficient exercise of moral courage by our rulers, nearly all the evils which ordinarily attend the practice may be avoided or at least greatly mitigated.

On this subject the International Encyclopedia says:

> The ancient works for irrigation were stupendous. The canal of the Pharaohs, which connected Pelusuim with the Red Sea, was an irrigating canal. There existed a work in Arabia long before the time of Solomon, which in some respects excelled all works of the kind, modern or ancient, and corresponds well with the fact that the Arabians of that time were among the first mathematicians. In Yemen, Arabia, there was an immense reservoir for holding water for irrigating the valley of Mareb. The reservior was made by a dam 2 miles long and 120 feet high. It was constructed of immense blocks of ashlar, and was so durable as to serve the purpose for which it was built more than two thousand years. It then gave way, scattering ruin in the course of the torrent which it let loose.
>
> It must be borne in mind that one of the best examples in modern engineering is a dam in France across the Furens which is 164 feet high but only 328 feet wide at the top. This work almost sinks into insignificance when compared to the ancient Arabian dam.
>
> The plains of Assyria and Babylonia were intersected with a system of canals both for irrigation and navigation. In many of them water was raised by mechanical means somewhat like that practiced at present in Egypt.
>
> The ancient Peruvians and Mexicans constructed immense aqueducts for irrigation purposes whose existing remains, now partially used, astonish the traveler. The same may be said of China.

THE WATER LAWS OF OLDER LANDS.

Rome, it may be said, once ruled all the countries of southern Europe, northern Africa, and western Asia, where irrigation had its birth and its greatest development in ancient times. Like air, water was regarded as a necessity to human life, of which every one might use so much as was requisite for personal requirements, but which was not capable of appropriation to private ownership farther than in this sufficient quantity. Streams, rivers, ponds, etc., which were not in private ownership were regarded as things which belonged to the people as a nation. The roads and rivers were specially counted as public things by the Romans. The codes authorized the use of the rivers as ship-ways, or for fishing, but the ownership itself was vested in the state. They were not the property of the ruling sovereign, but of the sovereign power of the people collectively, each one of whom could use them as his own, but might not injure, neither segregate any portion or constituent part of them for his own. And this right was extended to all, whether Roman citizens or not, who were at peace with Rome.

Public rivers are defined to be such as were perennial or ever flowing, but if located through private lands were not the property of the public unless navigable or capable of being made so by improvement, or from some other cause of public importance. A river was distinguished from other streams by its greater volume or more considerable local importance.

The bank of a river commenced at the limit of the spread of the waters at high tide, but when lands were not inundated, land below that line was property in public or private ownership. In the case of navigable rivers, and all streams which were public property, the beds belonged to the state. Should the waters leave the channel and take another, the river was considered to have moved, and the old bed became the property of those whose lands were taken for the new channel, while lands taken for this new channel became part of the public property—the river. In the case of non-navigable rivers and streams not regarded as public, situated on private property, the beds belonged to the riparian proprietors. While the beds were covered with water the rights of the proprietors were suspended, but revived when the waters receded. The banks of the public river might belong to the riparian proprietor to the extent that he had the right to take the fruits, cut the bushes, and fell the trees which grew thereon, but not so as to prejudice the use of the river or its banks by the public.

The public had a right to the use of the banks of navigable rivers, so that a qualified ownership of the soil of such banks was all that could be acquired by private persons. The owner of lands which were bounded by a ditch or wall following near the bank, or by a public road on the bank of a public stream, was not a riparian proprietor; to be such, his lands had to be bounded by the stream itself. Roman law made a marked distinction between rivers and other streams and the waters thereof. A river-bed and the water was each regarded as a public thing, the property of the state, necessarily excluded from private ownership, control, barter, or sale; the use of both was to be enjoyed by all.

The water of the river was the property of the people in common, and each, if the enjoyment of the public property would not be impaired, might divert a portion of the water from its natural channel for other purposes than those of his own domestic necessities.

The state was guardian of the common property, the water, and no person could use more than sufficient for his individual necessities and those of his family and cattle without a special permit. In the case of water sources and water-courses which were susceptible of private ownership, the right to use their waters for purposes other than the supply of the immediate animal necessities pertained primarily to the owners.

Springs and brooks being situated on private lands constituted parts of such property, but the water itself while running in its natural channel was the property of all the people. The banks and channels of public rivers were specially guarded from injury; the construction of works or the placing of obstructions, by the effects of which the current might be made more or less rapid, was forbidden. The construction of works upon the bank or in the channel of a public river, whether navigable or not, whereby either the high or low water flow would be affected, was also forbidden, and works which might have an effect such as described, erected without authority, were removed or abolished at the expense of the constructor.

It was declared lawful, however, for riparian proprietors, or those who lived near the bank of the public river, to erect works for the protection of a bank, provided that navigation was in no way impeded thereby, and that the river or the other bank was not injured. If damage resulted from any such work an official examination was made, and the works were removed or ordered changed, and security for ten years was exacted from their owner or constructor. There was a provision concerning the protection of river banks, whereby it was lawful for riparian proprietors to construct works for the repair or protection of the bank adjacent to their property.

If damage was threatened by such works to the lands of another, a writ of inquiry was ordered, and security was exacted for ten years against the results of such possible damage.

The diversion of water, whether of floods or low-water flow, from public rivers, reservoirs, or tanks, without the sanction of a special privilege in each case, was prohibited.

The water privileges were of two kinds: First, those granted to individuals, of water for use on individual lands; second, those affecting water for public use. When a joint right to divert was issued to several persons, the division of the water was left to those holding the right. The use to which water was to be put was not always stipulated in grants, provided that it was to be used in good faith and not wasted. The user of water was liable for damages "by reason of anything done, dug, sown, delved, or built, whereby the river was corrupted." It was declared that water privileges should be "exercised in such a manner as not to damage other persons having similar rights."

Immemorial possession and use of running water by a private individual, as for the operation of a mill or in irrigation, gave prescriptive rights to the continued enjoyment of such use.

No possessor of water, though having held it from time immemorial, had the right to use it wastefully to the prejudice of others.

Springs on private lands were the property of the land-owner, on the principle that to such proprietor belonged all above and all below the land and all it produced. The right to use spring water might be acquired by others by agreement or prescription.

Spring waters flowing off, joining with other waters, and forming brooks on other lands, became common property, but their use was dedicated to the owners of the lands along their course, so that such waters for purposes of diversion belonged to these riparian proprietors.

Water rising out of the ground on a private estate, as being a part of the spring, was the property of the owner of the land; but when any portion of such water had escaped from the tract where it came to the surface, it became a common property of all the people. But so long as it remained in channels on private estates only the owners of the banks of its channels could divert it from its course and use it, except this right should have been acquired as a servitude.

But even these bank proprietors could not divert such waters if in so doing other proprietors were injured.

Water drawn from its source or diverted or drawn from its course into an artificial and private channel, or when stored in a reservoir or tank, itself in private ownership, became private property.

The user might do with it as he chose, providing his use was in good faith—not wasteful. The rights to draw water from a private spring or stream by others than its owners, and to conduct waters across lands owned by others, ranked as servitudes. A predial servitude under Roman law was a definite right of enjoyment in some particular respect of one person's property by the owner of other adjoining or neighboring property. Such a servitude could be held only as an appurtenance to land owned, being called predial because it could not exist without an estate.

The right of passage across the lands of another and the right of conducting water through such lands appear to have been recognized as indisputable privileges from the earliest times of the Roman jurisprudence.

The right of way to construct a canal or other conduit through the property of another, and to lead the waters through it, was one of the chief rural servitudes. The right to take water through the property of another in a ditch or other conduit could be acquired by prescription use for a long period of years, or by agreement, or, in the case of public works, title to the land necessary could be acquired by expropriation and payment therefor. When acquired as a title, of course the right was complete. When as a servitude, the right was accorded for a certain purpose only. A right to draw and use water from another's spring or rivulet might be imposed by agreement or prescription as a servitude thereon.

MODERN ITALY.

"In northern Italy the waters of all streams, whether navigable or non-navigable, appertain to the royal or public domain." The old established claim of the cities, communes, and associations of proprietors and of noble individuals in Lombardy to the supplies of water which they had for long periods of time actually utilized, having been recognized, the Government asserted and maintained its ownership to all natural streams, whether navigable or not.

Diversions of water under the old claims were subjected to Government regulations, but when the Government had come into control of the streams, so many claims had grown up that the proprietorship of the state was almost a barren one.

In Piedmont the right of property in all running water was reserved to the state. This reservation applied not merely to the large class o rivers, but also to the streams and torrents, the water of which could only be used under specific grants from the Government. After all Italy had been brought under one Government there was promulgated in 1865 the code of Victor Emanuel, of which article 427 is as follows:

> The national roads, the shore of the sea, the harbors, bays, coasts, rivers, and torrents, the gates, the walls, the ditches, the bastions of forts and fortifications form a part of the public domain.

This provision of the code of 1865 is the law now in force in Italy, and under it all running waters, except those of very small streams, are claimed as property of the Government, representing the people as a nation; and they are administered very much as are the waters of the navigable streams of France.

Navigability itself was a ruling consideration in France, while a volume of water for irrigation was the point of importance which made the stream one of public utility in northern Italy. As a matter of fact, in northern Italy every stream of perennial volume, other than very small streamlets, is regarded as a river; and every stream of intermittent flow from the rain-fall or melting of snows, except the smallest, is regarded as a torrent.

The principle that ownership of the land carries with it all beneath its surface and all it produces has prevailed from the times of the earliest recorded laws in all the north of Italy. Waters rising out of the soil have always been regarded as the absolute property of the owner of the soil so long as he retained them within the bounds of his estate and did not permit his title to suffer abridgment by allowing some other proprietor to acquire a prescriptive right to the use of the waters. The springs always remain the property of the owner of the soil, but the right to use their waters may be wholly alienated and held by the owner of some other property. The principle as to ownership of a spring is the same in all Italy as it was for Piedmont and other parts of the Sardinian Kingdom.

As the law now stands in all Italy, the owner of one or both banks of a little stream may use its waters in irrigating his riparian lands, but he must restore the drainage and residue of it to the ordinary channel; while he who is not a riparian proprietor can not take such waters at all without the consent of all the riparian proprietors; nor can any one riparian proprietor assign his right to water from such a stream to any one else.

The riparian right to divert waters from a stream is confined to the case of very small streams, and is scarcely known in the valley of the Po. During the times of the ownership of the streams and waters by the sovereigns of the states, and by the petty feudal rulers, and by the sovereign power of the states, as the representatives of all the people in each case, the right to divert water from any river or torrent could only be acquired in the states of northern Italy by special grant or concession of privilege made on a formal application, after due examination and consideration of all the interests to be affected. And now that the country is united under one government, and the waters belong to the royal or public domain, the same rule, and substantially the same formalities in applying it, exist.

It appears that the policy of the rulers in Lombardy, until the later years of its existence as a separate state, has generally been either to dispose of the waters of its streams in absolute property by gift or sale to those who constructed the canals to lead them out, or itself to construct such canals and sell the waters directly, or indirectly through farmers of the canal revenues, to the irrigators. The Government of Piedmont has generally been more conservative in the care of its waters. Absolute grants of ownership of waters ceased in that country before the beginning of the present century. Water privileges for all time have been issued, but the full right of regulation was reserved to the Government, and the cession of proprietorship in the water was expressly disclaimed. There are, however, important works whose proprietors have absolute rights of ownership in the waters, acquired in the centuries gone by. During the later years of the existence of the Piedmontese Government its waters were disposed of only on long-term leases. This last-mentioned policy is that pursued by the Government of Italy since it has supplanted those of Lombardy and Piedmont, the duration and terms of concession being similar to those of France.

FRANCE.

While under the dominion of Rome all matters pertaining to the streams and waters of the country now called France were subject to Roman law. Long before the close of the Roman rule the people had the full protection due citizens of Rome, so that at the time of the conquest of Gaul by the Visigoths (A. D. 470 to 480) there was much land held in individual ownership, with the consequent private rights, on small streams; but under the Merovingian kings the freehold titles to land disappeared, property was held by a different tenure under the sovereigns, and all rights of ownership in water-courses and waters was vested in the rulers themselves. The feudal system then grew up, and the water-courses, from having belonged to the nation and the people, or to private individuals, under Roman law, and then exclusively to kings under Merovingian rule, became dependencies upon the liefs of the feudal courts, who assumed almost complete ownership of and control over them. A struggle was ever present between these nobles and the kings for the control of the water-courses, and the conflict did not cease until the Government had become centralized and feudalism overthrown, during the fourteenth century. In that century the study of the Roman law was actively reviewed in France, and feudalism being on the decline, the Roman law recognizing ownership of streams not of public importance, non-navigable streams, by the riparian proprietors became incorporated into the law of France.

The kings asserted their ownership of all navigable streams and left the control and virtual ownership of non-navigable ones to the bank-owners, but really without any formal laws upon which to ground their claim of title to them. The public possessions of the kings held for the benefit of the nation became known as the "public domain." This policy of holding fast to all the nation's property is still adhered to by the Government, so that water-courses and waters once declared navigable and raftable can never be alienated from the public domain and become in any sense private property.

The changes in the form of government occurring a little less than a century ago appear to have resulted in no completed action affecting the laws or customs respecting waters until 1803–'04, when the Code Napoleon, which is the present civil code of the country, was promulgated. The only direct statement relating to the ownership of water-courses or waters in this code is as follows: Highways, roads, and streets at the national charge, rivers and streams which will carry floats, shores, ebb and flow of sea (the land newly made by the sea), ports, harbors, roadsteads, and generally all portions of the national territory, which are not susceptible of private proprietorship, are considered as dependencies on the "public domain." A royal ordinance of 1835 enumerated all the streams and parts of streams in France deemed navigable and claimed as of the public domain, and other ordinances of later dates have added to the list.

The sovereign authority to declare streams navigable, and hence part of the public domain, has not been disputed, but riparian proprietors who have been dispossessed of their right to water for irrigation, by the exercise of this power, have claimed and been allowed indemnities for actual damage caused them. Although only certain streams and parts of streams have thus far been added to the public domain, the administration may at any time declare other streams or parts navigable or raftable, and thus make them public property, afterwards paying the riparian proprietors for actual damage. The state owning these water-courses is, of course, owner of the waters forming them, and these, with the beds, are alienable from the public domain; their use only can be granted. According to the terms of the civil code, water-courses not navigable are common property. If the ownership of non-navigable waterc-ourses can not be fixed elsewhere, then these streams belong to the nation, just as well as do those which have become part of the public domain.

Riparian proprietors claim the ownership of the channel bed to the center line in front of their property, and the claim is allowed, when the beds are permanently laid dry from any cause; alluvial deposits along their banks accrue to the benefit of the land-owner adjacent to whose field they form; islands forming in the channels belong to the adjacent bank owners, and prior to the passage of a law specially to the point in 1847 the owner of one bank, although he might have secured administrative authority to build a dam in front of his own property, could not carry it past the center of the stream, or connect it with the opposite bank, without the consent of the bank owner. Until very recent years the beds of streams of this class belonged to and were under control of riparian proprietors, except where the Government has exercised a supervision of works and channels to insure a free flow for flood waters.

The waters of non-navigable and non-raftable streams were formerly claimed as the private property of the riparian proprietors. Their origin and division and the necessarily common control of the streams upset this theory. Then they were claimed by these proprietors as a sort of property held in common by them for the exclusive benefit of their lands and industries. It was and is still claimed by the owners of lands not bordering the streams that the waters belong to the whole people of France; and while the riparian proprietors are given a right to use them in irrigation and otherwise, it is not exclusive, but the Government can grant concessions for the use of some part of them on lands not riparian, so long as rights already accrued by use be not unduly or injuriously limited or their exercise inconvenienced by such action. The riparian proprietors now say, if the waters belong to the nation, they, the bank owners, have a special and complete servitude on all such waters, which right to use is continuous and not forfeitable by failure to avail themselves of it at any time or any length of time, except as between themselves. The fact of the ownership of the waters of non-navigable and non-raftable streams by the nation is now pretty well settled, and the tendency of decisions is towards a declaration of ownership by the nation of the beds also so long as occupied by the waters—so long as they are courses for public waters.

Starting several centuries ago with almost complete ownership and control of the waters and channels of the streams not navigable nor raftable the riparian land owners have since been restricted in their rights, and now find themselves without any recognized claim of ownership in the waters, and only a semblance in the channel beds, until after these shall have been laid dry, but with a preferred privilege to the use of the waters.

We find irrigation constantly favored in the laws in preference to manufacturing and many other uses of waters, domestic necessities and navigation alone ranking it in the scale, and the first of these two uses being the only one decidedly preferred to it in the administration of the laws.

On non-navigable and non-raftable streams the administration in the theory interferes with private operations conducted by those who as bank owners have rights on the streams under the ancient usages and civil code to regulate works in the channels or on the banks with a view to preserving the channels in the interest of the public and for developing a free passage for flood waters, and with the view of preserving the interests of navigation on the main stream below.

On the water-courses of the public domain the policy of the Government is actuated by a solicitude for the interests of navigation, and then by an almost equal interest in promoting the economical and full use of the waters in agriculture, manufacturing, and industrial pursuits generally, and finally by a realization of the pressing necessity for promoting the arterial drainage of the country, in order that floods may be prevented and valuable lands reclaimed.

On non-navigable water-courses the administration is not authorized to interfere between the owners of works already constructed and those proposed or newly constructed. The administration is bound to presume that the proprietor of lands on streams has a right to water therefrom, and can only interfere to the extent of regulating his works. The engineers can advise the parties in interest and bring before them all the facts as to measure of water supply and extent of use, etc., but if on such showings agreements can not be arrived at, the administration has no alternative but to sanction the construction of any new work proposed, provided the work itself is unobjectionable, leaving the court to decide whether or not the new appropriator is entitled to water. On navigable streams the administration is invested with full powers, not only to regulate works of all kinds, but to consider all questions relating to water privileges. In case of both classes of streams the engineers are charged with the duty of collecting and arranging data respecting the supply and use of waters.

The construction and management of all public works except those specially confided to the minister of war, of the navy, of education, of posts and telegraphs, and some others are delegated to the secretary of state or minister of public works. The care of all waters and water-courses, whether of public domain or not, their control and the control of the acts of individuals on their banks, are regarded as of public concern, and the administration thus has to do with all affairs affecting streams. It is now the intention of the Government that all water-courses of public importance in France, whether navigable or raftable, and consequently of the public domain, or not floatable even for rafts and timber, but which are of public utility, shall be subject to the supervising care of special agents of the Government called guards. On non-navigable streams the guards are generally appointed on recommendation of the riparian owners, and others interested.

No work of any kind, sort, or description may be erected upon a navigable stream or river floatable for rafts, or timber, or upon any stream so declared, nor can any water be taken from such streams, except it be taken in a bucket or other similar hand vessel, without the project for which it is required and the plan by which it is to be constructed, if a work, or used, if a water privilege, having been first submitted to the administrative authority and publicly made known, so that it may be opposed, if necessary. Older rights and those of industries most needful are always protected in the administration of affairs from day to day; but no right is so old or use so pressing that its owners have the power to control the diversion of the people's water, or use it in a wasteful manner, or in any way hinder the full development and prosperity of other institutions dependent on water supply.

It is on rivers and portions of rivers where it has become necessary to construct dams for navigation, and those still higher, which have been dammed for purposes of flotation, that water privileges are chiefly sought after for power purposes, irrigation, municipal supply, and industrial use. Such water-courses are public property, under full control of the administration. Non-navigable tributaries of navigable streams, and these streams themselves above the points where they become navigable, are also under the control of the administration. Still or stagnant waters, those draining from marshes and ditches, that have free communication from navigable or raftable streams, and whose waters flow the year round, or waters where ferry-boats can enter at all times, and those cared for at the expense of the state, make part of the public domain, and a right to dispose of or use them may be had only by special authorization.

Projects requiring special privileges to use water or sanction of plans to erect works in water-courses are undertaken either as private enterprises of individuals to water their own lands, to run their own mills, or for other private purposes, or as speculative enterprises by individuals, associated landholders, or capitalized incorporated companies desiring to sell water to consumers. When water privileges or permits to construct works are desired by individuals, for their own private benefit, in the use of water or otherwise, on navigable streams, an application must be made to the prefect of the department where the intended work or diversion is to be made.

When water privileges on streams navigable and of the public domain are desired by individuals, companies, or societies, for speculative purposes, all permits or concessions have to be acquired by decree deliberated upon in the council of state. Whenever possible, the diversion of water for an irrigation canal or other use (requiring the construction of a dam in the river) is effected by a work which serves at the same time to hold back water for the promotion of navigation. Works designed for taking water for any purpose of a holder of a water privilege are always constructed and maintained at his expense, and when in close connection with a dam for navigation purposes, are carried out by the administration. Upon non-navigable water-courses which have not been declared to be dependencies on the public domain, in the civic code, and which have not been improved in the interest of navigation, the expense of cleaning and caring for the channel generally is borne by the riparian land owners.

Works erected and acts committed in the channels or on the banks of non-navigable or non-raftable water-courses, when they present no obstruction to free flood flow, are subject to regulation by the law as administered by the courts; but works located upon navigable streams, when not duly authorized by the administration, constitute infringements of the authority of the commission of public ways, and are subject to repression. Water-privilege rents for irrigation works are rated upon the basis of the increase in yield due to irrigation, and are fixed at a sum annually paid, equivalent to one-tenth of the increase in value of produce on the land irrigated over its produce before irrigation.

Without meaning to limit the duration of water concessions, the rents are revised every thirty years, for, though revokable at any time, water-right concessions on public streams are given for an indefinite time. Water privilege heads held in private control previous to the edict of 1566 declaring the inalienability of the public domain are free from the charge of rents, as are also those whose holders have titles derived by purchase from the Government.

The exclusive right to water for milling and irrigation purposes from streams too small to be regarded by the kings as of public importance were accorded to the owners of the bank lands, apparently on the ground that they owned the beds and waters as well as the banks, previous to the time of the Code Napoleon. In later years it appears to have become recognized that the waters were in reality a common property, and that the bank proprietors had only a right to use them and not a right of ownership in them.

Still there was the open question, to whom were the waters a common property; the riparian proprietors claiming to be the owners in common of the waters of each stream, and submitting to the control of the streams by the Government only as it was based upon the general police authority of the nation; while the Government asserted its right to control, not only because of its general police powers, but because of the fact that the waters were really common property of the whole people, and not of the riparian proprietors alone, and that public interests were to be promoted, as well as other private interests guarded by it, and that its mission was one to promote public utility as well as re-press or prevent abuse of private privileges in the protection of other privileges.

The continued and growing abuse of the riparian water-right privilege brought about an increased necessity for upholding this latter view, so that it became a popular sentiment, and owners of lands not riparian to the streams asserted a right to the waters for their irrigation on the ground that such waters were a common property of all the people; and asserting that the riparian owner's privilege of using them was not an exclusive privilege, but that upon a grant or permit from Government any land owner could divert them for use on his lands. In this view of the case by far the greater number of land proprietors were interested, so that the governmental policy of control was strongly upheld. Now the manufacturing interests took alarm. The owners of the hundreds of mills and manufactories depending upon water supply for power and other purposes scattered along the streams all over France, and holding rights, many of them dating back in the times of the counts, and all valuing the riparian right as a protection to their water supply, were arrayed against the advancing theory of the waters belonging to all the people and due to all the people for use. The Government continued to uphold the theory of the waters of these small streams being a common property of all the people, but no step was taken to accord land owners other than riparian proprietors any right to use them.

The case appears to have stood this way when the Code Napoleon was promulgated in 1804. This code contained provisions which in course of time were recognized as placing the ownership of the waters of the smaller class of streams in the nation, but declared the use of things of this class to be common to all. Left with this provision only, the waters of these streams would have been thrown open to use by all the people. But an article, under the head of "servitudes," seemed to place a special servitude (right of use) on these waters for the benefit of riparian estates. The Government had its hands strengthened in its policy of control and regulation, and the fundamental principle contended for by the owners of lands not riparian, as well as by Government, was recognized.

The ownership of water belongs to the State, without prejudicing the right to the same which corporations or individuals may have acquired by legal title in conformity with the provisions of special laws in relation to public real estate. The enjoyment of the ownership of water is subject to the following provision: No one may use the water of the rivers in such a manner as to obstruct navigation, nor construct in them works which hinder the free passage of vessels or rafts, or the using of any other means of water transportation. In a similar manner the hindrance or obstruction of the use of the banks is prohibited when they may be necessary for the same ends.

The proprietor of water, whatever may be his title, has no power to hinder the use of so much as is necessary for the supply of persons or stockmen who are in possession of or living on real estate; nor to oppose the indispensable works to provide for that necessity in such a manner as shall be the least burdensome to the proprietor. He may have the right to indemnity reserved, except from those inhabitants who have acquired the use of water by prescription or by other legal title.

The provisions of this code relating to the servitudes of water shall not interfere in any manner with rights legally acquired up to this date concerning the same.

The proprietor of water has no power to divert its course in such a manner as to cause damage to a third party from overflow or from any other cause. If any person dig a well on his premises, notwithstanding he may diminish the flow of water upon the adjoining land, he is not obliged to give indemnity. Every one who has acquired water, the use of which he may dispose of, has the right to pass through the intervening lands, subject to the obligation of indemnity to their owners, and also to the owners of any lower lands upon which the water may leak or descend; but edifices, their courts, gardens, and other appurtenances are excepted from the servitude established by the foregoing provisions. He who has the right of use has the right of way for water, and is obliged to construct the necessary channel through the intermediate lands, although there may be other channels for the use of other waters. He who has on his lands a channel for the use of water which belongs to him may prevent the opening of another, offering to give passage through his own channel, provided it does not cause damage to the claimant. He must permit the passage of waters across canals and aqueducts in the manner most suitable to the course of the waters which are to be conducted by them, and the volume must not be altered nor the two waters mingled in both aqueducts.

In the case of right of passage through intermediate lands, if it becomes necessary to conduct the aqueduct over a road, river, or public stream, it is indispensable that permission should be previously obtained from the authority to whose care the road, river, or stream is intrusted. Such authority shall only grant permission, subject to regulations binding the owner of the water for which passage is sought, not to hinder the passage of the water nor injure the highway, nor interfere with or stop the course of the river or torrent. He who without previous permission makes a passage for water or causes it to flow upon the highway shall be obliged to restore it to its former condition, and give indemnity to any one to whom damage may have been caused, in addition to paying the penalties imposed by the public regulations.

He who seeks to use the privilege (right of way through intermediate lands) must previously, first, prove that he can dispose of the water which he claims to conduct; second, affirm that the route which is solicited is the most suitable and the least burdensome to third parties; third, pay the value of the land which he shall occupy by the canal according to the estimate made by experts, with an addition of 10 per cent.; fourth, compensate for all immediate damages, including those which will result from dividing the land into two or more parts.

Where the use of a canal already built is offered, he who claims the passage of water must pay in proportion to the quantity of the same and the value of the land occupied by it and the necessary expenses for the preservation of the canal, without prejudice to the indemnity that must be given for any other expenses which may be occasioned by the passage which is to be conceded.

The quantity of water which may be passed through the aqueduct established on the adjoining land shall have no other limitation than that which results from the capacity of the water-way as determined by its dimensions. Should the person enjoying the use of the water-way be compelled to enlarge it, he must bear the necessary cost, and pay for the land which is merely occupied, and for any damages caused. The damage is to be estimated by experts with an addition of 10 per cent., and account shall be taken of both immediate and resulting damages. The legal servitude before mentioned carries with it, subject to provisions hereinafter contained, the right of way for persons and animals and the transportation of the necessary materials for the use and repair of the water-way.

The provisions and same laws concerning the passage of water are applicable to marsh lands requiring drainage or an outlet. The concessions which may be obtained from the competent authority are to be without prejudice to other rights previously acquired. Everyone who has the use of an aqueduct, whether it passes through his land or through lands adjoining, must construct and maintain the bridges, canals, aqueducts, subterranean and other necessary works, so that the rights of others may not be prejudiced. Those desiring to enjoy the use shall pay in proportion to that enjoyment, if there be no prescription or contract to the contrary. The code contains provisions for keeping the water pure and for the construction of such works as may be required, in order that the course of the water may not be interrupted.

The owner of land subject to the servitude of right of way may designate the place in which the servitude shall be constituted.

If the proper judge shall decide the place to be impracticable or very burdensome, the owner of the land must designate another. If the place is subject to the same objection as the first, the judge shall designate one which shall be established, taking into consideration the interest of both properties.

If there are several pieces of property through which must be given a passage or a public way, the servitude shall be that of the shortest distance. If the distance shall be the same upon the properties, the judge shall designate through which of them it shall be given passage.

The width of the right of way shall be such as the necessities of the case may be deemed, in the discretion of the judge, to require, but shall not exceed 5 meters nor be less than 2 meters, without the consent of the parties interested.

The court of cassation and the council of state have each decided also that the fall or slope of a channel is not the property of the land proprietors, and that it enters into the class of things which, by the terms of an article in the Code Napoleon, do not belong to anybody, the use being common to all, and the enjoyment regulated by the police laws; hence the administration grants a proprietor the right to back water into the channel in front of lands above him by means of his dam, so long as he does not injure or endanger the lands in any way. Here, again, was a step towards the abolition of the exclusive riparian control of the smaller stream, and a movement towards declaration of public ownership of the channels themselves. And thus the matter stands. The riparian proprietors still monopolize the right to use the waters from streams of this class. The code merely gives every riparian owner a privilege of using the water. No matter how old a privilege may be, the administration in the public interest has always the right to turn sufficient water past the dam to satisfy the personal wants of proprietors below, and it can even compel the construction of a sluice-way in the dam to be used for this purpose.

As a matter of fact, the streams are controlled and the waters apportioned out of those who have claims on them by administrative regulations. The matter of the ownership of springs has been one full of contention in France; but it is now well settled by the provisions of the code and the decisions under it. He who possesses a spring within his field may make use of it at his pleasure. The code defines certain circumstances under which the control of springs is limited and qualified, the causes being the necessities of communities for water for domestic purposes, the necessities of the state for water for purposes of navigation, the rights which persons other than the owners of springs may have acquired by purchase or by prescription. The courts can, in the interests of agriculture in general and for the benefit of local agriculturists, prevent wasteful or selfish use of spring waters.

The ownership and control of springs is so complete and absolute that so long as the waters remain within the property where they rise, even though used as a power for manufacturing purposes or otherwise, the administration can do nothing to interfere with the proprietor's use of them.

But if spring waters be led across or into property other than that containing the source, for whatever purpose, the stream is subject to regulations, as in the case of others. The owner of a spring can not change the course of its waters when they furnish the necessary supply to the inhabitants of a commune, village, or hamlet.

Government can take possession of springs to feed canals for navigation, but on condition that it pay a just indemnity.

The absolute right of ownership in a spring is also modified by purchased titles, by prescription, and by servitude set up by the division of an estate containing a spring.

SPAIN.

The Spanish law of waters, as it now exists, is a code in itself, which was finally determined and promulgated in 1866, after a study of the whole subject for eight years by a commissioner appointed for the purpose. The law of 1866 comprehends all that is treated in laws of various kinds relating at all to waters, high seas, sea-shores, beaches, bays, rivers, etc. The Spanish law makes the broad distinction between waters on private and corporate property, which it calls private waters, and those on the public domain, which are called public waters.

With respect to the acquirement of right to divert water for irrigation from streams on private or corporate property the law may be summarized as follows: Waters which rise on private property belong to the owner of the property, provided he does not forfeit his right by nonuse for twenty years.

Waters running through private property are private waters, subject to use by owners of the banks. They may appropriate them for the purpose of irrigation on their estates, to be taken in their order from the head of the stream down.

Works for the diversion of waters from a private stream may be constructed by the owner of the banks without official sanction, provided always that the amount of water to be diverted does not exceed 10 liters (about one-third of a cubic foot per second) in any one instance; but, if the proposed diversion exceeds this amount, notice must be given through the alcalde for the information of the governor of the province.

This notice is given for the purpose of setting before the people the facts in the case, and in order that an investigation may be held, which will determine whether or not the proposed appropriation will interfere with existing rights.

The waters of public streams are held to be the property of the kingdom. It is necessary to obtain an official sanction or grant of right before such waters can be diverted and used in public or private irrigation enterprise, except where the quantity diverted by any one appropriator does not exceed 10 liters per second, or where it is to be abstracted from navigable rivers by pumping machinery, or when the water appropriated is only the rain or storm water which drains rapidly away in the torrent beds. This grant of right is accorded only after extended and minute examination of the proposed project by the provincial authorities, and after hearing all that may be said by those whose interests may be opposed to the diversion. There is no such thing as unlicensed appropriation in large amounts, and no such thing as unregulated diversion of waters from the streams.

The waters are held by the Government for the use of the people. Under the Spanish law water is diverted for irrigation in large volumes from the public streams, but it is done under special sanctions from the authorities of the district, in a manner not to interfere with or injure other persons dependent upon its use.

MEXICO.

The problems of rain-fall, water supply, and irrigation are of primary importance in the Republic of Mexico. A study of the laws and systems pursued therein is of the greatest importance to American engineers and agriculturists engaged in the practical work of irrigation. Mexico is essentially a dry country; its cultivation is dependent on artificial distribution of water. Its indigenous vegetation presents all the characteristics of an arid region. From all historical evidences it is seen that irrigation was among its earliest necessities and was the most prominent care of its people, of whatever race or condition. The soil of Mexico, as well as of that portion of the United States which formerly belonged to our neighboring Republic, is fertile and fruitful when once vitalized by the application of water. The table lands are everywhere adapted for grazing, and water can generally be found in quantity sufficient for the use of cattle. The forests are valuable and abundant. That an increase in water-storage capacity would largely add to the agricultural value of Mexico is obvious, and such an increase is becoming especially necessary in connection with the construction and maintenance of railroads.

The sources from which the water supply is derived along the line of the Mexican Central are springs, wells, storage reservoir, and permanent streams, and these are all dependent upon the annual rain-fall. In most cases the supply of water at our water stations is obtained from wells dug by the company, and these vary in depth from 20 to 300 feet, and the water is raised to the tanks either by hand or steam pump. In a few cases they have springs that afford a gravity supply, but they are very few. In order to preserve the rain-fall, storage reservoirs have been built, from which the water is distributed by open canals or ditches, and in many places extensive aqueducts of masonry have been constructed to convey the water across valleys so as to utilize it for irrigation. This system of irrigation, by means of storage reservoirs, can to good advantage be greatly increased, as where land can be irrigated two crops a year are obtained; but at the present only a small portion of the rain-fall is utilized. The season known as the rainy season lasts some two months, and is for the most part confined to the period between June 15 and September 15. The following will show you the average amount of rain-fall at the City of Mexico for seven years and the State of Aguas Calientes for fifteen years:

Months.	City of Mexico.			State of Aguas Calientes, fifteen years.		
	Total number rainy days in seven years.	Average number rainy days.	Average quantity.	Total number rainy days in fifteen years.	Average days.	Average quantity.
			Inches.			*Inches.*
January	16	2	0.2	35	2	.38
February	15	2	0.1	25	2	.29
March	32	5	0.4	27	2	.17
April	40	6	0.3	8	1	.05
May	94	14	2.6	78	5	.74
June	136	19	3.9	162	11	3.62
July	167	24	4.5	216	14	3.89
August	149	22	5.7	219	15	4.66
September	115	16	3.8	173	12	3.84
October	76	11	1.1	99	6	1.29
November	32	5	.4	42	3	.34
December	15	2	.2	35	2	.43
	887	128	23.2	1,119	75	19.70

The only artesian wells on the line of this road are at the City of Mexico, where good water is found at the depth of from 200 to 500 feet below the surface. These wells are usually flowing, but with only a small head, and have to be pumped when a large supply is needed.

The laws and customs controlling water in Mexico, so far as the road is affected, require the provision of suitable passages for all water used for irrigation.

On February 14, 1856, a law was enacted controlling the distribution of water. The old unit of measure for water was the surco (or sulco) in the country, and the paja in cities, but an act of March 15, 1857, put the French metrical system in force in the Republic, and a decree of August 2, 1863, made the liter (0.26417 gallon)* the unit of measure for water, fixing upon 6½ liters per second of time as the equivalent of a surco (or sulco), and forty-five one hundredths of a liter per minute as the equivalent of a paja of the old measurement. In cases of legal contest, wherein a right to a certain quantity of water was claimed under prior titles, or documents, sanctioned by law, the measurement was still to be given in surcos.

Engineers and surveyors were required to have regard, whether in city or in country, to the degree of inclination (amount of fall) in water channels, to take into account in each case the amount of pressure, and to present in their statements both the formulas employed and the reasons for their calculations.

The royal instruction of October 15, 1754, was passed to regulate the sale and distribution of land and water rights in the Indies. Subdelegates were to be appointed by the viceroys and presidents of the royal audiency, who were to have jurisdiction of such matters, and they were directed not to disturb possessions in lands embraced in settlements, or on which labor had been expended, or which were cultivated or utilized for pasturage. It was also required that all persons who desired to possess royal grants of unoccupied lands and water, and those owners who had possessed, without occupation or cultivation from the year 1700 up to the date of the instruction, should present themselves before the subdelegates and prove their titles within a period of time to be designated by the same authority; and when they had titles to allege which were not yet confirmed, but were issued before the year 1700, they were to be allowed pacific possession in conformity with the law. They were, however, required to register the title. From those who had no title there was required a sworn declaration of long possession, which was allowed to stand as a just title by prescription. Those who desired to acquire title were required to expend labor upon, cultivate, or occupy the grants for a period of three months; and if the period expired without the requirements having been fulfilled by the grantee, the grant might be denounced by any one who fulfilled them.

---

* The metric system is founded upon the meter (about 39.37 inches), which was intended to be the ten-millionth part of the distance from the equator to the pole, measured over the surface of the earth, but in reality differs slightly from this measurement. The liter is a cubic decimeter, the decimeter being the tenth part of a meter.

The unit for land measure is the are, which is a square having sides of 10 meters in length. The hectare (100 ares) is about 2.471 acres.

It was also provided that possessors of lands sold or distributed in or after the year 1700 should never be molested, and their titles were thus confirmed; but those who did not possess their property as aforesaid were required to solicit confirmation of their titles from the audiencias of their district or from the proper authorities, and if they failed to do so within the period designated their possessions were forfeited to the crown, although labor might have been expended on them.

The guiding and fundamental principle throughout the whole of the regulations will be found to have been that all such property was annexed to or incorporated into the royal crown to such a degree that in order to hold possession it was necessary that individual possessors must have alleged and proved that their water rights had been conceded by special favor, because the law declares that to the prince, and to no other, appertained the right of distribution of water. This is still the controlling principle of Mexican law.* The waters must remain under the sole and absolute dominion of the sovereign, all waters of the public rivers (or water-courses of public and common use) being his rights. This principle was so far qualified that any one might take what he needed for domestic use, but no one could take public waters upon his private grounds for irrigation without royal permission. A torrent is a stream of water originating from snow and rain at certain seasons, that is, when the snow and rain raise the streams. Rivers are divided into public and private. The public river is one where all enjoy the right to fish. The private stream is one by which some contract or agreement has become private property, and differs in nothing from other private property, and in describing it "it has no banks." Banks are the precise limits between which the streams run in their natural course, which are as the shores to the sea. In concession of land, if concessions are made jointly of the waters originating upon it, they are appurtenances of the lands granted. Being a servitude, waters had their place among the royal country servitudes. Fountains and springs belong to the owners of the lands in which they rise as parts and appurtenances thereof, for which reason they are conceded with the lands.

A servitude is the right of doing something on the land of another, or of preventing the owner from doing something.

The servitude is a property appertaining to the thing, so that it adheres to it, no matter who may be the owner. Servitudes depend on the proximity of two predial estates, that of the person entitled to the servitude, and that of the person who has to submit to it. If for the enjoyment of the servitude the estate on which it is imposed requires some repairs, they must be done by him entitled to the servitude. The right of servitude is not susceptible of division, but its enjoyment may be limited to days, months, etc. Such rights are acquired in the same manner as other property, and are either continued or interrupted. Continued servitudes are those which may be used daily; interrupted ones, such as can not be so used.

---

* The rights of the prince descending to the Government of the Republic.

In connection with the use of water there are both urban and predial servitudes.

The predial servitudes relating to water are, first, the right of conducting water by means of canals or pipes over the land of your neighbor for the purpose of driving a mill, or of irrigating your land; second, the right of drinking out of a fountain, or of watering there your cattle.

The servitude of the aqueduct is the right of conducting water upon the ground or field away from the stream for irrigation or other use, specified in the right of servitude, which carries with it the right of way for the water-pipes, etc., and for those who have the care of them.

It is unlawful to construct any work damaging others. If the construction of any work on the banks of a stream causes damage to the lands of a neighbor, the law gives him a right of action for the damage occasioned, and the works constructed must be removed.

He who alleges his servitude is obliged to prove it; possession is not sufficient. The right must be acquired in one of three ways: by agreement, by inheritance, or by prescription. It is unlawful to alter the natural course of a stream to the prejudice of third parties; but a person through whose ground the water is conducted may alter the channel for the sake of its more convenient use upon his land, provided that other parties be not prejudiced thereby.

A servitude may be constituted not only at the source of the water, but upon any part of its course. It may be for a continuous flow, or a flow at certain intervals of time—that is, stated days or hours. The examination of springs must be made by experts, whose report must state under oath that the truth has been faithfully given, without favor toward either of the parties.

The measurements for distribution are regularly obtained from the examinations, or measurements to determine the amount of the natural flow, the distribution being made to each person according to his position on a line. Hence, in measurements of examination, no changes are made, whereas in those for distribution the water-ways are enlarged, diminished, and changed to conform to the letter of the grants of water. Measurements of examination are to be conducted at the most favorable distance from the reservoir or ditch, so that the water may run as nearly direct as possible and without too great rapidity of current. The reservoir shall be made in conformity with some geometrical figure by which its area can be calculated, to which shall be applied a marking-board in such a manner as to show the quantity of water that is withdrawn. The marking-board shall have marginal numbers showing the available height of the water, so that by multiplying this by the width the area of the vertical section may be formed. It is to be understood that water must always be taken in the manner in which it has been from the beginning, so that no more can be taken, nor can it be taken by any longer route. Those who are in possession of a water servitude must be maintained and protected. In order to constitute such a servitude the flow of water must either be continuous or at certain intervals of time.

Dominion can not be exercised upon the lands of another unless distributing tanks or aqueducts are built with separate basins, with apertures in the sides, having gates of the proper size to give to each the quantity to which he is entitled. If the form given to the aperture is that of a square, the area being given, the square root shall be the diameter of the orifice. If it should be circular, the diameter may be found by the rule of Archimedes, that as 11 is to 14, so is the area of the figure to the square of the diameter, the square root of which is the diameter of the required orifice.

In distributing water from basins or reservoirs all the parties interested must obtain their amounts from apertures at an equal depth, although the sizes of the openings may be different. In taking water from a horizontal canal, through orifices in its vertical sides, a stop of the same size and figure as the opening must be set into the wall on the side of the opening towards which the current runs, so as to drive the water into the orifices.

When various parties participate in the distribution of water, all tanks and receptacles and all openings for drawing it off should remain unchanged in their dimensions and proportions, so as to preserve to each the quantity publicly granted. The builder of such tanks and orifices shall be the judge of the shape most suitable, but they shall have a uniform altitude, increasing or diminishing the bases, if rectangular, but if circular their centers must be on the same horizontal line. It is an inflexible rule that the water which issues from those apertures should have the same fall, for two reasons—they start from the same level line of base; or, if they take water from a fall, it is from the same apron-stone upon which the waters fall, although carried away from thence in different troughs or chutes. The gravitation of water increases its velocity in proportion to the distance through which it falls. The point of delivery must be below that of the source. The surface of the water curves to correspond with the surface of the terrestrial globe, and in using a level, to avoid the error of assuming the water-level to be a straight line, the instrument should be set in the middle of each stretch of the line to be leveled, which may be longer or shorter according to the slope of the ground. All the proprietors who participate in the benefit derived from the works which have been treated of are under obligation to contribute to the payment of the expense of their execution in proportion to their interest, according to an appraisement by experts. Those who by their own culpable negligence have occasioned any damage must be responsible for it.

The owner of land in which there is a natural fountain or source, or who has dug a running well, may cover it, or confine it by a pond or dam, to detain its running waters for his own ground, and may use and dispose of the waters freely. If he have surface waters which pass upon another piece of land, the owner of such land, upon the lapse of twenty years, reckoned from the date on which he has constructed works designed to regulate their fall or course, may acquire property in the waters so received. But this provision does not prohibit the owner of the source of any water, or of a pool, or a dam, from availing himself of all of the enjoyment of the waters possible within the limits of his estate.

The lower lands must receive the waters which naturally, and without the work of man, come from the upper or higher lands, as well as the stone and earth which it takes in its course, nor shall the owner of the lower land make any works which obstruct the servitude, nor the upper any works that increase the servitude. The owner of the land on which there are works to conserve the water, or on which for an alteration of the water-course it becomes necessary to construct new ones, is required, in the absence of any special law to the contrary, either to make necessary repairs or constructions, or without demanding remuneration to allow the same to be made by land owners who have experienced, or are immediately exposed to injury from the water which he has arrested in its flow, or diverted from its natural course. The provisions of the foregoing are applicable to the case in which it is necessary to relieve any land of those materials which accumulate or hinder the flow of water, resulting in damage or peril to a third party.

In distributing water among a number of claimants the following allowances are made: For a flour-mill, 8 continuous sulcos; for a pulling mill, 3 sulcos; for sugar-mills, 8 sulcos; and to irrigate a tract of land of about 33⅓ acres, 2 sulcos, or if it be a cane plantation of the same size, 4 sulcos. The quantity is, however, not absolute, but depends on the slope of the ground and other circumstances.

When the water supply is found insufficient to meet the requirements of the parties interested, resort must be had to distribution by turns, some using water in the day-time and others at night, or any other way which may be agreed upon, because that which belongs to the whole public should be so controlled that all may have a share in the distribution.

LOWER CALIFORNIA.

The sub-prefect of the northern part of Lower California, reporting on the water supplies of that district, mentions the Colorado as the only important river in the district, and refers to information in regard to that stream already in possession of the Mexican Government. After enumerating various smaller streams and a few ponds and lagoons, which furnish drinking places for cattle, he says:

> None of the waters to which I have referred are used for agricultural purposes, because the small grains—oats, wheat, and barley—which are cultivated in this district belong to the temperate zone and are grown in winter. Corn, beans, and other products of this nature are planted only in damp soil, which does not need irrigation.

DURANGO.

The political chief of Oro, in the State of Durango, writes to the secretary of state of that commonwealth that in the district under his authority there are thirteen hot springs, some of which are used to good advantage in the irrigation of gardens. The rivers which fertilize a large part of the district are the Ramos and the Sestin, which unite to form the Nazas. The Sestin, from the neighborhood of Cerro Prieta to its confluence with the Ramos, has a length of about 60 leagues (156 miles), its greatest breadth being about 328 feet, and its general depth about 5 feet. The Ramos has a length of about 31 miles, with an extreme breadth of about 260 feet and an average depth of somewhat over 3 feet. The waters of these streams, whose volume may be estimated at about 25 cubic meters (882 cubic feet), are utilized in agriculture with very good results, wheat and maize being the favorite crops, and yielding the best returns when the precipitation of the rainy season is largest. Besides these rivers there are many small streams which, without being permanent throughout the year, afford sufficient water to make them useful in the irrigation of gardens. There are some unimportant ponds in the district, but no lakes or lagoons.

A law passed by the legislature of Durango, and dated November 11, 1881, contains substantially the following provisions:

No one is allowed to construct on the rivers or other waters belonging to the public, or along their banks, any new works, or to alter existing ones in such a manner as to change the direction, height, breadth, or depth of the dams, dikes, or aqueducts, without previous license from the public authorities.

Any person desiring such a license is required to state in writing to the proper local authority the kind of work which he proposes to execute, the materials of which it is to be constructed, its dimensions, and other necessary particulars, and the place where it is to be made.

The authority receiving application for license to construct works on the public waters or their aqueducts will note in writing the day and the hour in which it was presented, and will give the desired record of it. The same authority will publish the petition by posters in the locality in which the petitioner resides or by newspaper if there is one. A copy thereof will be furnished to the corporation attorney, so that within eight days the latter may give his opinion whether the proposed work will or will not be prejudicial to the public interests. This opinion will then be sent with the petition itself to the State government. The opinion of the attorney will be accompanied by that of an expert consulted by him, whose fees will be paid by the petitioner.

The petition, having been received by the State government, will be published in the next three issues of the official journal. If during its publication, or within eight days thereafter, no opposition is made to the proposed work, and if no objection shall have been set forth in the opinion of the corporation attorney, the State government will authorize the execution of the work, and will cause copies of all records in the case to be sent to the party interested, for whom they shall serve as evidence of title. The same should also be inscribed in the public register of property.

Any one desiring to oppose the execution of a work must present himself in writing to the state government within the period indicated in the last paragraph. On receiving such notice of opposition the government shall immediately have it sent, with a record of all its antecedents, to the judge having primary jurisdiction in the locality to which the proposed work appertains, in order that he may decide whether or not he ought to prevent its execution on account of its being in conflict with some acquired right, or causing, either to the public or to the individual opposing it, detriment for which indemnity can not be obtained.

If the damage which the work would cause is such as can be indemnified, the judge shall cite the person proposing to construct the work and the person opposing it to a verbal conference, to the end that they may mutually agree on the indemnity to be paid.

Whenever it shall appear that the opposition to a work is unfounded, the person making the opposition shall pay the costs of the proceedings thereby necessitated; and if there shall also appear to be rashness or malice in the opposition its author shall indemnify the party opposed for all the damages suffered through the delay in carrying out the work.

The amount of indemnity having been fixed, the work shall not commence until it is paid.

Judicial proceedings arising under this act will be in summary form, as provided by the code of civil procedure.

A decree having been pronounced, the records received from the State government must be returned, and with them must be sent an attested statement of the action of the local tribunal.

Changing the course of a river or other stream of public use, or draining off its waters by means of works constructed in it or on its banks, is absolutely forbidden.

In cases of urgent necessity, to prevent inundation, the destruction of embankments, reservoirs, or aqueducts, or other damages equally serious, permission may be granted for the construction of such works as the authorities may deem necessary. But if any work constructed under such circumstances would interfere with other works previously existing, it can not remain longer than the circumstances continue which render it necessary, unless permission be obtained under the provisions of this act, and such permission shall be applied for within three days after that of the local authorities is solicited. The latter authorities are required to apprise the State government of their action in cases of the class to which this paragraph refers.

The preceding provisions do not apply to the partial or total reconstruction of works already existing, or which have been executed according to this law, and which are not to be changed in their direction, height, breadth, and depth. A person having occasion to make partial or total reconstruction of any work conformably to this paragraph must notify the local authorities, so that they may assure themselves that the work proposed is really one of repair or reconstruction.

So far as they are not in conflict with the present law, the provisions of the civil code and code of procedure relative to the use of public waters, or to servitudes or works connected therewith, are left in force.

This law was promulgated on the 10th of November, 1881.

JALISCO.

The principal rivers which traverse this State are the Cuitzeo (sometimes called the Tololotlan) of Santiago, or Grande, the Verde, the Juchipila, the Lerma, the Zula, or Atotonilco, the Ayuquila, the Tuxpan, the Chacala, the Ameca, the Bolaños, the Apazalco, the San Pedro, the Acaponeta, the Cañas, and the Camotlan, most of which are also known under other names. The largest of these streams is the Cuitzeo, which rises in the town of that name, and after a course of 98 leagues (255 miles) enters the ocean to the northwest of San Blas. Its average flow is about 111 cubic meters (3,920 cubic feet) of water per second, and its use in irrigation, which is now small, might be largely increased. Opposite the town of Juanacatlan there is a cataract about 65½ feet in height, which would furnish power to the amount of about 30,000 horse-power, of which only the amount required for one flour-mill is now utilized. There are many points along this river, or near it, where hydraulic wheels after Poncelet's system could be advantageously used.

The Verde which rises in the State of Zacatecas, is a tributary of the Cuitzeo, and for a distance of 47 leagues (122 miles) its course lies within the State of Jalisco. Its waters, which have a flow of 50 cubic meters (1,766 cubic feet) per second, are utilized in irrigation to some extent, and by means of lateral canals they might be largely employed in working hydraulic motors.

The Juchipila, another tributary of the Cuitzeo, rises in Zacatecas, and its course lies within the State of Jalisco for only 17 leagues (about 44 miles). It has an average flow of 16 cubic meters (565 cubic feet) per second, and is utilized in irrigation.

The Lerma, which rises in the Almoloya region of the State of Mexico and empties into Lake Chapala al Oriente, flows through Jalisco only 12 leagues (about 29 miles). It has an average flow of 80 cubic meters (2,825 cubic feet) per second, but is available for irrigation only when its waters are high. This stream presents more advantages in the States of Michoacan and Guanajuato than in Jalisco.

The Zula rises within the State, and has a course of 30 leagues (78 miles) before emptying into the Cuitzeo. It has a flow of 8 cubic meters (282 cubic feet) per second, and its waters are employed on a small scale in irrigation.

The Ayuquila rises within the State, and after a course of 70 leagues (182 miles) empties directly into the Pacific. It has a rapid current throughout almost its whole length, and although it has an average flow of 30 cubic meters (1,059 cubic feet) per second, it serves to irrigate only small areas.

The Tuxpan rises within the State and empties into the Pacific, receiving in its course of 60 leagues (156 miles) the waters of numerous tributaries which rise in the spurs of the volcano of Colima. It is somewhat rapid and has an average flow of 28 cubic meters (989 cubic feet) per second. Its waters are employed to some extent in irrigation, but not so much in this State as in Colima.

The Ameca rises within the State, has a length of more than 55 leagues (143 miles), and empties into the bay of Banderas, on the Pacific coast. It is a fine stream, having an average flow of 20 cubic meters (706 cubic feet) per second, and is capable of being utilized in agriculture.

The Bolaños rises within the State, and after a course of about 48 leagues (125 miles) empties into the Cuitzeo. It has a rapid current, with an average flow of 15 cubic meters (530 cubic feet) per second. It is utilized in agriculture.

Several other streams, with volumes ranging from 2 to 10 meters (71 to 353 cubic feet) per second, are more or less used in agriculture; but the principal use both of these and those designated by name above is in stock-raising. There are also innumerable small streams, tributaries of the larger ones.

The most noteworthy lakes in this State are those of Chapala, Magdalena, Mexcaltitan, Atemanica, Cajititlan, San Marcos, Zacoalco, Atoyac, Sayula, Zapotlan, and Santa Maria del Oro, besides which there are many others, which, although smaller and not so well known, are nevertheless of great utility.

Lake Chapala is 90 kilometers (56 miles) long, and has an average width of about 17 kilometers (about 10½ miles). It is the most important lake in the State, whether considered with reference to the facilities it affords for internal navigation or to its utility in agriculture and stock-raising to the people along its shores; and by means of canals, especially one connecting it with the Ameca River, its waters might be more extensively utilized for both of these purposes. The other lakes mentioned are much smaller than Lake Chapala. With the exception of Lakes San Marcos, Zocoalco, Atoyac and Sayula, they all have potable waters; and the same is true of the numerous smaller ones not mentioned by name.

There are few permanent irrigation works in the State, mere temporary appliances being generally used to draw off the water for irrigation or for live-stock. The works at Bellavista, executed with great skill by Señor D. Gabriel Castaños, should, however, be mentioned as a noteworthy exception to this rule.

In the municipality of Atemajac de las Tablas (in the district of the same name) there are four reservoirs, but their chief use is the storage of water power for flouring and saw mills. In the municipality of Tescuitatlan there is a public reservoir known as the Santa Rosa, in which rain-water is stored. Its length is 502 meters and its breadth 260. In the municipality of Tizapan el Alto there is one reservoir—

that of Las Cuartas—in which enough water is stored for the irrigation of a small area on one ranch.

Reports are published from many other municipalities, and numerous small streams and springs are referred to as furnishing water for the irrigation of orchards, gardens, or fields. The aggregate area fertilized by their water is quite large, but there are scarcely any among them that have a volume of more than 1 or 2 cubic meters per second, and no important works are reported for making an increased area available to irrigation.

MICHOACAN.

The principal streams which lie wholly or partly within the limits of the State are the Lerma, the Balsas, the Marques, the Tepalcatepec, the Duero, the Astula, the Apisa, the Rio Grande de Morelia, and the Huetamo.

The Lerma is provided with dams and reservoirs to facilitate irrigation, and several towns or villages and forty farms along that part of the river embraced within the limits of Michoacan avail themselves of its waters to irrigate wheat, maize, chick-peas, etc. In the Duero and the Morelia there are some small dams. The other streams are turned to little account partly because of the broken character of the districts through which they run, and partly because of the limited extent to which agriculture in those districts is carried on. The volume of water in these streams is very large. The Balsas, for example, empties into the sea with a volume of 132 *bueyes*, 12 *surcos* of water;[*] and the Marques at a point called the Juntas, before receiving its last tributaries, has a flow of 44 *bueyes*. In the southern districts of the State irrigation is used in the cultivation of sugar-cane, indigo, and rice, each estate having one source or more from which a supply of water is obtained. The water is conveyed to the fields in covered conduits.

The population is generally located near the streams, and there are but few who have occasion to resort to wells. Such wells as there are range from 10 to 20 *varas*[†] in depth in the case of the deep ones, while the others range from 2 to 10 *varas*.

It is worthy of remark that in the higher and colder parts of the State the springs and fountains are permanent throughout the year and maintain a medium temperature throughout the day. In the hot part of the State the streams are more numerous, but many of them run dry in October, and do not flow again until the end of May. The chief cause of their disappearance is readily found in the rapid evaporation which occurs in such hot climates. According to observations made at Churumuco in May, 1883, a cubic meter of water exposed to a dry, hot atmosphere, the temperature being about 100° Fahr., lost by evaporation 2 to 2½ liters per hour, while observations made at Lake Sirahuen, with a temperature of about 59°, showed a loss of hardly one-fourth of a liter in the same time.

The stream known in different parts of its course as the "Caramecuara," "Las Joyas," and "San Juan" is used for the irrigation of 20 *caballerias*[‡] of land belonging to the different estates through which it flows before uniting with the Tacàmbaro; while the latter, which has a volume of 3 *bueyes* in the dry season and an average of 8 *bueyes* during the rainy one, irrigates 6 *caballerias* of farming land, as well as the fields and kitchen gardens near the city of Tacàmbaro. The Turivan has an average volume of 4 *bueyes* through the dry season, and in its whole course through the district irrigates 12 *caballerias* of land. The Puruaran, or Caliente, has a volume of 5 *bueyes* and 4 *surcos* from November to June, and from June to November its flow is considerably augmented by the rains. It irrigates about 7 *caballerias*. These four streams, with fourteen smaller ones, none of which irrigate more than a few hundred acres of land, have an aggregate volume of about 26 *bueyes* of water, and serve for the irrigation of an aggregate area of 55 *caballerias* (5,585 acres) of land. A small addition should be made to this total for areas irrigated from springs, ponds, and swamps.

---

[*] The *buey* is a somewhat indefinite expression, meaning a stream of water as large as the body of an ox, while the *surco* is the quantity conveyed in a furrow made for the purpose in irrigating land. Some years after the adoption of the metric system a decree was issued making 6½ liters (a little less than 1.72 gallons) per second the equivalent of the *surco*.

[†] The *vara* is a measure of about 2 feet 9 inches in length.

[‡] A *caballeria* = about 107 acres.

MORELOS.

In the district of Coatlan there are three rivers—the Amacusac, the Chalma, and the Tambembe. The Amacusac is formed by the union of the San Geronimo and the Chontalcuatlan, their confluence being a short distance outside of the district. The waters of the San Geronimo are utilized for irrigation on many wheat farms in the district of Villa Guerrero, or Tecualoya. During the rainy season it has a flow of about 35 cubic meters (1,236 cubic feet). The Chontalcuatlan, which receives a number of tributaries, furnishes water-power to many small factories, and its waters are utilized to some extent in mining. After watering innumerable orchards and gardens along its banks it still has a flow of 25 cubic meters (883 cubic feet) in the wet season, and from 10 to 12 cubic meters (353 to 424 cubic feet) in periods of drought. The Amacusac, formed by the union of the two rivers last named, has a flow of 60 cubic meters (2,119 cubic feet) during the rainy season, without including freshets, and in time of drought it has somewhat less than half that volume. Thus far but little use has been made of its waters in irrigation except for the orchards immediately along its banks. After receiving the waters of several tributatries this river takes the name of Rio Grande, and still lower, after passing beyond the limits of Morelos and uniting with the Pueblo, it is known as the Mezcala or Balsas until it reaches the sea at Zacatula.

The Chalma is the most important river in the district, not in respect to size, but on account of the fertility which it confers on the many towns and districts through which it flows. It rises in the State of Mexico, rapidly increasing in size as it receives the waters of numerous springs and rivulets, and becoming a considerable stream before entering Morelos. It waters extensive tracts of level lands in the vicinity of the sugar mills of Cocoyotla, Actopan, Santa Cruz, San Gabriel, and the estate of Cuachichinola, and at the same time irrigates the fields in the towns of Coatlan del Rio, Tetecala, Mazatepec, San Miguel Cuantla, Cuachichinola, and Puente de Ixtla. It has a flow of 25 or 30 cubic meters (883 to 1,059 cubic feet) during the rainy season, and 10 to 12 cubic meters (353 to 423 cubic feet) during the dry months.

The Tembembe is scarcely utilized at all in irrigation. Its flow during the wet season equals and often exceeds that of the Chalma, but during the rainless months it runs almost dry.

There is only one dam in the district of Coatlan del Rio. This was constructed in the Tembembe River, at a cost of about $20,000, for the irrigation of the extensive fields of the Miacatlan estate; and it also serves to supply the town of the same name with water. It is considered a meritorious piece of work in respect to its architecture, its extent, and its solid construction. The district being well supplied with water, there are no reservoirs for its storage.

The laws which govern the distribution of water are understood by the writer of the report to be those comprised in the civil code of the federal district and of the Territory of Lower California, this code being in force in Morelos.

OAXACA.

District of Cuicatlan.—A river known as the Rio Grande, which empties into the Papaloapam, flows through this district and furnishes water for irrigation at many points along its course. Its volume in the rainy season amounts to 200 cubic meters per second, or more; but during the dry months it falls to four or five meters. Of its smaller tributaries there are many which dry up during the latter portion of the year, but it also receives a considerable number of permanent streams, most of which are more or less utilized in the irrigation of maize, sugar-cane, or other crops.

District of Tiaxiaco.—Many small streams are enumerated, giving their source, direction, estimated volume, etc., the latter in most cases falling below one cubic meter per second during the dry season. Most of these streams are utilized to some extent in the irrigation of crops, besides furnishing water-power for mills. There are no large rivers in the district.

District of Yautepec.—The most important stream within its limits is the Rio Grande de Tehuantepec, which rises in the mountains of Quiechapa and Mixtepequez, and empties into the Pacific 10 or 12 miles from Tehuantepec. The average flow at the lowest estimate is about 5 *bueyes* per second. It is utilized in irrigating sugar-cane and maize at certain points along its course. There are also several smaller streams which are turned to account for the same purpose. Owing to the smallness of the rain-fall the streams in this district have greatly diminished in size, and there are no important bodies of water of any kind within its limits, nor have any laws been enacted on the subject of water distribution.

District of Ocampo.—The principal rivers which traverse this district are the Villa Alta and the Rio Mudo. The character of the country is not favorable to irrigation, and the streams which flow through it, though many of them are constant, are not turned to account for that purpose. The same remark will apply to the waters of a number of small lagoons found within its limits.

District of Choapam.—As regards rights to the use of water, the ancient Spanish ordinances in relation to lands and waters are in force.

District of Tuxtepec.—No irrigation is needed because of the abundant rain-fall. The provisions of the civil code of the federal district, amended in some few particulars, are legally in force under State authority, but in the absence of any need for the appropriation of water difficulties in regard to water rights seldom arise.

District of Juchitan.—There is scarcely any irrigation practiced. The Astula, which is the principal river in the district, has a volume of 8 cubic meters during the dry season, and its plains are referred to as "wide and fertile."

District of Teposcolula.—Reports from a number of municipalities mention irrigation as practiced on a small scale within their limits. The mayor or president of each municipality annually appoints an officer, whose duty it is to distribute the waters in fair proportion among those having fields or gardens to irrigate.

QUERETARO.

In the neighborhood of Juriquilla there are four small and unimportant reservoirs; one party is constructing one which will contain 1,100,000 cubic meters of water, and will command a large part of the valley of Queretaro. On an estate to the north of Juriquilla there are two good reservoirs, but they are dependent on the rains for their supply of water, and have only been filled six times in the last twenty-seven years. The largest one, known as the Santa Catarina, is 2,500 meters* long by 900 wide and 6 deep. The other, known as the Pinto, is 1,275 meters long by 600 wide and 4 deep. A reservoir of small size is found on the San Miguelito estate, northwest of Juriquilla. It is of little importance, but serves to irrigate some limited areas of tilled land.

There are many permanent streams whose waters are used in irrigation, but none having a volume of more than a few cubic meters. There are also a number of small lakes and lagoons and some important springs in the State.

There has been no State legislation especially bearing on the use of water, which is regulated by the civil code, the Spanish laws, and the ancient ordinances of land and water, according to their respective dates.

TAMAULIPAS.

The situation of this State in the northeastern part of the Republic, with the Gulf of Mexico bordering it on the east, renders it comparatively independent of any artificial means of supplying the crops with water.

A report to the State government from the council of Nuevo Laredo mentions the Rio Bravo as the only source of water for live-stock in the dry season. During the rainy season it is subject to heavy floods, and overflows the bottom lands along its banks, on which the farmers raise sure and abundant crops.

TLAXCALA.

The Zahuapan and the Attoyac are the only streams deserving the name of rivers. The former, which is tributary to the latter, is utilized between the town of Apetatitlan and its confluence with the Atoyac, by eleven estates, six towns, and a number of small farms, while it also furnishes water-power to several mills and factories. It is, however, but a small stream, its volume during the dry season not exceeding 1½ cubic meters per second, after receiving the waters of many springs and rills.

There is no place of any considerable population on the Atoyac, but it furnishes water for the irrigation of ten estates and the supply of six towns. In the rainy season it is a roaring torrent, swollen by the waters which pour into it from the mountains, but during the dry weather it dwindles to a volume of about 4 cubic meters per second.

In the eastern part of the State reservoirs are used for the storage of rain-water, that being the only means by which a reliable supply for man and animals can be secured. These reservoirs vary in size according to the needs of the localities where they are situated.

There has been no legislation in this State to regulate the appropriation of water for irrigation or motive power. The proprietors of land and manufacturing establishments use the waters of the rivers in accordance with the privileges conceded by the colonial government in the original titles to their property; and those who do not enjoy such rights have recourse to the authorities of the municipality controlling the water which they desire to use, and are allowed to take the water needed for irrigation subject to an annual tax, which goes into the municipal treasury.

---

* The meter=39.37 inches.

VERA CRUZ.

The water courses are not utilized in agriculture or in manufactures. In the former no machinery is used, nor is there any resort to irrigation, and when there is a prolonged drought the consequences are severely felt, the agriculturists making no efforts to utilize the waters that are at hand, but contenting themselves with the hope of rain while their crops perish.

Legislation on the subject of water is only rudimentary.

The principal rivers of the district are the St. Peter and St. Paul (one river) and the Cazones, both of which are navigable for short distances. No estimate is given as to their volume and no information as to irrigation, either on these streams or their tributaries, within the district.

A return from the district of Acayrican enumerates many small streams, including a number of arroyos which disappear during the dry season, but no mention is made of any use of these waters for irrigation.

A report from Orizaba enumerates various streams, some of which are used to a small extent in irrigation; but the largest (the Ingenio) has a flow of only 5½ cubic meters, while some of the others dwindle during the dry season to less than 1 meter.

From a list of the principal rivers which rise and flow through the State of Vera Cruz, those having a length of 40 leagues (104 miles) or upwards are presented below:

Panuco, Tamesi, Moctezuma, Calabozo or San Juan, De los Hules, San Pedro, San Marcos or Cazones, Tecolutla or S. Pedro and S. Pablo, Mautla or Rio Frio, Papaloapam or Quiotepec, Tesechoacan, Zapotla or San Juan, Blanco, Coatzacoalcos.

ZACATECAS.

In the municipality of San Alto mention is made of two streams and a number of springs which are used to a considerable extent in irrigation. The larger stream has a course of 6 leagues (about 16 miles) and a volume of 30 *surcos*. As regards water rights, the rule is that the different landed proprietors "take what water they need where their property is crossed by a stream, leaving the rest for others." There is some irrigation from small streams in other municipalities heard from.

In Nochistlan there are a few unimportant rivers and two small reservoirs which serve to irrigate small areas of land. At Juchipila there is a stream from which considerable water is obtained for the irrigation of orchards and gardens along its course, the quantity being increased at one point by a reservoir wherein water is saved for use during the dry season.

AUSTRALIAN IRRIGATION LEGISLATION.

The colonial governments of New South Wales and Victoria joined in a conference to examine the Murray River drainage basin, in order to arrange the terms on which this boundary area could be regulated. To some considerable extent it represents the problems involved in the flow and distribution of the interstate waters within our arid region. The legal control of the Murray, banks and basin, seems unquestionably to rest with the Colony of New South Wales, whose bondary line it is, but the larger considerations of physical geography, topography, hydrography, and climate forced a consideration of the interests of Victoria. It was finally proposed and decided upon that a joint trust be formed with these powers:

(1) After defining the areas, it was recommended that said joint trust "shall have power to regulate all diversions of water from the river and its tributaries."

(2) That certain tributaries may be regarded as feeders to the main or "Murray" river, or, as the term is, "compensation water." Other tributaries "may be diverted and used by the respective colonies through which they flow."

(3) The whole waters of the upper and lower rivers (Murray) are "deemed to be the common property of the" two colonies interested. Each colony in general to have the right to one-half the said waters, subject to reservation of "compensation water" aforesaid.

(4) "That all natural diversions" shall "be gauged" under the trust. The portions of such diversions not returned to main river channels "shall be debited" to the colony "diverting the same."

(5) That the trust "fix and determine" the "high-flood levels," and have control of all waters flowing above them, using them as may be deemed expedient.

(6) That all expenses be jointly borne, and that as far as possible united action be had in the construction of works.

The balance of provisions provide for the organization, etc., of said trust, its members and officers.

AN AUSTRALIAN REPORT ON AMERICAN IRRIGATION.

The following extended series of extracts are from a report on American irrigation to the governor of the Australian colony of Victoria, made by the Hon. Alfred Deakin, M. P., chairman of the royal commission on water supply, 1884-'85. They will be of great interest to the American reader, not only because of the author's lucid style, but because his field of investigation covers in a remarkable manner the lines of inquiry followed in collecting the materials for the first edition of this report, while he presents in much detail precisely the kind of information which it has been the object of the Department to collect:

EXTENT OF AMERICAN IRRIGATION.

The extent of the area irrigated in the West is the more surprising since the practice as compared with that of Europe is a thing of yesterday. In Mexico irrigation was practiced before the Spanish conquest, and there are a few spots in its old provinces, now forming the southwestern States of the Union, where, either at the Indian villages or at the missions, plots can be seen which have been cultivated for a century by its means. In Utah Americans began irrigating in a primitive way forty years ago, and their example was followed in that fashion, especially near the Mexican border and under Mexican tutelage, for a score of years. But the real development of American irrigation, now so wide-spread, has taken place entirely during the last quarter of a century, and mainly during the last fifteen years. During that period it has been lifted out of its early rudeness and carelessness into something like science and skill. Its traditions date no farther than this; its records do not date so far. The strides it has taken may be judged from the now current estimate that, as against 4,500 miles of canal in Lombardy, there are 12,000 miles of main canals in the West, and that the capital invested in and about them is expressed in millions of pounds sterling.

A VIVID DESCRIPTION OF ARIDITY.

The irrigated lands of America, though widely various, may be divided into two great classes. The rolling prairies of Kansas and sloping uplands of Colorado belong to one division. Poor and brown in ordinary seasons, their buffalo and bunch grasses are often green after favorable spring rains, and it seems but natural that, when a constant supply of water is secured, these treeless expanses should be gradually conquered by the march of settlement from thickly-inhabited and closely-cultivated districts. Not so with the sandy wastes stretching in a broad belt from the north to the south and southwest of the arid region. Here there is no prospect of any early invasion due to pressure of population or overflow from crowded towns. Here there is nothing to attract, and everything to repel. Here even the rich red mesa lands that lie under the shadow of the foot-hills are desolate at all times and all seasons—so desolate that it seems impossible they should ever sustain a living thing. From them the illimitable desert, bare and blinding in its glaring barrenness, stretches far away to the mirage towers that shift along a dull and undefined horizon. Much of the soil is so powdery, even in winter, that it follows in a lazy trail of cloud the horse of the solitary rider, or is sucked up in whirlwinds under the scorching summer sun. Elsewhere its gravelly and gritty surfaces, strewn with splintered bowlders, are seamed into gaping gulches and fissures of inappeasable thirst. There is no grass, the only vegetation being a withered-looking brush resembling salt-bush, the thirsty-looking cactus, a juiceless scrub like our ti-tree, or thorny variety of stunted palm.

Such is the Mapimi Desert in Mexico, the Maricopa Desert in Arizona, or the Mojave Desert in California; and such, without water, they must remain. As it is, these wastes of sandy aridity and gray innutritious herbage, surrendered by nature to solitude, surround oases created and sustained by irrigation. In the distance the track of a canal, pleasantly breaking the dull level of the dried-up plain, is marked sometimes for miles by a line of green bushes following its sinuous course. By and by this line broadens as if into a great green plantation, dotted with houses, divided into gardens, and decked with flowers. Its little fields, fringed with flourishing trees, are bright with fresh-springing pasture, upon which stock are gazing, or else crowded with dark orange groves and clustering vines. In the center of it is a tiny township, busy with teams and traders, where the train stops for a moment or two. When it starts again the houses and trees vanish as if by enchantment, and the engine rushes on through the dreary desert once more.

It is thus that the eye bears testimony to the fruits of irrigation in the South; and in the North, though in a less striking way, the lesson is the same. The unpretentious ditches that wind along the hill-sides or prairie ridges are not notable themselves until it is perceived that, where they are not, a scattered herd of rough cattle, a small party of roving Indians, or a burly rancher are the only objects of interest, while where they multiply are the buildings, the barns, and the business. A stretch of open country broken by long ridges of canals, its paddocks plotted off into little checks, with a barefooted Chinaman or high-booted European, spade in hand, directing the water from one to the other, are common features of the landscape, where one beholds industry and intelligence transmuting barren surfaces into orchards and fields of waving grain. Familiar, too, are the knots of active men, the little camp of tents, and toiling teams, that mark the progress of a new ditch into the wilderness, where it is to create a settlement and maintain it in the face of all seasons. The Indian village, the Mexican pueblo, the American township, all cluster about the natural stream, or the artificial stream which makes it serviceable; for in these parched regions its progress is everywhere a triumphal march. It is here veritably the water of life—life to the grass and flower, to the loaded tree, to man, and to the city of men, whose homesteads and harvests follow in its wake.

HOW THE WATER SUPPLY IS PROVIDED.

In western America the water supply is almost invariably provided by private companies. In one instance, that of Los Angeles, California, where this rule obtains, a water supply has been undertaken by the municipal body, but it is not employed for domestic purposes, being applied, curiously enough, to irrigation only. The outlay incurred is recouped by sale of the water to the farmers, a great number of whom have their plats within the city boundaries. The local governing body of Salt Lake, Utah, has also undertaken a similar work, though this is maintained out of the ordinary rates instead of by sale of water. Local governing bodies, however, do not, as a rule, go so far as this, even where, as in Los Angeles and Salt Lake, water for irrigation is as essential to the maintenance of towns as is water for drinking purposes. The utmost they do is to permit, as in Carson, City, Nev., a canal 6 feet wide to run along a main road unfenced, or, as in Phœnix, Ariz, to permit ditches 3 feet and 4 feet deep to cross their roads without requiring them to be fenced or bridged. Beyond this, municipalities do nothing. State governments have never done anything in the way of undertaking or assisting in the construction of irrigation works. They are not expected to undertake them, and there does not appear any likelihood of their ever having any proprietary connection with them. The Central (General) Government maintains if possible an attitude of even greater indifference. All the irrigation works of western America, with the exceptions above named, have been constructed and maintained wholly and solely by private persons. Not only has the Government spent nothing upon them, but it has known nothing of them. They have been constructed outside the law, extra legally, if not illegally. Even now only two States and one Territory have attempted to deal legislatively with any of the problems raised, and it is not claimed that in more than one of these has anything substantial been achieved. In Colorado the State engineer has issued one report, which includes a register of water-rights. In California the State engineer has issued one report specially dealing with irrigation, but there is no register of water-rights. In no other State or Territory is there either report or register. These reports are of great intrinsic merit, but have a further interest, inasmuch as they are the only official papers published by any State bearing upon irrigation.

DIFFICULTIES OF THE INQUIRY.

Only the fringe of the subject having been touched officially, the visitor who desires to study irrigation finds that the data upon which he must build his conclusions are not to be obtained ready garnered in a State office, but that they are virtually uncollected, and must be sought for in the fields of practical farmers. The officials of the Central Government and of the State governments exhibit the most considerate courtesy, but can only regret that they have been so hampered by want of means and authority that they have not been able to carry on their work in this direction, so as to place the matter upon a scientific basis. This condition of things is doubtless largely due to the newness of the country, and will tend to disappear as these regions attain to the age, population, and organization of the Eastern States. All that could be done to urge the legislature of California to action has been done by the State engineer, who, with his colleague in Colorado, has managed at last to partially educate public opinion as to the duty of the State in this relation. But their best endeavors at present can only point to the sources in which knowledge must be looked for. The farmers of America compare favorably with those of any country in method, quickness, and caution, but they are not given to recording exact quantities of water, or the special conditions of its use, or yet the results obtained with the exactness required for professional investigation. Many of them have been their own engineers or have employed engineers who either used no plans or have mislaid them. The many lawsuits as to the use of water now pending in California naturally render capitalists who have engaged in great irrigation enterprises within its boundaries somewhat chary of giving their private records for publication. Again, partly because of the neglect of the various States to collate facts and figures relating to irrigation, each district has grown up with its own theories, prejudices, and customs, differing often to a noteworthy degree from those of its neighbors.

DIFFERENT WORKS IN DIFFERENT STATES.

The circumstances of the several States also naturally lead to great differences in their irrigation works. The mountain torrents of Colorado require to be grappled with by large and powerful weirs before they can be raised, so as to cover the high rolling uplands, while the shallow rivers of Southern California call for light structures only capable of elevating water a few feet, so as to lead it across sandy plains. Farming in the bottom lands of Arizona has led to the use of wing-dams, which can direct the flood waters of spring along the ridges, and thence command the flats beneath, and a somewhat similar class serve for the low levees of Kansas, while its bench or mesa lands (the secondary flats or table-lands running up to foot-hills) call for larger ditches and stronger works, drawing their supply from the turbid Arkansas. In Utah and New Mexico we touch upon primitive works supplying small plats of land with little driplets of the precious fluid, out of which, with care and economy, thriving settlements are built up. The parent source of this system, and indeed of American irrigation, is Old Mexico, where irrigation, from the simplicity of the Egyptian water-lifter to the masonry weir and solid stone aqueduct of centuries ago, spreads its way over the whole of the territory closed in its temperate and tropic zones. If it is difficult to arrive at accurate information in the United States, in Mexico it is impossible. There is no trustworthy measurement of water, and but the lowest measure of products; a majority of those who till are too ignorant, and the minority who own the soil too indifferent to record their experience; the State does nothing to assist, and has no bureau to take cognizance of this most important factor of its chief source of wealth. Everywhere in the States or in Mexico private enterprise is supreme, and one learns only from private persons. The general condition is scanty collections of facts, and often opposite conclusions drawn from them.

IRRIGATION SYSTEM AND LAWS IN MEXICO.

Remembering the immense extent of the arid area, and the magnitude of the irrigation already undertaken in it, one can not but be surprised at the nature of the legislation under which it has been developed. Still the omissions and mistakes made in the States furnish some valuable material. The Aztecs were experts in the art of irrigation when Cortez landed upon their shores, and the Spaniards who conquered them brought their "Law of Waters" into force in their possessions. Under the Montezumas, water was the property of the commune; under the Spaniards it become the property of the king. In both, the public interest was thus permanently recognized. Private acquisition was permitted for domestic purposes, but not for irrigation or industrial uses, except upon an authority derived from the crown or its delegates as representing the public interest. Property in water, however, can be acquired by uncontested possession for twenty years, and is superior to property on land, since its owner has the right to carry it over any land which may lie between its source of supply and the farm to which he wishes to appply it, on payment of compensation and justification of the route. There are a great variety of enactments relating to water in the several provinces and municipal districts; but as the water available for private use has been almost all appropriated, there is now little ground for litigation as to new diversions. Public rights are jealously guarded; a land-owner near the head of a stream may not deprive a land-owner lower down of his share. Unless he can obtain an official authority, he can use no water that is not derived from springs upon his own property. The chief measures of water are the sulco, which is equivalent to a flow of 0·23 cubic feet per second; the naranja, which is one-third of a sulco; and the paja, which is equal to 0·00053 cubic feet per second. In the City of Mexico and other important municipalities the paja is the unit of measurement nominally employed. Law suits relating to the use of water are not uncommon; but nevertheless the law, with all its defects, appears to be fairly comprehended and obeyed. In what were Mexican provinces, California, Arizona, and New Mexico, the practice of irrigation was established, though on a very small scale, before their annexation to the United States, and has since developed to a considerable degree on the same lines, the only cardinal principle recognized being that of one appropriator over another in the order of priority of use, the issue of Mexican grants and the wholesale incorporation of English common law having combined to confuse the legal position of irrigation.

COLORADO AND ITS IRRIGATION LAWS.

In all matters relating to irrigation the knowledge of what is to be avoided is of equal value with the knowledge of what is worthy of imitation, and this is particularly the case in regard to irrigation law. The enactments which have proved advantageous, and their particular deficiences, are both worthy of close attention. As the laws of Colorado are by far the most successful, they may be fairly allotted the first place. By the constitution of this State all streams within its boundaries were declared to be public property. By this one declaration a thousand and one sources of contention as to riparian rights were altogether closed. By special enactment it next provided for the proving and registry of every water claim. These were allowed by the courts in their order of priority, and to the amount of water which had been actually used. When these points had been adjudicated upon the claims were then published as rights. The consent of the state engineer was required before the issue of any further rights. Under a further provision the national value of irrigation was recognized as in Mexico by the granting of a general power to any person to obtain an easement for his canal over his neighbor's land upon payment of compensation. Twenty-six water districts were defined according to the natural areas of drainage and supply, and a water-master for each was appointed, whose duty it is to decide disputes between appropriators and supervise the general distribution from a particular stream. By these simple means a host of difficulties and complexities were escaped, permanence was given to existing works, and encouragement offered for the construction of new works. It is not surprising, therefore, that in mileage of canals or acreage irrigated, Colorado more than doubles any other State, or that its works are the greatest and most permanent, and are most rapidly extending. The Territory of Utah has shown its appreciation of such results by copying as closely as convenient the legislation of Colorado. Its powerful church government has proved an invaluable administrative, judicial, and organizing agency. In California a move has been attempted, and much less achieved. In that state there is no constitutional or statutory provision that the waters shall be public property, but the common law of England has been incorporated in the civil code of the State, so far as it is not repugnant to or inconsistent with the Constitution of the United States, or the constitution or laws of this State (section 4468); as a consequence the doctrine of the right of a riparian proprietor to receive from the riparian proprietor above, and his obligations to deliver to the riparian proprietor below the water of the stream upon which his land abuts undiminished in quantity and unimpaired in quality has been revived.

CLIMATE AND IRRIGATION.

The irrigation area in America stretches from the snows of Colorado to the perpetual sunshine of Mexico, and from the shores of the Pacific to the valley of the Mississippi, embracing as great a variety of climate as is to be found in the whole of Australia. Over the whole of this great surface are scattered patches of irrigated land, and nowhere, north or south, east or west, does there appear to be any relinquishment of irrigation on account of climatic conditions. It is needless to add that, compared with the whole extent of this territory, the irrigated area is infinitesimal, but the fact stands that the high plains of Colorado, 5,000 feet above the sea, the bleak prairies of Kansas, the sandy waste of California at the sea-level, or the arid valleys of the Mexican plateau, 7,000 feet above it and within the tropical zone, are all susceptible of irrigation. The only want is want of water. Climate limits the Colorado farmer to a short season of one hundred days, while in Los Angeles or Leon cultivation is carried on all the year round. Climate determines the class of products that can be profitably raised, and temperature of course affects the quantity of water necessary to be used.

THE WATER SUPPLY.

Rain-fall.—The arid area of the United States, by the terms of Major Powell's definition, includes only lands where the rain-fall is under 20 inches per annum. Over the great belt in which irrigation has so far had its chief development the record for a series of years gives but a little more than half that quantity, so that 10 to 12 inches may be taken as a fair average, though the extremes show a much wider variation. In northern California and among the mountains to the east the rain-fall rises to 40 inches, while in the deserts of southern California it falls to 4 inches. In western Kansas the fall not infrequently reaches 20 inches, but this is so irregular that the farmer who relies solely upon a natural supply loses more by the dry seasons than he can make in those which are more propitious. The question as to whether settlement increase the rain-fall in the West as it has increased it in the Mississippi Valley is still undetermined, for though popular opinion is decidedly in the affirmative, the State engineer of Colorado points out that official records so far do not support the assertion. The exceptions to this are that Salt Lake, Utah, appears to be steadily gaining in depth and that dew is now observed at Greeley, in northern Colorado, a phenomenon quite unknown until irrigation had been practiced for some years. Nor does the mere amount of rain-fall indicate sufficiently the necessity for an artificial supply of water unless also the seasons in which it falls are taken into account. In parts of Dakota and Minnesota, where the rain-fall only averages about 20 inches, dry farming is carried on, while in districts of Texas, where the figures are as high, it would be impossible to obtain the same results without irrigation.

The explanation is that in Dakota nearly 75 per cent. of the rain falls in the season when the farmer needs it as against about 50 per cent. in Texas. Indeed a gradation may be observed in this scale from north to south, since in Kansas some 65 per cent. of the rain falls in the spring and summer, while in the extreme south, as at San Diego, only half of the whole rain-fall of 9 inches falls in the spring, and is consequently useless for agriculture. There is some irrigation in Dakota, as also in Iowa and Wyoming, but not nearly so much as in the States to the southward, where even if the rain-fall were as high its distribution would render it insufficient. The quantity of water needed is also affected by temperature, for the higher it reaches the more water is demanded. The loss by evaporation has not yet been determined for the several States, but it is stated that in very arid tracts it rises to over 60 inches per annum. The fact that irrigation is resorted to under such conditions should be borne in mind when we consider the wisdom of securing an artificial supply in places where the yearly fall is often sufficient.

Rivers.—That great backbone of the North American continent, the Rocky Mountains, traverses, with its companion, the Sierra Nevada, the whole of the Southwest, pouring from its snow-fields permanent streams in greater profusion that Victoria possesses. They rush from the rocky gorges out into the open country, running often bank high, and thus facilitating the diversion of their waters over the surrounding lands. But the majority of them are small, and where the supply is one peculiarity, of the utmost value in irrigation, is that they run along the ridges of the plain, while the country slopes away from their banks. In the south the rivers which supply the chief settlements are very shallow, and run in broad, sandy beds, often changing their course. The States have, as we have, streams which are a chain of pools for one-half the year, and often a torrent during the other half, while with them the melting of the snow supplies the water in volumes, as in the Murray, just when it is most required.

In Colorado the San Luis and Saguache dissipate themselves in the plains, while in southern California the Kern, in Utah the Jordan, and in Nevada the Carson, Truckee, and Humboldt terminate in lakes which have no outlet, thus furnishing parallels to the Wimmera, Richardson, and Dumnunkle of our own colony. One feature of many American streams, especially of those in sandy beds, is that they lose a great quantity of their flow by soakage, which in some cases returns to them by the same means. It has been observed of some rivers in New Mexico, as in Italy of some tributaries of the Po, that the stream tapped by a large irrigating ditch and robbed of a considerable share of its flood, regain it all again a few miles lower down. It has been found also that old river-beds still carry a flow underground, and that some running rivers have but a fraction of their streams above ground. In California sometimes as much as two-thirds of a stream has been found below its bed, and consequently what are called submerged or subsoil dams have been occasionally employed with great success, as in the Santiago Valley and at Downey, to arrest these escapes and bring the whole body of water to the surface. Another characteristic of American rivers is that no matter how clear the water may appear it almost invariably carries with it a sediment, which is in the majority of cases a valuable fertilizer. There are rivers, such as the King's River, California, which are said to carry no silt, and yet to fertilize the land, in which case it is to be presumed that the water acts as a solvent, disintegrating the coarser particles of the soil and preparing the fertilizing elements for absorption in plant growth. The topography of this State, California, has been especially favorable to small schemes, and has induced the farmer, by his opportunities of obtaining water when he most needs it at a minimum of labor and expense, to commence experiments on his own land.

Springs and wells.—In the matter of the supply obtained from underground, American experience is, on the whole, encouraging. In Los Angeles and San Bernardino Counties, Cal., there are springs or springy marshes called cienagas which irrigate from 20 to 400 acres each, and together supply an area of 7,000 acres of cultivated lands. Such springs are an important source of supply in Italy, where they are styled fontanili. Here some are so charged with mineral matter as to be unfit for use and have usually so small a flow as to be employed for orchard irrigation only. At San Gabriel, Cal., a vineyard 1,200 acres in extent is supplied solely by springs or artesian wells, of which there are twenty-one on the estate, ranging from 75 to 100 feet deep. In southern California, altogether there are calculated to be one thousand of these wells, varying in depth from 200 to 550 feet; some of them have a flow of 1.7 cubic feet per second, and suffice for the irrigation of small farms. On one estate there are fifteen of an average depth of 200 feet, yielding water at the rate of 2.2 cubic feet per second. Artesian water has been, if anything, rather dearer than canal water in California, but has the advantage of being at a higher temperature than snow-fed streams.

In Santa Clara County, Cal., there is an artesian tract yielding 2,000,000 gallons every twenty-four hours, but the greatest supply from such sources is at Denver, Colo., where a stream of 2,880,000 gallons per day is derived from eighty wells, which range from 300 feet to 900 feet deep. In sinking these the "club-churn" drills have been found cheaper and quicker than the diamond drill, sinking 45 feet in twelve hours, as against 15 feet with the diamond drill, or 90 feet in twenty-four hours as against 35 feet. When artesian water is used the wells are, where possible, put down upon the highest part of the farm from which the water can be most easily distributed; when the water is raised by means of a windmill from an ordinary well, which is usually upon low ground, it is delivered into a light wooden flume, which conveys it into a reservoir on some commanding spot. In California, and especially at Florin, water is raised from depths of 10 to 20 feet in a steady stream by means of windmills, one of which, as a rule, can supply 2 to 3 acres of land with water. Further south the water is raised from more than twice this depth by the same means. In most cases the water is bored for and struck, but does not rise to the surface, the windmill being employed to lift it the extra distance. If water were found without boring at 10 feet deep irrigation for vines or lucern would be considered superfluous. The utilization of such small quantities of water as can be obtained by these means attest the value set upon any supply, however minute. Though the streams of the West are considerable in number, they are small and far between in almost every district in which irrigation is necessary. There are most extensive areas without appreciable rainfall, without rivers, and without springs. The irrigable area is narrow and widely distributed, occurring, except in Colorado and Kansas, in comparatively small allotments.

IRRIGATION WORKS AND THEIR CONSTRUCTION.

It is next desirable to consider the means by which water is diverted and the methods of its application, so as to share any knowledge which Americans possess in these directions. To comprehend the nature of their works it is desirable to bear in mind their history, for they have rarely been the result of one foreseen plan, but have, as a rule, been brought into their present condition piecemeal. It must be remembered that they are not State works, and that in many cases they were not constructed by companies or capitalists, but by the farmers themselves, either singly or banded together. On the faith, perhaps, of a good season the settler had taken up land and after his crop was in had seen himself in danger of losing it, or else in sheer desperation he had settled without expecting a rain-fall and determined to try the Mexican custom of flooding his fields. In either case his necessity has been the same. He must have water or be ruined. If it did not fall from the clouds he has asked himself why it should not prove as efficient if obtained from the nearest stream. With this pressure upon him he has not waited to inquire into his legal rights or seek for engineering skill or hold public meetings. He has hitched his team and with plow and spade run a rough ditch to the river bank. By cutting this through, and if necessary throwing up a slight wing-dam to turn the water in, he has been able to soak his fields, save his crop, and probably get half as much again as an ordinary yield. Stirred by this gain, and by a strong sense of successful self-reliance, he has made his work permanent. A neighbor has joined him in enlarging the ditch, and then shared in its benefits. Others have been encouraged to face the same task. Where several were interested they have joined their forces, apportioned the work, and each carried out his share or paid for its being carried out for him. By these means a great number of so-called works have been constructed, and, learning from them, the small capitalist and the large capitalist have followed suit, and have built canals to supply water for use upon their own lands or upon lands which they wish to let or sell, or upon the lands of others to whom they intend to dispose of the water they have secured.

These works have been built often without engineers, almost always without plans, and their defects are patent. The weir head-gate or wing-dam, as the case may be, has been carried away several times, and has probably cost more to replace than a substantial structure might have cost. Then the easiest courses for the ditches have been chosen, so that, instead of running on high land, they have even followed old water-courses, and thus have commanded from the canal a much smaller area and more imperfectly than they should have done. There have sometimes been no surveys, and as a consequence curves have been too sharp and grades too steep, so that ditches gradually destroy themselves, cutting out their own banks and filling in their beds. Or, perhaps, an opposite fault has been committed, and there has not been current enough to keep down the water weeds which spring up in the channel and choke it.

Then, again, the natural result of individual effort of this kind has been that several canals have been built where only one was necessary. For instance, there are five ditches supplying the Mussel Slough district, California, where one would carry all the water with far less loss in the carriage. There are thirty-two canals taken out of the Kern River, where eight would have been abundant; and at Fresno half a dozen where two would have sufficed. What loss this involves may be estimated from a calculation of the State engineer, who, after a careful examination of two of these canals, finds that their combined stream could have been carried in one channel at a saving of 20 per cent. of the water conveyed. The engineering defects of such works are palpable, and are not disputed or disguised. At the same time it would be a mistake to condemn them out of hand. At least they have served their purpose for a time—it may be wastefully, but the waste could not have been prevented. Crop after crop has been saved—the farmer has kept his land, has built his house, and cultivated his plot comfortably by their means. If he now possesses the knowledge needed to irrigate and build ditches, and has the money in his pocket to enable him to use his knowledge, he owes it all to these first rude efforts of his by which he put the water upon his fields cheaply and without delay.

Everywhere, however, engineering work is characterized by extreme simplicity and economy; it is rarely massive and never ornamental. There is no attempt at finish, but only at efficiency. Water-works in the West are like railways, often made to pay for their own construction. At first just enough work is done to enable them to yield a return, and then additions are made from time to time, until at last they are brought into a condition of stability. In places where it is cheaper to build a new weir or wing-dam of brush and sand every year than to pay interest upon the sum required for a permanent structure the temporary work is invariably resorted to.

It is rare also that any work is built strongly enough to endure all contingencies. The practice is to put up a weir that will stand in ordinary seasons, foreseeing that it will be swept away by the first of the heavy floods which occur periodically every few years.

There are many ingenious engineering devices for decreasing expenses, but this principle of risk to save interest governs all. American engineers know that these works are not permanent when they build them. As a rule they have the professional dislike of building temporary works, and, not having to provide the funds, prefer structures that will prove a lasting credit to them; but shrewd capitalists have tested the principle in practice, and they find it pays to resort in many cases to these slighter works.

SOME OF THE PRINCIPAL WORKS.

Among th eillustrations of this combination of risk with very clever engineering there are none better than those to be found at Bakersfield, where Mr. James, as engineer for Messrs. Haggin and Carr, has had a large field for the display of his ability. Timber is cheap in America, and California is favored with the redwood, which is soft, easily worked, and yet durable; consequently it is almost wholly employed by Mr. James upon his 250 miles of canal. His main gates cost from £40 to £60, while his head-gates, controlling a flow of 30 feet or 40 feet of water 3 or 4 feet deep, are erected for £600. A wooden weir in the Callaway Canal, costing only £2,600, is 700 feet long, can be put in place in a couple of hours, and is ingeniously arranged so that its superstructure is rapidly removable. Many of the contrivances employed on these ranches are well worthy of imitation wherever shallow streams are to be dealt with in a level country. The combination of weir and bridge in the same wooden structure is another feature of these works well worth the attention of local governing bodies, one of these, 360 feet long, 20 feet wide, raising the water 5 feet, and reckoned to have a life of at least twenty years, being built for less than £2,000.

In the streams of southern California, which are of no great depth as a rule, brush-work is generally used for weirs and dams, sometimes being loaded with sand-boxes or sand-bags or protected with fascines, loaded down with cobble-stones. Thus the San Joaquin and King's River Canal, California, has such a wing-dam, 350 feet long, as has the Larimer and Weld Canal, Colorado, where the dam is 177 feet long and 5 feet 8 inches high. Examples of this class of construction on a great scale, though not for irrigation, may be found in the Yuba and Bear Rivers, where two dams may be seen, one of them 8,900 feet long, and the other 5,875 feet long, ranging from 3 feet to 15 feet in height, and from 60 feet to 120 feet in width. Perhaps the largest irrigation head-work in this style is that of the Eureka Canal, in Kansas, which is 1,500 feet long and 8 feet high, supported by a dike a mile long on the south side of the river, and diverting 5 feet of water through a cut in the banks of the Arkansas, 16 feet deep, into a canal 28 feet broad at the bed and 80 miles in length. The dimensions of these works, together with the stability of such head-gates as that upon the 76 canal, Fresno, Cal., which is also a bridge of 100 feet long and 20 feet wide, and raises the water 5 feet at a cost of £1,000, and the ingenuity of the head-gate of the Chowchilla Canal, resting upon a quicksand, as described in the engineer's report, are evidence enough of the ability which is displayed in many works. In northern California there are both dams and weirs, of great height and excellent simplicity of structure, erected for mining purposes, and now, in a few cases and on a small scale, utilized for irrigation as well as motive power. For the most subtsantial of all head-works, however, we must look to Colorado.

There are some small stone weirs in the South, and some fine pieces of masonry work of great antiquity in Mexico, but none of these are liable to such enormous strain as is met with in the wild cañons of the Rocky Mountains. The South Platte Weir, for instance, is 120 feet long from the cliff on the one side to its waste-gate of solid masonry, 24 feet wide, on the other, raising the water 14 feet by means of a frame-work of 12 by 12 timbers bolted into the bed-rock, filled with stones and planked on the face with 6-inch boards. The apron extends 54 feet up-stream and 18 feet below the weir, the water having a perpendicular fall. The waste-gate and off-take are both protected by substantial "booms" or "grids," the latter 72 feet long, built of 12 by 12 timbers. These admit the water through bars below the surface and protect the work from the trunks of trees, which are carried down with great force when the stream is high. These "booms" are in frequent use in Colorado, and are worthy of note for application upon the many Australian streams in which heavy floods invariably whirl along with them great quantities of timber with a force that would destroy an unprotected structure as speedily as a battering-ram. The weir across the North Poudre endures even fiercer floods, and is more massive in structure, stretching 160 feet across a rugged cañon, from wall to wall in the form of an arch, bending up-stream, and composed of strong cribs filled with stones; it raises the water 26 feet into its flumes. The lower face consists of three steps pitched with stones, which are so keyed in each other that the pressure upon them only serves to wedge them more firmly in. As it has stood two or three severe floods without sustaining any damage it may be considered a success, more especially as though situated in an out-of-the-way district over 20 miles from the nearest station, and a mile up an almost inaccessible gorge, its cost was less than £2,000. It was considered worthy of being made the chief subject of a special paper read before the Institution of Civil Engineers in London.

Enough has been said here to indicate the character of the chief classes of head-works, of which there are a great variety in each State. The minor works, such as drops, gates, or regulators, are usually of wood, and of simple design. In the South Platte Canal a much superior gate may be seen, the off-take from the main canal being by means of an earthenware pipe set in stones, beyond which is the usual gate and a measuring weir. The head-gates, however, include but a small part of the works undertaken in order to secure a supply of water. There is a prevalent idea that in America the streams only require to be touched with a spade to pour themselves upon the farmer's sown lands. That such is not always the case in Colorado may be seen from the fact that the South Platte Weir referred to above, built at a cost of £4,000, serves to raise the waters to the level of a tunnel 600 feet long, 20 feet wide, and 12 feet high, hewn through the solid rock, at an outlay of £12,000, emptying its tide into a wooden flume 2,640 feet long, 28 feet wide, and 7 feet deep, which cost nearly £20,000, and is supplemented further on by other wooden flumes along the 83 miles for which this artificial river has been excavated across the plains. The North Poudre Canal has about a mile of wooden flumes, and three tunnels, one of them 900 feet long, necessitating an outlay of £10,000 for its first mile before it touches the open country, through which it flows for 50 miles. Nor is expenditure of this character limited to great canals supplying large areas. The price that can be paid for water may be better understood by noting what the outlay is upon small areas.

At Pasadena, where there are but 1,500 acres to supply, the water is carried from the weir by a flume 700 feet long into an iron pipe 3 miles long, from 13 inches to 11 inches in diameter, to a reservoir with a capacity of 3,000,000 gallons, party rock-walled and partly cemented. From this another iron pipe conveys it to the land to be irrigated, while a lower portion is supplied from another source by a pump throwing 30,000 gallons an hour into another 500,000-gallon reservoir, from which it is distributed by a mile and a half more of iron piping. The total cost of these works is given as £8,000. The Lake Vineyard Company to the east have a concrete ditch 17,000 feet long and a quantity of iron piping simply to water their own vines. The supply to the neighboring colony of Anaheim is carried in a flume 6,970 feet in length. At Redlands there are 6 miles of iron piping 1 foot in diameter, carrying 5 cubic feet of water per second from the weir to the 2,400 acres which it is intended to irrigate, upon which there are stand-pipes and iron measuring weirs to every allotment. At Ontario, with its 8,000 acres, the arrangements are equally perfect, a large portion of its supply being obtained by a tunnel nearly 3,000 feet long, upon which £10,000 have been spent. An illustration of another class of water-works on a great scale may be seen among the mountains of Nevada, where there are wooden flumes from 50 to 80 miles in length, down which sawn timber is floated from the forests among the hills. The distance which great streams of water have to be carried before they can be utilized may be judged from a few illustrations.

The Dodge City Canal, Kansas, is 90 miles long and 50 feet wide; the San Joaquin and King's River Canal, California, 78 miles long and 68 feet wide; the South Platte, Colorado, is to stretch 160 miles when completed; while the Great Eastern, Kansas; the 76 Canal, Fresno, Cal.; the Larimer and Weld, Colorado; the Arizona Canal, Arizona, all range from 40 to 60 miles in length, with a breadth of over 30 feet. In considering the length of these canals, it should be remembered that some of them have been carried much farther than the natural circumstances required, passing irrigable lands in their course just as rich as those they reach beyond, but which are unsupplied because they do not belong to the proprietor of the ditch. The area of irrigable land under canals of these dimensions amounts often to from 50,000 acres to 250,000 acres each, but from none as yet is more than the smaller quantity under cultivation. In Utah, settlements have been abandoned because they were located too far from the streams supplying them. The higher up-stream an off-take of a canal is, and the shorter the distance water is carried to land, the less the loss by soakage. The more favorably situated flats, however, usually lie farther down-stream, and as these are always the first to be irrigated it becomes necessary for the later settler to take up higher ground, to water which he must go farther up the river. There is thus a tendency for the canals to become longer as the country is taken up. It is unnecessary to describe their construction, for they are merely ditches of sizes and grades varying according to the soil in which they are cut and the water they have to carry, which is from 1 cubic foot to 2,000 cubic feet per second. The average cost of a 30-foot canal is reckoned in ordinary country at from £200 to £300 per mile by Colorado engineers. The average grades chosen are from 1 to 3 feet per mile; the banks, in most places, being on the slope of 4 or 5 to 1. The breadth is adjusted so as to equalize the discharge, being greatest where the grade is least.

The amount of money which private persons have invested in these works shows that the prospects of profit are tempting. The San Joaquin Canal represents in direct and indirect outlay £260,000; the Dodge City, £160,000; the South Platte, £150,000; the Arizona, £100,000; the North Poudre, £50,000, and the City Ditch, at Salt Lake, £45,000. Several of these are built by companies which have other canals of considerable size and land purchases made in connection with them, in which even larger sums are sunk. Two companies in Colorado control between them nearly 500 miles of main canals, which, together with the land they were constructed to water, represent an outlay of more than half a million sterling. As far as can be judged there are no apprehensions entertained as to the future of such investments; their proprietors appear satisfied with their returns up to the present time, and not unwilling to enter upon extensions of their existing enterprises. Still the figures, even now, should make it plain that irrigation in America is not the simple matter it has been supposed, but one that taxes the capital and enterprise of even a speculative people.

THE PRINCIPAL IRRIGATION RESERVOIRS.

Next to head-works, the most important feature is the provision of storage, by means of which the surplus of winter rains or spring floods may be retained for use in time of need. The surveys made in California and Colorado so far have discovered many natural depressions of no great extent, but still valuable in connection with irrigation schemes. In Los Angeles County are to be found a number of reservoirs already built, some of them cemented; others, such as those of the Lake Vineyard Association, composed of the natural soil. Most of these are small, the largest containing 21,000,000 gallons. The cost of excavation here was from 7*s.* 6*d.* to 12*s.* 6*d.* per thousand cubic feet of storage. In New Mexico, by means of a series of earthen dams, one farmer has created seven reservoirs, from which he can command, with a reserve supply, some 2,000 acres of his estate. In Colorado the mountainous character of the country has been favorable to the construction of similar works, the State engineer recording a number of them at 6 feet to 35 feet deep and 10 acres to 500 acres in extent. The largest is that in connection with the Big Thompson Canal, which covers 427.35 acres to a depth of 35.8 feet, of which 21.8 feet is available, and is expected to water 12,000 acres. A chain of such reservoirs is being added to the North Poudre works previously referred to. But by far the greatest of these reservoirs is situated in the Bear Valley above Riverside and Redlands, Cal., where, by means of a wall of masonry 300 feet long and 60 feet high, 8,000,000,000 gallons, or more than the contents of the Yan Yean when full, are preserved, owing to exceptional natural advantages, at a cost of £12,000. This will give a continuous stream of 150 cubic feet per second for 100 days, which, on the scale of supply adopted at Redlands, should water at least 50,000 acres. A still larger reservoir is projected in southeastern Colorado, where water sufficient to supply 100,000 acres is to be stored, in connection with a canal 80 feet wide, 7 feet deep, and capable, with the reservoir, of irrigating twice that area.

CONSTRUCTION IMPLEMENTS.

The implements themselves are various, and a considerable portion of the saving is made in the knowledge when to use one and when to replace it by another. To begin with the simplest kind of construction, that of field ditching, the farmer does this, as a rule, with his plow, with which he can easily run a ditch of a few inches capacity across the field. If he intends to widen it while keeping it shallow he employs the ditch plow, which consists of a blade suspended behind the share so as to push the earth which it cuts to one side. In many soils this is found to be an invaluable implement. When the work is more roughly done, what is known as a V scraper is brought into play. This varies from a mere log of wood with a couple of old spade heads nailed in front, forming a sharp prow, which is its rudest form, to a triangle some 6 feet wide at its wooden base, from which proceed two long iron blades forming the acute angle. Its use is always the same. It is drawn by horses and steadied by the driver's weight, so as to push the earth outward from a simple plow furrow or series of furrows, and thus form a ditch. When this is over 6 feet in width a "side-wiper" is generally substituted, which is a long iron blade, lowered from a frame which rests upon four wheels, so that when drawn by a powerful team it slants the plowed soil to one side. In light soils and for large ditches an elaborate machine is used, which not only plows the earth but takes it up and shoots it out upon the banks a distance of 10 or 12 feet, to either side, at the rate of from 600 to 1,000 cubic yards per day.

But the implement most in use for operations of any extent is the iron "scraper," which is found in many forms, sometimes runs sledgewise, sometimes upon wheels, and ingeniously fitted so as to be tilted without effort. For a long pull wheels are considered best, and for steep banks runners have the preference, but scoops are preferred without either for sandy soil. The kind of soil to be moved and worked upon and the length of haul are always taken into account in determining the class of scoop used. In constructing a deep canal a haul of 1 foot upward is reckoned the equivalent of 50 feet on the level, and with an experienced driver and a team or two of horses or mules a scoop is expected to remove from 80 to 120 yards per day. Sometimes in railway work one man is told off to every four teams to fill the scoops, but in the majority of cases the driver does this himself. There is another implement known as the buck scraper, which for ordinary farming use in light soils and in practiced hands accomplishes remarkable results. It consists of a strong piece of 2-inch timber, from 6 feet to 9 feet long and 1 foot 3 inches high, with a 6-inch steel plate along its face projecting 2 inches below its lower edge, and is strengthed with cross-pieces at the back, where there is a projecting arm, upon which the driver stands. Like the ordinary scraper, it is also found on wheels and runners and in many patterns, and is drawn by a pair of horses. Instead of taking up the earth as the scoop does, it pushes the soil before it, and when under good command does such work as check-making, ditch excavating, or field leveling, in sandy soils, with marvelous rapidity. Work with the scoop costs, as a rule from 4*d.* to 6*d.* per cubic yard; when the cost reaches 9*d.* it is considered time to set it aside.

With the buck scraper work has been done in favorable localities as low as 2*d*, and even a penny, per cubic yard; and it is astonishing to note the number of uses to which this simple implement is successfully applied. Where the leveling of fields is difficult a machine is sometimes used which cuts off the tops of mounds or ridges and drops the stuff in the first hollow over which it passes. The windmills for raising water from wells have been already alluded to as have the boring machines at Denver. Where the water is to be raised from a running stream a wheel is employed turned by the current, raising little bucketsful and pouring them into a wooden flume from 12 feet to 20 feet high. Many little contrivances, such as a movable iron grate or "tapon," for diverting water at any point from field ditches, and shaped like a railway disk, are to be met with.

DISTRIBUTION BY PIPES.

In this connection it may be well to notice the variety of pipes employed for water supply and likely to be more employed as water becomes scarcer and fruit raising increases. Where suitable material is at hand it is not uncommon to find ditches, as at Lugonia, Cal., roughly paved for 6 or 7 miles, thus saving one-third of the water previously lost in this distance. Again, the South Fork ditch, from the Santa Ana, is made in a similar way, by neatly fitting cobblestones together, and with an equally satisfactory result. Near Passadena, as already mentioned, there is a concrete ditch more than 5 miles in length. This mode of ditching, however, is not always possible, and where such an outlay can be faced it is generally advisable to use pipes. The greater profits realized from fruit-growing encourage such an expenditure, by means of which a very small stream can be made to cover a comparatively large area.

Pipes can either be employed to bring water to land upon which it is to be used or they can also be carried on so as to distribute the supply throughout the cultivated area. This latter process, known as subirrigation, will be described at a later stage. When it is practiced a simple machine is generally used, by means of which a cement pipe is made in the ground and in position, thus saving the risk of transportation and some cost of labor. The scale on which this has been attempted is not as yet sufficient to demonstrate its universal efficiency. For main channels a concrete pipe, cheaper than earthenware piping, is largely in use in the "colonies" of southern California, as at Ontario and Pasadena, where it has proved durable and serviceable under low pressure. In the San Demas Cañon there are 3 miles of this pipe, 5 inches in interior diameter, carried along the face of a cliff. Its most formidable rivals have been a riveted and asphalted pipe and a light laminated pipe, both of wrought iron, the latter made by telescoping one sheet-iron pipe into another when submerged in asphalt and tar, and thus filling up the small space between them with the mixture. As a 4-inch pipe of this pattern is supplied for practically the same price as that in cement, and has proved itself capable of withstanding great pressure, the preference, on the whole, appears to be given to the iron. Where it is found, as in Utah, that a ditch 3 feet deep, which is 20 feet wide for the first 23 miles of its course, can in the next 2 miles carry all that is left of its stream in a width of 12 feet, it becomes plain that where water is valuable there is a fair margin to pay for piping.

METHODS OF IRRIGATION.

Flooding.—The earliest, easiest, simplest, and cheapest method of irrigation is by flooding. The water is then directed so as to cover the whole area under cultivation to a depth varying according to the crop and the quality of the soil. This plan is the most wasteful of water, but can not be avoided in the cultivation of cereals. The only work it involves in the field is that necessary to permit an even flow of water. With a regular slope this work is sometimes trifling, but as a rule some preliminary outlay is required for leveling inequalities, or else providing for the equal distribution of the stream from points of vantage. When the fall is slight, shallow ditches are run in Colorado from 50 feet to 100 feet apart in the direction of the fall; when the land is steeper they are carried diagonally to the slope or are made to wind around it, and from these, by throwing up little dams from point to point, the whole field is inexpensively flooded. When the fall is still greater and the surface irregular ridges are thrown up along the contour lines of the land, marking it off into plots called "checks," on the whole of the interior of which water will readily and rapidly reach an equal depth. When one plot is covered the check is broken and the water admitted so as in the same way to cover the next plot.

The ridges or "levees" must have rounded crests and easy slopes, or else they interfere with the use of farming machinery, such as the stripper. By means of diagonal furrows and checks remarkable results are obtained, even in very broken country. By their means it is claimed that in Colorado one man can irrigate 25 acres per day. Where checks have not been used upon ground with an acute incline, the water has soon worn deep channels through it, utterly ruining it for agricultural purposes; or again, where the water has been allowed to flow too freely the consequence has been that all the fertilizing elements of the soil have been washed away. In flooding the aim is, therefore, to put no more water upon the land than it will at once and equally absorb or can part with without creating a current sufficient to carry off sediment. The neglect of these precautions has caused the abandonment of several settlements made in Utah before the art of irrigation was properly understood.

In southern California checks are employed even more successfully than in Colorado, the levees being built by buckscrapers, so as to prepare large areas for crop at 2*d.* per cubic yard of material moved, or 6*s.* per acre.

The lands there are not so rolling as in the northern uplands, where the average cost of preparing land for irrigation is from 8*s.* to 16*s.* per acre. As much higher estimates have been given in Victoria, it should be noted that the higher price is for country more difficult than the average of our northern plains. It would be possible, by grading and terracing, to water very steep slopes, but the labor would not be paid for by any cereals that could be raised. Both the depth and number of floodings are varied according to soil and crop. With a clay soil the waterings are light and frequent, while with a sandier quality they are heavier and rarer. Much, too, depends upon the distance and nature of the subsoil. There is considerable uncertainty with regard to the measurements given for flooding. It is sometimes placed as low as will give a depth of 2 or 3 inches, and at other times as high as from 5 inches to 10 inches at a single watering. There are cases in which as many feet have been used. The number of waterings is best determined by the crop itself, and the most skillful irrigators are those who study its needs and take care to supply them without giving an excess of water. The quantity used alters, therefore, from season to season, so that only an average can be given.

In Colorado, where water is used more lavishly than in any other State, some good judges have agreed that an average of 14 inches should be ample, and this is certainly not too low. Where the soil is liable to become hard and will retain moisture, wheat is often grown with two floodings, one before the ground is plowed, and the other when it is approaching the ear. When two waterings are given after sowing, one is when the wheat commences to "tiller," and the other when it reaches the milky stage. Where irrigation does not precede the plowing, it is postponed as long after the appearance of the crop as possible. Sometimes wheat has three or even as many as four floodings; but this is unusual, as overwatering occasions "rust." Experience shows that it is easy to exceed the quantity required by the crop, and that every excess is injurious. Extravagance is the common fault, so much so that the most successful irrigators are invariably those who use the least water. The less water, indeed, with which grain can be brought to maturity the finer the yield.

Furrows.—Peas and potatoes are not irrigated by flooding, but from furrows 4 feet to 10 feet apart, and this is found the more economical and more successful system for vines and fruit trees.

Under the flooding system, the ground, if not protected from the sun, cakes quickly. When the water is run down furrows drawn by a plow between the plants, this caking is avoided, and the water soaks quietly to the roots. When flooding was practiced in orchards it was found to bring the roots to the surface and enfeeble the trees, so that they needed frequent waterings. Sometimes the furrows feed a small hole at the foot of the tree, from which the water soaks slowly in. When this is done mulching is found desirable over the hole to reduce the loss by evaporation. The general rule is to protect the trees by small ridges, so that the water does not affect the surface within 3 or 4 feet of them. The simple furrow, however, is most generally in use. Oranges are watered three or at most four times in summer; vines, once, twice, or often not at all after the first year or two; and other fruits according to the caprice of the owner, the necessities of the season, and the nature of the soil, one to four times. It is impossible to be more exact. An even greater difference, comparatively in the quantity of water used, obtains in the furrow irrigation of fruit trees and vines than has been noted in regard to cereals. To such an extent does this prevail, that not only do districts differ, but, of two neighbors who cultivate the same fruits in contiguous orchards, having exactly the same slope and soil, one will use twice or thrice as much water as the other. Judging as far as possible from conflicting testimonies, the cardinal principle appears to be just the same. To attain the best results the trees must be carefully watched, and supplied with only just enough water to keep them in a vigorously healthy condition.

Another all-important principle, as to which there is no question, and which is testified to on every hand, is that the more thoroughly the soil is cultivated the less water it demands—a truth based partly, no doubt, upon the fact that the evaporation from hard, unbroken soil is more rapid than from tilled ground, which retains the more thoroughly distributed moisture for a longer period. For the irrigation of cereals, works are required on a larger scale proportionately than for fruit; because in the first case the water is demanded in greater quantities at particular times, while in the latter the supply can be more evenly distributed throughout the year, though of course the irrigating season with both is much the same. In the Northern States irrigation is limited to a hundred days, while in the South it can be employed at discretion all the year round. In both regions winter and autumn irrigations are growing steadily in favor. Land which receives its soaking then needs less in summer, and is found in better condition for plowing. It is argued that moisture is more naturally absorbed in that season and with greater benefit. Everywhere the verdict of the experienced is that too much water is being used, and the outcry against oversaturation in summer is but one of its forms.

Sub-irrigation.—Irrigation beneath the surface, if not excessive, is considered the most perfect method of supplying water to vegetable life, and it has been the aim of many to devise a scheme by which this can be done with the greatest economy. The idea is to replace soakage from above, by either flooding or furrows, with what is called "seepage;" that is, subterranean and lateral soakage, which, to be perfect, should not wet the surface. The one advantage possessed by surface over sub-irrigation is that, when carefully managed, irrigation by soakage is a perennial source of fertilization, on account of the quantity of deposit which is obtained with the water from most streams in certain seasons. Irrigation by seepage can not produce this beneficial effect, but it can avoid the dangers of excessive saturation or surface caking, or of washing out the richer elements of the soil, as well as accomplish an enormous saving in the water used. Two difficulties have presented themselves to its complete success. The first of these is the tendency of the apertures in the pipes to become choked by the roots, which tend to form a mat about it. The main difficulty, however, so far rather feared than experienced, is that the constant seepage of water would have such a solidifying effect upon the soil, closing its pores and converting it into an almost impenetrable mass, that it would become necessary, after some years, to break it up to a considerable depth by cultivation. Of this it is too early to pronounce, but it certainly appears that sub-irrigation is the hope of most intelligent irrigators, because it promises a great economy of water, and the most direct application of it to the thirsty tree that it is possible to devise. The average cost of making and laying pipes for sub-irrigation is given by an authority at £[illegible] per acre, a sum which the owners of land under intense culture could afford to pay.

Open ditches are wasteful.—The present practice is the most wasteful that could be devised. There is waste along all the miles of open canals, both main and secondary, with a consequent loss to the owers of from 25 per cent. to 50 per cent. of the stream they take in. Sometimes it is even greater, a canal in the San Joaquin Valley, which took in 90 cubic feet per second at its head, only delivering 14 cubic feet per second on the farms 28 miles away. Where the canal owner's loss ends, that of the farmer begins. He loses all along his laterals tapping the secondary canal; all along his sub-laterals intersecting his farm, and again, all that is not absorbed by the crop over which he pours his periodic flood; besides which has to be added the loss from evaporation. As a matter of fact, therefore, he only receives the benefit of a very small proportion of what he pays for. Some put the loss of farmer and canal proprietor together as high as nine-tenths of the water diverted; others at three-fourths, and it is rarely calculated at less than the latter figure. There is certainly ample room for saving at every turn. In Utah, as in Italy, another economy is effected by requiring those entitled to water to take it at night as well as by day, so that instead of the supply running to waste for eight to ten hours out of the twenty-four, the whole capacity of the ditch is utilized every minute during the irrigating season. This custom has the further advantage that the water is thought to act more favorably upon the soil by night than if it were under the burning rays of the sun. The manual labor or skill required for controlling water is not great, and it calls for patience and attention rather than activity. To see the irrigator, spade in hand, engaged in a leisurely way, directing the stream gushing from his ditch, it would scarcely be suspected that upon so unimpressive a proceeding the whole future of the orchard in which he is engaged entirely depended. There seems an incompatibility between causes and effects which asserts itself in many ways, so that it becomes an effort to realize that the rude ditches which wind their rugged banks across trim fields or among regular rows of vines or orange-trees, are actually the generous source from which all the profusion of foliage and fruit is being invisibly fed.

FERTILIZATION BY IRRIGATION.

Part of this incompatibility no doubt arises from the fact that there is something more than water conveyed in canals, and that this something more is extremely valuable, though usually left out of the calculation. Water of itself can work wonders, but when allied with sediment, which in nine cases out of ten appears to consist either of decayed vegetable matter or to contain elements that replenish the soils by which it is absorbed, the results become multiplied. In France the practice of pouring large bodies of water heavily charged with sediment upon inferior lands for the purpose of reclaiming and enriching them is extensively adopted. This is not systematically attempted to the same extent in America, though the sandy sage-brush lands of Utah and Nevada have been turned into rich meadows in the same way; but it is generally recognized that where irrigation is so controlled as to admit of just as much water being placed upon the land as it can drink at a draught, without allowing it either to stand or run away, then the consequence is invariably a maintained or an increased production. Not only is the crop secured, but whether it be grain, root crop, or fruit, the yield is often largely enhanced so as to reach, in arid regions or upon poor soils, a yield equal to that obtained upon fertile lands enjoying a plentiful rain-fall. Farmers' estimates of what this gain actually is differ considerably, ranging from 30 to 100 per cent. That there is a gain, and a great gain in many instances, no one thinks of disputing, though there may be some looseness in the figures quoted concerning it. There seem to be no products of which the crop may not be increased by irrigation, and there are none that will not suffer from over-irrigation. The richest silty water, instead of having a fertilizing influence, will be fatal if allowed either to stagnate or to rush too rapidly through a field. But with this danger provided against, irrigation may mean fertilization to such an extent as to render any further artificial enrichment of the soil unnecessary. In most parts of the West this has been the only fertilization which has maintained land under years of cropping.

IRRIGATION DRAINAGE.

As a matter of fact there are no drainage works worthy of the name in America, the farmer having quietly left the water to settle this problem for itself. Water is always valuable in these regions, and what one farmer allows to flow by another is only too eager to acquire. Canal proprietors have not found any necessity to spend money in making provision for the surplus water which passes their area of supply, as it is generally extremely easy to let it find its way into the natural water-courses which run at lower levels than the artificial stream. How to get water is the one question of importance; how to get rid of it has been found in nineteen cases out of twenty only too easy. With a deep subsoil or a good fall it seems as if drainage may always be unnecessary, and these are conditions very frequently met with. There are, however, lands comparatively level in which, sooner or later, it will be required; and there are one or two localities in which the need of drainage-works is rapidly becoming an imperative necessity. Among these by far the most striking illustration is furnished at Fresno, Cal., a district in which the same facts are also extremely valuable as indicating the change in character of an arid plain submitted to years of extravagant irrigation. Fifteen years ago its sandy soil, sparsely covered by struggling herbage, grassless and treeless for scores of square miles, maintained only a few herds of cattle. There was no sign of cultivation within its borders; water could only be obtained by sinking from 40 feet to 80 feet, and the rain-fall was both irregular and insufficient. The King River, which was its one available stream, sometimes carried no more than 500 cubic feet per second, and when the first "colony" was established it was stoutly maintained that the whole of its waters would not suffice to supply this little plot marked out in the midst of the wild.

For some time—indeed, even after the canal to supply this colony had been constructed—so rapidly did the open ditch absorb the intake that it was thought that the water would never reach the settlement at all. Week by week the tiny thread of fluid trickled and wound its way along; at last, it entered the fields prepared for it, and, the flow steadily strengthening, crept farther and farther on, feeding an ever-widening district, until to-day there are fifteen canals drawing their waters from this river, irrigating 55,000 acres of land, which form a chain of settlement all around the central Californian colony, and extending 16 miles beyond it. Water can now be struck anywhere across the whole plain at 10 feet, and often at 6 feet. The seepage from the canals has been great indeed, for it seems to have filled the whole subsoil, which has sucked it up like a sponge until it can hold no more. One important consequence is, that irrigation by flooding or furrows is being abandoned at Fresno, as the irrigation by seepage maintains a constant supply within easy reach of the roots of vines and trees.

The once arid region has become thoroughly moistened. Where till lately the contention for water was keen and ceaseless, one hears now of suits against canals on account of their supersaturation of adjoining vineyards. Nor is this to be wondered at, seeing that in the midst of the once parched plain there are now patches of artificial morass created, as in the Poudre Valley, Colorado, by over-irrigation, and continued for want of drainage. For in Fresno, and Fresno alone, has drainage become a vital question. The largest vineyard in the district, that of Mr. Barton, has not been watered for two years, and the enterprising proprietor has actually excavated ditches around his property so as to drain it, to a depth of 6 feet. The Eisen vineyard close by, one of the oldest and best known in the district, is now involved in a suit which its proprietor is bringing in self-defense against the canal proprietors for flooding his land. It is not only excess in flooding that has to be avoided, but excess of seepage, which is just as bad. Not only is the creation of a morass on the surface fatal, but the morass condition below is proportionately injurious. Roots, of course, will not penetrate below the perpetual water line, and thus, if the water rises in the soil the depth from which they draw their nourishment is liable to be greatly diminished.

It has been suggested that if the pipe method of subirrigation were adopted the same pipes might be made available for drainage. If this could be accomplished without materially increasing the cost it should contain a solution of the difficulty in a few cases, but, as a rule, where drainage is needed subirrigation in any season would be superfluous if not injurious. A remarkable evidence of the rate of seepage in sandy soils is notable in the Fresno district, and that is two little ditches, a foot or so apart, each of them carrying a swift stream of water, which is soaking though the bank of a small canal, and which they divert from the field beyond. A few ditches of this description compose the whole of the drainage work yet done in western America. Even here the drainage problem does not appear to threaten the requirement of works any more expensive than those already in use, and, except in localities as peculiarly situated as Fresno, it is improbable that any outlay to provide them will be needed, at all events for many years to come.

CAPILLARY ATTRACTION OF WATER.

For a complete comprehension of these facts, however, it is necessary to read them by the light of a knowledge of a peculiar property possessed by many soils, and which forms a most important factor in all calculations as to the limits of irrigation. It has been found by experiment in California that water rises rapidly in coarse, sandy soils, but only to a moderate height; while in finer soils, whether clayey or of a silty formation, the rise is slower but higher. So that in a few weeks or months, as the case may be, the water attains twice or thrice the height that it climbs to in the former. This has been said to be accomplished by means of a "capillary attraction," in which heat may, perhaps, be an important agent, seeing that the phenomenon is not observed in Colorado to anything like the same extent as in the California slope, and presents the result of experiments made upon different soils to test their capacity in this direction. A consideration of these results points to the superior value in suitable soils of subirrigation, or irrigation by seepage from below, over all methods of surface application, because it is thus possible to avoid caking the soil and loss by evaporation.

EXTENSION OF THE IRRIGATING AREA.

Taking together the facts as to seepage of water from rivers or ditches, and those relating to the rising of water by means of what is callecd capillary attraction, one is furnished with the key to the gradual diminution of the water necessary for irrigation of the same land, which has been noted in almost every part of the West. In Colorado alone, in situations like that of Greeley, upon a deep porous soil, with a rapid fall and quick drainage, as much water is said to be used to-day as in the initiation of the practice of artificial watering twelve years ago. Everywhere else the verdict of experience is that the water goes farther every year.

The ranch-owner, who doubted if his spring or brook would suffice for 20 acres, extends the area of his cultivation bit by bit until it reaches 80 or 100 acres, and he still has some to spare.

Bishop Musser, of Salt Lake, who has made an especial study of irrigation in Utah and abroad, states that when the city was first founded there was only water enough from a particular source for 800 or 900 acres, while now the same amount supplies more than 5,000 acres. In another Mormon settlement, named Bountiful, where at first it was supposed that only a few families could be placed on account of the smallness of the stream of water available for irrigation, there are now between 4,000 and 5,000 people, all maintained by means of the same supply. The whole of Utah has been peopled and all its cultivation based upon little driblets of water in this way. Yet the sandy aridity, which is absolutely worthless without water, may be soon over-wet, and it is found that where a piece of ground is fed by good seepage to irrigate it as well kills the crop. Here, as at Fresno, Riverside, Mussel Slough, and in Tulare County, Cal., maybe seen farms and vineyards up to 160 acres in size irrigated solely by seepage from ditches which run along the upper edges of their fields.

The distance that water will penetrate, even without any discoverable dip in the land, has been partially indicated by experiments in subirrigation, when the pipes and orifices, though 50 feet apart, have saturated the whole soil between them. With a fall in the country the seepage extends for far greater distances, and, curiously enough, an instance is reported in the San Joaquin Valley where, upon the construction of a canal, a well a mile or two on the upper side increased several feet in depth after the canal had been some time running.

Another most instructive fact is that as the water supplied diminishes the crops tend to increase. They now raise more grain in Utah with half the water than they did when they concentrated double the supply upon a smaller area. For the first year or so of irrigation the soil becomes soppy, but afterwards, while seeming drier, it is not nearly so thirsty; when it is very shallow flooding ceases and seepage alone is relied upon. Irrigation is said to close the pores of the soil with an infiltration of rich, impalpable silt, so that it absorbs more slowly and retains what is absorbed much longer.

Under good cultivation the soil thus enriched becomes far more fruitful than it originally was; but too much water makes the land cold, and eventually turns it into a quagmire. When soakage, as from flooding, is accompanied by soakage upwards by "capillary attraction," the consequence in California is the formation of what is termed "hard-pan," an impenetrable layer which resists the entrance of roots and yields them no nourishment. Where this is feared flooding is suspended and the subterranean supply depended upon. Such is the rapidity with which roots push for water, even where moisture can be found, 15 or 20 feet from the surface, no flooding is needed after the first year or two. The roots of vines have been known to penetrate nearly 30 feet in a little over three years, while even lucerne roots travel 15 or 20 feet downwards to moisture. But the catalogue of facts, proving in a variety of ways the injurious effects of over-irrigation, and the marvelous results to be accomplished in time by small streams of water, might be multiplied indefinitely.

THE DUTY OF WATER AND ITS CONDITIONS.

A preliminary doubt as to water measurements has to be taken into account, for until recently different standards have been in use; and still there is, even in flourishing districts, the greatest laxity in applying what standards they have. In Los Angeles, for instance, the zanjero, or water-master, has relied solely upon his eye to judge of the stream a farmer was entitled to receive; and though practice no doubt had enabled him to allot something like an equal share to each person concerned, it is plain that any attempt to define the quantity in recognized measures could only be an uncertain approximation. In every State the use of water for mining purposes has preceded or, in the first instance, overshadowed that for irrigation; and, consequently, what estimates have been made in the past have been expressed in "miners' inches." This was supposed to define the quantity of water flowing through an aperture an inch square, but, as in some parts the pressure adopted was that of a 4-inch head, while in other places the head was 6 inches, there was evidently abundant room for variation, even in the determination of the capacity of a single inch. When, again, a number of inches came to be measured at once it became possible either to adopt an aperture 1 inch high and the specified number of inches in length, or to take the square of the whole number of inches as giving the dimensions of the orifice, in which case, again, there was another great cause of variation. The State engineer of Colorado has calculated that the miner's inch in that State has been .026 cubic feet, or, roughly speaking, a fortieth of a cubic foot; and this is now generally adopted as its equivalent, though, as a matter of fact, in more southerly States, where water has been scarce, the miner's inch has only meant one-fiftieth of a cubic foot.

Taking into account this initial cause of confusion in the measurement of water, we next find that the quantity of land which any given unit of water will irrigate is governed, first, by the kind of soil, subsoil, the rain-fall, temperature, and evaporation of the particular area irrigated, next by the kind of crop grown, and the method of watering it, as well as by the length of time which that land or neighboring land has been irrigated, and lastly by its position with regard to seepage, and its capacity of capillary attraction. It is plainly no easy matter, even when all the terms of the special instance are known, to fix the duty of water under these circumstances. But in almost every instance the records of American experience are wanting in respect to one or more particulars, and hence, again, there is only room for the vaguest conclusions.

Instances can be quoted in which a flow of 1 cubic foot per second has supplied 9,000 acres, while in others it only supplies 50 acres. It is vain to attempt to arrive at accuracy in the face of such extremes as these. The manner in which water is sold in the States puts another barrier in the way. A water right there does not mean a right to any given quantity of water, but a right to have a stream of a certain capacity turned into the purchaser's lateral for as often and as long as he pleases. Each farmer accordingly draws upon the supply just according to his fancy in each season. As yet, as there is water in plenty, the Colorado companies do not restrict their customers to the stream they have purchased, but give them whatever flow they happen to have. The farmer, for his part, does not measure the quantity he receives nor yet the quantity which flows away from him, so that on neither side is there any opportunity of obtaining exactitude as to the quantity actually absorbed by the land. Where measurements have taken place, as in southern California, it has usually been at the farmer's receiving point, from which there is more or less loss, according to the nature of his soil, the make of his ditch, and the distance to be traveled before the field is reached, which renders these almost equally unreliable.

In the face of this array of disturbing causes it is utterly impossible to do more than notice a number of rough generalizations, which have some force in special localities. The more sandy the soil the more readily it receives and parts with water, while, as the soil becomes heavier, it absorbs less, and retains it longer; the deeper the soil, the more water is required in the first instance, while with a retentive subsoil succeeding waterings can be greatly diminished. The heavier the rain-fall the greater the duty of water in equal temperatures, and when evaporation comes into play the duty has to be correspondingly reduced. Where the land is in a position to receive seepage from higher irrigations, or is so porous as to draw a sufficient supply from its own laterals, or is so saturated as to need for a time no water even in its canals, which are, perhaps, as at Fresno, turned into drainage-ditches, the duty, of course, tends to become nominally enormous. Then, again, small grains as a rule take twice as much water as corn or potatoes, and many times as much per acre as orchards, which are watered on an economical method. Even the waterings given to one grain, such as wheat, vary according to locality from one to four, oats requiring more and barley a little less. In Riverside the orchards are often only watered once from furrows in winter, and once, twice, or thrice, according to the idea of the owner, in summer. Where flooding takes thousands of gallons the furrow system only requires hundreds, and subirrigation tens of gallons for a similar area, though, of course, under different crops.

COMPARISONS AND CONFLICTS.

Setting aside the question of the actual quantity of water used or needed for navigation, we find that, even comparing the flow of water allotted to farmers for as long as they like, there are the widest differences. Taking the flow of one cubic foot to the second (available during the season for cereals of Colorado, and all the year round for the orchards of California), without making allowance for differing rain-falls, this supplies in Colorado 53 acres; Italy, 70.2 acres (Col. Baird Smith); Utah, San Bernardino, Cal., and France, 80 to 100 acres; San Gabriel, Cal., 120 acres; Fresno, Cal., 160 acres; India, 150 to 200 acres (sira cotton); Los Angeles and Anaheim, Cal., rather over 200 acres; Riverside, Cal., nearly 300 acres; Ontario, Redlands, Cal., Algeria, and parts of India, 400 acres; Sierra Madre, Cal., 580 acres; Spain, as high as 1,000 acres; Pasadena, Cal., 1,665 acres; and by subirrigation, according to one or two experiments, from 1,500 to 9,000 acres.

In Kansas, Arizona, and Mexico the figures given are too conflicting to be quotable. There are the same contrasts as to the depth of water which should be put upon land. In Colorado two or three waterings are given of from 3 to 5 inches in depth; in some parts of southern California waterings of 12 inches in depth have been given, and in other parts a total sufficient in the year to make a depth of several feet. On the other hand, there are farmers in these districts who, according to their own testimony, employ less than half the quantity used by their neighbors, and with equal if not superior results.

If the Colorado farmer were to use all the water at his disposal, he would cover his fields nearly 4 feet deep. The practice appears to be, on the average, to use about one-fourth of this, but there is such a difference in soils that this is but a poor guide. Where a coarse sandy soil, with porous subsoil, can take 10 feet in the season, a fine compact alluvial, with clay subsoil, would be injured with 1 foot; hence, 10 acres of the latter can be irrigated to one of the former by the same quantity of water. A natural measure of the duty of water in many places may be supplied by the rain-fall of good harvest years, making allowance for the time of fall. In central California 13 inches during a frostless winter and spring have proved sufficient, and probably if 12 inches could be secured from rain-fall and ditch together during the spring it would prove more than ample for flooding cereals.

THE COST OF WATER—THE PRICES PAID.

The prices paid for water are so complicated by the conditions under which it is sold that it is almost impossible to do more than quote the rates in different localities. The water itself costs the appropriators nothing beyond the expense of putting it upon the land, which differs, of course, in every State and every district. This first outlay for works furnishes one clue of an uncertain character to the price of water. Where farmers unite for the purpose of securing a joint supply, they work or pay their share of the construction, and afterwards their proportion of the sum necessary to keep the works in repair, so that it is difficult in many instances to determine exactly what their water costs them. In Colorado it is considered that an irrigable area should be supplied with an outlay upon main works of £1 or 25*s*. per acre, an estimate which appears to agree, on the whole, with experience elsewhere.

Occasionally, as in Kansas, where very large canals run through very favorably situated country, main works of a temporary character can be built for as low as 10*s*. per acre, while on the other hand, where special difficulties intervene, as at Salt Lake, in the price to be paid for easements over private lands one finds the canal costing 50*s*. per acre to build. This is by no means the maximum of first expenditure.

With extra works, such as fluming or tunneling, as in Colorado, or wooden channeling, as in the city ditch at Salt Lake, Utah, or expensive piping, as at Pasadena, or the Highlands Canal in Los Angeles County, Cal., the cost may rise, as in the last two instances, to £8 and £10 12*s*. per acre. Here, of course, the supply is for small areas under intense culture. The greater the scale of the undertaking the less the cost per acre.

The 150,000 acres at Bakerfield, Cal., can be watered by one proprietary for 10*s*. 8*d*. per acre, whereas, if divided into a number of different schemes, adapted here and there to the condition of ownership rather than to the natural surface of the land, it would probably have cost twice as much. Or, take the 76 canal beyond Fresno, Cal., which now supplies only 20,000 acres, at a first cost of about 25*s*. per acre; with an extension of its secondary canals, so as to allow it to supply the 40,000 acres lying under them, the outlay per acre would be reduced to 20*s*.; while if the complete plan, which is for the irrigation of 180,000 acres, were carried out, this would be still further brought down to 15*s*. per acre. Water, therefore, is dearest where the schemes are smallest; that is, where the works are relatively most costly.

The same fact is again illustrated by the price asked for water-rights, which are almost invariably highest in small schemes. Thus, in such "colonies" as Ontario, Etiwanda, or Pomona, Cal., where land is sold in 10-acre blocks, a water-right costs from £15 to £20 per acre, while upon 80 acre blocks it can be purchased in Colorado for £3, in Utah for about 50*s*. and in Kansas for half that sum. Having a water-right, the farmer is then liable only to a yearly assessment for maintenance. This, on the other hand, is highest as a rule where the water-right is cheapest, ranging from 8*s*. per acre in Kansas, and 4*s*. an acre in Utah, to 2*s*. 6*d*. in Fresno, and 2*s*. in several colonies in Los Angeles County.

In Colorado the maximum rate of 6*s*. per acre per annum is rarely charged, the water-right owners only paying the 6*d*. or 9*d*. per acre, which is actually spent on repairs, and the same custom prevails in some parts of Utah; but in both of these instances the schemes are large.

The prices of water-rights vary from a variety of causes, such as whether the water-owner has land of his own to sell or not, so that particular instances offer but little guide to an exact estimate of their value; nor do they furnish any clew to the quantity of water actually sold.

In Kansas water is paid for according to the acreage of the purchaser, who takes as much as he likes in return for his yearly rental. This most wasteful of practices was tried and abandoned in southern California, as it will be abandoned in Kansas when water becomes more valuable. Meanwhile its steady increase in price is everywhere noticeable. Thus, at the foundation of Greeley, Colo., 80 acres with water could be purchased for £60; a few years later the water alone became worth £100; to-day the same watering right is bring £200, and with the land is worth £600. In all the "colonies" of California there has been as great a rise in the price of water, though there it is to be found in almost every instance linked to the land. This puts another difficulty in the way of estimating the exact price of water, for though the water is really that for which the money is paid some deduction has to be made for the area upon which it is to be utilized.

Land which in the arid state brings only £1 per acre, is sold at £10 or £15 per acre when under a ditch, and something like this proportion is maintained even for higher priced dry lands, which rise from £5 to £40, and from £15 to £100, when artificially watered.

When the land and the water-right are sold apart the canal-owner makes two profits, one in the tripling or quadrupling of the price paid for the land, which is his chief profit, and the other upon the water-right, the price of which represents his outlay upon works, with liberal interest added. The first profit, made nominally upon the land, which is often greater than here stated, is, of course, really another profit upon the water, and as the cost per acre of the works is, as a rule, less than the cost per acre of the land, the gain upon the investment in water is much larger than appears. Where there is no sale of land, that is, where the water has been brought to land already sold, or for sale by persons other than the canal-owners, the price of the water is much higher, reaching sometimes as much as 20*s*. or 25*s*. per acre per annum. At Los Angeles, Cal., water is sold by what is called a "head," which under their loose measurement varies from 2 cubic feet to 4 cubic feet per second, at 8*s*. per day or 6*s*. per night in summer within the city, twice that price outside of its boundaries, and half the price in winter.

At Orange and its neighboring settlements the price for a flow of about 2 cubic feet per second is 10*s*. for twenty-four hours, or 6*s*. per day and 4*s*. per night, and in winter 6*s*. for the twenty-four hours. At Riverside the cost is about 7*s*. 6*d*. per day, or 5*s*. per night, for a cubic foot per second, or 12*s*. for the twenty-four hours. These prices, varying indefinitely as the conditions of sale vary, furnish but an insecure basis for any generalization.

Possibly a better idea of the importance of water than can be derived from any list of purchases and rentals in particular places may be obtained by a glance at its capital value. It has been calculated that the flow of a cubic foot per second for the irrigating season of all future years is worth from £15 to £25 per acre in grain or grazing country to £30 in fruit lands. This is the price paid to apply such a stream to a special piece of land for as long as the farmer may think necessary, the knowledge that an excess of water will ruin his crops being the only limit. But if a flow of a cubic foot per second were brought in perpetuity without any limit as to the acreage to which it might be applied, or the time or circumstances of applying it, the capital value of such a stream in southern California to-day would be at least £8,000.

PRODUCTS AND THE WATER PRICE.

What price can be paid for water, or land and water together, depends upon the products raised and the price of those products at the homestead, by taking which as a guide consideration of complicated questions as to markets and freights may be avoided. So far as American experience goes there appears to be no limit to the scope of irrigation, which embraces the fruits and cereals of the temperate zone, as well as the products that are raised only under a tropical sun. Apples, blackberries, and barley are irrigated in Colorado or northern California, as are the rice, cotton, and sugar in the hot lowlands of Mexico. Over a large area of the West it may almost be said that as nothing can be grown without irrigation anything can be grown by irrigation.

Wherever water has been plentiful and the ground fairly level it has paid to grow irrigated grain. There are thousands of acres in Colorado and Utah which have never grown any other crop, and are still growing it. The irrigated area under grain in Mexico is very large and the yield heavy, while it is a moderate estimate that in the States 5,000,000 bushels of wheat are raised by its means.

It is generally calculated that grain can be grown at a profit under irrigation for 2*s*. 6*d*. per bushel, and even where, as in Arizona, the crop has to be teamed 12 or 14 miles across the desert at a cost of 7*d*. per bushel to railways, upon which the rating is all against the local grower, grain is found to pay. Of course the chief prosperity in the wheat districts was when 4*s*. and 5*s*. a bushel were regularly realized and a profit of at least 50*s*. per acre was counted upon. All this has changed since the fall in prices, which has brought profits down to 20*s*. per acre, with a yield of 25 bushels. Grain pays still, but very poorly, and even in better times it is generally considered the poorest paying crop that can be raised. Still it does pay for irrigation, and this is an important fact to the farmer who can not afford to wait for the higher returns from intense culture. Nor does grain-growing noticeably impoverish the land where proper precautions are taken against the washing out of the fertilizing matter in the soil and for the utilization of any sediment there may be in the irrigating water.

In Utah a rotation of crops is adopted; but in Colorado are to be found instances where grain has been grown every season for ten or fifteen years without perceptibly injuring the land. In Arizona and Mexico the native population have raised their wheat and Indian corn from the same plots for scores, if not for hundreds, of years, and to them the idea of manuring is quite unknown. Here and there a farmer may be found who takes the pains to use the droppings of his stock upon his fields, but this is the exception. As a practice systematic fertilization is unthought of, and so far no serious injury appears to have resulted from its neglect where any falling off in yield has been followed by change of crop. This is of interest as showing at all events that the need of expensive restoration of the soil is not likely to assert itself in our richer lands until after some or perhaps many years of irrigation. Neither does the grain itself suffer if the seed be carefully selected. In southern California irrigated wheat has a slightly thicker skin, makes more bran, and to the practiced eye is slightly darker in hue than that from the wet northern region, but it is said even there to be fully equal in quality to unirrigated wheat, a testimony which was repeated by millers in Mexico, Arizona, and Colorado. It is not from any such fallacious anticipations that grain-growing by irrigation is condemned in the States. Though all kinds of grain can be grown well and at a profit, the growing is considered a mistake, because the profit is too small. Land and water that will grow grain will yield crops which are much more remunerative. Grain may be taken in rotation with potatoes, which flourish under irrigation in a sandy loam, or with peas or lucern, which act as restoratives to the soil.

All kinds of root crops and all kinds of vegetables can be grown, and are grown, usually at a somewhat higher profit than grain. These again have as a rule a smaller profit than can be obtained from stock, which, in its turn, yields to the profits derivable from grapes and fruit.

STOCK-RAISING ON IRRIGATED LAND.

It is a more remunerative occupation to grow beef and mutton or bacon, for which there is just as steady a demand. Two-thirds of the 50,000 acres irrigated at Phœnix is under grain, but this little valley also raises its 100,000 hogs. Dairy produce is successfully raised in northern California by means of irrigation, where, indeed, it is applied to little else on account of the regular and sufficient rain-fall which can there be counted upon. Even in Australia many towns owe a considerable proportion of their vegetable supply to the Chinese irrigator. It would be a mistake to ignore these minor ways in which irrigation can be very profitably employed, especially in the neighborhood of centers of population, but it would be an equally great mistake to suppose that irrigation is only practiced on this scale. A prevailing misconception as to irrigation is that it is employed only for small areas under high culture. The fact that great stock-growers in California, such as Messrs. Haggin & Carr, or Messrs. Miller & Lux, irrigate thousands of acres for stock purposes appears to be lost sight of. Much Mexican irrigation is carried on upon the same plan. Where the great land-owners have their immense estates one can see not hundreds but thousands of acres artificially watered; and where smaller proprietors enjoy a share of the coveted irrigable area they cultivate so closely to each other's borders that the fenceless area as far as the eye can reach appears one gigantic irrigated field. The great valleys of the Ortiz, the Concho, the Florido, and the Nazas, the wide sloping plains of the Laguna country in the neighborhood of Lerdo, and in the province of Leon, exhibit the patient industry of the peasants and a marvelous fertility secured by means of an artificial water supply of the rudest character. On the great cattle and sheep ranches of New Mexico the proprietors, some of them Australians, are enlisting the same invaluable ally in order to protect themselves against the occasional ravages made in their flocks and herds by bad seasons. It pays as a rule to irrigate natural grasses, for by this means the carrying capacity of land is increased 33 per cent. The Chowchilla Canal, in Fresno County, Cal., 30 miles long, 30 feet wide at its mouth, and 2½ feet deep, is used almost solely for this purpose, and there are 20,000 acres of natural-grass land irrigated in one property in Kern County.

THE VALUE OF ALFALFA.

But the mainstay of the American stock farmer, large and small, is lucern, there styled alfalfa, which, though unsuccessful in England, is highly prized in France. In every Western State this is grown to profusion. There are 35,000 acres of it grown by irrigation at Bakersfield. In Yolo County, Cal., almost the whole of the 13,000 acres watered from the Woodland Canal is under lucern; it is to be found upon almost every colony plot in southern California, and is the surest source of revenue in Utah and New Mexico. The area planted with this crop is increasing with marvelous rapidity. It is said to carry 10 sheep or even 20 sheep to the acre if it be cut for them. It is not a new growth in Victoria, but without irrigation its marvelous qualities have only partially developed themselves. At Dookie, with only the natural rain-fall, it can be cut but once a year, yielding about three-quarters of a ton to the acre; while at Bacchus Marsh, with irrigation or water within reach of its roots, it can be cut five or six times, yielding 7 or 8 tons, and lasts fifteen to twenty years.

There are some 300 acres of it in this locality, thriving upon a natural seepage, and though rather delicate in its earlier stages, owing to the lack of irrigation, when once firmly rooted it raises the value of the land to from £50 to £75 per acre. It is sown broadcast and freely, and with a little wheat, oats, or barley mixed in it; is rarely manured, though better for an occasional scarifying and top dressing; is never fed down, but cut early and often, and found to possess splendid fatteniмg qualities. Under irrigation lucern seems to flourish everywhere, particularly in sandy loam and in a warm climate free from frost, and though the yields given vary they are all great. Three cuttings are sometimes obtained in the first year, making a total crop of 4 tons to the acre but the general thing is, as in Utah, to obtain only one crop in this period. After this 6 tons are expected in the second year, and 8 to 12 tons in the third year. There are poor soils where it is cut only twice or three times, and other soils on which its quality does not keep pace with the quantity, but on those that most resemble our own plains the cutting is rarely less than four times, and the yield generally over 10 tons per acre in the course of the year.

FRUIT-RAISING BY IRRIGATION.

But the products for which irrigation is most necessary, and in which it yields the largest, are grapes and fruit. The great land-owner in America not only plants his thousands of acres of lucern and perhaps his ten thousand acres of grain, but, with incessant enterprise, plants his hundreds of acres of vines and fruit-trees. When irrigation is employed, however, the production is almost wholly in the hands of small proprietors, men often of some education and some capital, who have found an attractive field for the exercise of their intelligence in bringing small allotments into a condition of the highest productiveness. Judging by the results obtained in southern California, to which this class of cultivation is as yet chiefly confined, it has not proved an unprofitable speculation. It is safe to predict that in a short time grain-growing will be given up on all small areas of irrigation and that a commencement will have been made upon the larger tracts to follow the same example. It pays better to grow fresh vegetables for towns or can them for export, or to establish chicken farms or bee ranches than to raise grain for export. Already in northern California the great farms, so famous a few years ago for their yields and extent, are being cut up into vineyards and orchards, and where along the old mining ditches any vintage ground can be secured it is being put to the same uses.

Twenty acres under vines or fruit-trees are preferred to 160 acres under grain. There is more regular employment and more regular leisure, with less stress at a particular season for adult male labor. An acre in raisins was reckoned as valuable as 5 acres of wheat, when the price of wheat was nearly twice what it is now.

The fruits grown are oranges, lemons, limes, apricots, pears, figs, peaches, pomegranates, nectarines, apples, plums, quinces, cherries, olives, almonds, walnuts, and chestnuts. From some of these two crops a year are obtained, but of course none of them bear for some time after planting. This is not all lost time to the American farmer, who grows great crops of vegetables between his fruit trees until they are ready for bearing. The period during which no return is expected, even under irrigation, is considerable; as, for instance, it is for peaches, apricots, almonds, and vines, four years; for oranges, ten years from the seed, five years from the bud; olives, from seven to ten years, unless the Spanish practice of planting branches is followed, in which case it takes only two years; and walnuts seven years. When the profits do come, however, they are proportionately large.

Nearly 50 per cent. of the fruit grown in California is canned, but only 5 per cent. is dried. The production is increasing enormously every year. Vineyards are utilized not only for the supply of grapes but of raisins and wine; and there is no branch of production into which capitalists and small farmers are now entering upon a greater scale or with more confidence than wine-growing. The clearest heads in California consider the overproduction of wines or raisins an impossibility, and experience is teaching them that at existing prices the investment is remunerative, although wine-making is developed in the face of a prejudice quite as unreasoning as that which has till lately faced colonial vintages. For other fruits, though drying is occasionally adopted, the chief reliance is upon the canning process practiced in every fruit-growing center. The taste for fruit, whether fresh, dried, or canned, is one that appears to grow by what it feeds on, for the demand in America seems to increase almost as fast as production. The markets of the East are, of course, open to the irrigating West, but rates of transports are relatively high, and cempetion from the West Indies and the Mediterranean is keen, so that it can scarcely be said to be a home market in the ordinary sense of the term.

The injurious effects of overirrigation are just as potent in fruit-growing as in every other crop. It is claimed on the authority of a commission of experts, appointed by the French Government to inquire into the remedies for phylloxera, that regular furrow irrigation in summer keeps the disease in check, but it has been proven in Fresno that an excess of water injures both the wine and raisin qualities of the grape. There is a special disease to which orange trees are subject which strips the tree of its leaves, prevents the fruit from coming to maturity, and finally kills the tree, which a special committee of the Southern California Horticultural Society, after an exhaustive inquiry, has declared to be wholly due to overirrigation and deficient cultivation. The citrus family can endure more water than any other class of fruit-tree, but it is clear that the limit of the water consumption of any of them is soon reached, and that to go beyond it is injurious if not fatal.

PROSPECTS OF IRRIGATION IN AMERICA.

We have now taken a rapid glance at the products of 2,500,000 acres of Western America, watered by 12,000 miles of main canals and 120,000 miles of subsidiary ditches, at an expense of many hundreds of millions of dollars. The estimates of the value of the yield from irrigated vineyards and orchards are not official, but those engaged in supplying the markets put the production of California vineyards this year at £1,000,000 and of the orangeries and orchards of the same State at half as much again.

A good deal of fruit is grown for home consumption in neighboring irrigating States, but prohibitive railway rates have prevented the full expansion of this and other classes of production. Utah and Colorado, entirely dependent upon irrigation, draw their revenue from other classes of products—the latter, in 1883, raising in value £1,100,000 of grain and root crops, the former £700,000. To assess the total value of the products raised by means of irrigation, many of which could not be raised without it, would be no easy undertaking; but it is quite clear from the statistics that it must be expressed in millions sterling. Adding the enhanced stock-bearing capacity of the country, and the value of industries not directly productive, which are dependent upon the irrigating settlements, would make up a grand total that would probably surprise the Americans themselves. There is no reason to suppose that the list of products capable of being profitably grown under irrigation is yet exhausted. Experiments are continually being made with fresh crops, and the result is generally favorable where climate and soil conditions are studied. Great as the produce of the artificially-watered West now is, the prospects are that it will become very much greater; and the opinion of those qualified to form a judgment is that irrigation, marked as have been its successes, is yet in its infancy, and has given no more than a promise of what it is destined to achieve.

HEALTHFULNESS OF IRRIGATED LANDS.

There are irrigated lands in which health seems entirely unaffected; there are others where the influence of malaria is but too patent, and the task is to discriminate between them. The river bottoms, as they are termed, flats, but little raised above the level of streams, are, throughout the southern parts of the United States, recognized as malarious whether irrigation is practiced or not. Fever, ague, and chills are prevalent in such localities in Missouri, in Louisiana, as in the southwestern area. From their position these lands are easily irrigable, and hence settlers are tempted upon them and become subject to the same complaints. Whether irrigation, as is probable, increases the danger in such spots is not known, but in places similarly situated, though not malarious previous to irrigation, it seems that the practice has acted injuriously. Where the soil is saturated and artificial morasses are formed, as at Fresno, fever is naturally found in the immediate neighborhood. Along the lower lines of this district the miasma rises to a height of 10 feet, and here, as in the counties further south, the sleeping-rooms are always placed in a second story in consequence. Much of this region was malarious before irrigation was practiced, and in parts the formation of channels is said to have actually reduced the danger. This, however, in such circumstances, can only be entirely removed by complete drainage. Much importance is attached to the source of the water drank, and wells are sunk to great depths so as to avoid all seepage and secure a pure supply.

On the bench or mesa lands of California or Kansas, in those of Colorado, with their rapid natural drainage, or in the porous lands of Arizona and New Mexico, malaria is as yet unknown; nor does there seem much prospect of its appearing. It is feared only in lands naturally swampy, or readily made so. It is not regarded as a fatal complaint, though the repeated attacks to which its victims are subject necessarily have a permanently weakening and depressing effect. There are many who seem to escape even in these localities, but there are others whose sallow and sickly looks only too plainly indicate the presence of malaria.

UNITY OF LAND AND WATER.

Another matter arising out of American experiences which it is desirable to notice is the relation between the ownership of land and that of water. Where a farmer has his own canal to his own land no question arises. Where a number of farmers excavate a ditch and parcel the water out between them, the only question is as to whether the water used by each can be applied where he pleases, or whether it must be applied to particular acres specified in the contract. If he can sell his water to another or turn it upon new land, the business of the company becomes more complicated and the value of the lands first irrigated is not so well maintained. If, however, as is often the case, the farmers have been unable to make the ditch without assistance and have called in a capitalist to join them, he frequently arranges to take up a certain amount of unoccupied land which can be served by the canal and from the sale of which he looks to derive a considerable share of his profit. To prevent competition, therefore, he generally stipulates that the water rights which the farmers receive in return for their investment of labor or capital shall attach to their particular acreage and can not be transferred to any other land. By this means he secures for himself the market for all irrigated land outside of these acreages. When he sells what land can be irrigated by his share of the water his interest in the canal determines, and the works become the property of those who own the various ear-marked acreages which it is confined to supplying, unless by common sensent the proprietors then decree otherwise.

Capitalists often construct canals into unoccupied country as a speculation, and sell so much land with a right to so much water attached until rights covering the whole flow of the canal are parted with, and the new owners of the land become joint proprietors of the work which feeds it. In this way land and water are bought and sold together, the area of the land being measured by the quantity of water; for in the West all value may be said to inhere in the water. Land is plentiful and almost worthless. The owner of the water really owns the land, for it is useless without his supply. The quantity of available water, and not the area of a territory, defines its agricultural extent; consequently where capitalists have built canals to lands which they do not own and have secured the water they have really acquired the land too. They have the farmers absolutely at their mercy, and enjoy a monopoly of a most arbitrary kind. A land-owner who obtains a water-right can carry a stream to his own property at a distance through land as good as his which never can be cultivated except with his consent, and which will fetch only one-tenth of what his irrigated land will fetch, though the two are only divided by a fence.

A recognition of the danger of allowing water to be monopolized without regard to the land has led a commission appointed to inquire into Californian irrigation to declare that, "as a matter of public policy it is desirable that the land and water be joined never to be cut asunder; that the farmers would enjoy in perpetuity the use of the water necessary for the irrigation of their respective lands; that when the land is sold the right to water shall also be sold with it, and that neither shall be sold separately." Major Powell, in his careful draft of a land system adapted to the arid region, most emphatically recommends that "The right to use water should inhere in the land to be irrigated, and water-rights should go with land titles." In Colorado the feeling has gone so far that a proposal has been made in the legislature to compel all canal owners to supply any persons with water which they are not themselves using, at fixed rates; but as this would simply mean transferring to land owners who had invested nothing in canals part of the profit to be made by those who had so invested, the proposal was not entertained. Indeed, where the companies, as at Denver, sell the water-right with the land, and then contract to maintain a water supply in perpetuity for a fixed sum per annum, the system is unobjectionable, providing that, as in these cases, the water-right has been properly obtained.

In Colorado and Utah, notwithstanding their peculiar situation, the water is given to the first applicant, though he has to purchase the land to use it upon, which without the water would be worthless. It would have been more economical and more simple to have sold the water and given the land. Be this as it may it is essential that they should always go together. The practice of tying water-rights to the land has another argument besides that of avoiding monopoly, and this is that it tends to a more careful use of the water by its concentration upon a smaller area.

THE COLONY SYSTEM.

At first, as at Greeley, colonies were established upon something of a communal basis beyond the joint ownership of water-works, but this is now very rare. It is still frequently the case to find them organized upon a temperance basis, or by the union of those of the same nationality, as in the Scandinavian and German colonies. The joint interest in the sources of their irrigation supply remain, but all other kind of community has disappeared. Under the most favorable plan a piece of irrigable land is marked out into small holdings; either the land owner or a company construct works to supply these with water, and the lots are then sold to any purchaser with water-rights attached. By liberal advertising and easy terms of sale new centers of population and production are created in this way in a very short time, so that the barren plain in the course of a few years becomes dotted over with these oases until one joins another, and at last they inclose and support a thriving and well-built city, such as Fresno is to-day. Altogether there are some fifty of these colonies in California, some of them planned upon a large scale, such as Riverside, and containing their township within themselves. It becomes the interest of the original owners to make the advantages which their lands offer widely known, and, consequently, they turn themselves into emigration agents of the most energetic kind. The Eastern States are deluged with pamphlets; even the Old World is reached by means of the printing-office and by correspondence through the relations of those already settled. The aim is to make the place attractive, and no expense is spared to insure success. In one such enterprise at Ontario the proprietors have laid out nearly £100,000 upon 8,000 acres of land, bought at 28s. per acre; of this sum about £10,000 was spent upon head-works for the water supply, which is conducted in 26¼ miles of cement pipes to the corner of each 10-acre allotment, and in 3¼ miles of iron pipes to the township for domestic purposes, at a cost of over £10,000. More than £20,000 in land was given to establish an agricultural college now built in the center of the settlement, nearly £4,000 spent in planting trees and making streets, and £700 in securing a railway station. There is a double avenue running through the colony 7 miles long in a straight line and 200 feet wide, planted with eucalyptus trees, and intended to contain a cable tramway, and from the masts of which will be suspended electric lights, run by hydraulic power. Over £7,000 was spent in advertising this colony, and the result is confidently awaited. Many persons, weary of city life, are drawn from the New England States, while numbers are attracted from the Old World by the inducements held out to them.

The colony enterprise has many advantages for those who engage in it. To join in it does not imply so great a trial as that of facing the wilderness with no neighbor less than miles away. It permits of society, of the establishment of schools, churches, and libraries, and the enjoyment of comforts which can not be secured in isolation. It furnishes, in fine, a frame-work for commercial organization and the beginning of local government. It appeals, too, to a larger class than that usually drawn to agriculture. The physical labor required is not so severe; there is more scope for intelligence, and it offers remunerative employment for a small capital.

SMALL HOLDINGS UNDER INTENSE CULTURE.

This is due not to the colony organization, but to the fact that by means of irrigation small holdings under intense culture are proved to be profitable. The land and water which will produce 25 to 35 bushels of wheat at 2*s*. 6*d*. per bushel will produce, under fruit trees, a crop worth twenty or thirty times as much. One-twentieth or one-thirtieth of the area under fruit instead of grain will yield as great a return and a larger percentage of profit. It has been found in parts of Europe where the water is the property of one owner and the land of many others that the tendency of irrigation is to establish a monopoly in land. This is the case whenever the water is not attached to the land, and owing to a defective code lawsuits are frequent. But where water is attached to land and rights are indisputable there is exactly the opposite tendency—to cut up the land into small farms. It needs both men and money to prepare and plant 20 acres of fruit trees at once. It is as much as a hard-working man can do to attend to 20 acres of oranges or 25 acres of vines himself, and then he needs light assistance in the picking season. It is calculated that he can by frugality maintain himself and family upon half as much. Hence in the colonies 40 acres is a large estate; it requires hired labor and yields a considerable revenue.

Whether colony life yields large profits or not, the visible evidences are all of prosperity. The little holdings are neatly tilled, with an air of perfect security, owing to their being often unfenced or fenced only by a row of trees; the houses are neat, well finished, well furnished, and of some architectural pretensions; the people are comfortably dressed and well nourished, and their cattle in capital condition. Many of them brought their savings with them, and they are apparently content with their investment. The poorest places in these colonies have a far greater air of comfort than grain farms of 200 or 300 acres in extent. Whole colonies have been settled direct from Europe by a peasantry trained to the most frugal and industrious habits, and with these success is immediate. The much more extravagant American has a harder time of it if he starts upon his 10 acres with less than £500, as he must maintain himself by laboring for others the greater part of his first three or four years. Still there are numbers who enter upon their little plots without even the money to pay for them or build a house or buy their tools. Many of these are dependent upon advances from the land companies, and, though interest is charged, the general result is that in a few years the hardy colonist has his homestead clear and a profit from it which in a few years more suffices to maintain him and employ him always upon his own land. Ten-acre blocks are gaining in favor in some districts, and nowhere can one observe deserted colonies, or parts of a colony, which show signs of the total failure of effort.

WHAT HAS BEEN ACCOMPLISHED UPON SMALL HOLDINGS.

The success of small settlements in Utah is evidence of what can be accomplished in the face of the greatest difficulties. The tide of immigration constantly pouring into Salt Lake City consists of families often entirely destitute, and who have, as a rule, to become indebted to the Church for their start. They have nothing but small plots of bare land, barren by nature, and are obliged from the very start to yield tithes yearly of all they produce; to give their labor to make the ditch which brings them water, and buy back their debts to the Church with interest. Yet these peasants are enabled to makes homes for themselves which, though plain, are not uncomfortable, and to steadily improve their credit, though trading at the store established in the Church interest, which is not obliged to offer the lowest prices.

With these lessons in the value of intense culture it is not surprising that the most intelligent and most enterprising irrigators desert grain-growing for either stock-raising or fruit-growing as quickly as possible, nor that the newspapers and authorities of weight are persistently bringing before the eyes of others the relatively unprofitable character of wheat-growing, and urging them to attempt higher culture, for its increase means the increase of population and of natural wealth. Railway accountants in California calculate that an acre in vines gives as much freight as 9 acres of grain. A 640-acre grain farm can be managed by a farmer with two grown-up sons, except in harvest time, and at all other seasons the broad, bare fields and rude homestead are not indicative of permanent improvements.

On the Barton vineyard at Fresno, which has 540 acres under vines, thirty men are employed all the year round, without pickers. The winery, which is to receive the 600,000 gallons upon which the proprietor calculates, is a great building, 330 feet long by 96 feet wide, besides which there is a distillery and office in addition to the usual farm buildings surrounding a handsome residence and garden. The capital invested is £60,000, and the amount spent annually upon the 330,000 vines nearly £5,000. Thus under intense culture the same area as the grain farm is made to produce a hundred-fold. With 640 acres under grain a farmer's position is precarious without irrigation and but poorly profitable with it. Under fruit or vines it is a great estate and its owner a wealthy man. The Barton vines are used to produce wine, while on small holdings they are usually employed to make raisins. It is calculated that the value of the products of Riverside will in the course of a few years be £200,000 per annum, and, though the oldest, it is not the best managed colony in California.

IN THE NILE VALLEY.

[This description of Egyptian irrigation is summarized in the main from a report made to the colonial government of Victoria, Australia, in 1887, by the Hon. Alfred Deakin.]

The cultivated area of Egypt is comprised within the Valley of the Nile and its Delta, and are the entire creation of that river, built up by its deposits during many cycles of time. "Aristotle plainly affirmeth the region of Egypt (which we esteem the ancientest nation of the world) was a mere gained ground, and that by the settling of mud and limous matter brought down by the river Nilus, that which was at first a continued sea was raised at last into a firm and habitable country."* Outside of the valley stretches the veritable Sahara, with but here and there, amidst its endless desolation, the relief of a cluster of palms and perhaps a little pasture. Even these oases are fed by subterranean channels supplied from the same source, and their extent altogether is comparatively insignificant. The Egypt of the past was five times as large as the Egypt of the present, but both have been virtually defined by the limits of the river's overflow, which has greatly contracted since a natural dam, whose site is now marked by the first cataract, was swept away. Political Egypt is two-thirds as large as Russia, the largest territory in Europe, but peopled and productive Egypt is only the size of its smallest territory, Belgium, and, so defined, is the narrowest country in the world. It consists of the Valley of the Nile, 550 miles long, and varying in width from 14 to 32 miles, but with an arable breadth nowhere exceeding 9 miles, until it reaches the Delta at Cairo, from whence it expands in fan-shape to a width of 160 miles at the Mediterranean. The depth of the soil of the Delta, which has all been deposited by the river, commencing sometimes below the level of the sea, averages 33 to 38 feet, with a maximum of 50 feet near Kalvûb. It is estimated to be increasing in width and depth of deposit per century average between 4 and 5 inches.

There are some springs of considerable flow, and a few lakes still used for storage, but the Nile itself is practically the sole source of the water supply. According to the estimate of M. Linant—which is probably too high—the discharge at the mouth averages 3,500,000 of cubic feet per minute at Low Nile, and 17,500,000 of cubic feet at High Nile. The current at Low Nile averages 2 miles, and at High Nile 3 miles an hour. A further approximate estimate is that one-third of the river overflows at High Nile. This is utilized in two ways. In Upper Egypt, except under the Ibrahimieh Canal, the primitive system is still pursued. The country is divided by embankments into a succession of great basins from 8,000 to 40,000 acres in extent. Sir Colin Moncrief says (1884):

---

* Sir Thomas Browne's "Rendodoxia Epidemica."

> As the Nile rises in August, these basins fill to a depth of several feet. The water lies in them till October, depositing its fertilizing mud. It is then drawn off, the land is plowed and sown, and a crop of wheat or beans obtained the following March or April. This system allows of only one crop a year, and valuable sub-tropical plants like sugar-cane and cotton can not be grown.

But in Lower Egypt, and in the lands under the Ibrahimieh Canal in Upper Egypt, where the old system has been supplemented by the modern ones of weirs, reservoirs, and permanently-flowing canals, the supply flows throughout the year, to permit of the cultivation of rice, sugar-cane, and cotton. The lands of Lower Egypt are, therefore, perpetually under cultivation, and there is no time to flood the fallow fields in the manner practiced in Upper Egypt. In the Delta there are three seasons of four months each: summer, from April to July, when the estimated discharge of the river ranges from 720,000 to 1,500,000 cubic feet per minute; the flood season, from August to November, with a discharge of from 11,220,000 to 23,160,000 cubic feet per minute; and winter, with a discharge of 1,500,000 to 3,300,000 cubic feet per minute. Each of these seasons has its crops and appropriate methods of cultivation. Yet the Nile is somewhat capricious in its gifts, and does not bestow them with that scientific precision required to permit of permanent irrigation in all seasons of all years. In Lower Egypt it is for three months too high, and for nine months too low. A project has been broached by which the Wadi Raïan, suspected of being the site of the Lake Moeris, which, according to Herodotus, Strabo, and Diodorus, added so immensely to the prosperity of ancient Egypt, should be converted into a reservoir half as large again as the Lake of Geneva, covering nearly 400 square miles, and containing more than 1,000,000,000,000 cubic feet. Until this stupendous work be undertaken, says Cope Whitehouse, Egypt must continue to depend upon an unregulated Nile, and can not hope to materially enlarge its irrigated area.

There are altogether about 6,000,000 acres under cultivation, that is, under irrigation, for in Egypt the words are synonymous. The Delta contains 5,000,000 acres commanded by works, of which about 2,625,000 are actually irrigated, and 840,000 acres more are fit for irrigation, while the balance consists of morass and desert which could only be watered advantageously after considerable expenditure. As during the inundation the water is above the level of the cultivated land, irrigation is rendered easy. The perennial canals, which are employed at Low Nile as well, are of varying size and depth, the larger carrying 3 feet deep of water in summer, and 20 feet in flood season. They leave the river at from 3 to 5 feet below mean low-water level, and, in the upper valley, at about 28 feet below ground level, gradually decreasing in depth until they run out on the surface. In 1873 there were 1,917 miles of navigable, and 6,583 miles of unnavigable canals. Some of the former are of considerable size, the Ibrahimieh, for instance, being 93 miles in length, with a width at ground-level of 230 feet for the first 38 miles, and of 161 feet afterwards, giving a net discharge of about 16,380 cubic feet per minute in summer, and of 70,140 cubic feet per minute for 100 days in time of flood. The Nahran Canal is 167 miles, and the Yusufi overflow channel 166 miles in length. Most of the works were built under Mehemet Ali, by the forced labor of the Fellâhin, and consequently their true cost can not be determined. The annual state outlay upon their maintenance amounts to about 2 shillings an acre commanded. There is, in addition to this, the *corvée*, or compulsory labor, required from the villagers, which was equivalent in 1884 to an army of 165,000 men working for 100 days, and in 1885 to an army of 117,700 men working for an equal period. This practice is being gradually abolished.

The water is diverted from perennial canals by permanent or temporary dams through simple cuts in the bank. The former are composed of masonry piers 8 feet thick, with openings 15 feet wide, closed by timber beams set vertically, supported by the masonry in the bed of the canal, and above by a cross-beam placed from pier to pier. They are often surmounted by arches, thus forming a bridge on the same structure. When the watering is over the beams are lifted, and the stream passes on to the next dam. The temporary work is of earth, occasionally a little strengthened with piles. There is a little furrow irrigation in orchards and gardens, such as those of the Khedive, at Gezireh, where, by simply fitting a flower-pot laid upon its side with its mouth up-stream into little channels, the flow was delayed so as to permit of sufficient soakage into the soil to supply the trees, while the surplus water passed through the small aperture at the bottom until stopped by another flower-pot. But, as a rule, all watering is managed by submersion, the fields being readily divided into plots, by ridges made of Nile mud. The duty of water is estimated in the roughest way. Rice requires a constant stream and much manure; cotton and sugar are watered every two or three weeks; the first needing a small, but the second a liberal allowance in each watering. The quantity of water said to be employed for such crops from perennial canals in the Delta is uncertain, but appears to supply from 1⅓ acres to 2½ acres per cubic foot per minute. With beans, lentils, and maize a considerably higher duty is obtained. Under the inundation system the one watering given appears to show a minimum of 6 cubic feet per minute to the acre; but this varies greatly in different districts. Cereals are grown chiefly in Upper Egypt, under the primitive system, being sown in the ground after its inundation, without plowing, and not needing to be irrigated. A considerable area is under pasture, each group of cultivators having its small patch, upon which their sheep, or usually tethered camels, asses, and buffaloes are fed; but much green stuff is cut, always by hand, either for transport to the cities or for feeding cattle. The canals are greatly used for carrying produce to market or to the railway. But even the great advantages they offer for this purpose have been hitherto but imperfectly enjoyed, owing to the numerous illegal obstructions placed upon them, and unjust exactions in the shape of tolls.

The great natural advantages of the country have their compensating disadvantages. The land near the river banks is about 17 feet above its low-water level. The fall is very regular, and is reckoned at 5 inches to the mile along the river, and about the same away from it. This renders the excavation of canals easy, as in our northern plains, but makes continuous cleansing necessary and drainage difficult, and causes loss from soakage along the ditches. In summer the regulators upon them are closed, and they become storages. The Nile water, richly laden with fertilizing materials, deposits it in the channel as well as in the fields, sometimes, when they have been dammed to a depth of 8 feet. The dredging of the Ibrahimieh Canal costs over $200,000 a year, and on the other canals it is reckoned to occupy 60,000 men for five months in the year. The annual state outlay upon the canals is $3,000,000, a large portion of which is spent in cleansing them. Mr. L. D'A. Jackson, civil engineer (Hydraulic Works, 1885), calculates that the work required to be done each year by private proprietors and by the state is equivalent to the removal of 500,000,000 cubic feet of silt a distance of 200 feet, and to a height of 40 feet, at an expense of $2,500,000 for the perrennial canals of Lower Egypt alone. In 1884, $290,000, and in 1885, $305,000, was spent in works of protection against the Nile, which is embanked for many miles by dikes of great antiquity. The drainage difficulty is even more serious, and by the neglect of proper provisions for the removal of the surplus waters large tracts of land have been soured or water-logged. The subterranean up-flow has to be provided against as much as floods upon the surface. Indeed, it is water rising through the soil that brings to the surface the salts which do the chief damage. There are very few proper locks or sluices, and constant saturation sometimes causes seed to rot in the soil. Under present control these dangers are being faced; old drainage canals are being straightened and cleared of obstructions; improper levels rectified, and new arterial drains, 20 and 30 miles long, projected. The evil is probably aggravated by extravagance in the use of water. The soil has, in places, those signs which, in America, would be considered distinct evidences of over-watering.

The use of manure has grown, and is growing, since the perennial canals do not carry the sediment which, coming down in the annual inundations, had hitherto acted as a fertilizer. Crops, such as cotton and sugar, have already threatened to seriously impoverish the soil unless systematic fertilization is resorted to. Owing to the common use of cattle-droppings for fuel, it is only pigeon dung that is generally employed, and, of course, in but very limited quantities, though great numbers of them are reared in every homestead for this purpose, and large quantities are brought from Upper Egypt every year. A great deal of fertilizing earth has been obtained from the ruins of ancient villages, once built of unbaked clay, but this requires to be used with care and discrimination on account of its varying elements. It is something, however, to find the value of manure acknowledged by those who use the rich waters of the Nile.

Fearing the failure of the immense masonry barrage which crosses both branches of the Nile a short distance below Cairo at the head of the Delta, upon which the supply of water to the perennial canals largely depends, the government, in 1885, made an agreement with the Irrigation Society of Behera, by which it undertook to pay $210,000 a year for thirty years for a supply up to a certain level, with a maximum of about 156,250 cubic feet per minute at Low Nile, lifted by two powerful sets of steam pumps into the Western Canal or Rayah Behera. The weir has since been rendered secure, but the agreement indicates the value of water and the difficulty of obtaining it, even in parts of Egypt. Owing to the defective alignment of some of the silting up of other canals, the task of raising the water a second time from the channels to the fields has been cast upon a large, if not the largest, body of the cultivators. In 1864, according to Figari Bey, the number of sâkiyehs, or wooden water-wheels, used in Central and Lower Egypt was about 50,000, turned by 200,000 oxen, and managed by 100,000 persons, who watered 4,500,000 acres. The water-wheels are of several varieties, costing, on the average with the well, $150 each, that most in use sufficing for 5 acres, or 10 acres if worked day and night, and employing three bullocks and two men on each shift. In the estimate of Figari Bey some steam pumps were probably overlooked, for, twenty years later, there were 2,000 of these at work in Lower Egypt, with coal ranging from $10 to $20 per ton. It can now be bought in Alexandria for $5 per ton. The cost of steam pumping is about $1.50, but the price at which it can be hired varies from $2 up to $5 per acre. If paid in kind, the charge is one-fifth of a cotton, and one-quarter of a rice crop, as the latter requires more water. A 10-horse power engine gives an ample supply for 100 acres during the season. There are also "shadoofs" (Egyptian water-lifters, or swing buckets) innumerable in constant employ, which require six men to keep watered 1 acre of cotton or sugar-cane, or 2 of barley.

Over 1,000,000 acres of the irrigated land belongs to the State, the Fellâhin upon them being its tenants, with a life interest and a title to their improvements; half as much is included in great estates, while the balance is in the hands of small proprietors. Omdehs, or notables, and sheiks, who control the village communes, often own estates of 1,000 or even 2,000 acres, but the holdings of the great majority of their constituents, who are working proprietors, are very small. The Crown tenants, of course, pay rent, but all pay a "land tax" of from $1 to $8 per acre, which might be more properly named a water rent, as no tax is levied if no water is given. It is clear that, if in addition to the taxes there is the cost of pumping and four months' labor taken by the *corvée*, the produce must be great to yield any profit to the cultivator. The cost of the crop, including taxes and pumping, averages $25 per acre. The value of land averages $60 per acre in Upper Egypt, and from $100 to $125 in Lower Egypt, but it not infrequently reaches $100 in the one and $300 to $350 in the other. Its variation may be judged from the fact that rents run from 50 cents to $50 per acre. Labor, of course, is plentiful and cheap—wages averaging from ten to fourteen cents per day—but on the other hand the agricultural implements employed are of the most primitive character; the plow used is made on the same model as is delineated upon monuments thousands of years old, and the Nile mud, though freely and easily worked after the subsidence of the water, requires constant attention throughout the year.

The principal products are cotton, wheat, barley, beans, maize, sugar-cane, rice, and clover. In the Delta, those grown in summer are cotton, rice, sugar-cane, melons, cucumbers and clover. During the floods the maize, cotton, rice, and sugar-cane are cultivated. The winter crops are wheat, beans, barley, and clover. The common rotation is a first year of cotton and clover, a second year of maize, wheat, and clover, and a third year of maize, beans, and clover. Cotton is too exhausting to the soil to be grown every year. It could be grown every second year if the water supply were larger, but the present practice is to grow it every third year only, or, what is the same thing, not more than one third of a farm is put under this crop in each year. It is by far the most profitable product in Egypt, an acre being worth from $75 to $125, as against $35 for rice, $25 for wheat, and $20 per acre for fodder, beans, maize, or lentils. In Upper Egypt, wheat, flax, and beans are chiefly sown, while by the use of sâkiyehs and shadoofs, millet, cucumbers, and melons are grown in summer. The food of the country, which is grown by irrigation, of course does not appear in this return. Some fruit is grown, a great deal of forage, and a great variety of vegetables.

Trees are comparatively rare in the Delta; but larger estates are sometimes planted with figs, mulberries, acacias, and sycamores, while the growth of other varieties, notably of the weeping willow, myrtle, elm, and cypress, are now being encouraged. Numbers of date palms are grown upon its borders. Large estates are reckoned to return a profit to their landlords, taking one year with another, of $25 per acre; those of moderate size, also with hired labor, $22.50 per acre, while the fellâhin, in their own plots and with their own family labor, gain as much as $32.50 per acre, irrigation here, as in France and Spain, favoring the small proprietors. The immense Khedivial plantations farmed by the State with most expensive machinery gave a profit of only $6.25 per acre. Since they have been let to private proprietors they have returned a rent of $7.50 per acre.

It should be noted that under despotic government and with the state undertaking the chief irrigation works the local communes are intrusted with the retailing of water. Where the state has attempted to irrigate on public estates it has only achieved a miserable failure. Beyond this the lessons of Egyptian experience, though somewhat vague in detail, point clearly enough to the importance of the questions of silt, drainage, and fertilization, as presenting the most important of the difficulties to be surmounted.

A French estimate of the total population in 1800 was 2,000,000; it is now nearly 7,000,000. The country, however, practically depends for its resources upon the fellâhin, who are less than a third of this number. Upon them and their labors rest the whole superstructure of Egyptian society. The population of 5,000,000, and a national debt of $515,000,000—all are supported by the fruits of irrigation and the industry of 2,000,000 irrigators.

The total area of Egypt (land and water) is about 8,000,000 feddans, or 8,240,000 acres (1 feddan = 1.03 acres). Of this, 4,963,460 feddans, or 5,112,364 acres. Agricultural population forms 61 per cent. of the total. Total population, 6,817,265. There is an annual increase of population of 1.25 per cent.

	Population.	No. of villages.	No. of farm animals for every 103 acres.
Lower Egypt	3,965,664	2,359	17
Upper Egypt	2,776,982	1,420	13

The crops of Egypt, wholly the result of irrigation in 1888, were:

	Acres.
Wheat	1,237,260
Maize and durrah	709,180
Clover	1,236,515
Cotton	994,743
Beans	1,051,875
Barley	601,784
Lentils	113,489
Rice	166,822
All other crops	294,612
Total	6,386,300

In Lower Egypt the soil yields four crops in three years; in Upper Egypt, seven crops in eight years.

In 1888 the "double cultivation" was 1,503,057 acres. In 1888 the exports amounted to £10,418,212, or $52,091,065. In 1890, the population was 2,000,000; by the census of 1882 it was nearly 7,000,000. It is now fully that number.

BRITISH INDIA.

Irrigation in British India sustains the largest population, and is the most costly and extensive in the world. It has been practiced on the Indian peninsula from time immemorial. During the past third of a century, owing to the failure of the ancient works and the consequent destruction of crops with accompanying famine, the British rulers have been compelled to assume large risks and make great outlays. It is estimated that about $120,000,000 have been expended under government direction for irrigation work alone. As much more has also been used in the construction of canals for navigation, highways, and country roads as well as railroads, for the purpose of making markets for the crops raised under the new system.

The total population was estimated in 1888 at 269,477,728. The total area in square miles is 1,378,044. The average density per square mile of population is 184.3. Over two-sevenths of the entire population are connected with agriculture. Total area cultivated is given for 1888 at 144,006,000 acres. Of this area 24,836,000 acres are under irrigation.

The area most highly irrigated is the territorial divisions known as the northwest provinces and Oudh. It includes the great canal system of the Upper and Lower Ganges; other works of the largest magnitude are found therein. There are 68,000,000 acres cultivated, of which only 5,000,000 are under ditch. Wells are used largely in these provinces; they number several thousand and serve about 2,000,000 acres of land. No statistics of well irrigation are kept. The Punjab includes an area somewhat larger. The total irrigated by canal is now about 2,000,000 acres. About 1,500,000 acres cover, it is estimated, the area irrigated by wells. In the Presidency of Bombay, with a total area of nearly 79,500,000 acres, the area irrigated from all sources does not exceed 1,600,000 acres; the area irrigated from public works being less than 750,000 acres.

In the Madras Presidency, out of an area of 89,500,000 acres not more than 3 per cent. is irrigated from public works. The total area under irrigation will not exceed 5,500,000 acres. Of the population of British India and its native dependencies it is estimated that at least 20,000,000 persons are supported from land irrigated by village and neighborhood wells. The storage reservoir system is of enormous extent and great importance. In the island of Ceylon alone over 5,000 irrigation tanks and reservoirs are reported. In the province of Mysore, India, 20,000 such tanks are reported. The number, large and small, will run into the hundreds of thousands. The average duty of water will range from 200 to 400 acres, according to locality. The snows from the Himalyan ranges afford a vast reserve against the enormous evaporation, which is a consequence of the equatorial position of British India. The great extent of the country and the differences in physical configuration and climate produce considerable variety in rain-fall and seasons.

Near the mountains irrigation is almost unnecessary, but the decrease in quantity is extremely rapid. North of the Punjab, near the foothills, the mean annual fall is 115 inches; 30 miles distant it is but 31 inches, descending to 20 inches at 70 miles, 15 at 100 miles, and 6 inches at 350 miles from the mountains. In the Sind the average rain-fall will be less than 7 inches, while in the southern portions of the peninsula it will range from 80 to 100 inches.

The following table, though not of as recent date as desirable, will give a clear view of the British Indian irrigation system:

Statistics of Indian canals, collected from Jackson's and other engineers' works.

Name of canal.	Source of supply.	Length, including branches, etc.	Width.	Depth.	Fall per mile.	Discharge per second.	Area irrigated.	Outlay, 1877-'78.	Revenue, 1877-'78.	Interest.	Working expenses.	Profit and loss.
			Feet.	*Feet.*	*Feet.*	*Cu. feet.*	*Acres.*					*Per cent.*
Ganges	Ganges	4,010	140-110	10 - 8	1.5	6,750	1,045,013	3,055,015	275,462	127,192	105,462	1.51
Western Jumna	Jumna	415	360-120	4¾- 2½			507,974	575,921	141,000	19,474	37,516	19.42
Eastern Jumna	do	748					206,732	261,235	81,401	10,428	23,027	20.68
Boree Doab	Ravi	1,185	120-112	4¾- 2½		3,000	266,995	1,537,990	93,876	67,955	50,240	— 1.62
Agra	Jumna	453	140- 70	10 - 7		2,000	163,634	804,479	3,709	32,215	8,319	— 5.14
Dun	Small streams	66					13,202	62,452	5,196	2,727	2,530	— .12
Sirhind	Sutlej	530	200 *b.*	28 -10		4,500	788,000	1,537,990		53,077		— 4.5
Upper Sutlej and Chenab	do	223	60- 20	6 - 3			94,621	55,812	8,362	2,322	11,307	—10.19
Lower Sutlej	do	690					284,680	10,808	21,883	486	16,370	46.59
Orissa*	Mahanaddi	228	160	7			183,000	1,778,090	4,549	74,591	20,762	— 5.48
Sone	Sone	331	180 *b.*	9			241,990	1,908,504	5,090	68,461	11,543	— 4.92
Shahpur and Shahiwal	Jhelum	36	18- 10	6 - 4½			4,445	3,757	625	95	522	.35
Tambaddra †	Tambaddra	195	*t* 106- 90*b*	9 - 8	.3-.5	3,000	183,300	1,708,211				
Punjab	Indus	618		6 - 3			180,137	57,547	22,140	2,589	19,001	.95
Sind												
Shahadadpur	do	428					171,465	126,081	20,722	5,265		4.59
Sukkur												
Eastern Nara	do	214	206- 20	16 - 4			194,803	323,881	17,961	12,610		1.91
Mutha	Mutha	140				450	5,361	584,956	2,514	17,097		— 3.5
Krishna	Krishna	45				382	2,934	89,016	1,198	5,189		— 3.4
Godavari	Godavari	882	225-114	8 -21			1,000,000	787,778	163,328	33,140	25,837	12.94
Kistna	Kistna	611	230-200	8			470,000	484,590	91,094	20,861	24,603	9.8
Pennair	Pennair	200					70,000	134,020		6,031		— 4.5
Vellore	Vellar						224,219	25,300		1,139		— 4.5
Palar	Palar						37,672	108,371	2,102	4,877	1,012	— 3.5
Cauvery	Cauvery	646			1.5	1,637	796,968	133,964	116,071	6,628	1,120	81.30

*Protects from inundation 249,000 acres.

† Seventeen locks for 368 feet fall.

The legal regulations in British India rest largely upon the canal act of 1873, framed upon the reports made to the Imperial Government by two prominent engineers who visited Egypt and southern Europe for the purposes of investigation. This act relates to northern India only. Madras and Bombay have their own government, organizing such work under "Orders in Council," and they do it very badly.

The northern India canal and drainage act asserts the right of the State "to use and control for public purposes the water of all rivers and streams flowing in natural channels, and of all lakes and natural collections of still water." The act is of an elaborate character, organizing a great staff of canal officers, giving power to enter private lands, defining compensation, procedure for granting water supplies, levying rates, constructing works, and granting all the powers necessary to carry on such vast stations. The Imperial administration has been a success. All attempts to engraft local self-government are a conceded failure. The general verdict unites favorably on the proposition that the Government investment has paid in actual dividends as well as in good order and prosperity to the people.

A BRIEF MEMORANDUM

OF THE

DECISIONS

OF THE

FEDERAL, STATE, AND TERRITORIAL COURTS

UPON

QUESTIONS RELATIVE TO THE USE AND CONTROL OF THE WATER IN THE ARID REGION OF THE UNITED STATES.

PART VII.

TABLE OF CASES.

A.

Alder Gulch Con. Mg. Co. *v.* Hayes; 6 Mont., 31.
American Co. *v.* Bradford; 27 Cal., 360.
Anaheim Water Co. *v.* Semi-Tropic Water Co.; 64 Cal., 185.
Anderson *v.* Fisk; 36 Cal., 625.
Atchinson *v.* Peterson; 20 Wall., 507.

B.

Baker *v.* Brown, 55 Texas 377.
Barkley *v.* Tieleke; 2 Mont., 59.
Barnes *v.* Sabron; 10 Nev., 217.
Basey *v.* Gallagher; 20 Wall., 670.
Bear River & Auburn W. & M. Co. *v.* N. Y. Mg. Co.; 8 Cal., 327.
Biddle Boggs *v.* Merced Mg. Co.; 14 Cal., 279.
Blaisdell *v.* Stephens; 14 Nev., 17.
Blanc *v.* Klumpke; 29 Cal., 156.
Bliss *v.* Johnson; 76 Cal., 597.
Boynton *v.* Longley; 19 Nev., 69.
Boynton *v.* Clear Lake Water Co.; 40 Cal., 396.
Broder *v.* Natoma W. Co.; 101 U. S., 274.
Brown *v.* Evans; 18 Nev., 141.
Brown *v.* Muller; 65 Cal., 89.
Brown *v.* Smith; 10 Cal., 508.
Burbank *v.* W. Walker River Ditch Co.; 13 Nev., 431.
Burnett *v.* Whitesides; 15 Cal., 35.
Butte Canal & Ditch *v.* Vaughn; 11 Cal., 143.
Butte Table Mountain Co. *v.* Morgan; 19 Cal., 609.

C.

Campbell *v.* B. R. & A. W. & M. Co.; 35 Cal., 679.
Caruthers *v.* Pemberton; 1 Mont., 111.
Cate *v.* Sanford; 54 Cal., 24.
Cave *v.* Crafts; 53 Cal., 135.
Charnock *v.* Rose; 70 Cal., 189.
Chiatovich *v.* Davis; 17 Nev., 133.
Clark *v.* Willett; 35 Cal., 534.
Coffin *v.* Left-Hand Ditch Co.; 6 Colo., 443.
Coffman *v.* Robbins; 8 Ore., 278.
Columbia Mg. Co. *v.* Holter; 1 Mont., 296.
Coker *v.* Simpson; 7 Cal., 340.
Conger *v.* Weaver; 6 Cal., 548.
Cole Silver Mg. Co. *v.* Virginia Gold Hill W. Co.; 1 Law, 470.
Covington *v.* Becker; 5 Nev., 281.
Crandall *v.* Woods; 8 Cal., 136.
Crane *v.* Winson, 2 Utah, 248.
Crary *v.* Campbell; 24 Cal., 634.
Crisman *v.* Heiderer; 5 Colo., 589.
Cross *v.* Kitts; 69 Cal., 217.

D.

Daley *v.* Cox; 48 Cal., 127.
Dalton *v.* Bowker; 8 Nev., 190.
Davis *v.* Gale; 32 Cal., 26.
Denver *v.* Mullen; 7 Colo., 345.
Dick *v.* Bird; 14 Nev., 161.
Dick *v.* Caldwell; 14 Nev., 167.
Dilley *v.* Sherman; 2 Nev., 67.
Dodge *v.* Martin; 7 Ore., 456.
Dorr *v.* Hammond; 7 Colo., 79.

E.

Eddy *v.* Simpson; 3 Cal., 249
Edgar *v.* Stevenson; 70 Cal., 286.
Ellison *v.* Jackson Water Co.; 12 Cal., 542.
Ellis *v.* Cone; 58 Cal., 289.
Esmond *v.* Chew; 15 Cal., 137.

F.

Fabian *v.* Collins; 3 Mont., 215.
Farley *v.* Spring Valley M & I Co.; 58 Cal., 143.
Farmer *v.* Ukiah Water Co.; 56 Cal., 11.
Farmers' High Line Canal *v.* Southworth (Colo.), Lawyer's Rep. Annd., 1889, W. 767.
Ferrea *v.* Knipe; 28 Cal., 340.
Feliz *v.* City of Los Angeles; 58 Cal., 73.
Fleming *v.* Davis, 37 Texas 183.
Fraler *v.* Sears Union Water Co.; 12 Cal., 555.
Frey *v.* Lowden; 70 Cal., 550.
Frisbie *v.* Whitney; 9 Wall., 186.

G.

Gale *v.* Tulumne Water Co.; 14 Cal., 25.
Gallagher *v.* Basey; 1 Mont., 457.
Gibson *v.* Pucha; 33 Cal., 310.
Ginocchio *v.* Amador C. & M. Co.; 67 Cal., 493.
Golden Canal Co. *v.* Bright; 8 Colo., 144.
Gould *v.* Stafford; 77 Cal., 66.
Gregory *v.* Nelson; 41 Cal., 278.
Grigsby *v.* Clear Lake W. Co.; 40 Cal., 396.

H.

Hale *v.* McLea; 53 Cal., 578.
Hammond *v.* Rose; 11 Colo., 524.
Hanson *v.* McCue; 42 Cal., 303.
Harris *v.* Shontz; 1 Mont., 212.
Hayden *v.* Long; 8 Ore., 244.
Henderson *v.* Nichols; 67 Cal., 152.
Henshaw *v.* Clark; 14 Cal., 461.
Heyneman *v.* Blake; 19 Cal., 579.
Higgins *v.* Barker; 42 Cal., 233.
Hill *v.* King; 8 Cal., 336.
Hill *v.* Smith; 27 Cal., 476.
Hill *v.* Smith; 32 Cal., 166.
Hill *v.* Newman; 5 Cal., 445.
Himes *v.* Johnson; 61 Cal., 259.
Hobart *v.* Ford; 6 Nev., 77.
Hobart *v.* Wicks; 15 Nev., 418.
Hoffman *v.* Stone; 7 Cal., 47.
Hoffman *v.* Tuolumne Co., W. Co., 10 Cal., 412.
Horn *v.* Jones; 28 Cal., 194.
Huston *v.* Bybee; Ore. Lawyers' Rep. Ann'd (1889) II., 568.
Huston *v.* Leach; 53 Cal., 262.
Hutton *v.* Frisbie; 37 Cal., 475.

I.

Irwin *v.* Phillips; 5 Cal., 140.
Irwin *v.* Strait; 18 Nev., 436.

J.

James *v.* Williams; 31 Cal., 211.
Jennison *v.* Kirk; 98 U. S., 453.
Johnson *v.* Superior Court; 65 Cal., 567.
Jones *v.* Adams; 19 Nev., 78.
Junkans *v.* Bergin; 67 Cal., 267.

K

Kaler *v.* Campbell; 13 Ore., 596.
Keeney *v.* Carillo; 2 N. M., 480.
Kelley *v.* Natoma Water Co.; 6 Cal., 105.
Kidd *v.* Laird; 15 Cal., 161.
Kimball *v.* Gearhart; 12 Cal., 27.

L.

Lake *v.* Tolles; 8 Nev., 285.
Larimer Co., R. Co. *v.* People ex rel. Luthe; 8 Colo., 614.
Larned *v.* Tangeman; 65 Cal., 334.
Ledu *v.* Jim Yet Wa; 67 Cal., 346.
Leigh Co. *v.* Independent Ditch Co., 8 Cal., 323.
Lovaroni *v.* Miller; 34 Cal., 231.
Lewis *v.* McClure; 9 Ore., 273.
Lobdell *v.* Simpson; 2 Nev., 274.
Lobdell *v.* Hall; 3 Nev., 507.
Logan *v.* Driscoll; 19 Cal., 623.
Lorenz *v.* Jacob; 63 Cal., 73.
Lorenz *v.* Jacob; 59 Cal., 292.
Los Angeles *v.* Baldwin; 53 Cal., 469.
Los Angeles Water Co., *v.* Los Angeles City; 55 Cal., 176.
Lower Kings R. D. Co. *v.* Lower Kings R. & F. Co.; 60 Cal., 408.
Lux *v.* Haggin; 69 Cal., 255.
LytleCreek Water Co. *v.* Perdew; 65 Cal., 447.

M.

McCrary *v.* Beaudry; 67 Cal., 120.
McDonald *v.* Bear River & Auburn W. & M. Co.; 13 Cal., 220.
McDonald *v.* Askew; 29 Cal., 200.
McGillevray *v.* Evans; 27 Cal., 92.
McKinney *v.* Smith; 21 Cal., 374.
Maeris *v.* Bicknell; 7 Cal., 261.
Mathew *v.* Lerrea; 45 Cal., 51.
Miller *v.* Vaughn; 8 Ore., 333.
Minto *v.* Delaney; 7 Ore., 337.
Monroe *v.* Ivie; 2 Utah, 535.
Moore *v.* Clear Lake Water Works; 68 Cal., 146.
Moore *v.* Willamette Transportation Co.; 7 Ore., 355.
Mosier *v.* Caldwell; 7 Nev., 363.

N.

Natoma W. & M Co. *v.* McCoy; 23 Cal., 491.
N. C. & S. Canal Co. *v.* Kidd; 37 Cal., 282.
Nevada Water Co. *v.* Powell; 34 Cal., 109.
Norris *v.* Glenn; 1 Idaho, 590.

O.

O'Connor *v.* North Truckee Ditch Co.; 17 Nev., 245.
Ogburn *v.* Connor; 46 Cal., 346.
Ophir Silver Mfg. Co. *v.* Carpenter; 4 Nev., 534.
Ortman *v.* Dixon; 13 Cal., 33.
Osgood *v.* El Dorado W. & M. Co.; 56 Cal., 571.

P.

Park's C. & M. Co. *v.* Hoyt; 57 Cal., 44.
Parke *v.* Kelham; 8 Cal., 77.
Phœnix Water Co. *v.* Fletcher; 23 Cal., 482.
Pope *v.* Krinman; 54 Cal., 3.
Price *v* Riverside L. & I. Co.; 56 Cal., 431.
Priest *v.* Union Canal Co.; 6 Cal., 170.
Proctor *v.* Jennings; 6 Nev., 83.

Q.

Quirk *v.* Falk; 47 Cal., 453.

R.

Railroad Co. *v.* Schurmier; 7 Wall., 272.
Reed *v.* Spicer; 27 Cal., 57.
Reno Smelting M. & R. Works *v.* Stevenson (Nev.); Lawyers' Rep. Ann'd (1889) IV, 60.
Reynolds *v.* Hosmer; 51 Cal., 205.
Robinson *v.* Imperial Silver Mg. Co.; 5 Nev., 44.
Rominger *v.* Squires; 9 Colo., 327.
Richardson *v.* Kier; 34 Cal., 63.
Richardson *v.* Williamson; 24 Cal., 289.
Rupley *v.* Welsh; 23 Cal., 452.

S.

San Francisco & Alameda W. Co. *v.* Alameda W. Co; 36 Cal., 639.
Schilling *v.* Rominger; 4 Colo., 100.
Schultz *v.* Winter; 7 Nev., 130.
Schulz *v.* Sweeney; 19 Nev., 359.
Shaw *v.* Oswego Iron Co.; 10 Ore., 371.
Shively *v.* Hume; 10 Ore. 76.
Shoemaker *v.* Hatch; 13 Nev., 261.
Shook *v.* Colohan; 12 Ore., 239.
Sieber *v.* Frink; 7 Colo., 148.
Simpson *v.* Williams; 18 Nev., 432.
Smith *v.* Logan; 18 Nev., 149.
Smith *v.* O'Hara; 43 Cal., 371.
Spear *v.* Cook; 8 Ore., 380.
Spring Valley W. Works *v.* San Mateo W. Works; 64 Cal., 123.
Standard *v.* Round Valley Water Co.; 77 Cal., 399.
St. Helena Water Co. *v.* Forbes; 62 Cal., 182.
Stein Canal Co. *v.* Kern Island Irr. Co.; 53 Cal., 563.
Stockman *v.* Riverside L. & T. Co.; 64 Cal., 57.
Strait *v.* Brown; 16 Nev., 317.
Swift *v.* Goodrich; 70 Cal., 103.

T.

Tartar *v.* Spring Creek M. & Mg. Co.; 5 Cal., 395.
Taylor *v.* Welch; 6 Ore., 198.
Tenney *v.* Miners' Ditch Co.; 7 Cal., 335.
Thomas *v.* Guirand: 6 Colo., 530.
Thompson *v.* Lee: 8 Cal., 275.
Titcomb *v.* Kirk; 51 Cal., 288.
Tolman *v.* Casey; 15 Ore., 83.
Tolle *v.* Coneth; 31 Lex., 362.
Toombs *v.* Hornbuckle; 3 Mont., 193.
Tripp *v.* Overocker; 7 Colo., 72.
Tuolumne Water Co. *v.* Chapman; 8 Cal., 392.
Turner *v.* Tuolumne County W. Co.; 25 Cal., 398.
The Mining Débris Case; 8 Saw., 628.
The Mining Débris Case; 9 Saw., 441.

U.

Union Water Co. *v.* Crary; 25 Cal., 504.
Union M. & M. Co. *v.* Ferris, 2 Saw., 176.
Union M. & M. Company *v.* Danberg; 2 Saw., 450.

V.

Van Sickle *v.* Haines; 7 Nev., 249.

W.

Ware *v.* Walker; 70 Cal., 491.
Weaver *v.* Eureka Lake Co.; 15 Cal., 271.
Weaver *v.* Conger; 10 Cal., 233.
Weill *v.* Baldwin, 64 Cal., 476.
Weis *v.* Oregon Iron & Steel Co.; 10 Ore., 496.
Western Pac. R. R. Co. *v.* Tevis & Kerr; 41 Cal., 489.
Wheeler *v.* Northern Colo. Irr. Co.; 10 Colo., 582.
White *v.* Todd's Valley Water Co.; 8 Cal., 443.
Wilcox *v.* Hausch; 64 Cal, 461.
Wilkins *v.* McCue; 46 Cal., 606.
Winter *v.* Winter; 8 Nev., 129.
Wixon *v.* Bear River & Auburn W. & M. Co.; 24 Cal., 367.
Wolf *v.* St. Louis Independent W. Co.; 10 Cal., 541.
Woolman *v.* Garringer; 1 Mont., 535.

Y.

Yosemite Valley Case; 15 Wall., 77.
Yunker *v.* Nichols; 1 Colo., 551.

Z.

Zimmler, adm'r, *v.* San Louis Water Co.; 57 Cal., 221.

BRIEF OF DECISIONS[*]

Abandonment.

When the water of a stream leaves the possession of a party, all his right to and interest in it is gone.

Eddy *v.* Simpson, 3 Cal., 249.

If an appropriator of water, after using the same, allows it to return to the stream without intention of using it again, that water becomes a part of the stream, and is subject to appropriation by another.

Eddy *v.* Simpson, 3 Cal., 249; Schulz *v.* Sweeny, 19 Nev., 359; Woolman *v.* Garringer, 1 Mont., 535.

The prior appropriator can not claim water after it has been abandoned by him and appropriated by another.

Eddy *v.* Simpson, 3 Cal., 249; Barkley *v.* Tieleke, 2 Mont., 59.

Rights of a prior appropriator of water may be lost by his acquiescence in an adverse use thereof by another during the period limited by the statute of limitations. This would not apply to any portion of said water of which the prior appropriator did within said period resume, and afterwards, retain possession.

Union Water Company *v.* Crary, 25 Cal., 504; Davis *v.* Gale, 32 Cal., 26; Smith *v.* Logan, 18 Nev., 149; Woolman *v.* Garringer, 1 Mont., 535.

The attempt to convey a water right by an imperfect conveyance, while it may not operate as an absolute transfer, clearly operates as an abandonment by the grantor of his right acquired by appropriation, and the right of the buyer relates to the date of his taking possession as an original appropriation by him.

Barkley *v.* Tieleke, 2 Mont., 59.

One who has abandoned his prior right to the use of water can not by afterwards making a sale of the same revive his prior right in favor of his grantees, even if the same is made in good faith.

Davis *v.* Gale, 32 Cal., 26.

Abandonment, evidence of.

An appropriator of water who for many years makes no use of the water, allows his ditch to become obliterated, and interposes no objection to the diversion of the water by a subsequent appropriator, will be presumed to have abandoned his right of priority.

Dorr *v.* Hammond, 7 Colo., 79.

The facts that water was appropriated for a particular purpose, and that the purpose has been fully accomplished, and that when accomplished the appropriators dispersed, and allowed a long time to elapse without using the ditch, and then sold it for a nominal sum, may be received in evidence as tending to show abandonment.

Davis *v.* Gale, 32 Cal., 26.

A failure to use for a time is competent evidence on the question of abandonment; and if such non-use be continued for an unreasonable period, it may fairly create a presumption of intention to abandon, but this presumption is not conclusive, and may be overcome by other satisfactory proofs.

Davis *v.* Gale, 32 Cal., 26; Sieber *v.* Frink, 7 Colo., 148.

Abatement of nuisance.

See Actions for diversion of water, Nuisance.

Acquiescence.

See Abandonment, Estoppel, Prescription.

---

[*] This brief of decision is enlarged from one made for the United States Irrigation Survey and published by the Interior Department (1890). The table of cases and the digest of decisions down to April, 1890, have been prepared under the direction of the editor.

Act of Congress.

See Statutes.

Action against trespassers, who may maintain.

A party who is in possession of a ditch and the water incident thereto has an equitable interest therein, and can maintain an action against trespassers.

Barkley *v.* Tielcke, 2 Mont., 59.

Action for diversion of water, tenants in common.

Actions for diversion of the waters of ditches are in the nature of actions for the abatement of nuisances, and may be maintained by tenants in common in a joint action.

Parke *v.* Kilham, 8 Cal., 77.

In an action for the diversion of water from a ditch and land owned by the plaintiff and others, his co-owners are not necessary parties.

Himes *v.* Johnson, 61 Cal., 259.

Action for injury to water rights, who may maintain.

One to whom lands have been conveyed acquires thereby the legal title to such lands, even though there may be an oral agreement to reconvey, and may maintain an action to establish water rights connected with said land.

Smith *v.* Logan, 18 Nev., 149.

Action for invasion of water right, who may maintain.

Until a claimant is himself in a position to use water, the right to the water does not exist in such a sense that the mere diversion and use of the water by another is a ground of action either to recover the water or damages for the diversion.

N. C. & S. Canal Co. *v.* Kidd, 37 Cal., 282.

Adverse use.

See Prescription.

Agriculturists and miners.

See Miners and Agriculturists, relative rights of, Miners' rights not superior to others.

Application to beneficial use.

See Appropriation.

Appropriation.

The first appropriator of water from a natural stream upon the public lands for a beneficial purpose has a prior right thereto to the extent of such appropriation.

Atchison *v.* Peterson, 20 Wall., 507; Basey *v.* Gallagher, 20 Wall., 670; Irwin *v.* Phillips, 5 Cal., 140; Tartar *v.* Spring Creek M. & Mg. Co., 5 Cal., 395; Hill *v.* Newman, 5 Cal., 445; Conger *v.* Weaver, 6 Cal., 548; Hoffman *v.* Stone, 7 Cal., 47; B. R. and A. W. and M. Co. *v.* N. Y. Mg. Co., 8 Cal., 327: Hill *v.* King, 8 Cal., 336; Butte Canal and Ditch Co. *v.* Vaughn, 11 Cal., 143; Ortman *v.* Dixon, 13 Cal., 33; McKinney *v.* Smith, 21 Cal., 374; Union Water Co. *v.* Crary, 25 Cal., 504; Davis *v.* Gale, 32 Cal., 26; Osgood *v.* El Dorado W. and M. Co., 56 Cal., 571; Himes *v.* Johnson, 61 Cal., 259; Brown *v.* Mullin, 65 Cal., 89; Junkans *v.* Bergin, 67 Cal., 267; Ware *v.* Walker, 70 Cal., 591; Schilling *v.* Rominger, 4 Colo., 100; Coffin *v.* Left-Hand Ditch Co., 6 Colo., 443; Wheeler *v.* Northern Colo. Irr. Co., 10 Colo., 582; Golden Canal Co. *v.* Bright, 8 Colo., 144; Hammond *v.* Rose, 11 Colo., 524; Lobdell *v.* Simpson, 2 Nev., 274; Ophir Silver Mg. Co. *v.* Carpenter, 4 Nev., 534; Dalton *v.* Bowker, 8 Nev., 190; Barnes *v.* Sabron, 10 Nev., 217; Strait *v.* Brown, 16 Nev., 317; Jones *v.* Adams, 19 Nev., 78; Atchison *v.* Peterson, 1 Mont., 561; Barkley *v.* Tielcke, 2 Mont., 59; Keeney *v.* Carillo, 2 N. M., 480; Farmers' High Line Canal *v.* Southworth (Colo.), Lawyer's Rep. (1889) IV, 767; Crane *v.* Winsor, 2 Utah, 248; Monroe *v.* Ivie, 2 Utah, 535; Kaler *v.* Campbell, 13 Ore., 596.

The diversion of the waters of a stream with the object of drainage simply, or without the intention of applying them to some useful purpose, does not constitute an appropriation.

Maeris *v.* Bicknell, 7 Cal., 261; McKinney *v.* Smith, 21 Cal., 374; Thomas *v.* Guiraud, 6 Colo., 530.

Appropriation—Continued.

One who uses the waste water from the mining operations of another acquires by such use no right, unless that water had been turned back into the original channel without any intention of recapture, and thus became *publici juris.*

Woolman *v.* Garringer, 1 Mont., 535.

To constitute a legal appropriation, the water claimed must be applied to some beneficial use or purpose.

Maeris *v.* Bicknell, 7 Cal., 261; Weaver *v.* Eureka Lake Co., 15 Cal., 271; Davis *v.* Gale, 32 Cal., 26; Sieber *v.* Frink, 7 Colo., 148; Larimer R. Co. *v.* People, *ex rel.* Luthe, 8 Colo., 614; Wheeler *v.* Northern Colo. Irr. Co., 10 Colo., 582; Dick *v.* Caldwell, 14 Nev., 167; Farmers' High Line Canal *v.* Southworth (Colo.), Lawyers' Rep. (1889), IV, 767.

The true test of appropriation of water is the successful application thereof to the beneficial use designed, and the method of diverting or carrying the same, or making such application, is immaterial.

Thomas *v.* Guiraud, 6 Colo., 530.

If land be rendered productive by the natural overflow of water thereon without the aid of any appliances whatever, the cultivation of such land by means of the water so naturally moistening the same is a sufficient appropriation of such water to the amount necessary for such use.

Thomas *v.* Guiraud, 6 Colo., 530.

Appropriation completed, relates back:

Although the appropriation is not deemed complete until the actual diversion or use of the water, still if such work be prosecuted with reasonable diligence, the right relates to the time when the first step was taken to secure it.

Kelley *v.* Natoma Water Co., 6 Cal., 105; Maeris *v.* Bicknell, 7 Cal., 261; Kimball *v.* Gearhart, 12 Cal., 27; N. C. & S. C. Co. *v.* Kidd, 37 Cal., 282; Osgood *v.* Water and Mining Co., 56 Cal., 571; Ophir Mining Co. *v.* Carpenter, 4 Nev., 534; Irwin *v.* Strait, 18 Nev., 436; Sieber *v.* Frink, 7 Colo., 148; Wheeler *v.* Northern Colo. Irr. Co., 10 Colo., 582; Columbia Mg. Co. *v.* Holter, 1 Mont., 296.

Appropriation, diligence:

To acquire a right to water from the date of the diversion thereof, one must, within a reasonable time, employ the same in the business for which the appropriation is made. What shall constitute such reasonable time is a question of fact, depending upon the circumstances connected with each particular case.

Conger *v.* Weaver, 6 Cal., 548; Maeris *v.* Bicknell, 7 Cal., 261; Parke *v.* Kilham, 8 Cal., 77; Kimball *v.* Gearhart, 12 Cal., 27; Weaver *v.* Eureka Lake Co., 15 Cal., 271; Sieber *v.* Frink, 7 Colo., 148; Wheeler *v.* Northern Colo. Irr. Co., 10 Colo., 582; Atchison *v.* Peterson, 1 Mont., 561; Keeney *v.* Carillo, 2 N. M., 480; Ophir S. M. Co. *v.* Carpenter, 4 Nev., 534.

Diligence in the prosecution of work such as the appropriation of water by constructing a ditch for its use does not require unusual or extraordinary efforts, but only such constancy or steadiness of purpose or labor as is usual with men engaged in like enterprises, who desire a speedy accomplishment of their designs; such assiduity in its prosecution as will manifest a bona fide intention to complete it within a reasonable time.

Kimball *v.* Gearhart, 12 Cal., 27; Ophir S. Mg. Co. *v.* Carpenter, 4 Nev., 534.

Appropriation, extent of.

The appropriation of the water of a stream for a particular purpose is an appropriation of only so much of the water as is necessary for that purpose, and the surplus, if any, may be taken by others.

Ortman *v.* Dixon, 13 Cal., 33; McKinney *v.* Smith, 21 Cal., 374; Davis *v.* Gale, 32 Cal., 26; Nevada Water Co. *v.* Powell, 34 Cal., 109; N. C. & S. C. Co. *v.* Kidd, 37 Cal., 282; Edgar *v.* Stevenson, 70 Cal., 286; Butte Canal & Ditch Co. *v.* Vaughn, 11 Cal., 143; Barnes *v.* Sabron, 10 Nev., 217; Simpson *v.* Williams, 18 Nev., 432; Lobdell *v.* Simpson, 2 Nev., 274; Sieber *v.* Frink, 7 Colo., 148.

The quantity of water appropriated in any given case is to be measured by the capacity of the ditch or flume at its smallest point; that is, at the point where the least water can be carried through it.

Higgins *v.* Barker, 42 Cal., 233; Atchison *v.* Peterson, 20 Wall., 507; Ophir Mining Co. *v.* Carpenter, 6 Nev., 393; Caruthers *v.* Pemberton, 1 Mont., 111.

Appropriation, extent of—Continued.

Appropriation of all water in a stream means as it ordinarily flows, and another may take the surplus in times of extraordinary high water or freshets.

Edgar v. Stevenson, 70 Cal., 286.

In determining the quantity of water appropriated it is proper to consider the acts of the appropriator, the manner in which the ditch was constructed, the general size, etc. The appropriator would not be limited to the quantity turned into his ditch in the first place, unless by the general plan, size, and grade of the ditch it was not capable of carrying more than was first diverted. If by reason of obstructions or irregularity in the grade of the ditch it was not capable of diverting as much water as its general size would indicate, the appropriator would be allowed a reasonable time to remove such obstructions or adjust the grade, and then fill the ditch to its capacity.

White v. Todd's Valley Water Co., 8 Cal., 443.

The erection of a dam across a natural water-course is an actual appropriation of the waters of the stream to that point, but no farther. Any one may appropriate the water found below the dam.

Kelly v Natoma Water Co., 6 Cal., 105.

If one appropriates a part of the waters of a stream for a certain period of time, any other person may not only appropriate the residue and acquire a right thereto as perfect as the first appropriator, but may also acquire a right to the quantity of water used by the first appropriator at such times as it is not needed or used by him.

Smith v. O'Hara, 43 Cal., 371; Barnes v. Sabron, 10 Nev., 217.

The right to acquire, by the prior appropriator is limited to the amount of water appropriated. In subordination to his right thus limited others may appropriate the remainder of the water running in the stream.

Butte Canal & Ditch Co. v. Vaughn, 11 Cal., 143; Ortman v. Dixon, 13 Cal., 33; McKinney v. Smith, 21 Cal., 374; Nevada Water Co. v. Powell, 34 Cal., 109; Higgins v. Barker, 42 Cal., 233; Brown v. Mullin, 65 Cal., 89; Junkans v. Bergin, 67 Cal., 267; Lobdell v. Simpson, 2 Nev., 274; Proctor v. Jennings, 6 Nev., 83; Barnes v. Sabron, 10 Nev., 217; Strait v. Brown, 16 Nev., 317; Chiatovich v. Davis, 17 Nev., 133; Thomas v. Guiraud, 6 Colo., 530.

The prior appropriator has a right to have the water so appropriated flow down to the point of his appropriation undiminished in quantity and quality. A subsequent appropriator would have the right to use water from said stream in such a manner as not to cause any positive or sensible injury to the former appropriator.

Bear River & Auburn W. & M. Co. v. N. Y. Mg. Co., 8 Cal., 327; Hill v. King, 8 Cal., 336; Butte Canal and Ditch Co. v. Vaughn, 11 Cal., 143; Phœnix Water Co. v. Fletcher, 23 Cal., 482; Natoma W. & M. Co. v. McCoy, 23 Cal., 491; Nevada Water Co. v. Powell, 34 Cal., 109; Stein Canal Co. v. Kern Island Irr. C. Co., 53 Cal., 563; Lobdell v. Simpson, 2 Nev., 274; Crane v. Winsor, 2 Utah, 248.

The right of a riparian proprietor to the waters of a river should be determined by the application of the principles of prior appropriation.

Reno Smelting M. & R. Works v. Stevenson (Nev.) Lawyers' Rep., 1889, IV, 60.

A subsequent appropriator from a natural stream has no right to destroy the ditch of a prior appropriator, or to materially diminish the quantity or deteriorate the quality of the water to which the latter is entitled; nor has the prior appropriator a right to extend his use of water to the prejudice of the subsequent appropriator.

McKinney v. Smith, 21 Cal., 374; Nevada Water Co. v. Powell, 34 Cal., 109; Higgins v. Barker, 42 Cal., 233; Stein Canal Co. v. Kern Island Irr. Co., 53 Cal., 563; Brown v. Mullin, 65 Cal., 89; Junkans v. Bergin, 67 Cal., 267; Lobdell v. Simpson, 2 Nev., 274; Proctor v. Jennings, 6 Nev., 83; Sieber v. Frink, 7 Colo., 148; Larimer County R. Co. v. People, *ex rel.*, 8 Colo., 614.

The right to use water for purposes of irrigation, when its use is not indispensable, but for the purpose of increasing the products of the soil, must be subordinate to the right of a co proprietor to supply his family, tenants, etc., their natural wants for necessary and domestic purposes.

Baker v. Brown, 55 Tex., 377.

Appropriation, extent of, character of use considered in determining.

A beneficial use, without regard to the nature thereof, will sustain the right by appropriation; but the nature of the use may be important as denoting the extent of the water appropriated. Water taken for a mill is not taken as an article of merchandise, to be sold in the market; it is merely taken for use as a motive power, and, having subserved this purpose, may be taken by others.

McDonald *v.* Bear River & Auburn W. & M. Co., 13 Cal., 220.

The appropriation of water to a beneficial use by consumers receiving it through a ditch belonging to a public carrier of water is accomplished at the time the water is actually used beneficially by the consumer, and consumers thereof are not necessarily upon an equality, but may have different priorities of right.

Farmers' High Line Canal *v.* Southworth (Colo.), Lawyers' Rep. (1889), IV, 767.

Appropriation, Indian may acquire right by.

An Indian may acquire a right to the use of water on the public lands by appropriation, and may maintain an action for diversion of such water. This right would carry with it the right to repair a temporary damage to his ditch or dam, and those who might obtain possession under him would have the same right.

Lobdell *v.* Hall, 3 Nev., 507.

Appropriation, manner of making, may be regulated by the legislature.

The legislature can not prohibit the appropriation or diversion of unappropriated water for useful purposes from natural streams upon the public domain, but it may regulate the manner of effecting such appropriation or diversion, and may designate how the water shall be turned from the stream or how it shall be stored and preserved.

Larimer County R. Co. *v.* The People, 8 Colo., 614.

Appropriation, notice, effect of.

A notice of intention to appropriate is evidence of possession, but of itself alone is not sufficient. Taken with other acts it amounts to sufficient evidence. It forms one of a series of acts which, taken together, make the right perfect.

Conger *v.* Weaver, 6 Cal., 548; Thompson *v.* Lee, 8 Cal., 275; Columbia Mining Co. *v.* Holter, 1 Mont., 296.

Appropriation of land and water requires different character of acts.

Public land is appropriated by one character of act, water by another. The digging of a ditch on public land is not an appropriation of land for a mill-site, nor is the mere appropriation of a mill-site an appropriation of water for milling purposes.

Robinson *v.* Imperial Silver Mg. Co., 5 Nev., 44.

Appropriation, right attaches when.

Although one may not have completed his work for diverting or using water, and therefore has not completed his appropriation, yet he has a right to the use of so much of the waters of the stream as may be necessary to prevent his works from injury while in the process of construction.

Weaver *v.* Conger, 10 Cal., 233.

Appropriation, rights acquired by.

An appropriation of water at a given point carries with it an implied authority to do all that shall become necessary to secure the benefit of such appropriation. To this extent the appropriator acquires an easement in the adjoining lands. This right is, however, restricted to the narrowest limits, and it must be exercised in such manner as to occasion as little damage as possible to the owner of the adjoining premises.

Crisman *v.* Heiderer, 5 Colo., 589.

The appropriation of water flowing through the public lands confers no right on the appropriator, either against the Government or its grantees, in the absence of Congressional legislation qualifying the effect of the Government patent. And this is so, although the customs, laws, and decisions of the courts of the States wherein the land lies recognize and enforce rights acquired by prior appropriation in controversies between occupants of public lands without title from the Government.

Union M. & M. Co. *v.* Ferris, 2 Saw., 176.

Appropriation, rights acquired by—Continued.

By appropriation one acquires only the right of possession and use of water, qualified by the right of others to its use, in such manner as shall not materially diminish or deteriorate it, at the place of his appropriation, in quantity or quality.

Columbia Mining Co. *v.* Holter, 1 Mont., 296; Alder Gulch Con. Mg. Co. *v.* Hayes, 6 Mont., 31.

Appropriators, prior and subsequent.

If two parties have acquired rights to the use of the water in a stream and the volume of that water is increased by others turning into said stream the water from their ditch without intention of retaking it, said increase, becoming *publici juris*, does not affect the relative rights of the appropriators. Those rights remain the same as they would if the increase had been due to a natural cause.

Davis *v.* Gale, 32 Cal., 26.

Priority of appropriation shall determine the right to water of a natural stream; the water is not "appropriated" until it is applied to some beneficial use.

Farmers' High Line Canal *v.* Southworth (Colo.), Lawyer's Rep., Ann. 1889, iv., 767.

Appropriators, relative rights.

The question in controversies between two appropriators where the prior appropriator asks damages from the subsequent appropriator, or seeks to restrain him from using the water is, has the prior appropriator's use and enjoyment of the water for the purposes for which he claims its use been impaired by the acts of the subsequent appropriator?

Atchison *v.* Peterson, 20 Wall., 507; Union Water Co. *v.* Crary, 25 Cal., 504; Hill *v.* Smith, 27 Cal., 476.

Different users of water, obtaining their supply through the same ditch, may, under some circumstances, have different priorities of right to the water.

Farmers' High Line Canal *v.* Southworth (Colo.), Lawyer's Report, Ann. 1889, iv, 767.

The appropriation of mining water is open to all persons, and the legislature has no power to enact laws that will permit an irrigating company to control or manage the water of any part of the Territory in disregard of the rights of individual claimants.

Monroe *v.* Ivie, 2 Utah, 535.

Where several parties who had appropriated water from the same stream at different times and in different amounts entered into a contract to construct a new ditch, their several interests in the water to be carried in such ditch must, in the absence of any direct agreement, remain the same as prior to such contract and construction of such ditch, both as to the quantity to which each was entitled and as to the date his rights attached.

Rominger *v.* Squires, 9 Colo., 327.

The use of water for mining purposes is one of the uses recognized and protected by the laws, both of the State and Federal Governments, and while an appropriator of the water of a natural stream is entitled to have such water flow down to him undiminished in quantity, any deterioration in quality occasioned by the use of it above for mining purposes must be an injury without consequent damages.

Bear River W. Co. *v.* New York Mg. Co., 8 Cal., 327.

Appropriator's right co-extensive with his ditch.

The right to have water flow into a ditch is co-extensive with the ditch itself, and when a water-ditch extends into two or more counties an action for damages caused by acts preventing the water from flowing into the ditch, and for an injunction to prevent such acts may be brought in any county into which the ditch extends. Although the act complained of occurred at the head of the ditch, it was injurious to the whole length thereof.

Lower Kings R. D. Co. *v.* Lower Kings R. & F. Co., 60 Cal., 408.

Appropriator's rights in water in a natural stream usufructuary.

An appropriator of water so long as such water continues to flow in its natural course acquires no specific property in the water itself. His rights, like those of a riparian owner, are strictly usufructuary.

Eddy *v.* Simpson, 3 Cal., 249; Kidd *v.* Laird, 15 Cal., 161; McDonald *v.* Askew, 29 Cal., 200; Alder Gulch Con. Mg. Co. *v* Hayes, 6 Mont., 31,

Appropriator, right to remove obstructions.

An appropriator of the waters of a natural stream flowing through public lands has a right, as against subsequent purchasers from the United States, to go upon the land of such purchaser higher up the stream than the point of diversion and remove obstructions from the bed of the stream, so as to cause its waters to flow in their natural channel to the point of diversion.

Ware *v.* Walker, 70 Cal., 591.

Appropriators tenants in common.

Where different persons separately appropriate the waters of a stream and are severally using the same under certain regulations as to the time and manner of such use they are tenants in common, and each of them may maintain an action to enjoin a tresspasser from diverting any portion of the water thus appropriated.

Lytle Creek Water Co. *v.* Perdew, 65 Cal., 447.

Appurtenance.

See Water-right.

Covenant which runs with land.

A covenant between two adjoining land-owners to appropriate and convey the waters of a stream into a reservoir for their joint use runs with the land, and the successor of one on whose land the reservoir is situated can not, by changing the point of diversion, claim all the water.

Weill *v.* Baldwin, 64 Cal., 476.

Customs, local, must be proved.

See Practice.

Dam, appropriation by means of.

When one appropriates water by means of a dam and ditch sufficient for the purpose in the natural condition of the stream as it then existed, he may not afterwards raise his dam higher to obviate obstructions to its use occasioned by physical changes in the stream, whether natural or artificial, if such action on his part would work an injury to subsequent appropriators who were not responsible for the changes in the stream.

Nevada Water Co. *v.* Powell, 34 Cal., 109.

Dam, duty of owner.

The owner of a dam is bound to see to his property, and to so govern and control it that injury may not result to his neighbors.

Fraler *v.* Sears Union Water Co., 12 Cal., 555.

Dam, harmless when erected, may not be abated.

A dam erected on a stream in a manner nowise injurious or prejudicial at the time of its erection to rights of others on the same stream, but which, by reason of circumstances that could not have been anticipated, happening subsequently and operating in connection with it, does cause injury to others, is not such an obstruction as to authorize its abatement or justify a recovery of damages against the person so building the dam for injury thus occasioned.

Proctor *v.* Jennings, 6 Nev., 83.

Damages, actual, not necessary to an equitable relief against wrongful diversion of water.

Equitable relief will be granted for a wrongful diversion of water, even though no actual damage is shown. Every violation of a right imports damage, and this principle is applied whenever the act done is of such a nature as that by its repetition or continuance it may become the foundation of an adverse right.

Barnes *v.* Sabron, 10 Nev., 217.

Damages, when actual, necessary to justify an action.

See Injury; not always necessary to justify an action.

Damage by breaking of dam or ditch.

See Negligence.

Damages from ravine adopted as part of a ditch, who responsible for.

One who adopts a natural water-course as a part of his ditch does so to the extent of the capacity of his ditch, and he is liable for injuries to lands resulting from an overflow of that water-course caused by his failure to have it properly cleared of obstructions or of his turning into it a quantity of water which, added to the natural waters flowing therein, exceeded its carrying capacity.

Richardson *v.* Kier, 34 Cal., 63; Richardson *v.* Kier, 34 Cal., 263.

Damages, liability of corporation to stockholders.

Where several persons owning a ditch and water right form a corporation, the express object of which is to own, keep in repair, and enlarge such ditch, and to control and divide the use of said water for the benefit of the several stockholders in accordance with their interests in the stock of said corporation, that corporation is bound to discharge the duties prescribed in the certificate of incorporation, and for any failure or neglect to discharge these duties it would be liable to any stockholder who is injured thereby to the extent of his damages.

O'Connor *v.* North Truckee Ditch Co., 17 Nev., 245.

Damages, when ditch-owner liable for.

A ditch-owner would be liable for an injury caused wantonly or by gross negligence; but he is not liable for a mere accidental injury, where no negligence is shown, to a miner locating along the line of such ditch subsequently to the construction thereof, neither party claiming ownership of the soil.

Tenney *v.* Miners' Ditch Co., 7 Cal., 335.

Damages, when prior appropriator entitled to recover.

A prior appropriator of water is entitled to recover damages for injuries caused by the acts of subsequent appropriators on the stream above in erecting dams or other obstructions, by which the regularity of the flow of water is so disturbed as to cause actual injury, or in diverting the water to the use of which he is entitled.

Coker *v.* Simpson, 7 Cal., 340; Phœnix Water Co. *v.* Fletcher, 23 Cal., 481; Natoma Water and Mg. Co. *v.* McCoy, 23 Cal., 490.

Deed, construction of.

A deed which conveys a certain tract of land, and also the prior right to the use of a part of the water of a stream flowing through said land, must be construed as conveying a right to water over and above that of a mere riparian owner.

Dalton *v.* Bowker, 8 Nev., 190.

Diligence in perfecting appropriation.

In determining whether the work necessary to the appropriation of water has been prosecuted with diligence, it is proper to take into consideration the circumstances surrounding the parties which would affect any person who might be engaged in the same undertaking, such as the nature and climate of the country, the condition of the weather, and the difficulties of procuring labor and materials.

Kimball *v.* Gearhart, 12 Cal., 27; Ophir S. M. Co. *v.* Carpenter, 4 Nev., 534.

In determining whether diligence has been exercised in prosecuting the work for the appropriation of water, matters incident to the enterprise, and not those incident to the person, such as the illness of the appropriator or his lack of pecuniary means to prosecute the work, are to be considered in excuse for great delay.

Ophir S. M. Co. *v.* Carpenter, 4 Nev., 534; Keeney *v.* Carillo, 2 N. M., 480.

Distribution of water for public use.

See Ditch-owners are public carriers.

Ditch, authority of court of equity over.

If one own a ditch, and right of way for same, a court of equity has no authority by its judgment to allow the ditch to be washed away for mining purposes, even after providing that such portion of the ditch as might be destroyed should be replaced by a metal pipe or flume which would answer all purposes of the ditch. The court should not license a trespass on such property, or compel the owner thereof to exchange the same for other property for the convenience of a private person.

Gregory *v.* Nelson, 41 Cal., 278.

Ditch capacity, how proved.

The carrying capacity of a ditch is a question of fact, which does not require for its proof unusual scientific attainments or peculiar skill. Men who have acquired a knowledge upon such subjects from experience in mining and in measuring and selling water to miners as non-experts are as competent as experts to testify to the fact.

Frey *v.* Lowden, 70 Cal., 550.

Ditch, conveyance of.

See Right of way, conveyance of, water-right, when an appurtenance.

Ditch, enlargement of.

If one is entitled to all the waters of a stream at the point where his ditch starts out, the capacity of that ditch or its enlargement is of no moment to others having ditches on the stream.

James *v.* Williams, 31 Cal., 211.

Ditch, character of, as an excavation not changed by flumes at different points.

Flumes constructed at different parts of the line of a ditch can not change the general character of the work as an excavation; such flumes are merely connecting links and a part of the ditch. A statute giving a lien for labor bestowed or material furnished upon buildings, wharves, or other superstructures does not include ditches. Equity raises no lien in regard to real estate, except that of a vendor for purchase money.

Ellison *v.* Jackson Water Co., 12 Cal., 542; Horn *v.* Jones, 28 Cal., 194.

Ditches, liability of owner for damages from.

See Negligence.

Ditch-owners and miners, relative rights.

The two rights to work the mines and to divert the water of steams from the natural channels stand upon an equal footing, and when they conflict they must be decided by the fact of priority upon the maxim of equity, *Qui prior est in tempore, potior est in jure.*

Irwin *v.* Phillips, 5 Cal., 140; Wixon *v.* Bear River & Auburn W. & M. Co., 24 Cal., 367; Levaroni *v.* Miller, 34 Cal., 231.

The owner of a mining claim and the owner of a ditch or water-right stand upon the same footing; that is, their respective rights attach from the date of appropriation, the first in time being the first in right; but where both rights can be enjoyed without interference with or material impairment of each other, the enjoyment of both is allowed.

Jennison *v.* Kirk, 98 U. S., 453; Hill *v.* Smith, 27 Cal., 476; Clark *v.* Willett, 35 Cal., 534.

Ditch-owners are public carriers.

Owners of ditches or canals, as such, are carriers and quasi-public servants. They are awarded certain privileges, and are charged with certain duties and subject to reasonable control.

Price *v.* Riverside L. & I. Co., 56 Cal., 431; McCrary *v.* Beaudry, 67 Cal., 120; Wheeler *v.* Northern Colo. Irr. Co., 10 Colo., 582.

Ditch-owners as carriers, duties of.

Ditch-owners, as such, are carriers, and must furnish water at the established rate (the county commissioners being empowered to fix a maximum rate) to the class of persons using it in the manner named in the articles of incorporation.

Golden Canal Co. *v.* Bright, 8 Colo., 144; Wheeler *v.* Northern Colo. Irr. Co., 10 Colo., 582.

Ditch, right of way for.

See Easement, Right of way.

Ditch, water-rights co-extensive with.

See Appropriator's right.

Ditch, repairs of, liability for.

See Estoppel.

Ditch, value of, how proved.

The ordinary way of proving the value of a ditch is by showing its capacity, the value of the water in its vicinity, and the probable duration of the demand.

Clark *v.* Willett, 35 Cal., 534.

Diversion of water from reservoir will be enjoined, when.

One who constructs on the public lands a reservoir to collect and store, for the purposes of irrigation, the water flowing down a ravine, acquires a vested right of property in the reservoir and water, of which he can not be divested for mining or other private purposes, and a court of equity will enjoin miners from injuring the reservoir or diverting the water therefrom.

Rupley *v.* Welch, 23 Cal., 452.

Diversion of water illegal, may be prevented.

One attempting to illegally divert water belonging to another may be ejected from the possession of ground occupied by him for completing such illegal diversion, and can not complain of the means taken to defeat his object.

Butte Table Mountain Co. *v.* Morgan, 19 Cal., 609.

Diversion of water, liability for.

One who diverts the water of a natural water-course, that was accustomed to flow through the land of another, and that other thereby suffers injury, is liable to damages for the injury thus inflicted.

Ellis *v.* Tone, 58 Cal., 289.

In an action for diversion of water, the defendant is not liable for damages to another appropriator from the same stream resulting from a deficiency of the water supply, unless he was diverting from the stream more water than he was entitled to at the precise time the deficiency complained of existed.

Brown *v.* Smith, 10 Cal., 508.

Diversion of water; pleading in action for.

In an action for diversion of water, the fact that the diversion was accomplished by one means or another is not important enough to require several counts setting forth the different modes of diversion.

Gale *v.* Tuolumne Water Co., 14 Cal., 25.

Diversion, right of.

See Appropriation.

Diversion, right of, as affected by recital in deed.

See Estoppel.

Diversion, riparian owner's right of.

See Riparian rights.

Diversion, sufficient allegation in complaint for.

The allegation, in a complaint for the diversion of water, that the plaintiff was entitled by virtue of prior appropriation to all the water flowing in the stream at the head of his ditch, entitles him to prove a diversion of water from smaller branches of the stream supplying water to that point.

Priest *v.* Union Canal Co., 6 Cal., 170.

Diversion of water, wrongful, may be restrained.

Equity will restrain the continuous wrongful diversion of water at the instance of a prior appropriator thereof, although no actual damages are averred or proved. Equitable relief is granted in such cases to prevent wrongful acts from ripening into a right.

Moore *v.* Clear Lake Water Works, 68 Cal., 146.

Easement for flow of water.

The rule that the owner of a tract of land has an easement in a lower adjacent tract to the extent of burdening it with the water naturally flowing to it from the upper tract applies only to waters naturally so flowing, and the servitude of the lower tract can not be made more burdensome by the acts or industry of man.

Ogburn *v.* Connor, 46 Cal., 346; Boynton *v.* Longley, 19 Nev., 69.

Easement for irrigating purposes.

All lands in this Territory are held in subordination to the dominant right of others who must necessarily pass over them to obtain a supply of water to irrigate their lands. It is not, therefore, necessary that there should be a conveyance in writing to establish an easement for right of way for a ditch.

Yunker *v.* Nichols, 1 Colo., 551.

Easement, grant of right of way for a ditch.

A grant of the right to all the water in a stream, and of the right to enter on the land of the grantor and construct and maintain all dams, ditches, pipes, or flumes necessary and proper for conveying such water over said land to the place of its use, vests in the grantee the right to convey said water at different times and places, or to change or enlarge his ditch, and to use it in any manner he pleases, if the grantor is not injured by such use.

Spear *v.* Cook, 8 Ore., 380.

Easement on public lands.

See Statutes, act of July 26, 1866, Appropriator, right to remove obstructions.

Easement, right of way for ditch.

A grant of the right of way for a ditch over a tract of land is an easement only, and is not a grant of the land or water flowing over it. When an easement is granted, nothing passes as an incident to such grant but what is necessary for its reasonable and proper enjoyment.

Miller *v.* Vaughn, 8 Ore., 333.

Easement, right of way under act of July 26, 1866.

To one who had, prior to the passage of the act of July 26, 1866, constructed a ditch over public land and had acquired a right to the water carried therein, recognized by the local customs, laws, and decisions of the courts, that act operated as a grant of the right of way, and of the ditch through which the water was running at the date thereof.

Broder *v.* Natoma Water Co., 101 U. S., 274; Broder *v.* Natoma Water Co., 50 Cal., 621.

Eminent domain.

Statutes conferring the power to condemn private property to the use of another without the consent of the owner are in derogation of the common law and must be strictly construed.

San Francisco and Alameda W. Co. *v.* Alameda W. Co., 36 Cal., 639.

The supplying of the inhabitants of a town with pure, fresh water is a public use, in behalf of which a corporation is authorized to exercise the right of eminent domain. The right of an individual to enjoy the flow of water in its natural channel upon or along his land may, under the laws of this State, be condemned for public use.

Heyneman *v.* Blake, 19 Cal., 579; St. Helena Water Co. *v.* Forbes, 62 Cal., 182; Spring Valley W. Works *v.* San Mateo W. Works, 64 Cal., 123; Lux *v.* Haggin, 69 Cal., 255.

The right of eminent domain is restricted to the taking of private property for public use. It can not be exercised in favor of the owners of mining claims, to enable them to obtain water for their own use in working such claims, though the intention may also be to supply the water to others for mining and irrigating purposes.

Lorenz *v.* Jacob, 63 Cal., 73.

To authorize the condemnation of private property there must be a real necessity; the mere fact that it would be convenient and profitable to the corporation to acquire the property would not justify the exercise of the right of eminent domain.

Spring Valley W. Works *v.* San Mateo W. Works, 54 Cal., 123.

The proprietor of an irrigating ditch has a property ownership both in the ditch and the right of way therefor, which can not be taken or damaged for public use, except upon payment of just compensation.

Tripp *v.* Overocker, 7 Colo., 72.

Estoppel.

One having a right by prior appropriation to the use of the waters of a stream, who stands by and allows another to purchase from a third party wrongfully claiming to have the right to said water, without asserting or making known his claim, is estopped from afterwards asserting that claim.

Fabian *v.* Collins, 3 Mont., 215.

If a prior appropriator of the water of a stream stood by and saw another appropriate the water of that stream at great expense, under the mistaken idea that he was thereby acquiring a prior right thereto, and did not inform him of the mistake, he, the prior appropriator, and his vendors are estopped from afterwards claiming such water.

Parke *v.* Kilham, 8 Cal., 78.

Estoppel—Continued.

The facts that a ditch was constructed at heavy cost and was maintained and used with the knowledge of the true owners, and without any objection or opposition on their part, are not sufficient to operate an estoppel. There must be some degree of turpitude in the conduct of a party before a court of equity will estop him from the assertion of his title.

Biddle Boggs *v.* Merced Mg. Co., 14 Cal., 279; Anaheim Water Co. *v.* Semi-Tropic Water Co., 64 Cal., 185; Stockman *v.* Riverside L. and I. Co., 64 Cal., 57; Lux *v.* Haggin, 69 Cal., 255.

Estoppel, recital in deed.

A recital in a deed to the effect that the grantee is about to divert the waters of a certain stream (which flowed through the grantor's land), and to appropriate the same, followed by a grant of the right of way to conduct water over the land of the grantor, does not estop said grantor from denying the right of the grantee to divert the waters of said stream.

Zimmler, adm'r, *v.* San Luis Water Co., 57 Cal., 221.

Estoppel, use of water, notice.

One who acquires a right to the use of a part of the water of a ditch, not to exceed a certain definite amount, upon condition of paying his *pro rata* share of the needed repairs, has the option of using whatever amount he may desire within the fixed limit and he will not be held liable beyond the proportion so used; if, however, he gives notice that he will require a certain amount, he will be bound by such notice, and estopped from showing that he did not need or use that amount.

Brown *v.* Evans, 18 Nev., 141.

Flumes do not change general character of a ditch.

See Ditch, character of, not changed by flumes.

Foreign water.

See Water-course, natural, may be utilized.

Government, right of, as riparian owner.

See Riparian rights, Government as owner.

Indian, appropriation by.

See Appropriation, Indian may acquire right by.

Injunction, decree construed.

A decree which forbids interference with the waters of a creek which rise above a certain dam does not prohibit the use and enjoyment of the waters which may remain and flow down after the ditch of the complaining party has been supplied, but simply prevents interference with the water above the dam or the amount necessary to fill such ditch.

American Co. *v.* Bradford, 27 Cal., 360.

Injunction, jurisdiction of superior courts.

The superior courts in California have jurisdiction to grant a preliminary injunction restraining an alleged trespasser from diverting the waters of a stream during litigation and to require him to remove the means by which the diversion is made.

Johnson *v.* Superior Court, 65 Cal., 567.

Injunction granted to prevent acts injurious to a water right.

An appropriator of water is entitled to protection against acts which materially diminish the quantity of water to which he is entitled or deteriorate its quality for use to which he desires to apply it. Equity affords the appropriate remedy, by way of an injunction, for such wrongs.

Cole Silver Mg. Co. *v.* Virginia Gold Hill W. Co., 1 Saw., 470; Tuolumne Water Co. *v.* Chapman, 8 Cal., 392; Rupley *v.* Welch, 23 Cal., 452; Phœnix Water Co. *v.* Fletcher, 23 Cal., 481; Moore *v.* Clear Lake Water Works, 68 Cal., 146; Lake *v.* Tolles, 8 Nev., 285; Barnes *v.* Sabron, 10 Nev., 217; Harris *v.* Shontz, 1 Mont., 212; Gallagher *v.* Basey, 1 Mont., 457; Barkley *v.* Tieleke, 2 Mont., 59; Fabian *v.* Collins, 3 Mont., 215; Schilling *v.* Rominger, 4 Colo., 100; Keeney *v.* Carillo, 2 N. M., 480; Crane *v.* Winsor, 2 Utah, 248.

Injunction the proper remedy for injury to a riparian right.

Equity, by way of injunction, affords to a riparian proprietor the proper remedy against the wrongful diversion or obstruction of the waters of a natural water-course.

Lux *v.* Haggin, 69 Cal., 255; Shively *v.* Hume, 10 Ore., 76; Weiss *v.* Oregon Iron and Steel Co., 10 Ore., 496.

Injunction, when issued to protect water rights.

Where it is shown that the injury to a water right is continuing or likely to be continued, a judgment for damages may be sustained, but an injunction should not issue.

Coker *v.* Simpson, 7 Cal., 340.

Injunction, when, will be granted to prevent injury to a water right.

Whether a court of equity will interfere to restrain acts claimed to be injurious to the rights of a prior appropriator of water will depend upon the character and extent of the injury alleged, whether it be irremediable in its nature, whether an action at law would afford an adequate remedy, whether the parties are able to respond for the damages resulting from the injury, and other considerations which ordinarily govern a court of equity in the exercise of its preventive process of injunction.

Atchison *v.* Peterson, 20 Wall., 507.

Injury not always necessary to justify an action.

There may be an invasion of a right which will justify an action although actual damage is not shown. But a distinction must be taken between those uses of water which are the exercise of the riparian proprietor's natural rights and those which are not; in the former case actual damage must be shown, but need not be in the latter.

Union M. & M. Company *v.* Dangberg, 2 Saw., 450.

Injury to joint property.

If one of two joint owners of a flume used for mining purposes consents to or directs the cutting of a water ditch above the flume, whereby the water from the ditch flows over and injures the flume, the parties thus opening the ditch, in compliance with the request of one of the joint owners of the injured property, can not be held liable for the injuries that followed.

Crary *v.* Campbell, 24 Cal., 634.

Injury to water used for mining.

Where a large number of persons are mining on a small stream and each deteriorates the water a little, so that the combined acts of all render the water unfit for use, each of such persons can not successfully defend an action on the ground that his act alone did not materially affect the water.

Hill *v.* Smith, 32 Cal., 166.

Injury, who liable for.

Where two or more parties act, each for himself, in producing a result injurious to another, they can not be held jointly liable for the acts of each other.

Blaisdell *v.* Stephens, 14 Nev., 17.

Invasion of water right, remedy for.

See Injunction granted to prevent acts injurious to a water right.

Irrigation.

See Eminent domain, riparian rights, use for street sprinkling.

Joint liability.

See Injury, who liable for.

Joint property, liability for injury to.

See Injury to joint property.

Jurisdiction of suit for injury to water right.

See Ditch, water right co-extensive with.

Land, condemnation of, for ditch purposes.

See Eminent domain.

Land, covenant which runs with.

See Covenant which runs with land.

Land, possession sufficient for maintenance of action for injury thereto.

See Possession.

Liability of corporation to stockholders.

See Damages, liability of corporation to stockholders.

Limitations, statute of.

The statute of limitations does not commence to run with regard to lands held under a Mexican or Spanish grant until the final confirmation thereof by the Government of the United States.

Richardson *v.* Williamson, 24 Cal., 289; Reed *v.* Spicer, 27 Cal., 57; Anderson *v.* Fisk, 36 Cal., 625.

Limitations, statute of, effect on action for diversion of water.

Actions for diversion of water must be brought within the period prescribed by the statute of limitations after the date the cause of action accrued. The continuance of the wrongful diversion is a new cause of action or a new nuisance.

Toombs *v.* Hornbuckle, 3 Mont., 193.

An adverse, exclusive, and uninterrupted use and enjoyment by one person and those under whom he claims of all the water of a creek taken therefrom by means of a ditch and conveyed to certain mining grounds for mining purposes for twelve years, or for any period beyond that of the statute of limitations prescribing the time of entry shall be made upon real property, will bar the owner of the land through which the creek runs of his riparian rights; but where the ditch was constructed in which he reserved the right to use the water a part of each year for his own purposes such adverse use by grantees from the original appropriator can not be established unless it is shown that the use of the water by them has been in hostility to the use of it by the owner under such reservation.

Huston *v.* Bybee, Ore., Lawyer's Reports, 1889, II, 568.

Maintenance of ditch, extent of liability for.

See Estoppel, Use of water, Notice.

Miners and agriculturists, relative rights.

Where the titles of two parties to public mineral land rest on possession alone—one using it for mining and the other for agricultural purposes—the older possession, as between the two, gives the better right. In the use of their lands they are to be governed by the common-law rule applicable to adjoining land-owners, expressed in the maxim, *Sic utere tuo ut alienum non lædas.*

Wixon *v.* Bear River & Auburn W. & Mg. Co., 24 Cal., 367; Gibson *v.* Puchta, 33 Cal., 310.

Miners' rights.

Miners have no right to enter upon private land and subject it to such uses as may be necessary to extract the precious metals which it may contain. These operations are calculated to destroy the entire value of the land, and will be restrained by injunction.

Boggs *v.* Merced Mining Co., 14 Cal., 279; Henshaw *v.* Clark, 14 Cal., 461.

Miners' rights, injury to.

See Injury to water used for mining.

Miners' rights not superior to those of other appropriators.

The rights of miners and persons owning ditches constructed for mining purposes are not necessarily paramount to other rights and interests of a different character, but their superiority must rest upon priority in acquisition. One who appropriates for mining purposes the waters of a stream must take and use the same in such manner as not to injure the property rights of others acquired prior to the time the water was thus appropriated.

Wixon *v.* B. R. and A. W. & M. Co., 24 Cal., 367; Hill *v.* Smith, 27 Cal., 476; Levaroni *v.* Miller, 34 Cal., 231.

Miners' rights to water of a stream.

The true rule governing the rights of several miners located on the same stream is that each is entitled to use in a proper and reasonable manner both the channel of the stream and the water flowing therein, and where, from the situation of the claims, the natural and necessary consequence of the working of some will result in injury to others it will be *damnum absque injuria*, and will furnish no cause of action to the party injured.

Esmond *v.* Chew, 15 Cal., 137.

See Appropriation, rights acquired by.

Miners' rights, rule governing.

Miners who have located claims on the side of a hill subsequently to the location of others in the bed of a stream in the vicinity must so use and work their claims as not to injure those of the prior locators.

Logan *v.* Driscoll, 19 Cal., 623.

Navigable stream defined.

Where a stream is naturally of sufficient size to float mill-logs, timber, and small boats, the public have a right to its free use for that purpose; nor is it essential that such capacity continue through the year.

Shaw *v.* Oswego Iron Co., 10 Ore., 371.

Negligence, liability for, in construction of dam or ditch.

One who constructs a dam or ditch for the purpose of appropriating water is bound to exercise in the construction and management thereof that degree of care and prudence which men generally, or ordinarily prudent men, use in like instances when the whole risk is their own. Both the degree and fact of prudence must depend upon the particular circumstances.

Hoffman *v.* Tuolumne County W. Co., 10 Cal., 412; Wolf *v.* St. Louis Independent Water Co., 10 Cal., 541; Fraler *v.* Sears Union Water Co., 12 Cal., 555; Burbank *v.* W. Walker River Ditch Co., 13 Nev., 431; Turner *v.* Tuolumne County W. Co., 25 Cal., 398; Richardson *v.* Kier, 34 Cal., 63; Campbell *v.* B. R. & A. W. & M. Co., 35 Cal., 679.

Notice of appropriation.

An appropriator of water who, after duly posting a notice of his intention to take the water and while prosecuting the work for perfecting such appropriation, posts a second notice of intention to take the same water, does not thereby abandon his claim under the first notice. Notices of intention to appropriate water are to be liberally construed.

Osgood *v.* El Dorado Co., 56 Cal., 571.

Notice of appropriation.

The notice of intention to appropriate, in order to cause such appropriation to relate to the date of the notice, must be sufficient to put a prudent man on inquiry.

Kimball *v.* Gearhart, 12 Cal., 27; Robinson *v.* Imperial Silver Mg. Co., 5 Nev., 44.

Notice of nuisance, when necessary.

A party who continues a nuisance, but is not the original creator of it, is entitled to notice that it is a nuisance, and a request must be made that it may be abated before an action will lie for that purpose, unless it appear that he had knowledge of its hurtful character; when the extent of the nuisance was increased by such party the rule is otherwise.

Grigsby *v.* Clear Lake W. Co., 40 Cal., 396.

Notice, what, necessary.

The inclosure of ground is not necessary to give notice of appropriation of public land for a canal or ditch.

Conger *v.* Weaver, 6 Cal., 548.

Nuisance, diversion of water.

See Action for diversion of water.

The diversion of a water-course or of water from one rightfully entitled to the use thereof is a private nuisance.

Parke *v.* Kilham, 8 Cal., 77; Tuolumne Water Co. *v.* Chapman, 8 Cal., 392.

Nuisance, pollution of water.

The owners of a water ditch are entitled to have the water flow therein in its natural state when they claim such water by appropriation, and its pollution by a stranger is a private nuisance.

Crane *v.* Winsor, 2 Utah, 248.

Nuisance, parties defendant.

Where several parties owning mines at different points on the same stream or its tributaries discharge the débris from said mines into the stream, by which it is carried down and deposited on the lands of another, said miners may all be properly made parties defendant in a suit to enjoin such action.

The Mining Débris Case, 8 Saw., 628.

Nuisance, public, a private person may maintain an action against.

A private person may maintain an action against a public nuisance if it is specially injurious to himself or his property.

The Mining Débris Case, 9 Saw., 441; Blanc *v.* Klumpke, 29 Cal., 156; Grigsby *v.* Clear Lake Water Co., 40 Cal., 396.

Nuisance, when notice before action to abate necessary.

See Notice of nuisance, when necessary.

Nuisance, who may sue to enjoin.

One tenant in common of land injured by a public and private nuisance may sue to enjoin the nuisance without making his co-tenant a party to such suit either as complainant or defendant.

The Mining Débris Case, 8 Saw., 628.

Obstruction, right of appropriator to remove.

See Appropriator, right to remove obstruction.

Obstruction, right of riparian proprietor to place, in the stream.

See Riparian rights.

Overflow of land, prescriptive right.

See Easement for flow of water.

Owner of ditch, public carrier.

See Ditch-owners as carriers, duties of.

Parties, proper in action for diversion.

The several appropriators of the water of a stream have not that community of interest that would qualify them to maintain a joint action for the diversion of the water and for a settlement of the various rights of such appropriators.

Schultz *v.* Winter, 7 Nev., 130.

Parties, who necessary, in suits concerning water rights.

In an action to determine the relative rights of parties to the use of the water of a stream, those persons above who have diverted water from said stream and returned it undiminished in quantity before it reaches the party claiming to be injured are not necessary parties to such suit.

Smith *v.* Logan, 18 Nev., 149.

Partition of water.

Water flowing in a ditch is not susceptible of division, and where such property is held by tenants in common, the only partition the courts can make is to order a sale and a distribution of the proceeds.

McGillivray *v.* Evans, 27 Cal., 92; Lorenz *v.* Jacobs, 59 Cal., 262.

Partners, conveyance by one does not affect the interests of the other.

One of two parties who appropriate water by means of a ditch can convey only his interest therein; he can not by his conveyance affect the interest of the other in the water nor his right to the use of the ditch for the flow of the water to which he is entitled.

Henderson *v.* Nichols, 67 Cal., 152.

Percolating water.

Percolating water, or water passing through the soil in any manner other than in a well-defined channel, cannot be distinguished from the estate itself, and the owner of the soil may use it as he may desire, free from any usufructuary rights of others.

Hanson *v.* McCue, 42 Cal., 303; Huston *v.* Leach, 53 Cal., 262; Cross *v.* Kitts, 69 Cal., 217; Mosier *v.* Caldwell, 7 Nev., 363; Strait *v.* Brown, 16 Nev., 317.

Percolating water.

When it does not appear that a spring is fed by any defined flowing stream, it must be presumed that it is formed by the ordinary percolations of water in the soil.

Hanson *v.* McCue, 42 Cal., 303.

Personal property, when water becomes.

Water, when collected in reservoirs or pipes, and thus separated from the original source of supply, is personal property, and is as much the subject of sale as ordinary goods and merchandise.

Heyneman *v.* Blake, 19 Cal., 579.

Place of use.

The right to water acquired by prior appropriation is not in any way dependent upon the *locus* of its application to the beneficial use designed or to the particular use to which it was first applied.

Atchison *v.* Peterson, 20 Wall., 507; Maeris *v.* Bicknell, 7 Cal., 261; McDonald *v.* B. R. & A. W. & Mg. Co., 13 Cal., 220; Davis *v.* Gale, 32 Cal., 26; Coffin *v.* Left Hand Ditch Co., 6 Colo., 443; Thomas *v.* Guiraud, 6 Colo., 530; Woolman *v.* Garringer, 1 Mont., 535.

Point of diversion.

One entitled to divert a quantity of water from a stream may take the same at any point on the stream, and may change the point of diversion if the rights of others be not injuriously affected by the change.

Kidd *v.* Laird, 15 Cal., 161; Butte Table Mg. Co. *v.* Morgan, 19 Cal., 609; Junkans *v.* Bergin, 67 Cal., 267; Sieber *v.* Frink, 7 Colo., 148; Hobart *v.* Wicks, 15 Nev., 418.

One entitled to divert a quantity of water from a stream can not change the point of diversion, if by such change the rights of other appropriators be injuriously affected.

Butte Table Mg. Co. *v.* Morgan, 19 Cal., 609; Nevada Water Co. *v.* Powell, 34. Cal., 109; Columbia Mg. Co. *v.* Holter, 1 Mont., 296.

One having acquired a right to divert water, whether by express grant or by prescription, whether such right rests in the parole license or the presumed consent of the proprietor, may change the point of diversion at pleasure, if the rights of others are not injuriously affected by such change. The difference as to the manner in which such a right was acquired relates to the mode of determining the existence and extent of the right, and not to the manner of its exercise and enjoyment.

Kidd *v.* Laird, 15 Cal., 161.

Pollution of water a nuisance.

See Nuisance, pollution of water.

Possession sufficient to maintain action for injury to land.

The rightful possession of land is sufficient to enable one to maintain an action for an interruption to that possession or for any injury to the property.

Crandall *v.* Woods, 8 Cal., 136; McDonald *v.* B. R. & A. W. & M. Co., 13 Cal., 220; Norris *v.* Glenn, 1 Idaho, 590; Simpson *v.* Williams, 18 Nev., 432.

Powers of water commissioners.

See Water commissioners.

Practice, distinct causes of action.

An entry upon and ouster from a dam-site and dam in process of construction and a canal-site, and canal in process of construction, and a diversion of the water claimed by means of the dam and canal, are two distinct causes of action, which can not be united in the same statement of cause of action in a complaint, but should be separately stated.

N. C. & S. Canal Co. *v.* Kidd, 37 Cal., 282.

Practice, local customs must be proven.

Courts will not take judicial notice of local customs. One who alleges the existence of a right to water appropriated under a local custom, such as is recognized by the act of July 26, 1866, must prove the existence of such custom.

Lewis *v.* McClure, 8 Ore., 273.

Prescription.

A right to the use of water may be acquired by an exclusive and uninterrupted enjoyment of the water in a particular way for a period corresponding to the time fixed by statute of limitations as a bar to an entry on land.

Crandall *v.* Woods, 8 Cal., 136; Union Water Co. *v.* Crary, 25 Cal., 504; American Co. *v.* Bradford, 27 Cal., 360; Los Angeles *v.* Baldwin, 53 Cal., 469.

Prescription—Continued.

One who was allowed, at a time when there was sufficient water in the stream to supply the wants and demands of all parties, to divert and use water without objection by a riparian owner or former appropriator, but whose use and diversion were objected to when the water became scarce and the supply insufficient for all, does not by such use acquire a prescriptive right to such water.

Felix v. City of Los Angeles, 58 Cal., 73; Anaheim Water Co. v. Semi-Tropic Water Co., 64 Cal., 185.

No right by prescription can be acquired as against the Government.

Union M. & M. Co. v. Ferris, 2 Saw., 176; Mathew v. Ferrea, 45 Cal., 51; Ogburn v. Conner, 46 Cal., 346; Wilkins v. McCue, 46 Cal., 656; Vansickle v. Haines, 7 Nev., 249.

If one goes upon public land of the United States and appropriates water for a lawful purpose, and is permitted to continue in its adverse enjoyment and use for more than ten years, such appropriation ripens into a title which can not be disturbed by one succeeding to the rights of the United States.

Tolman v. Casey, 15 Ore., 83.

One who has acquired a prescriptive right to the use of water as against a proprietor on a natural stream can not claim such right against the same person as to lands lying farther down the stream and afterwards acquired from the Government by him.

Union M. & M. Co. v. Ferris, 2 Saw., 176.

Prescription, burden of proof.

The burden of proving an adverse use of water for the statutory period, with the knowledge and acquiescence of the person having the prior right, is cast upon the person alleging such adverse use.

Union M. & M. Co. v. Ferris, 2 Saw., 176; the Mining Débris Case, 9 Saw., 441; American Co. v. Bradford, 27 Cal., 360.

Prescription, extent of right.

The right acquired by prescription is measured by the right enjoyed; it is always confined to the right as exercised for the full period of time prescribed by the statute.

Boynton v. Longley, 19 Nev., 69.

Prescription pleadings.

One claiming a right to water by virtue of the adverse use thereof for the statutory period must set up said right in his pleadings in order to entitle him to submit testimony in support of such claim.

American Co. v. Bradford, 27 Cal., 360; Lux v. Haggin, 69 Cal., 255.

Prescription, what necessary to establish right by.

One who claims a right to water by reason of an adverse use for the statutory period must show that such use was open, peaceable, and uninterrupted, and under claim or color of right.

Union M. & M. Co. v. Dangberg, 2 Saw., 450; the Mining Débris Case, 9 Saw., 441; Grigsby v. Clear Lake Water Co., 40 Cal., 396; Cave v. Crafts, 53 Cal., 135; Ledu v. Jim Yet Wa, 67 Cal., 346; Winter v. Winter, 8 Nev., 129.

To establish a right by prescription or adverse use, the acts by which such right is sought to be established must operate as an invasion of the rights of the party against whom it is set up. The enjoyment relied upon must be of such a character as to afford ground for an action by the other party.

Union M. and M. Co. v. Ferris, 2 Saw., 176; Grigsby v. Clear Lake Water Co., 40 Cal., 396; Anaheim Water Co. v. Semi-Tropic Water Co., 64 Cal., 185; Dick v. Bird, 14 Nev., 161; Dick v. Caldwell, 14 Nev., 167; Boynton v. Clear Lake Water Co., 40 Cal., 396.

Prescription right to overflow land.

See Easement for overflow of water.

Prior appropriation.

See Appropriation.

Private property may be taken for public use.

See Eminent domain.

Property of Government in stream.

The Government, as proprietor of lands through which a stream of water naturally flows, has the same property right in the stream that any other owner of land has, be it usufructuary otherwise.

Union M. and M. Co. v. Ferris, 2 Saw., 176; The Mining Débris Case, 9 Saw., 441; Lux v. Haggin, 69 Cal., 255; Vansickle v. Haines, 7 Nev., 249.

Protection of land against stream, right of.

See Riparian proprietor.

Public land, easement on.

Land claimed by a pre-emptor remains public land until he proves up and pays for it. Land upon which pre-emption filing is placed after the passage of the acts of July 26, 1866, and July 9, 1870, may at any time before proof and payment be subjected to the right of way for a ditch or reservoir under the provisions of said acts.

Farley *v.* Spring Valley M. and I. Co., 58 Cal., 142.

See Statutes, act July 29, 1866.

Public lands, rights acquired by possession.

See Miners and agriculturists, Relative rights, Riparian rights.

Public land, rights of settlers on.

A tract of the public domain upon which one has settled with the intention of acquiring title thereto under the pre-emption law remains public land subject to disposition by the proper authorities until such settler has perfected his right by showing compliance with the requirements of said law and payment of the purchase price.

Frisbie *v.* Whitney, 9 Wall., 187; Yosemite Valley Case, 15 Wall., 77; Hutton *v.* Frisbie, 37 Cal., 475; Western Pac. R. R. Co. *v.* Tevis & Kerr, 41 Cal., 489.

Occupation and improvement of public land with a view to pre-emption confers an inchoate right that may be protected by the courts against the claims of other persons who have not an equal or superior right. Such a settler however, acquires no vested right until the purchase money has been paid and a receipt issued.

Frisbie *v.* Whitney, 9 Wall., 187.

Purchaser of land presumed to have notice of water rights.

One who buys land is presumed to buy with notice of the water rights in use on the premises.

Coffman *v.* Robbins, 8 Ore., 278.

Real property, water in a natural stream is.

Although an appropriator may be entitled to the flow of the water undiminished at the head of his ditch, yet the water in the stream is not his personal property but a part of the realty, and he can not maintain an action for the value of the water, as for personal property sold and delivered, against one who has wrongfully diverted the waters of said stream.

7 Parks C. & M. Co. *v.* Hoyt, 57 Cal., 44.

Real property, water ditches and rights are.

See Water ditches are real property.

Reasonable use of water.

See Riparian rights, reasonable use.

Relation.

See Appropriation, relation.

Reservoirs, natural depressions.

One may utilize as a reservoir for storing water a natural depression on the public land which includes the bed of a stream, but he must see to it that no legal right of prior appropriators or other persons is in any way interfered with by his acts.

Larimer County R. Co. *v.* People *ex rel.*, 8 Colo., 614.

Right of way, change of direction of ditch.

One who has acquired the right to go upon a tract of land and construct a ditch across the same may change the course of such ditch from the line originally surveyed, and if such diversion worked no actual injury to the owner of the land, he will not be liable for even nominal damages.

Conger *v.* Weaver, 6 Cal., 548.

Right of way, conveyance of.

A deed which conveys the right of way for an existing ditch is in effect a conveyance of the ditch itself.

Reed *v.* Spicer, 27 Cal., 57.

Right of way through city.

A municipal corporation which accepts the dedication of streets across which a ditch has been previously located and right of way therefor acquired, takes the same subject to the prior rights of the owners of the ditch; and when the necessities of the public require that such ditch be bridged at the street crossings, it is the duty of the city, and not of the owner of the ditch, to construct such bridges.

Denver *v.* Mullen, 7 Colo., 345.

Right of way under act of July 26, 1866.

Under act of Congress of July 26, 1866, one has a right to construct a ditch across the public lands of the United States, subject only to the liability of paying for any damage to the possession of a settler on the land.

Hobart *v.* Ford, 6 Nev., 77; Shoemaker *v.* Hatch, 13 Nev., 261.

Riparian owner, boundary line of land.

Where a navigable stream has been meandered in making the public surveys the meander line is run for the purpose of marking the sinuosities of the stream rather than the boundaries of the tract of land bordering on such streams, the stream itself and not the meander line as actually run on the ground is the true boundary of tracts bordering on such streams.

Railroad Company *v.* Schurmier, 7 Wall., 272; Minto *v.* Delaney, 7 Wall., 337; Moore *v.* Willamette Transportation Co., 7 Ore., 355.

Riparian proprietors.

The section of the civil code of California which provides "the rights of riparian proprietors are not affected by the provisions of this title" declares, in effect, that those appropriating water under the previous sections shall not acquire the right to deprive of the flow of the stream those who shall have obtained from the State a title to, or right of possession in, riparian lands before proceedings leading to appropriation were taken.

Lux *v.* Haggin, 69 Cal., 255.

The common law doctrine of riparian rights is unsuited to the condition of the State of Nevada.

Reno Smelting M. & R. *v.* Stevenson, (Nev.) Lawers' Reps. (1889), IV, 60.

Riparian proprietors, lease, estoppel.

An upper riparian proprietor, who enters into an agreement with a lower proprietor, whereby the latter grants for a certain term the right to the use of the waters of the adjoining stream for domestic purposes and irrigation is not, upon the expiration of the agreement, thereby estopped from asserting his rights as a riparian proprietor to the use of the waters of such stream.

Swift *v.* Goodrich, 70 Cal., 103.

Riparian proprietors, rights as against appropriators of water.

An appropriation of water on public lands of the United States, made after the act of July 26, 1866, did not give the appropriator any right as against a riparian owner under a grant from the United States made prior to said act.

Lux *v.* Haggin, 69 Cal., 255; Vansickle *v.* Haines, 7 Nev., 249.

Riparian proprietor, right to protect his land from injury by stream.

A riparian proprietor has a right to protect his land from a threatened change in the channel of an adjoining stream and to erect works to prevent the old course of the stream from being altered.

Barnes *v.* Marshall, 68 Cal., 569.

See Waste.

Riparian rights, division of water by parol agreement.

Where the water of a stream which passes through the lands of different persons has been divided by them by parol agreement, and each party has constructed ditches, and has received, cared for, and enjoyed his portion of said waters for years, such parol agreement should be upheld in equity.

Coffman *v.* Robbins, 8 Ore., 278.

Riparian rights, extent of.

The owner of land through or along which a natural stream flows has a right to the reasonable use of the water of such stream during its passage, but has no right in the *corpus* of the water.

Union M. & M. Co. *v.* Dangberg, 2 Saw., 450; Eddy *v.* Simpson, 3 Cal., 249; Crandall *v.* Woods, 8 Cal., 136; Kidd *v.* Laird, 15 Cal., 161; Hale *v.* McLea, 53 Cal., 578; Pope *v.* Kinman, 54 Cal., 3; Lux *v.* Haggin, 69 Cal., 255; Weiss *v.* Oregon Iron & Steel Co., 13 Ore., 496.

Riparian rights, extent of—Continued.

Every proprietor of land through which flows a stream of water has a right to the use of the water flowing in its natural channel without diminution or obstruction, except so far as upper riparian owners may use said water for domestic use, stock, and reasonable irrigation.

Taylor *v.* Welch, 6 Ore., 198; Hayden *v.* Long, 8 Ore., 244; Coffman *v.* Robbins, 8 Ore., 278; Shively *v.* Hume, 10 Ore., 76.

The owner of land on a water-course has a right to the free flow of the water to his land without obstruction, and an owner above in protecting his land from injury can not cut off the water of the stream by a dam.

Bliss *v.* Johnson, 76 Cal., 597.

When a natural stream of water flows through lands belonging to different persons, each usually has the right to enjoy it for the ordinary purposes of life; the right to drink it, to use it for culinary purposes, and to water animals. Any surplus after these purposes are supplied may be used for irrigation, and should be equitably divided between the several proprietors.

Shook *v.* Colohan, 12 Ore., 239.

Riparian rights, extent of, necessities.

A riparian proprietor is entitled to take from the stream as much water as is necessary for watering his cattle and for domestic uses, even though such necessities may consume all the waters of the stream.

Union M. & M. Co., 2 Saw., 450; Ferrea *v.* Knipe, 28 Cal., 340; Hale *v.* McLea, 53 Cal., 578; Lux *v.* Haggin, 69 Cal., 255.

Riparian rights, equitable title confers.

One who has entered and paid for his land under the pre-emption law and has received a certificate of purchase, or one who has entered land under the homestead act and has continued to reside thereon, has the equitable title to such land, and is entitled to riparian rights.

Union M. & M. Co. *v.* Ferris, 2 Saw., 176.

Riparian rights, Government as owner.

The Government, as proprietor of the land through which a stream flows, has the same property and right in the stream that any other proprietor would have.

Union M. & M. Co. *v.* Ferris, 2 Saw., 176.

Riparian rights, grantees of Government.

The grantee or patentee of the Government acquires common-law rights in the waters flowing through the land granted, except when such rights are reserved.

Lux *v* Haggin, 69 Cal., 255; Vansickle *v* Haines, 7 Nev., 249.

A stream of running water is part and parcel of the land through which it flows inseparably annexed to the soil, and the use of it as an incident of the soil passes to the patentee of the land.

Union M. & M. Co. *v.* Ferris, 2 Saw., 176.

Riparian rights, irrigation.

A riparian proprietor may take water from the stream and may make reasonable use of it for purposes of irrigation.

Union M. & M. Co. *v.* Ferris, 2 Saw., 176; Ellis *v.* Tone, 58 Cal., 289; Anaheim W. Co. *v.* Semi-Tropic W. Co., 64 Cal., 185; Lux *v.* Haggin, 69 Cal., 255; Swift *v.* Goodrich, 70 Cal., 103; Coffman *v.* Robbins, 8 Ore., 278.

A riparian proprietor is not entitled to divert and use all the water of a stream for the purpose of irrigation without regard to the wants and necessities of other riparian proprietors, although the amount so diverted and used was no more than necessary for the irrigation of his lands.

Union M. & M. Co. *v.* Ferris, 2 Saw., 176; Hale *v.* McLea, 53 Cal., 578; Ellis *v.* Tone, 58 Cal., 289; Larned *v.* Tangeman, 65 Cal., 334; Gould *v.* Stafford, 77 Cal., 66.

Riparian rights, obstruction of stream.

While a riparian owner to whom the water first comes in its flow has a right to use it for domestic purposes and for watering cattle, he has not the right to so obstruct the stream as to prevent the water running substantially as in a state of nature it was accustomed to run.

Ferrea *v.* Knipe, 28 Cal., 341; Lobdell *v.* Simpson, 2 Nev., 274.

Riparian rights, possession confers.

One who appropriates public land acquires a right to the use of water flowing through it, and this right is good as against every one, except the Government and those who may have acquired prior rights thereto.

Crandall v. Woods, 8 Cal., 136; Leigh Co. v. Independent Ditch Co., 8 Cal., 323; Huston v. Bybee (Ore.), Sawyers Rep., 1889, II, 568.

Riparian rights, possession of unsurveyed lands.

A mere possessor of unsurveyed public land has no riparian rights.

Covington v. Becker, 5 Nev., 281; Lake v Tolles, 8 Nev., 285.

Riparian rights, reasonable use.

A reasonable use of the waters of a stream by a riparian proprietor may be defined as any use that does not work actual, material, and substantial damage to the common right which each proprietor has, as limited and qualified by the precisely equal right of every other proprietor.

Union M. & M. Co. v. Dangberg, 2 Saw., 450; Lux v. Haggin, 69 Cal., 255.

Sale of water, effect on prior right to its use.

One who has built a mill on a stream thereby appropriates the water-power at that point, and does not by the conveyance of the water at a point above his mill lose his prior right over one who has claimed the water below the mill for mining purposes.

McDonald v. Askew, 29 Cal., 200.

Springs.

The owner of a head spring is not justified in exhausting it, for purposes of irrigation, to the injury of owners lower down on the main channel of the of the stream.

Fleming v. Davis, 37 Tex., 183.

Statutes, act of July 26, 1866.

The doctrine of right by prior appropriation was recognized by the act of Congress of July 26, 1866.

Atchison v. Peterson, 20 Wall., 507; Basey v. Gallagher, 20 Wall., 670; Union M. & M. Co. v. Ferris, 2 Saw., 176; Cave v. Crafts, 53 Cal., 135; Osgood v. El Dorado W. & M. Co., 56 Cal., 571.

The act of July 26, 1866, confirmed rights already held under the local customs, laws, and decisions of the courts; it did not introduce any new system or any new or different policy on the part of the Government; it recognized, sanctioned, protected, and confirmed the system already established and provided for its continuance.

Jennison v. Kirk, 98 U. S., 453; Broder v. Natoma Water Co., 101 U. S., 274; Titcomb v. Kirk, 51 Cal., 288; Jones v. Adams, 19 Nev., 78.

The act of July 26, 1866, conferred upon parties desiring to divert water from a natural stream the right to construct across the public lands ditches for that purpose, subject only to the liability of paying for any damages to the possession of a settler on such lands.

Hobart v. Ford, 6 Nev., 77; Shoemaker v. Hatch, 13 Nev., 261.

It is not necessary, in order that a right may be entitled to protection under section 9 of the act of July 26, 1866, that there should be a union of the three conditions therein mentioned; that is, that said right should be recognized by the local customs, laws, and decisions of the courts.

Basey v. Gallagher, 20 Wall., 670; Barnes v. Sabron, 10 Nev., 217.

The act of July 26, 1866, does not affect the rights of one who had acquired a right to land and water flowing across it prior to the passage of said act.

Union M. & M. Co. v. Ferris, 2 Saw., 176; Union M. & M. Co. v. Dangberg, 2 Saw., 450; Lux v. Haggin, 69 Cal., 255.

The act of Congress of July 26, 1866, was adopted simply to protect those who were at the time diverting water from its natural channels on the public lands and no diversion had been previously authorized.

Vansickle v. Haines, 7 Nev., 249.

One has a right under the act of Congress (July 26, 1866) to go upon Government land and divert the waters of a natural stream, and to the extent of his appropriation he acquires a vested right therein, and whoever afterwards purchases above or below him takes subject to such prior appropriation.

Kaler v. Campbell, 13 Ore., 596.

Statutes—General Statutes Colorado, section 1718.

That portion of section 1718, General Statutes of Colorado, which limits the amount of compensation to be paid to the owner of a ditch by one who desires to enlarge or use the same, under the provisions of said law, to a reasonable proportion of the cost of construction of said ditch, is unconstitutional. The compensation for taking or damaging private property against the owner's consent must be ascertained by a jury or board of commissioners.

Tripp *v.* Overocker, 7 Colo., 72.

Statutes, act of March 3, 1869, Nevada.

The statute of March 3, 1869, merely provides for a right of entry on the land of another for the purpose of surveying for a ditch or flume and the manner in which such lands may be condemned, and does not confer any right of priority upon one complying with its provisions.

Barnes *v.* Sabron, 10 Nev., 217.

Texas.

The colinization law of Texas and the statutes of the State recognize the right to use water for irrigation purposes.

Tolle *v.* Correth, 31 Tex., 362.

Statute of limitation.

See Limitations, statute of.

Subterraneous streams.

See Underground streams.

Tenants in common, appropriators are.

See Appropriators, tenants in common.

Trespasser, appropriation by.

See Water right, when an appurtenance.

Underground streams.

The rules of law which govern the use of streams flowing upon the surface of the earth are equally applicable to underground currents of water flowing in defined channels.

Hanson *v.* McCue, 42 Cal., 303; Cross *v.* Kitts, 69 Cal., 217; Keeney *v.* Carillo, 2 N. M., 480; Strait *v.* Brown, 16 Nev., 317; Taylor *v.* Welch, 6 Ore., 198; Shively *v.* Hume, 10 Ore., 76.

Use, beneficial, is test of appropriation.

See Appropriation.

Use, by riparian proprietor.

See Riparian rights, extent of.

Use of water for street sprinkling is use for irrigation.

A contract by which it is agreed to furnish water to the inhabitants of a city "for domestic purposes" does not include water for irrigation. Water used for sprinkling streets is water used for the purposes of irrigation.

Los Angeles Water Co. *v.* Los Angeles City, 55 Cal., 176.

Use, place of.

See Place of use.

Usufructuary rights.

See Appropriator's rights in water of a natural stream are usufructuary, Riparian rights, extent of.

Waste.

A person having the right to the exclusive use of the water flowing through a ditch constructed across the land at any point, where he may desire to turn it for irrigating purposes during the spring and summer months, has the preference during the season when he requires the water for irrigation, but he has no right to waste it at any time, at other times the owner of the ditch has the full right to use it.

Huston *v.* Bybee (Ore.), Lawyer's Rep. (1889), II, 568.

Water commissioners, extent of authority.

A board of water commissioners, under the act of California of May 15, 1854, has no authority to enter upon a private water-course and to disturb the owners thereof in its use and enjoyment.

Charnock *v.* Rose, 70 Cal., 189.

Water commissioners' actions may be reviewed by the courts.

It is the duty of the board of water commissioners, upon petition, to locate and lay out a proposed water ditch, and when it is constructed to apportion the water among those interested according to their respective interests; but the action of the board in making such apportionment is subject to review by the courts.

Daley *v.* Cox, 48 Cal., 127.

Water companies, rights and privileges of.

Corporations organized to furnish the inhabitants of a city with pure, fresh water, like companies organized to furnish gas to the inhabitants of a city, are engaged in a "species of trade and commerce," and are governed by the provisions of the State law relating to such corporations.

Heyneman *v.* Blake, 19 Cal., 579; Price *v.* Riverside L. & I. Co., 56 Cal., 431.

Water-course defined.

To constitute a water-course there must be bed, banks, and water; the water must usually flow in a certain direction and by a regular channel; the water need not flow continually, but the stream must have a well-defined and substantial existence.

Barnes *v.* Sabron, 10 Nev., 217.

Water-course, natural, used to carry water acquired by appropriation.

One who avails himself of a natural water-course to conduct water he has appropriated to the place where he designs to use it does not abandon the water thus turned into the natural stream, and may divert the same quantity at the place he desires to use it.

Hoffman *v.* Stone, 7 Cal., 46; Butte Canal & Ditch Co. *v.* Vaughn, 11 Cal., 143; Davis *v.* Gale, 32 Cal., 26; Ellis *v.* Tone, 58 Cal., 289; Schulz *v.* Sweeny, 19 Nev., 359.

Water-course, natural, used to convey water.

One who has brought water from a distance and emptied it into a natural stream with the intention of taking it out again may not so reclaim it as to diminish the quantity to which a prior locator or appropriator was entitled.

Butte Canal & Ditch Co. *v.* Vaughn, 11 Cal., 143; Burnett *v.* Whitesides, 15 Cal., 35; Wilcox *v.* Hausch, 64 Cal., 461.

Water-course, natural, used to convey water, burden of proof.

Upon one who turns water into a natural water-course for the purpose of conveying it to the place where it is to be used and there diverting it from said stream is cast the burden of showing that he has not taken from the stream more water than he turned into it.

Butte C. & D. Co. *v.* Vaughn, 11 Cal., 143; Wilcox *v.* Hausch, 64 Cal., 461.

Water ditches are real property.

A water ditch and the water right appurtenant thereto are real property.

Hill *v.* Newman, 5 Cal., 445; Lower Kings D. Co. *v.* Lower Kings R. & F. C. Co., 60 Cal., 408; Dodge *v.* Marten, 7 Ore., 456.

Whether ditch property in the mineral regions of this State, although conceded to be real estate, is to be regarded by courts of equity with the same measure of favor that is bestowed by them upon land held and cherished for itself, and whether such courts will interfere by way of injunction to protect ditch property, admits of at least serious doubt.

Clark *v.* Willett, 35 Cal., 534.

Water ditch, when public property.

An irrigating ditch, constructed, repaired, and controlled by two or more persons does not cease to be private property because they have not accurately defined their respective rights therein, or because they have selected some one to distribute the water among those interested therein. Such ditch is not subject to the control of the board of water commissioners for the district in which it is situated.

Cate *v.* Sanford, 54 Cal., 24.

Water, diversion of.

See Diversion of water.

Water, personal property.

See Personal property.

Water right, co-extensive with ditch.

See Appropriator's right co-extensive with his ditch.

Water right, deed of, does not convey mill-site.

A deed conveying the right to the use of the water of a river between certain points does not convey the land of a mill-site on the river.

Robinson *v.* Imperial S. Mg. Co., 5 Nev., 44.

Water right, transfer of.

An executed contract which passed the equitable title to a ditch to which a water right was appurtenant, is sufficient to insure the grantee the rights for which he stipulated as against an adverse claimant.

Ortman *v.* Dixon, 13 Cal., 33.

The right to water acquired by appropriation is a species of realty, and requires for its transfer the same form and solemnity as is required for the conveyance of any other real estate.

Barkley *v.* Tieleke, 2 Mont., 59; Smith *v.* O'Hara, 43 Cal., 371.

Right to water acquired by appropriation may be transferred like other property.

McDonald *v.* B. R. & A. W. & M. Co., 13 Cal., 220; Union Water Co. *v.* Crary 25 Cal., 504; Dalton *v.* Bowker, 8 Nev., 190.

The right to the use of a water-course in the public mineral lands, and the right to divert and use the water taken therefrom acquired by appropriation, may be held, granted, abandoned, or lost by the same means as a right of the same character issuing out of lands to which a private title exists.

Union Water Co. *v.* Crary, 25 Cal., 504.

Water right, when an appurtenance.

A right which secures to the owner of a tract of land water for irrigating or other purposes necessary to the beneficial enjoyment of the land becomes appurtenant to said land and passes by a conveyance thereof.

Cave *v.* Crafts, 53 Cal., 135; Farmer *v.* Ukiah Water Co., 56 Cal., 11; Standart *v.* Round Valley Water Co., 77 Cal., 399.

If the right to use the water were acquired by appropriation for the purpose of operating a mill on the stream, such right would pass by the transfer of said mill property to a vendee.

McDonald *v.* B. R. & A. W. & M. Co., 13 Cal., 220.

The water supply of a mill will ordinarily pass with a conveyance of the mill, but in order to do so it must belong to the mill, must be the property of the owner thereof.

Ginocchio *v.* Amador C. & M. Co., 67 Cal., 493.

The purchase by a mining company of a water ditch and rights appertaining thereto does not necessarily constitute said ditch and water rights appurtenances of the mining claim. Upon one who asserts that a ditch and water rights are appurtenant to a mining claim is cast the burden of proving that such is the fact.

Quirk *v.* Falk, 47 Cal., 453.

The right to water appropriated to irrigate a certain tract of land by one who had no title to said land, but was a mere trespasser, does not become appurtenant to the land, and does not pass to a purchaser from the owner of the land.

Smith *v.* Logan, 18 Nev., 149.

To entitle one to recover in an action in ejectment he must show that he is entitled to possession of the premises; but he is not required to show that he is entitled to the enjoyment of a stream of water running through the premises or that he was damaged by the diversion of it.

Dilley *v.* Sherman, 2 Nev., 67.

When a canal or aqueduct has been constructed in two separate parts by different contractors at different times, the two sections being fed in part from different sources, and the Supreme Court of the United States has decided that the two sections constitute separate and distinct works, the water supply of the one must be held not an appurtenance of the other section.

Reynolds *v.* Hosmer, 51 Cal., 205.

Water rights acquired under license to use.

One who takes possession of water under a verbal license to use the same, during the time that the grantor did not need the use thereof, acquires no rights which could be sold and transferred to another.

Fabian v. Collins, 3 Mont., 215.

Water rights are real property.

The right to running water may exist without private ownership of the soil upon the ground of prior appropriation. The right to water must be treated as a right running with the land and as a corporeal privilege bestowed upon the occupier or appropriator of the soil, and as such it has none of the characteristics of mere personality.

Hill v. Newman, 5 Cal., 445.

Water, use of, by those entitled may be regulated by a court of equity.

It is within the power and authority of a court of equity to ascertain and determine the extent of the rights of property in water, flowing in a natural water-course, acquired by persons who hold and are entitled to them, and to regulate between or among them the use in the flow of the water in such a way as to maintain equality of rights in the enjoyment of the common property.

Frey v. Lowden, 70 Cal., 550.

INDEX.

A.

Page.

Altitudes, and their relations to irrigation—
  California, of 34
  Coast Range table lands 9
  Cuyamaca Mountains, of 136
  Dakota, of 79
  Dayton 43
  Foot-Hills, Lower 13
  Fresno County, in 12
  Harney Peak, Dakota 79
  Kern County, of 12
  Mount Whitney 9
  Nevada, State of 75
  Plains region, of 4
  Plateau region, northern Arizona 7
  Rain-fall, belt of 30
  San Jacinto Mountain, of 29, 30
  San Luis Valley, of 66
  Tulare County, of 12
  Valleys, California, of 14
  Walla Walla, at 43
Artesian wells, relating to 20, 25, 26, 27, 28, 29, 43, 48, 50, 53, 58, 90, 92, 93, 96, 100, 101, 102, 104, 109, 301
  Albert Howard, Colorado, the 88
  Basins of 27
  Belt of 13, 85
  Billings, at 90
  Boring for, Grafton, Dak 93
    for, Yankton, Dak 93
    cost of 25
    in India and other countries 90
  Boisé City, Idaho, at 100
  Box Elder County, in 53
  California, in 102
  City of Mexico, at 283
  Colorado, in 104
  Dakotas, of the 92, 93, 94, 95
  Davis County, of 57
  Denver Basin, in 104
  Dodge City, at 82, 143, 144
  Economic value of 89, 90
  Estimate, an authoritative 96
  Flowing, in California 102
  Flowing, at Tombstone, Ariz 92
  Fresno County, of 11
  Garden City, at 82, 143, 144
  Groups of 25
  Groups of, successful, Dakota 93
  Geology of 93, 95
  Helena, Mont., at 100
  Kansas, in 97
  Kern County, Cal., in 11
  Laramie Plains, on 105
  Leon, Mexico, at 99
  Los Angeles, at 20

Page.

- Artesian wells, relating to—Continued.
  - Limitations of irrigation, by J. W. Powell 105, 106
  - Lift of, in western Texas 98, 99
  - Millard County 53
  - Miles City, Mont., at 100
  - Nebraska, of 96
  - Nevada, of 75, 101, 102
  - Northwest, of the 100
  - Oxford, Idaho, at 100
  - Pasco, Wash 100
  - Reasons for inquiry into 106
  - Roslyn, at 100
  - San Bernardino Basin, of 27
  - San Gabriel County, Cal 301
  - Santa Clara County, in 301
  - San Diego County, in 107
  - San Joaquin, of 14
  - San Luis Valley, of 60
  - Salt Lake Valley, of 56, 106
  - Staked Plains region, on 91, 98, 99
  - Table of elevation, depth, and pressure 94
  - Table of observation by geologists 97
  - Tulare County, average flow from 11, 53
  - Use of 105
  - Utah, in 48, 100, 101
  - Warm Springs, Oregon 100
  - Wyoming, in 105

B.

- Basins—river, and irrigation—
  - Carson 146, 148
  - Columbia River 43, 44
  - Denver, artesian 104
  - Drainage of 13, 114
  - Drainage of, in Oregon 44, 49
  - Hydrographic 6, 40
  - Klamath, of 8, 44
  - Mojave, of 8
  - Murray River drainage 295
  - Rincon 104
  - Rio Pecos catchment 149
  - San Bernardino 27, 104
  - San Fernando 20, 25, 102
  - San Gabriel 24, 25
  - Southern California, of 24
  - Total area of 114
  - Truckee 146, 148
  - Washoe 145
  - White Sand Hills 99
  - Yellowstone 40

C.

- Canals and irrigation, names of—
  - Anderson, the 125
  - Arizona, the 304
  - Beardsley, the 122
  - Big Thompson, the 305
  - Buena Vista, the 125
  - Cache La Poudre, the 69
  - Calloway, the 122, 303
  - Chowchilla, the 305, 315
  - Crocker, the 23
  - Dixon, the 124
  - Dodge City, Kans., at 145, 304
  - Eureka, Kans., at 303
  - Farmers', the 125
  - Frazer, the 126
  - Fresno (76), the 303, 304

Page.

- Canals and irrigation, names of—Continued.
  - Gates, the ... 125
  - Gila River, on the ... 61
  - Goose Lake, the ... 123
  - Grand River, the ... 143
  - Grand Valley, the ... 67
  - Great Bear River, the ... 50
  - Great Eastern, the ... 304
  - Hurley, the ... 126
  - Ibrahuniek, the ... 321, 323
  - James, the ... 126
  - James and Dixon, the ... 123
  - Joice, the ... 124
  - Kern Island, the ... 121, 124, 125
  - Kern County, system of ... 127
  - Larimer and Weld, the ... 304, 305
  - List of ... 33
  - Maricopa County, in ... 61
  - McCord, the ... 122
  - Meacham, the ... 126
  - Miles of, in Weber, Utah, Cache, and Salt Lake Counties ... 49
  - Nahran, the ... 322
  - North Poudre, the ... 304
  - North Poudre Land and Canal Company's, the ... 142
  - Northern, the ... 149
  - Old South Fork, the ... 124
  - Pioneer, the ... 123
  - Perennial, the ... 322
  - Plunkett, the ... 126
  - Railroad, the ... 123
  - Résumé of Kern ... 127
  - Rio Grande, on ... 66
  - Riverside Works ... 29
  - Salt River Valley, in ... 61
  - San Joaquin and King's River, in ... 304, 305
  - South Dodge, at ... 144
  - Southern, the ... 149
  - South Fork, the ... 28
  - South Platte, the ... 303, 304
  - Statistics of Indian works ... 327
  - Stine, the ... 124, 125
  - Tabulated statement ... 64
  - Upper and Lower Ganges, of ... 326
  - Union Colony, the ... 68, 69
  - Western, the ... 323
  - Wible, the ... 123
  - Wilson, the ... 126
- Crops under irrigation—
  - Alfalfa or Lucern .. 19, 39, 41, 43, 51, 55, 58, 60, 61, 62, 71, 77, 102, 121, 133, 315, 316, 333
  - Barley ... 34, 39, 41, 43, 58, 60, 62, 77, 287, 314, 324
  - Beans ... 287, 321, 322, 324
  - Bermuda grass ... 62
  - Blue grass ... 62
  - Buffalo grass ... 81, 297
  - Bunch grass ... 297
  - Cereals ... 34, 39, 43, 58, 308, 322
  - Chick peas ... 291
  - Clover ... 83, 324
  - Corn ... 21, 41, 48, 55, 58, 62, 71, 77, 268, 287
  - Cucumbers ... 324
  - Grain ... 13, 50, 51, 53, 65
  - Grasses ... 40, 48, 65
  - Hay ... 50, 51, 53, 77
  - Hay, by subirrigation or percolation ... 43
  - Hay, price per ton in Arizona ... 60
  - Hay, Salt River ... 60
  - Maize ... 287, 291, 293, 322, 325
  - Melons ... 58, 324

Page.

- Crops under irrigation—Continued.
  - Native grasses 14
  - Native Blue-stem 77
  - Natural grasses 5
  - Oats 41, 43, 48, 62, 69, 71, 77, 83, 287
  - Peas 307
  - Potatoes 39, 43, 48, 71, 77, 307
  - Pumpkins 58
  - Red clover 39
  - Rice 267, 291, 314, 321, 322, 324
  - Root crops 51
  - Rye 77
  - Timothy (hay and grass) 39, 62, 77
  - Tomatoes 62
  - Vegetables 43, 58, 77
  - Wheat 6, 7, 13, 15, 20, 34, 39, 41, 43, 48, 58, 60, 62, 69, 71, 77, 287, 291, 307, 319, 320, 321, 324
- Colonies, irrigation, references to—
  - American, the 13
  - Central, the 12
  - Easterby, the 13
  - Fresno county, in 12, 13
  - Greely, the first irrigators 67
  - Land, co-operative 29
  - Nevada, in 13
  - Ontario, at 28, 132, 134
  - Riverside, at 29
  - Scandinavian, the 13
  - Union, the 67
  - Washington, the 13
- Climate, references to 19, 134
  - East of Cascade Mountains 6
  - Mild 11
  - Utah, of 48, 49

D.

- Dams used in irrigation—
  - Bear Valley, at 139, 140
  - "Crit," the 48
  - Cuyamaca, the 136, 137
  - Mud-sill, a 48
  - North Poudre, at head of, the 142, 143
  - Salt River, Arizona, at 111
  - San Diego, diverting, the 137
  - Subsoil, a 129
  - Sweetwater, San Diego County, Cal. at 31, 113, 115, 116, 117, 118, 119, 120
  - Tambembe, the 292
  - Tucson (Nos. 1, 2, and 3), at Pantano, near 111, 112, 113
  - Wing, the 128
- Districts, irrigation—
  - Acayrican, in Mexico 295
  - Choapam, in Mexico 293
  - Coatlan, in Mexico 293
  - Cuicatlan, in Mexico 293
  - Juchitan, in Mexico 293
  - Ocampo, in Mexico 293
  - Teposcolula, in Mexico 293
  - Tiaxiaco, in Mexico 293
  - Tuxtepec, in Mexico 293
  - Yautepec, in Mexico 293
- Ditches, irrigation—
  - Area under, total 169
  - Areas in Arizona 60, 167
    - Black Hills 163
    - California 166
    - Colorado 63, 168
    - Dakotas 163
    - Eastern Washington 166
    - Idaho 164

Page.

- Ditches, irrigation—Continued.
  - Areas in Kansas, southwestern 167
    - Montana 164, 165
    - Nebraska 169
    - Nevada 166
    - New Mexico 167
    - Oregon 165
    - Rockies, east of 63, 168
    - Texas, western 167
    - Utah 165
    - Wyoming 76, 169
- Ditches—
  - Ash, the 124
  - Blanks and forms relating to 150. 151, 152, 153
  - Castro, the 125
  - Cost of shares in Provo 49
  - Cotton Ranch, the 124
  - Edwards, the 123
  - Emery, the 123
  - Eureka, the 145
  - Johnston, the 123
  - Jordan, near the, Utah, the 49
  - Jones and Luckey, the 123
  - May, the 124
  - McCaffrey, the 122
  - Miles of 25
    - San Luis Valley, in 66
    - Arkansas Valley, in 82
  - Mileage, table of 64
  - Monarch, the 61
  - Montana, in 41, 42
  - Pottinger, the 123
  - Provo, the 49
  - System of, in Yuma County 60, 61
    - in Montana 42
  - South Fork, the 306
  - Zanjero or overseer, the 25, 26
- Drainage—
  - Area 6, 43, 112, 323
    - of the Rio Pecos 149
    - of Nevada 75
  - Arterial, of Southern California 103, 104
  - Mountain 27, 34
  - Natural basins 71, 317
  - Rocky Mountain ranges, of 40
  - Supply the, from 86

F.

- Flumes and headgates 32, 128, 130, 138, 149, 306, 335
- Foreign countries, irrigation in—
  - Africa 105
  - Australia 300
  - Arabia 106
  - Asia 34, 105, 106, 265, 269
  - Belgium 320
  - British America 4, 5, 80
  - British India 328
  - China 34
  - Denmark 79
  - Durango, State of 287
  - Egypt 265, 266, 320, 323, 324, 328
  - England 79, 315
  - Europe 105, 265, 266, 269, 296, 320, 328
  - Tlaxcala, State of 294
  - France 272, 281, 309, 315, 325
  - Guanajuato, State of 289
  - India 265, 269
  - Italy 79, 272, 273, 267, 301, 308

Page.

- Foreign countries, irrigation in—Continued.
  - Jalisco, State of 289-291
  - Lombardy 267, 273, 296
  - Lower California 287, 292
  - Mexico 4, 5, 91, 92, 282, 289, 296, 300, 303, 314
  - Michoacan, State of 289, 291
  - Morelos, State of 292
  - New South Wales 295, 296
  - Norway 79
  - Portugal 79
  - Queretaro, State of 294
  - Russia 320
  - Sardinian Kingdom 275
  - Scotland 79
  - Spain 62, 281, 282, 325
  - Syria 265
  - Tamaulipas, State of 294
  - Turkey 79
  - Vera Cruz, State of 295
  - Victoria, Australia 295, 320
  - Wales 79
  - Zacatecas, State of 289, 295
- Forts, United States irrigation at—
  - Adams 43
  - Collins 142
  - Lowell 112
  - Lupton 87
  - Sumner 148
- Fruit trees under irrigation 134, 316
  - Almonds 15, 17, 62, 316
  - Apple 17, 39, 43, 60, 62, 314, 316
  - Apricot 17, 39, 55, 60, 62, 65, 316
  - Cherry 12, 17, 316
  - Chestnut 316
  - Citrus 11, 29
  - Crab-apple 60
  - Date 15, 35, 60, 62, 325
  - English walnut 17
  - Fig 12, 15, 17, 20, 35, 54, 60, 62, 316, 325
  - French prunes 62
  - Lemon 15, 17, 34, 35, 58, 60, 62, 316
  - Lime 316
  - Mulberry 62
  - Nectarine 15, 17, 35, 316
  - Olive 15, 17, 35, 55, 60, 316
  - Orange 15, 17, 19, 25, 29, 32, 34, 35, 58, 60, 62, 133, 307, 316
  - Orange orchards 18, 19
  - Orchards 11, 21
  - Peach 12, 17, 39, 40, 43, 55, 60, 62, 316
  - Pear 17, 39, 40, 43, 60, 62, 316
  - Plum 17, 39, 40, 43, 316
  - Pomegranate 15, 62, 316
  - Prune 17, 35, 39, 40, 60, 99
  - Quince 62, 316

I.

- Irrigation—
  - Advantage of 18, 63
  - Alexandria, at 326
  - Alita, at 11
  - Alosta, at 21
  - Altadena, at 21
  - Analiena, at 7
  - Ancient works of 269
  - Apetatitlan, at 294
  - Arlington, at 21
  - Arizona, character of its 56, 62
  - Australian legislation for 297

Page.

igation—Continued.
  Australian report on American 296, 297, 298, 299, 300, 301, 302, 303, 30,4305, 306. 307, 308, 309, 310, 311, 312, 313, 314, 315, 316, 317, 318, 319, 320
  Ayusa, at 21
  Bakersfield, at 124, 125, 127, 303, 315
  Benson, at 112
  Big Springs, at 99
  Boisé City, at 39
  Bombay, at 530
  Brighton, at 87
  Brownsville, at 96
  British India, in 326, 327, 328
  Calabasas, at 91
  Cairo, at 326, 350
  Capacity of Nevada for 74, 75
  Carson, at 297
  Character of, in Arizona 56
  Chino, at 102
  Classes of, California 128, 129, 130, 131, 132, 133, 134, 135
  Climate and, in America 300
  Colorado, in 63
  Coolidge, at 82
  Commissioner of 73
  Construction, plans, projects, etc 111, 301, 302, 305, 306
  Construction in Wyoming 76, 77
  Counties enriched by, in California 35
  Crops of Egypt, 1888 327
  Croyden, at 51
  Cucamonga, at 11, 102
  Dallas, the 98
  Delano, at 11, 102
  Denver, at 55, 70, 87, 88, 90, 301, 318
  Deming, at 92
  Development of, by districts 63, 73, 76
  Difficulties of 298
  Different works in different States 298
  Distribution system, San Diego, Cal 31
  District law 23
  Divisions of California 13
  Divisions of the arid region 4, 5, 6, 7
    of Arkansas No. 2 64
    of Intramountain region 37
    of Rio Grande 64
    of South Platte 64
  Dodge City, at 82, 143, 144
  Douro, at 99
  Drainage areas 309, 310
  Duarte, at 21
  Eaton, at 86
  Eastern Washington and Oregon 42, 43, 44
  Effects of 7
  Effects on health 16, 17
  Egyptian, the Nile Valley 320, 321, 322, 323, 324, 325, 326
  Ellensburg, at 42, 43
  Enterprise, northern California 13
  Engineering, problems of 85
  Estimate of people supported by, in other countries 106
  Etiwanda, at 103
  Evans, at 87
  Extent of American 296
  Extension of, in arid regions 310, 311
  Fertilization by 308, 309
  First colony of 67
  Fruit raising by 17
  Flooding by 306
  Flooding, Arizona, in 61
  Florence, at 58, 60, 62
  Florin, at 301
  Flumes by 31

Page.
Irrigation—Continued.
Ford, at 144
Fresno, at 7, 8, 29, 309, 310, 317
Furrows 307
Garden City, at 86
Germania, at 98
Glendora, at 21
Grafton, at 92
Grand Junction, at 67
Greeley, at 67, 70, 85, 87, 88, 300
Groups or systems of 25
High culture produced by 35
Horse Shoe Bend, at 147
Huntsville, at 50
Hutchison, at 89
Idaho, in 38
Influence of, on humidity 70
Joseph, at 52
Juanacatlan, in 289
Kalvub, at 320
Kern County works 121, 129
Kern County, not a necessity in 12
Lake Donner surveyed for, purposes 75
Las Vegas, at 167
Law cases, table of 330, 331
Laws in Colorado 299
Legal condition of 171
Legislation of Australia 295, 296
Lemoore, at 10, 11
List of districts of 23
Lewiston, at 30, 42, 43
Lordsburg, at 21
Los Angeles, at 7, 24, 27, 121, 297
Madras, at 328
Maricopa, at 91
Marienfeld, at 91, 98
Markleville, at 147
Mexico, laws of, on 299
Midland, at 91, 99
Modena, at 266
Mormons, laws of, on 44, 45, 46
Monrovia, at 21
Mojave Desert, on 27
Moxie Ranch, at 43
National City, at 31, 116
Nile Valley, in the 320, 326
No cultivation without 41
North Yakima, at 42
Odessa, at 91, 99
Olancha, at 19
Omaha 96
Ontario, at 129
Open ditches wasteful for 308
Pasadena, at 21, 129, 304
Pasco, at 43
Pecos, on the 4
Percolation, by 21
Phœnix, at 111, 297
Piedmont, in 272, 273
Pipe system, Kern County 12
Platteville, at 87, 88
Panama, at 104
Prescott, at 56
Private enterprise, by 42
Provo, at 49
Prospects of, in America 316, 317
Pueblo, at 88
Pumping in southwestern Kansas, by 82
Redlands, at 21, 28, 304, 305

Page.

Irrigation—Continued.
  Reno, at 145, 147
  Result of, in California 18
    in Idaho 39
  Rialto, at 21
  Rio Pecos, New Mexico 148, 149
  Riverside, at 21, 29, 102, 131, 305, 310, 320
  Salt Lake, at 44, 49, 50, 65, 319
  San Anita, at 21
  San Bernardino, at 21, 138
  San Carlos, at 58
  San Diego, at 7, 27, 30, 31, 32, 136, 300
  San Dumas, at 21
  San Francisco, at 9, 34, 102
  San Gabriel, at 7
  San Jacinto, at 32, 135
  San Joaquin Valley 23
  Santa Fé, at 148
  Season for 43, 45, 50, 52, 53, 54, 56, 70
  Sources of principal works 303
  St. Helena, at 96
  St. Paul, at, session on 163
  Sterling, at 87
  Sumner, at 12
  Survey for 85
  Systems of 25, 306, 307, 308
    Abestine 328
    canal, Fresno County, Cal 21
    circling 268
    colony 318, 319
    distribution, San Diego 138
    different, in California 128, 129, 133, 134
    Hermit Valley 32
    North American Cordillera 5
    pipe, value of 121
    San Diego Flume Company 31
    San Diequito 32
    sinking galleries or tunnels for underground currents 109
    small storage or tanks 109
  Southwest Kansas, in 82
  Subirrigation, on 308
  Subirrigation by conduits 25
  Sweetwater River, at 31
  Tahoe, at 145
  Tehachipi, at 8
  Tehuantepec, at 293
  Tejunga, at 21
  Temescal, at 102
  Testimony at Boisé City 39
  Tipton, at 10
  Tombstone, at 92
  Tools employed in 305
  Tree growth, effects of, on 19
  Truckee, at 145
  Tucson, at 91, 111
  Tulare Lake, proposed plan of lowering, for 120
  Tumacacori, at 91
  United States survey 107
  Use of stationary pumps for 109
  Utility of, by the Senate committee 170
  Utah, in 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56
  Value of 82, 83
  Value, character, and results of, Hon. E. A. Stephenson 39
  Vermillion, at 95, 105
  Victoria, in 296
  Vivienda, at 102
  Wadsworth, at 147, 148
  Walla Walla, at 42, 43
  Western Kansas, in 80

Page.

- Irrigation—Continued.
  - Yankton, at 92, 93, 95, 96
  - Yuma, at 107, 111
- Irrigation companies, names of—
  - Arkansas Valley 74
  - Bear Valley Land and Water 129, 130, 131, 138, 141
  - Bear Valley Reservoir 28
  - Buena Vista Canal 125
  - Delivery and Distribution Works, at San Diego 135
  - Denver Pacific Railway 67
  - Farmers' Canal 125
  - Gate's Canal 125
  - Gila Bend Canal 61
    - River Irrigation 61
  - Goose Lake Canal 123
  - Hesperia Land and Water 20
  - Highland Park Water Works, Los Angeles 133, 134
  - James Canal 126
  - James & Dixon Canal 123
  - Kern Valley Water 126
    - River Water and Irrigation 122
  - Lake Hemet Water, San Diego 135
  - Lake Vineyard 304
  - Larimer and Weld 74
  - Lower New Kern Irrigation 123
  - Meacham Canal 126
  - Mission Valley Storage and Delivery 32
  - Northern Colorado Irrigation 151
  - North Fork Water 28
  - Pioneer Canal 123
  - Plunkett Canal 126
  - Riverside Water Works 29
  - Riverside Water 29
  - San Diego Flume 31, 136
    - Land and Town 116
    - River Works and Projects 136, 137, 138
  - San Luis Rey 32
  - South Dodge Canal 144
  - Stine Canal 125

L.

- Land—
  - Acres requiring irrigation in Arizona 59
  - Acres under cultivation in Egypt 321
  - Acres unsurveyed in Rapid City district, southwestern Dakota 80
  - Actually irrigated, area 63
  - Agricultural area 12, 58, 149
  - Alfalfa, for 128
  - Alluvial 124
  - Arable 10, 50, 53, 54, 59, 114, 148
  - Arable, price in Arizona 59
  - Arid 3, 5, 7, 38
  - Area irrigated in California 32, 33, 36
    - of Colorado 66
    - of Colorado River drainage 58
    - in Dakotas 80
    - irrigable 19, 23, 76
    - sub-irrigated 37, 43
    - total 33
    - under ditch in Colorado 63
    - of water shed 30
  - Bench, area 19, 20, 34, 42, 43, 298, 317
  - Bottom, area 8, 17, 19, 41, 43, 58, 67, 86, 89, 112, 294, 398
  - Cienagas or wet places 24, 28, 91, 92
  - Colony 102
  - Colorado Plateau, on 6, 14
  - Columbia River Plains, in 42
  - Cottonwood Flat, on 114
  - Cucamonga Plain, in 104

Page.

Land—Continued.
- Deserts, the Colorado, 8, 32, 102, 107, 138
  - Indio, 21
  - Mapimi, in Mexico, 297
  - Maricopa, in Arizona, 297
  - Mojave, 20, 21, 102, 297
  - Sahara, 320
- Districts in North and South Dakotas, 80
  - under water in Utah, 49
- Estimated cost of improvement, Staked Plains, 100
  - areas under artesian well irrigation, 96
- Farming areas, 58, 69, 71, 76, 91, 309
- Fertility of, in Arizona, 58
- Foothills, the, 6, 9, 11, 13, 21, 58, 65, 81, 85, 87, 92, 102, 149, 297
  - of Cascade, 42
  - of counties partially irrigated, 36
  - of Orville, about, 19
  - of Sierras Nevada, 7, 18
  - value of, San Joaquin Valley, 11, 12
- Fruit-producing, the, 34
- Government, the, 20, 67, 68
- Great Plains, on, 80, 81, 82
- Growth of, enterprise and values, of, 21
- Healthfulness of irrigated, 317
- Hill, the, 10, 12
- "Hog wallows," in, 16
- Homestead law, 67, 72, 80
- Hydrological areas, in, 6
- Idaho sage brush, 39
- Irrigable, 19, 21, 24, 77, 127, 304
  - in Fresno County, 21, 22
  - in Los Angeles County, 23
  - the value of non-irrigable, 20
  - value increased under irrigation, 42
- Lamanda, at, 21
- Little Crow Flats, at, 87
- Mandelin Plains, at, 19
- Marquis Plateau, at, 145
- Maynard Flats, at, 87
- Mesa or bench, 14, 15, 27, 31, 40, 42, 58, 59, 67, 92, 111, 149, 297
- Mexican Plateau, a, 300
- Mountain and hill, 10
- Non-irrigated, 23
- Oatman Flat, at, 114
- Pan-handle region, in, 91
- Parley's Park, at, 51
- Plains region, in, 4. 23
- Porous, the, 317
- Public, 19, 35, 41, 44, 48, 49, 66, 84
- Riparian, 273
- Rockies, the, ratio of mountain, plain, and forest area, 108
- Sage brush, the, 39, 309
- San Bernardino, classified, at, 27
- San Jacinto Plains, on, 104, 135
- Sandy Bottom, the, 31
- Small farms and holdings, 71, 319, 320
- Southern Joaquin Plains, in, 11
- Staked Plains, at, Texas, 91, 99
- Stock-raising on irrigated, 315
- Sub-irrigated, 43
- Swamp, 120
- Table, the, 5, 14, 15, 40, 42, 79, 92, 107, 112, 282
  - of Southern Arizona and of New Mexico, 6
- Under canals and ditches, Arizona, 59
- Unity of land and water, 317, 318
- Valley, of the, 10
- Value of, in Egypt, 324
- Value of, with perpetual water right, 49

Page.

- Lakes, as irrigation sources—
  - Atemanica, at 290
  - Atoyac, at 290
  - Burnside, at 147
  - Cajitilan, at 290
  - Chapala, at 290
  - Clear, the 9
  - Devils, the 93
  - Donner, the 75, 145
  - Dry, the 9
  - Eagle, the 9, 19
  - Elizabeth, the 9
  - Fall, the 9
  - Geneva, the 321
  - Goose, the 9, 123
  - Great Salt, the 5, 50, 56, 50, 53, 100, 297, 300, 310
  - Honey, the 9
  - Pyramid, the 147
  - San Marcos 290
  - Santa Maria del Oro 290
  - Sayula 290
  - Tahoe 9, 75, 145, 146
  - Tulare 8, 9, 120
  - Utah 49, 51, 56
  - Zacoalo 290
  - Kern 8, 9, 124
  - Klamath 9
  - Magdalena 290
  - Mercaltitan 290
  - Moeris 321
  - Mono 9
  - Owens 9
  - Pangwitch 49
- Laws relating to irrigation and water—
  - Arizona, statutes of 176, 177, 178
    - Acequias, public and private rights in 176
      - when taken out by private persons 176
      - not to be interfered with 176
    - Animals to be controlled by shepherd 177
    - By-paths prohibited over fields 176
    - Community ownership of ditches 177
    - Conveyance of waters, incorporation for 178
    - Convictions, appeals allowed on 178
    - Crossing of roads by ditches 177, 178
    - Customs of Sonora in force 178
    - Damages, how assessed 176
    - Dams, not to impede irrigation 176
    - Elections, order and conduct 177
    - Exclusive right to water, when 177
    - Fines for refusal to labor 177
    - Funds, road-making for 178
    - Inhabitants, right to construct acequias 177
    - Justices of the peace, their duties 177
    - Laborers, when required 177
    - Land-owners required to labor 177
    - Overseers, pay and duties of 177
    - Reduction works, when prohibited 176
    - Riparian rights, not recognized 176
    - Scarcity of water, how met 177
    - Trees on ditches, owned by 178
    - Water regulations in force 178
  - California, statutes of* 180, 181, 182, 183, 184, 185, 186, 187, 188, 189, 190, 191, 192, 193, 194, 195
    - Acquisition of lands and water 182, 189, 190, 191, 192
    - Agents, power to appoint 181, 182
    - Assessments, how made and paid 180
    - Assessors and deputies, qualifications and duties of 180, 183, 184, 185, 187, 188, 189, 191

---

* Wright district act and acts amendatory.

Page.

Laws relating to irrigation and water—Continued.
California—Continued.
Board of equalization, duties..........183, 188
Board of supervisors, powers of.......... 179
Bonds of district, mode of issue, classes, and sale..........183, 188, 189, 193, 194
Bonds, official amount of..........180, 182, 188, 189, 193
Boundaries, changes of..........179, 189, 190, 191, 192
By-laws, when framed and published.......... 181
Canvass of votes, how made..........180, 181, 184, 185, 187, 188, 189, 190, 192
Certificates, when issued..........180, 184, 185
Collector of taxes, election and duties of..........180, 184, 185, 188, 189
Compensation of officers.......... 187
Construction of works..........181, 182, 186
Contracts, how made and enforced 186
Directors, election and duties of..........181, 186, 188, 189, 191, 192, 194
District for irrigation purposes, its powers..........179, 190, 191, 192, 193, 194, 195
Divisions of district..........179, 180, 184, 190, 191
Elections, how held and what for..........99, 180, 181, 187, 189, 190
Electors, qualifications of.......... 180
Freeholders, right to form district.......... 179
Interest on bonds, amounts of 182, 184
Newspapers, advertising in..........182, 184, 185, 186, 189, 191, 193
Oaths, use and administration of.......... 180
Resident board of directors..........181, 182
Property, assessment, sales, redemption of..182, 183, 184, 185, 186, 188, 189, 191
Salaries, schedule of 187
Secretary board of directors of..........180, 181, 183, 184, 188, 191
Treasurer irrigation district of..........181, 182, 185, 186, 188
Water rights, public control of..........181, 182, 186, 187, 188
Water rights, ownership of, by district..........179, 182
Colorado, statutes of....191, 192, 193, 194, 195, 196, 197, 198, 199, 200, 201, 202, 203, 204, 205, 206, 207, 208, 209, 210, 211, 212, 213, 214, 215, 215
Certificates of priority, now issued.......... 196
Claims to water must be filed.......... 191
Clerks of courts, duties, etc..........197, 198, 199, 200, 201, 202
Commissioner, for water districts 199, 207, 208
bond of.......... 212
powers of distribution, etc..........199, 200, 201, 213
Construction of ditches, etc, time allowed.......... 191
Corporation ditches, control of..........202, 203, 204, 205, 206, 209, 210, 212
County commissioners, irrigation duties of..........202, 206, 210, 211
Diminution of flow, rights of owners affected..........194, 195
by lowering of channel 195
Distribution of water, act regulating..........212, 213
District courts, required to adjudicate 195
filing descriptions with.......... 175
powers of..........196, 197, 198
referees to be appointed by.......... 198
powers given to..........198, 199, 200
Ditch owners as common carriers.......... 206
Ditches to be kept in repair, penalties for failure 203, 204
willful injury to, trespass on 204, 205
Evaporation and seepage, allowance for 203
Fees, provisions for 199, 202
Foaling streams and ditches forbidden.......... 205
Flumes, construction and care of 204, 205
Governor, duties of 208, 212, 213
Headgates to be maintained by owners.......... 204
Irrigation districts, their powers.......... 207
Judges, their duties and powers 198, 199, 200, 201, 202
Measurement of water, mode of 205, 208, 209
Newspapers, use of for legal notices 196
Numbering ditches, when and how.......... 197
Possessory land title, conveys water.......... 194
River appropriations, provisions for..........194, 195, 196, 197, 198, 199, 201, 202
Private ditches, regulation of.......... 202
Private lands, taken under eminent domain.......... 191
Rates for water, regulations of..........210, 211, 212
Referees, their fees and pay 201

Page.

- Laws relating to irrigation and water—Continued.
  - Colorado—Continued.
    - Reservoirs, owners and construction of. 203
    - Right of way, relating to 195, 202, 203, 209, 216
    - Sheriffs, their powers 198, 202
    - State engineer, competent in hydraulics 208
      - duties of 208, 209
    - State land commissioners 209, 210
    - Superintendents division of irrigation 213, 214, 215
    - Taxation, irrigation works free from 209
    - Vested rights maintained 191
    - Water rights, act to protect 215
    - Water wheels, right to use 191
  - Dakota, statutes of 217, 218, 219, 220, 221, 222
    - Act for artesian wells 218, 222
    - Abandoned, right of way, when 218
    - Additional assessments 221
    - Advertise for bids 220
    - Appeals to district court 219
    - Application by freeholders 218
    - Appointment of viewers 218, 219
    - Appointment, mode of 220
    - Assessed lands, description of 222
    - Assessment, board of 220
      - meetings of 220
      - modes of 220
      - principles of 221
      - reviews of 221
    - Attorney-general, duty of 221
    - Blanks, attorney-general's office 221
    - Board assessment, meeting of 220
    - Clerk county, duty of 221
    - Code, civil 221
    - Code, political 217
    - Collection of tax 220, 221
    - Commissioners created 218
    - Compensation of officers 221
    - Construction, bids for 220
    - Contract, security of 220
    - Contractors, mode of payment 222
    - Damaging lands, penalty for 217
    - Delinquency, sale for 221
    - Description assessed lands 222
    - Deterioration of lands 217
    - Diminution of water 217
    - Disqualification of officers 221
    - Disqualification by interest 222
    - Duty of overseers 219, 220
    - Failure of, compliance with law 217
    - Fee of viewers 219
    - Fund, artesian well 220
    - Land-owner's rights 217
    - Locating right of way 218
    - Location, order for 219
    - Model for assessment 220
    - Model for appointment 220
    - Model for collection 220
    - Model for railway collection 219
    - Overseers of highways 222
    - Penalty for non-payment 219, 222
    - Plat, filing of 214
    - Repeal of law 222
    - Report on damages 219–221
    - Right of way 418
    - Sale of land for delinquency 221
    - Tax, general township 220
    - Tax, railway share of 219
    - Water-courses unobstructed 217
    - Water rights, under 216, 217
    - Wells, references to 218, 219, 220, 221

Page.

Laws relating to irrigation and water—Continued.
  Idaho, statutes of 222, 223, 224
    Appraisers, to hear water cases 223
    Appropriation of water, right to use 222, 223
    Beneficial use to be defined 223
    Canals, construction and care of 222, 223
    Claim, notice of, to be posted 222
    Company or corporation, action of 222, 223
    Common property defined 224
    Damages, on what grounds 224
    Distribution of water, how 223, 224
    Diversion to be complete 222
    Fines, when levied 224
    Frontage on stream 222
    Husbandry, protection of 224
    Labor, when required 224
    Necessary works to be provided 224
    Newspapers, notices in 223
    Rights of owners to be protected 223, 224
    Water district, how formed 224
      master, how elected 224
        and deputies, powers 224
  Kansas, statutes of 225
  Montana, statutes of 226, 227, 228, 229, 230
    Agricultural use of water 226
    Appeals, when taken 228
    Appraisers, appointment of 226
    Appropriation, what is required by 229, 230
    Appropriation of water to be beneficial 229
    Certificates of appropriation 225
    Company or corporation, power and obligations of 228
    Costs of suits 225, 226, 227, 228
    County roads to be crossed 228
    Courts, appeals to, and powers of 226. 227, 228
    Damages, how punished 226, 227
    Diverting water unlawfully 229
    Fines, when levied 226, 227, 229
    Measurement of water 230
    Public highways to be repaired 227
    Rights of way 226, 227, 228, 229
    Sale of water 226, 227, 228
    Water, access for use not to be forbidden 229
  Nebraska, statutes of 230
  Nevada, statutes of 230, 231, 232, 233, 234, 235, 236, 237, 238, 239, 240
    Acts passed, titles of 230, 236, 237, 240
    Annual water rent, conditions of 239
    Appeals, when allowed 234
    Appropriations 232
    Arable lands, when irrigated 241
    Artesian wells, bounty for 240
    Beneficial use of water 231
    Board of county commissioners, their powers 231, 232
    Board of reclamation, its powers 237, 238, 239
    Bonds, appropriation for 238
      issue and redemption 238, 239
    Certificates of priority, how issued 233, 234
    Clerk of the supreme court 233, 234
    Civil engineer, provided for, duty of 238
    Construction of works, how provided for 232, 234, 235, 238, 239
    Corporations, how regulated 233, 234
    County, its relation to irrigation districts 231
    Courts, powers of 231, 232, 233, 234, 235
    Damages, willfully done 234
    District courts, their jurisdiction 231
    Ditches, owners of, their priorities 232, 233, 234
    Ditches, their regulation 235
    Division of water, when unlawful 237
    Diversion of water, when 235
    Elections, when held 238

Page.

- Laws relating to irrigation and water—Continued.
  - Nevada—Continued.
    - Headgates, use and protection of 231, 232
    - Interest on bonds 239, 240
    - Irrigation districts, how formed 237
    - Newspapers, notices in 233, 234
    - Priorities, water right 233, 234, 235
    - Public property in water reservoirs, provisions relating to 232, 233, 234, 235
    - State, comptroller of, his duties 239
      - governor of, his duties 230, 236, 239
      - officers, unlawful interest in 239
      - treasurer of, his duties 239
      - surveyor-general, his duties 238
    - Water commissioners, their duties 230, 231, 232, 235
  - New Mexico, statutes of 240, 241, 242, 243, 244
    - Acequias, public 240, 241, 242
      - private 241, 242, 243
    - Access to water for cattle not deniable 243, 244
    - All impediments to irrigation prohibited 240
    - Appraisers, for compensation or damages, their duty 241
    - Compensation for right of way 241
      - when refused 241
    - Commissioners of ditches 242, 244
    - Community, construction of ditches 240
    - Elections for irrigation purposes 240
    - Fines, when levied 242, 243
      - recovered, used for ditch purposes 241
    - Justices of peace, their duties 240, 241, 242
    - Major-domos, elected by people 242
      - their duties, pay, etc 241, 242, 243, 244
    - No payment for land when ditch is public 240
    - Obligation to labor enforced 242
    - Overseers of ditch repairs, etc 242, 243
    - Property in ditches 241
      - when lying in different counties 241
    - Proprietors of land obligated to labor 243
    - Pueblo Indians, their community, rights to water 244
      - elect major-domos 244
    - Rivers and streams as public ditches 240
    - Salt lakes, public property in 244
    - Shepherds, to control herds 240
    - Tenants of land 243, 244
    - Water sources, all declared free 244
    - Wells, their use 244
  - Oregon, statutes of 239
    - Conveyance of water, right of way for 239
    - Patents for State lands, water rights of 239
    - Right of way granted 239
    - Use in irrigation 239
  - Utah, statutes of 247, 248, 249, 250, 251, 252, 253
    - Advertising, provided 250, 251
    - Agreement, to pay tax 250
    - Appraisals of land 252
    - Appraisement of land 251, 252
    - Assessments, for irrigation 251, 252
    - Average flow of water supply 248
    - Ballots to be counted by 250, 251
    - Board of references 248
    - Books of record, water rights in 248
    - Bonds to be filed 251
    - Canals in district 250, 253
    - Canals for irrigation 247, 253
    - Certificate, district election 250, 251
    - Certificates, water right 248
    - Claims for water or damages 248, 249
    - Clerk of district 250, 251
    - Commissioners, water 248, 253
    - Certificates, liability of 253
    - Constructions, use of water 248

Page.
Laws relating to irrigation and water—Continued.
Utah—Continued.
Construct, works to 253
Construction of irrigation works, by whom 253
Corporations, how formed 248, 249, 253
County recorder 248
Dams, when to be constructed 252
Damages, payment for 250, 252
Definitions, in law 249
Distribution of water, who by 248, 250
District work 250, 251
Ditch, right of way 247, 250, 251, 252, 253
Ditches, construction of 247, 250, 251, 252, 253
Diversion of water, when unlawful 253
Domestic purposes for 249
Duty of county comptroller 250, 253
Duty of district officers 250, 252
Duty of recorder 248
Duties of selectmen 248
Duties of trustees 250, 253
Elections for officers 250, 251
Estimates for works 250, 251
Exemptions from 252
Homestead, lien on 247
Injury to settler 247
Irrigation districts 250, 253
Judges of election 250, 251
Lakes, when used 252
Landholders to form water districts 250, 253
Location of districts 250
Maps of districts 251
Measurement of water 249
Misdemeanor, when guilty of 252
Notices, water districts 250, 253
Officers of water districts 250, 253
Patents, for lands, lien on 247
Powers of trustees 250, 253
Pre-emption, allowed lien on 247
Primary rights 247, 249
Prior appropriation 247, 248, 249
Priority of possession 247, 248
Public domain, references to 247
Public highways, navigable rivers are 248
Rate of taxation, how determined 251
Real estate, owned by water district 250, 252
Reclamation, water for desert land 247
Right of way 249, 250
Roads, when used 252
Roll-list required 250, 251
Secondary rights 248, 249
Selectmen, ex-officio water commissioners 248
Settlers on public domain 247
Streams in different counties 251
Streams, not navigable 247, 248
Suits in equity 248
Surplus water, use of 249
Tax, for irrigation 250, 253
Tax-payers, obligation of 250, 252
Terms of district trustees 251
Treasurer of district 250
Trustees, for water districts 250, 253
Unusual flow, secondary rights to 249
Uses of water 248
Utah, laws of, sessions of 1878–1880 ..... 247, 253
Value of lands 250
Water, when insufficient 249
Water rights, how secured 247, 250
Texas, statutes of 244, 245, 246, 247
Act to encourage irrigation 244

XEROX

Xerox University Microfilms

Ann Arbor, Michigan 48106

WESTERN AMERICANA

Reproduced from the original in the collection of

THE HENRY E. HUNTINGTON LIBRARY AND ART GALLERY

Page.

- Laws relating to irrigation and water—Continued.
  - Texas—Continued.
    - Appropriation of unused waters 244, 245
      - of land for right of way 245, 247
      - prior, provided for 245
    - Canals, injury to 246
    - Commissioners' courts, powers of 246, 247
    - Condemnation of land 247
    - Construction works, when to begin 245
    - Contract for right of way 245
    - Corporations, forming of powers and duties 245, 246, 247
    - Domestic use, of way 245
    - Fares, when levied 246
    - Fences, regulation of 245
    - Grant of right of way 246
    - Health to be protected 247
    - Irrigation works, how inaugurated 247
      - over public lands 246
    - Owners of land, failing to protect works 246
    - Police regulations, to protect ditches 246
    - Use of water, public right to 247
  - Wyoming, statutes of 253, 254, 255, 256, 257, 258, 259, 260, 261, 262, 263, 264
    - Adjudication provided for 262
    - Agriculture to have preference of water over manufacturing 263
    - Appeals from arbitration 254
    - Appraisers, their duties 253, 254
    - Appropriation of water 255, 256, 257, 258, 259, 260, 261
    - Arbitration provided for 204
    - City rights to water protected 260
    - Compensation for damages provided 254
    - Commissioners of irrigation provided for 255
    - Commissioners' duties defined 255, 256, 257
    - Damages for leakage, etc 259
    - Districts provided for 255
    - Domestic use of water to have preference 263
    - Engineer for the Territory provided for and duties defined 261, 262, 263, 264
    - Fish to be protected 260
    - Incorporation provided for 262
    - Jurisdiction of courts 259
    - Land and water rights defined 252
    - Machines for raising water, right to 254
    - Possessory titles to land, water use attached 253
    - Prior rights guarantied 263
    - Prior rights protected 253
    - Rights of way for ditches defined 253
    - Surplus water to be sold 263
    - Water declared public property 263
    - Witness fees, mileage, etc 259

P.

- Pipes—
  - Asphalt concrete 133
  - Conduit 131
  - Wrought-iron laminated 132
- Population—
  - Arizona (estimated), of 59
  - British India (total), of 326
  - California, of 35
  - Egypt, Upper and Lower 325
- Products, value of—
  - Arizona, in 60
  - California, in 34, 37
    - cattle of 15
  - Colorado, in 65
  - Cotton, of 54, 314, 321, 322, 323, 324
  - Dakotas, in the 77
  - Indigo, of 291
  - Montana, in 41
  - Nebraska, in 80, 84

Page.

Products, value of—Continued.
  Sheep, of........ 15
  Sorghum, of........ 62
  Sugar, of........54, 58, 62, 291, 293, 314, 321, 322, 323, 324

R.

Rain-fall of arid regions..3, 6, 11, 12, 27, 31, 34, 40, 43, 48, 55, 58, 70, 83, 89, 91, 103, 133, 167, 272, 293, 309
  Bear Lake, at........ 139
  Belts........ 30
  Benicia, at........ 8
  British India, in........ 326
  California, in........ 103
  Cascade Mountains, east of........ 6
  Clear Lake, at........ 8
  Dakota, in........ 79
  Dayton, at........ 43
  Des Moines, at........ 55
  Distribution of........ 24
  Effect on irrigation........ 30
  Emery County, in........ 54
  Fort Redding, at........ 7
  Fort Lyon, at........ 7
  Great Plains region........ 81
  Greeley, at, effects on........ 70
  Idaho, average annual, in........ 39
  Increase, at high altitudes........ 43
  Increasing in West........ 81
  Kern River Cañon on........ 12
  Los Angeles, at........ 24
  Mexico, in........282, 283
  Millerton, Cal., at........ 7
  Monterey, at........ 7
  Mount San Jacinto, on........ 30
  Mount Nebo........ 53
  Mountains, in Utah........ 48
  Natural........ 19
  Piute County, in........ 52
  Pillarcitos, at........ 8
  Plains, on the........ 88, 89
  Rocky Mountains, on the........ 108
  Sacramento, Cal........ 7, 8
  San Diego, at........ 8
  San Francisco, at........ 8
  Salt Lake, at........50, 51, 52, 56
  Seasons of Arizona........ 59
  Shepherd rains, Arizona........ 59
  Sierra (winter), on the........ 127
  Southern California, effect of intercepting mountains........ 27
  Southern Texas........ 4
  Stockton, Cal........ 7
  Storage reservoirs, in relation to........ 89
  Texas, in........ 88
  Utah, annual of........ 48, 49
  Use of........ 109
  United States, in the........ 302
  Valleys in the........ 27
  Visalia, at........ 8
  Walla Walla, annual, at........ 43
  Washington........ 43
  Yuma, Ariz........ 114
Ranches—
  Bellevue........125, 126
  Buena Vista........ 123
  McClung........ 123
  Moxie........ 42
Reservoirs—
  Alpine County, in........ 147

Page.

- **Reservoirs—Continued.**
  - Areas of, surface and capacity 141
  - Atemajac de las Tablas 290
  - Bear Lake, at 50, 141
  - Bear Valley, at 28
  - Capacity of 63
  - Cuyamaca, at 31, 136
  - Divisions, at South Platte, No. 1 64
    - Arkansas, at No. 2 64
    - Rio Grande, at No. 3 64
  - Hemet Valley, in 135
  - Hope Valley, in 146
  - Juriquilla, near 294
  - Las Cuartas, at 291
  - Los Angeles County, in 305
  - Mormon Creek, at 20
  - Natural, the 56, 59
  - Oatman Cañon, at 114
  - Pinto, at 294
  - Proposed at Pantano 111, 112
  - Proposed at Sierra Lakes 145, 148
  - Principal irrigation, the 305
  - Quererato, Mexico, at 294
  - Santa Catarina, at 294
  - San Miguelito estate, on 294
  - San Pedro Valley, in 112
  - Santa Rosa, Tescuitatlan, at 290
  - Sites for 19, 31, 52, 66, 111
    - head of the Weber, at 50
  - Space and water supply 141
  - Storage 30, 42, 70, 89, 107, 133, 136
  - Bear Lake Valley, at 138, 139
  - Subterranean 56, 87
  - Sweetwater, at 119, 120
  - Tabulated summary of, in Colorado 65
  - Temecula Cañon storage, at 32
  - Tlaxcala, in 294
  - Wyoming, in 76
  - Yuma County, Ariz., in 113
- **Rivers and valleys in irrigable regions—**
  - Acaponeta 291
  - Aqua Fria 111
  - Amacusac 292
  - Ameca 289, 290
  - American 8, 13
  - Apazalco 289
  - Apisa 291
  - Arkansas 63, 81, 82, 86, 89, 106, 143, 144, 145, 167, 298, 303
  - Astula 292, 293
  - Atloyac 294
  - Ayuquila 289, 290
  - Bad 79
  - Balsas 291
  - Barenda 149
  - Bear 13, 42, 50, 54, 305
  - Beaver 86
  - Big Sioux 79
  - Big Thompson 87
  - Blanco 295
  - Boisé 39, 42
  - Bolanos 289, 290
  - Cache La Poudre 50, 67, 68, 69, 87
  - Calabozo or San Juan 295
  - Calaveras 8
  - Camotlan 289
  - Canas 289
  - Cannon Ball 79
  - Carson 9, 146, 147, 300
  - Castle 54

Page.

Rivers and valleys in irrigable regions—Continued.
  Casones 295
  Chacala 289, 290
  Chalma 292
  Cheyenne 79
  Chiquita 6
  Chonechilla 8
  Chontalcuratlan 292
  Coatzacoalcos 295
  Colorado 6, 29, 55, 56, 57, 58, 86, 99, 111, 115, 287
  Columbia 5, 6, 29, 42, 43
  Consumnes 8, 13
  Cunarron 5, 86
  Cuitzeo 289
  Cuyama 9
  Dakota 80
  De los Hules 295
  Deschutes 44
  Diamond 146, 147
  Dog 145
  Dolores 143
  Duero 291
  Dutch 147
  Dumnunkle 301
  Eel 9
  Elk 9
  El Cajon 136
  El Sur 9
  Feather 8, 13
  Francisco 58
  Fresno 8, 13
  Gallatin 40
  Gila 6, 56, 58, 60, 62, 91, 111, 114, 115, 155
  Grand 55, 67, 79, 143, 168
  Grass 53
  Green 52, 54, 55, 67, 79
  Hassayampa 61
  Heart 79
  Hemet 31, 135
  Houdo 149
  Honey Lake 19
  Hope 146
  Huetamo 291
  Humboldt 300
  James, or Dakota 79, 92
  Jordan 48, 51, 300
  John Day 44
  Juclupila 291
  Jefferson 40
  Kameah 8
  Kern 8, 9, 13, 121, 123, 124, 125, 126, 127, 301, 302
  Kings 8, 13, 309
  Kittitas 43
  Klamath 8, 9, 42
  Lerma 289, 291
  Little Grand 54
  Little Missouri 79
  Little Truckee 145
  Long 147
  Los Angeles 8, 9, 15, 17, 25
  Lower San Gabriel 25
  Lower Santa Ana 25
  Mad 9
  Madison 40
  Mantla, or Rio Frio 295
  Maple 79
  Marques 291
  Merced 8, 13

Rivers and valleys in irrigable regions—Continued. Page.
- Missouri 4, 40, 79, 80, 81
- Mississippi 62, 300
- Moctezuma 295
- Mojave 27
- Mokelumne 8, 13
- Montezuma 143
- Moreau 79
- Mouse 79
- Murray 296, 302
- Nachez 43
- Napa 8
- Nazas 289
- Nile 57, 320, 321, 323
- North Platte 63, 81
- North Spring 149
- Old 124
- Ogden 50
- Otter 40
- Owens 19, 20
- Owyhee 44
- Pajaro 9
- Parnuco 297
- Papaloapam 297
- Pawnee 86
- Payette 39
- Pecos 99
- Pitt 8
- Platte 68, 88
- Pleasant 147
- Po 273, 383
- Powder 40, 44
- Provo 51, 52
- Poudre 309
- Queretaro 294
- Rabbit 53
- Ramos 287
- Red 79, 80, 92, 95
- Republican 82
- Rio Bravo 294
- Rio Grande 4, 56, 57, 63, 66, 148, 291, 292, 293
- Rio Grande de Morelia 289
- Rio Grande de Tehuantepec 293
- Rio Mudo 295
- Rio Pecos 148
- Rio Verde 56
- Richardson 301
- River systems in Idaho 38
- Roque 42
- Rosebud 40
- Round 19
- Rush 53
- Russian 8, 9
- Sacramento 8, 9. 13, 19, 131
- Saguache 300
- Salinas 8, 9
- Salt 6, 56, 58, 62, 101, 111
- San Buenaventura 9
- San Bernardno 102, 104, 139
- San Diego 9, 31, 136
- San Diequito 31, 136
- San Fernando 23, 24, 102
- San Gabriel 9, 23, 24
- San Geronimo 292
- San Jacinto 31, 104, 135
- San Joaquin 7. 8, 9, 10, 11, 12, 13, 23, 27, 28, 102, 120, 308
- San Juan 55
- San Lorenzo 9

Page.

Rivers and valleys in irrigable regions—Continued.
- San Luis 66, 74, 300
- San Luis Rey 9, 31
- San Marcos 295
- San Pedro 6, 58, 92, 112, 289, 295
- San Pitch 52
- San Simon 92
- Santa Ana 9, 27, 28, 29, 103, 104, 139, 306
- Santa Clara 8, 9
- Santa Cruz 6, 56, 58, 91, 92, 112
- Santa Inez 9
- Santa Maria 9
- Santa Margarita 9
- Santiago 301
- Sestin 287
- Seven 149
- Sevier 52, 53, 54
- Sheyenne 79
- Silver King 147
- Skull 53
- Smith 9
- Smoky Hill 81
- Snake 6, 42, 44
- Sonoma 8
- South Pablo 295
- South Platte 63, 87
- South Spring 149
- Spanish Fork 51
- Stanislaus 8
- St. Peter and St. Paul 295
- Sulphur 92
- Susan 19
- Sweetwater 31, 116, 136
- Tambemba 292
- Tamesi 295
- Tecolutla 295
- Tepalcatepec 291
- Tesechoacean 295
- Thistle 52
- Tie Juana 31
- Tietan 43
- Tongue 40
- Toole 53, 56, 101
- Truckee 75, 145, 147, 148, 300
- Tulare 9
- Tule 8
- Tuohumie 8, 13
- Tuxpan 289, 290
- Upper Santa Ana 138
- Utah 51, 56
- Vermillion 79
- Villa Alta 293
- Virgin 54, 55
- Walnut 86
- Weber 51
- Wenatchee 43
- West Fork of the Carson 146, 147
- White 8, 44, 79
- White Water 32
- White Woman 86
- Winniera 301
- Yakima 43
- Yellowstone 40, 41, 100
- Yuba 8, 303
- Zahuapan 294
- Zapotla 297
- Zula 289, 290

Rocks and strata, references to 10, 14, 17, 85, 86, 87, 88, 92, 93, 95, 139

Page.

S.

- Seasons, in relation to irrigation—
  - Delta, in the 321
  - Drought, of 51, 61, 77, 82, 143, 148, 292, 293, 294, 295, 300
  - Non-irrigating, the 134
  - Rainy, the 10, 11, 12, 59, 116, 121, 133, 282, 287, 292, 294
- Sloughs, used in irrigation 9, 11, 123, 124, 125, 310
- Soils and their irrigable character—
  - Alluvial 5, 8, 13, 57, 58, 282
  - Black and sandy loam 77
  - Clay 51, 54, 70, 307
  - Infiltration, of 267, 268
  - Limestone 149
  - Mesa and table lands, on 41
  - Quicksand 87, 303
  - Red loam 41
  - Sandy 11, 17, 19, 50, 51, 89, 127, 310
  - Subsoil 69
- Small fruit, under irrigation 6, 34, 43, 77
  - Blackberries 17, 62, 314
  - Grapes 17, 34, 35, 39, 60, 62, 65, 99, 316
  - Mulberries 325
  - Raisins 17
  - Raspberries 17
  - Strawberries 17, 19, 62, 71
- States, references to—
  - California 4, 6, 7, 9, 15, 17, 19, 20, 21, 26, 29, 30, 34, 37, 40, 56, 57, 62, 74, 75, 84, 129, 139, 148, 163, 297, 298, 299, 300, 301, 305, 307, 310, 314, 316, 317, 320, 333
  - Colorado 4, 5, 6, 38, 55, 67, 73, 74, 82, 84, 85, 88, 90, 143, 163, 265, 297, 298, 300, 304, 305, 307, 314, 317, 318
  - Dakotas, the, North and South 4, 79, 80, 84, 85, 105, 163
  - Georgia 267
  - Iowa 300
  - Kansas 4, 81, 82, 85, 86, 163, 297, 298, 300, 317
  - Louisiana 317
  - Minnesota 88, 93, 300
  - Missouri 317
  - Montana 4, 5, 38, 84, 163
  - Nebraska 4, 82, 84, 163
  - Nevada 4, 5, 6, 19, 38, 49, 55, 56, 57, 84, 91, 145, 146, 148, 163, 297, 304, 309
  - Oregon 4, 5, 6, 38, 43, 44, 84, 163
  - Texas 4, 5, 40, 88, 91, 148, 265, 300
  - Washington 4, 6, 38, 44, 84, 163
- Snow-fall, in arid region 6, 13, 14
  - cubic, feet of 39
  - Idaho, in 39
  - melting in summer 127
  - perpetual snow 9
  - Rocky Mountains, on 82, 108, 109
  - Sierras, on the 13, 107
  - Utah, in 48
  - Nevada, average depth of 75

T.

- Taxable values of California 35
- Trees, in irrigable areas—
  - Acacias 325
  - Ash 58, 62
  - Black oak 12
  - Box-elder 39
  - Catalpa 62
  - Cedar 8
  - Cork elm 62
  - Cottonwood 8, 30, 58, 62, 112
  - Cypress 325
  - Elm 12, 137
  - Fir 8
  - Locust 39, 58, 62
  - Lombardy 62

Page.

- Trees, in irrigable areas—Continued.
  - Magnolia, 62
  - Mesquite, 62
  - Myrtle, 325
  - North Carolina poplar, 62
  - Oak, 8, 136
  - Palm, 62
  - Pepper, 62
  - Pine, 8, 12, 136
  - Poplar, 39
  - Redwood, 12, 303
  - Sycamore, 8, 325
  - Tamarack, 62
  - Timber, forest, 40, 58, 70, 74, 79, 107, 108, 333
  - Umbrella, 62
  - Walnut, 39, 316
  - Weeping willow, 325
  - Willow, 8, 30, 62
- Territories, references to—
  - Alaska, 4
  - Arizona, 4, 5, 7, 38, 55, 88, 60, 81, 84, 91, 105, 163, 297, 309, 317
  - Idaho, 4, 5, 38, 42, 43, 44, 84, 163
  - Indian, 4
  - New Mexico, 4, 5, 6, 38, 56, 58, 81, 84, 91, 92, 105, 148, 149, 163, 265, 298, 299, 301, 305, 315, 317
  - Utah, 4, 5, 6, 38, 55, 56, 67, 84, 163, 296, 297, 298, 299, 300, 304, 306, 308, 309, 310, 314, 315, 317, 318, 319
  - Wyoming, 4, 6, 38, 76, 79, 84, 163, 169, 300
- Testimony and statements as to irrigation—
  - Aughey, Prof. Samuel, 81
  - Baker, P. G, 23
  - Breckenridge, William M, 111
  - Burton, J. R, 71
  - Carpenter, L. G, 63, 168
  - Castanos, Senor D. Gabriel, 292
  - Cartee, L. F, 39
  - Chaffee, Bros, 28
  - Chamberlin, Professor, 93
  - Cole, Mr, 267
  - Culver, George E, 105
  - Deakin, Hon. Alfred, 294, 295, 296, 297, 298, 299, 300, 301, 302, 303, 304, 305, 306, 307, 308, 309, 310, 311, 312, 313, 314, 315, 316, 317, 318
  - Dunbar, Thomas P, 71
  - Eaton, F, 121
  - Farnish, Mr, 60
  - Fernow, B. E, 108
  - Gilbert, G. G, 144
  - Gilbert, J. W, 144
  - Hall, William H, 26, 27, 30, 31, 32, 103
  - Hicks, Professor, 96
  - Hughes, Thomas, 22
  - Indian agent's report, Arizona, 115
  - International Encyclopedia, from, 269
  - Jackson, L. D. A, 323
  - Jones, Prof. M. E, 49, 50, 101
  - Judd, Orange, 84
  - Linant, M, 320
  - Manuel, George, 21
  - Marsh, Hon. George P, 265, 266, 267, 268, 269, 276
  - Maxwell, State engineer, Colorado, 63, 168
  - Meade, Elwood, 76, 169
  - Mills, T. B, 167
  - Moncrief, Sir Colin, 321
  - Nettleton, Edwin S, 108, 168
  - Newell, Prof., U. S. G. S, 167
  - Powell, Director J. W, 96, 165, 167, 318
  - Oury, F. W, 111
  - Roseler, Frank E, 98

Page.

Testimony and statements as to irrigation—Continued.
  Schuyler, James D 115
  Shorb, J. De Barth 62
  Soule, E. E 144
  Thomas, Governor 100
  Tweedale, W 82, 83, 84, 85, 86, 87, 88
  Ulrich, J. C 142
  Van Diest, P. H 90
  Walker, Francis A 84
  West, George H 85
  Wheeler, George M 96
  Wilbur, C. D 81

U.

United States, references to 3, 5, 9, 17, 21, 55, 81, 84, 89, 91, 92, 115, 265, 268, 282, 298, 299, 300, 317

V.

Value of product, California 34
Vineyard, Barton, at Fresno 319
  Raisin region, in the 10
  Phyloxera, pest of the 131

W.

Water, amount, character, duty, etc., of—
  Amount of, used in India, cubic feet 18
    Spain 18
  Appropriated for irrigation 70
  Bearing strata 86, 87, 88
  Blank contracts used in Colorado 153, 154, 155, 156, 157, 158, 159, 160, 161, 162, 163
  Blank showing the manner of meeting tax 48
  Capillary attraction of 310
  Commissioner of 69
  Cost of, per hour in Los Angeles County 25, 26
  Cost of, Yakima Valley, Washington 43
  Daily consumption of, for different kind of crops 83
  Deed for, form of 73
  Depth of, at Yuma 114
  Digest of decisions in United States State courts on appropriations, uses, jurisdictions, in suits 333, 334, 335, 336, 337, 338, 339, 340, 341, 342, 343, 344, 345, 346, 347, 348, 349, 350, 351, 352, 353, 354
  Distribution of, in Arizona 63
    in Los Angeles County 25, 26
    methods and measures 285
    by pipes 306
  Duty of 7, 15, 28, 63, 311, 312
  Evaporation of 7, 56, 61, 70, 86, 107, 308
  Fertilizing quality of 83
  Flood, the 324
  Flow of, Big and Little Rock Creek, in 20
    Colorado River, in 29
    Mojave River, in 20
    southwest Kansas, in 82
  Fort Adams as, store-house 43
  Gauge of 45
  Horary, or time distributory system of 47
  Increase of 7
  Laws, Colorado, of, reference to 72, 73
    France, of 273, 274, 275, 276, 277, 278, 279, 280, 281
    Mexico, of 283, 284, 285, 286, 287, 288, 289, 293
    Modern Italy, of 272
    Older lands, of 269, 270, 271
    and practices 46, 47, 48
      regulations 15, 16
    of Spain 281, 282

Page.

- Water, amount, character, duty, etc., of—Continued. 15, 16
  - Legal relations of 279
    - servitude of 283
  - Liter, unit of measure for 24
  - Lost in bowlders 28, 45, 46
  - Master or zenjero 69
  - Maximum of, in Cache La Poudre 46
  - Measurements of 283
  - Mexican use and control of 41
  - Miner's, inches of, furnished by Yellowstone River 128
  - Module for measurement of 44
  - Natural public property in 50
  - Ogden, head of 21, 61, 125
  - Percolation of 289
  - Poncelet's system 312, 313, 314
  - Price of 74
    - perpetual rights 46
  - Primary rights of 271
  - Privileges and their character 85, 86
  - Pumping by 24
  - Re-appearing in Ciengas 287, 288, 289
  - Regulations, State of Durango 289, 290
    - Jalisco 287
    - Lower California 291
    - Michoacan 74
  - Rented 89
  - Reservoirs, to prevent loss of 73, 74
  - Rights, farmers' service 277
    - France, in
    - under State constitutions— 171, 172
      - California 172
      - Colorado 172, 173
      - Idaho (proposed) 173, 174
      - Montana 174
      - New Mexico (proposed) 174
      - North Dakota 174
      - Washington 174
      - Wyoming (proposed) 240
    - treaties United States guarantying Mexican customs 68
    - Union Colony, of Colorado 295
    - Zacetas, at Mexico 92
  - San Simon Valley, in 324
  - Shadoofs or Egyptian lifters 7, 11, 53, 70, 85, 87, 89, 125, 308, 310, 311
  - Seepage of, in river, valleys, etc 30, 136
  - Sheds of 139
    - Bear Valley 147
    - Carson River 49
    - Utah 301
  - Springs of California 99
    - Comanche 75
    - Nevada
  - Storage of— 39, 106, 107, 109
    - altitudes, at high 34
    - California, in 148
    - Carson and Truckee basins, in 40, 41, 42
    - Montana, in 31, 66
    - Necessary 85
    - Surplus in the Rocky Mountains 291
  - Small Mexican streams: Caramecuara 291
    - Las Joyas 293
    - Oaxaca 292
    - Purnaran or Caliente 291
    - San Juan 292
    - Tacambaro 292
    - Turivan
  - Supply of, in— 5, 29, 33, 112, 300
    - Arid mountain region 14
    - By pumping, in California 6
    - Colorado Plateau, on 86
    - By drainage

Page.

Water, amount, character, duty, etc., of—Continued.
  Supply of, in—Continued.
    Exhaustion of 109
    Foot Hill region, Mt. Shasta, and San Bernardino ranges 13
    Idaho, in ....
    Montana, sources of, in 42
    Nevada, in 75
    Owens Valley, in California 20
    San Joaquin Valley, in 10
  Sources of 297
      Tamaulipas 294
      Vera Cruz, Mexico 295
    Subterranean 7, 13, 14, 48, 129
    Wyoming, in 76
    Surface, on 70
    Surplus of 26, 323
    System, distribution of 47
        Los Angeles County, in California 25
    Tia, Juana, head of 36
    Underflow or sheet water 85, 88, 91, 92
          Kansas and Upper Arkansas, in 143, 145
          Texas, in 91
    Use of wells 105
    Utilizing subterranean 14
    Value of 28
    Vera Cruz and Zacatecas, at 295
    Volume from Yellowstone River 40
    Waste 107
  Weirs or drops 127, 128
    North Poudre 303
    South Platte 303, 304
    Wooden 303
  Winds—
    Chinook, a warm 6
    Dry 108
    Hot 70
    Trade 14
    Windmills 14, 38